Assessment and Recommendations For Habitat Protection

Strawberry Point, Whidbey Island

Prepared for

Island County
Planning and Community Development Department

January 30, 2009

Note:
Some pages in this document have been purposefully skipped or blank pages inserted so that this document will copy correctly when duplexed.

ASSESSMENT AND RECOMMENDATIONS FOR HABITAT PROTECTION

Strawberry Point, Whidbey Island

Prepared for

Island County Planning and Community Development Department
P.O. Box 5000
Coupeville, Washington 98239

Prepared by

Herrera Environmental Consultants, Inc.
2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
Telephone: 206/441-9080

January 30, 2009

Contents

Tables

Figures

Acknowledgments

This document was prepared by Herrera Environmental Consultants, Inc. (Herrera). The watershed conditions characterization was performed by the Island County Planning and Community Development Department (PCDD).

Executive Summary

The Island County Planning and Community Development Department retained Herrera Environmental Consultants, Inc. (Herrera) to assist with developing recommendations for habitat protection at Strawberry Point on Whidbey Island, Washington. Based on an assessment of historic and current conditions, this report presents recommendations to protect habitat for both salmonids and forage fish that occur along the Strawberry Point shoreline. Strawberry Point has been identified as a high priority site for the protection of juvenile salmon and as a very high priority site for protection of forage fish. The goal of this project is to protect and maintain the nearshore processes and aquatic habitats at Strawberry Point for the benefit of both salmonids and forage fish species.

Strawberry Point is located in Island County on the northeastern shoreline of Whidbey Island on Skagit Bay in Puget Sound. Located approximately 2 miles from the mouth of the Skagit River, the northern portion of Strawberry Point comprises approximately 6 miles of wide, sandy beach and several creek mouths, flanked by forested flat bluff tops and steeper bluff faces to the southwest of the shoreline. A portion of the project area (32 acres) lies within Deception Pass State Park; the rest of the project area (380 acres) is characterized by shoreline, forested shoreline bluffs, agricultural lands, and rural residences.

To develop specific and appropriate recommendations for habitat protection, Herrera characterized the aquatic nearshore habitat conditions and conducted an analysis of the most important physical and ecological processes and conditions that influence aquatic habitat in the project area, in particular: coastal geology and geomorphology and coastal shoreline vegetation conditions. In addition, information from a recent Island County study on watershed conditions in the Strawberry Point project area was incorporated as appropriate.

The analysis and conclusions presented in this assessment and recommendations for habitat protection report are based on a review of existing information, as well as observations and data collected during a site visit to Strawberry Point on April 9, 2008. Detailed results and conclusions of the analysis are presented in this report, focusing on how both historical and current conditions influence habitat quality in the Strawberry Point project area.

Results of the analysis were evaluated and synthesized by the Herrera project team, in coordination with Island County, to develop specific implementation actions designed to protect the nearshore processes and aquatic habitats at Strawberry Point for the benefit of both salmonids and forage fish species. Recommendations were developed for the entire Strawberry Point project area as a whole, as well as for site-specific areas at the watershed scale. Some of the key recommendations for voluntary protection measures, presented in more detail in the main body of the report, include the following:

- Discourage land use practices that reduce native nearshore vegetation or adversely affect ecological functions (e.g., by contributing to erosion or lack of recruitment potential for large woody debris).

- Discourage the installation of new shoreline structures (such as revetments or bulkheads), and encourage the replacement of existing structures with "softer" means such as placing wood at the toe of the bluff or restoring the native shoreline vegetation.

- Protect the riparian corridor of streams within individual watersheds within the project area, and encourage the voluntary replanting of currently exposed areas in the riparian zone.

- Where maintenance of views is desired (e.g., in residential development areas), discourage the complete removal of shoreline vegetation and encourage "windowing" of large woody vegetation.

- Acquire some of the undeveloped lands on areas adjacent to streams, wetlands, or the shoreline and/or implement conservation easements to protect these areas in the future.

- For any new development in the project area, encourage the use of best management practices and low impact development techniques and strategies.

- Provide outreach to homeowners and developers in the area, with a focus on educational materials that inform residents on how land use practices can affect habitat conditions in the upland portion of the nearshore and areas downstream (e.g., the shoreline).

Introduction

The Island County Planning and Community Development Department (Island County PCDD) retained Herrera Environmental Consultants, Inc. (Herrera) to assist with the development of recommendations to protect nearshore marine and freshwater habitat at Strawberry Point on Whidbey Island, Washington. Based on an assessment of historic and current conditions of coastal geology and geomorphology, shoreline vegetation resources, aquatic nearshore habitat, and overall watershed conditions, this report presents recommendations to protect and improve habitat for salmonids and forage fish that occur along the shoreline of Strawberry Point. This effort was partially funded by a grant from the Salmon Recovery Funding Board (SRFB).

Strawberry Point is located in Island County on the northeastern shoreline of Whidbey Island on Skagit Bay in Puget Sound (Figure 1). This study focuses on the northern portion of the Strawberry Point shoreline as well as the broader area of influence, referred to in this report as the project area. Located approximately 2 miles from the mouth of the Skagit River, the northern portion of Strawberry Point comprises approximately 6 miles of wide, sandy beach and several creek mouths, flanked by forested flat bluff tops and steeper bluff faces to the southwest of the shoreline. The north/northwestern portion of the project area (32 acres) is within Deception Pass State Park; the rest of the project area (380 acres) is characterized by shoreline, forested shoreline bluffs, agricultural lands, and rural residences (approximately 260 single-family homes and associated development).

Project Goal and Objectives

The Salmon Recovery Plan (SRP) for Water Resource Inventory Area 6 (WRIA 6) describes Strawberry Point as a high priority site for juvenile salmon protection and a very high priority site for forage fish protection (Island County 2005). The primary goal of this project is consistent with the WRIA 6 SRP Goal 1: to achieve a net increase in salmon habitat through voluntary inventory and protection.

The goal of this project is to protect the nearshore processes and aquatic habitats at Strawberry Point for the benefit of both juvenile and adult salmonids and forage fish species. To meet this goal, four specific project objectives were established: (1) identify and assemble relevant existing data, (2) fill needed data gaps where possible, (3) evaluate relevant data, and (4) recommend implementation actions for habitat protection.

Figure 1. Vicinity map of the Strawberry Point project area on Whidbey Island, Washington.

Assessment Methodology

The assessment presented in this report involved:

- An analysis of the coastal geological and geomorphic conditions of the Strawberry Point project area
- An analysis of the nearshore and related habitat conditions and coastal processes
- A characterization of current shoreline vegetation conditions
- An assessment of overall watershed conditions.

Analysis and conclusions presented in this report were based on a review of existing information and observations and data collected during a site visit to the Strawberry Point project area on April 9, 2008, conducted both by boat and by walking the shoreline and nearshore of the project area. This day was the peak of spring tides, with a low tide of -2.82 feet mean lower low water (MLLW) occurring at 2:00 PM Pacific Daylight Time (PDT), and a high tide of 11.6 feet MLLW occurring at 6:54 AM PDT. Tidal heights were those observed at Seattle and modified according to National Oceanic and Atmospheric Administration (NOAA) adjustments for Ala Spit, the nearest NOAA adjustment location (approximately 4 miles northwest of the Strawberry Point project area). These tidal conditions allowed the investigators to observe geomorphological features in the project area as well as to identify the strongest tidal flows and most significant tidal fronts in the nearshore.

For consistency with a recent study conducted by Island County–the Strawberry Point Watershed Characterization (Island County 2008a)–this assessment considered the various watersheds that occur within the Strawberry Point project area. The recent study divided the project area into seven discrete subwatersheds or coastal drainage areas (which are described in more detail in the *Results and Discussion* section, below). Where applicable, the analysis presented in this report addresses each of the individual subwatersheds. Each subwatershed/coastal drainage area is listed sequentially below, moving from southeast to northwest (also see Figure 1):

- Watershed 23
- Coastal Drainage Area 1
- Watershed 18
- Watershed 16
- Coastal Drainage Area 2
- Watershed 14
- Coastal Drainage Area 3.

Assessment of Geologic and Geomorphic Conditions

Habitat features and their quality along Strawberry Point are influenced by historic and current geologic and geomorphic conditions of the shoreline and nearshore. The approach to the interpretation of shoreline geomorphology in the project area was primarily process-based, involving an examination of oceanographic conditions as well as an assessment of human modifications. Physical processes lead to the formation of recognizable and classifiable geomorphic features. A high-resolution geologic map was consulted and used as a baseline map to characterize the surficial geology of the area (WDNR 2005a). In addition, other recent studies of the coastal geomorphology of north Whidbey Island (Herrera 2007, 2008a) were used to obtain detailed information regarding the recent geologic history of the area. The following existing sources provided additional pertinent information:

- A detailed (7.5-minute) geologic map of the Ebey's Landing National Historical Reserve (WDNR 2005b)
- Master's thesis describing the surficial sediment deposits of central and northern Whidbey Island (Carlstad 1992)
- Reference regarding the Everson Interstade (Armstrong et al. 1965), an important geologic time period in the area
- Island County mapping report (Johannessen and Chase 2005)
- PhD dissertation describing the geomorphology of Puget Sound beaches (Finlayson 2006)
- A recent survey of Puget Sound bluffs (Shipman 2004)
- A geologic map showing the sea-level history during the Everson Interstade (WDNR 2004).

Field observations and shoreline photographs taken during the April 2008 site visit were used to verify the information obtained from these existing resources. This allowed the identification of small-scale variability at the site level that could not be captured in the larger scale regional sources of information.

Oceanographic Characterization

A number of studies have investigated the general circulation of marine waters in Skagit Bay and Puget Sound (Collias et al. 1973; Babson et al. 2006; Yang and Khangaonkar 2009). In particular, Collias et al. (1973) provided basic information about the hydrography of the waters surrounding Strawberry Point and emphasized the complexity of currents in the project area. During the site visit, observations were made of the direction of tidal flow in the channel

separating Whidbey Island from the Skagit River delta. Oceanographic fronts, common near the project area and indicative of the presence of freshwater riverine plumes and suspended fine sediment, were also observed and noted.

Waves are the dominant physical process transporting sediment on the beach foreshore in the project area. Waves in Puget Sound are fetch-limited and are generated almost exclusively by local winds. The nearest publicly available meteorological (wind) data are from the Arlington Airport. Although wind patterns on Whidbey Island are unusual, with winds blowing into and out of the Strait of Juan de Fuca, as well as north and south confined by the Olympic and Cascade mountain ranges, the Arlington data provide a reasonable estimate of the strongest winds that influence the project area. Because fetch is the dominant variable regulating wave height, the size of waves along the beach can be estimated using simple algebraic wind-induced wave estimation formulas that account for the basin geometry (USACE 1984; Finlayson 2006).

Human Modifications

As part of the geomorphic conditions assessment, an analysis of aerial photographs and early survey material was completed to determine changes in the shoreline since European settlement. This analysis involved the use of geographic information system (GIS) resources by overlaying historic and current georeferenced photographs and historical mapping sources on lidar-derived hillshade data from 2002. An objective of this analysis was to identify landslides and to measure the change in the position of the shoreline over time.

Human modifications and the past and present location of the shoreline were identified and mapped from observations during the site visit and from the analysis of aerial photographs and available survey material. Aerial photographs taken in 1956, 1965, 1971, 1981, 1990, 1997, and 2006 together with a topographic sheet (T-sheet, or shoreline map) dating from 1909 (USCS 1909), and a historic sheet (H-sheet, or a hydrographic map or nautical chart) were used. These photographs and early survey maps provided information on the estimated location of the shoreline and the migration (advance) of subtidal platforms over time. Human modifications as well as the past and present location of the shoreline determined from these sources were verified by observing existing onsite conditions. In addition, the effects of human modifications were assessed by comparing such modifications to similar land-use practices and their related impacts to the marine nearshore environment elsewhere in western Washington.

Characterization of Nearshore Aquatic Habitat Conditions

Nearshore habitat conditions were characterized based on a review of existing information and observations during the site visit. The characterization of the nearshore included an assessment of the marine and streams habitats (and associated fish utilization) within the project area. However, due to property access limitations and potential associated high cost, field characterization of the stream channels was not included in this study.

Fish habitat use along the Strawberry Point shoreline was characterized through a review of existing data and information. Several available data sources, assessment inventories, studies, and management plans provided relevant information. Sources relied upon for this characterization included the following:

- Assessments of pocket estuary and shoreline habitat conditions for juvenile salmonids conducted by the Skagit River System Cooperative (Beamer et al. 2003, 2005)
- The Strawberry Point Watershed Characterization (Island County 2008a)
- High resolution aerial photographic interpretation (Google Maps 2008)
- Oblique aerial photographs from the Washington State Department of Ecology (Ecology 1976–1997, 1992, 2000)
- WRIA 6 Multi-Species Salmon Recovery Plan (Island County 2005)
- Puget Sound Intertidal Habitat Inventory 1996 for Skagit County and Northern Whidbey Island of Washington State (WDNR 1997)
- Documented spawning areas for forage fish (Bargmann 1998; Island County et al. 2003; Stick 2005; WDFW 2008a, 2008b, 2008c)
- Shoreline management/zoning designation data from Island County (Island County 2008a).

Characterization of Nearshore Vegetation Conditions

The shoreline vegetation is an essential component of the nearshore environment and has important impacts on watershed function. Therefore, shoreline land cover and vegetation types were characterized as part of this study. Study methods included a combination of aerial photographic interpretation and site visit observations, using land cover types consistent with those used in Island County's previous mapping efforts. Additional sources of data were incorporated into the analysis, as appropriate. The primary data sources used in this study included the following:

- Strawberry Point Watershed Characterization (Island County 2008a)
- High-resolution aerial photography (Google Earth 2008; USDA 2006)
- Oblique aerial photographs from Ecology (Ecology 2006).

Shoreline vegetation conditions were characterized in all areas within 200 feet of the shoreline throughout all Strawberry Point watersheds and coastal drainage areas (described below, under the *Watershed Characterization* section), referred to in this report as the study area. This study

area was selected to be consistent with the regulatory jurisdiction established by the Washington State Shoreline Management Act, which extends from the ordinary high water mark (OHWM) landward 200 feet (Revised Code of Washington [RCW] 90.58.030).

Rectified aerial photographs (USDA 2006) and aerial oblique shoreline photographs (Ecology 2006) were examined to identify robust vegetation assemblage types based on land use, species composition, and habitat structure. The selected land cover categories were based on a combination of: (1) land cover types identified in the Strawberry Point Watershed Characterization (Island County 2008a), and (2) assessment of the level of detection resolution afforded by interpretation of the aerial photographs and Google Earth images. The land cover categories used in the analysis included the following:

- Coniferous forest
- Mixed forest
- Mixed forest, manicured understory
- Deciduous forest
- Shrub
- Bluff face (and other steep slopes)
- Field
- Lawn
- Large woody debris
- Impervious.

Land cover type polygons were digitized over aerial photographs using ArcMap 9.2, with a minimum map unit of approximately 150 feet at an approximate resolution of 1:1500 to 1:2000. To augment the aerial photograph digitizing process, Google Earth imagery was used to provide a higher resolution interpretation of land cover characteristics. To further provide watershed-specific land cover descriptions, an effort was made to capture breaks in land cover types along watershed boundaries. Given the difficulty of capturing land cover type characteristics on the bluff face and other steep slopes along the shoreline when digitizing the aerial photographs, these areas were digitized separately using a process described in detail in Appendix B.

National Wetland Inventory (NWI) data provided by the U.S. Fish and Wildlife Service (USFWS) and Island County GIS data for wetlands were reviewed as part of the land cover analysis. No previously mapped wetlands were identified within the project area. Soil survey GIS data from the Natural Resources Conservation Service (NRCS) were also reviewed, but general soil types did not appear to influence land cover types at the level of resolution used in this study. It is likely that the varied land use history in the project area masks much of the influence that the soil types have on land cover types (at least in non actively erosive areas).

High resolution geologic data were examined to explore any correlation between land cover types and soil stability characteristics (WDNR 2005a). The geologic GIS dataset was first interpreted to identify areas of the bluff characterized by historic landslides and significant soil instability. Digitized land cover types were then overlain onto this dataset to examine how polygon boundaries related to changes in slope type. In many cases, boundaries of old landslides

corresponded with forest type transitions, which helped to both refine the polygons and support the hypothesis that land cover types at Strawberry Point appear to represent the interaction of land use practices and geomorphic conditions.

In addition, a land cover dataset for Strawberry Point provided by Island County (Island County 2008b) was used to confirm and refine the digitized land cover polygons developed as part of this study. The Island County dataset covered a significant area of the Strawberry Point watersheds, and Herrera's nearshore study built on this comprehensive mapping effort by providing an enhanced level of detection in subtle shifts in vegetation community types in the shoreline zone and by providing coverage of previously unmapped areas.

Descriptions of land cover types, polygon attributes (i.e., land cover types assigned to each polygon), and polygon extents were revised following the April 9, 2008 site visit based on direct observations and further assessment and interpretation of Google Earth imagery and the photographs (taken during the site visit, as well as the existing aerial and oblique photographs). Land cover type distribution in the project area was subsequently quantified on a per-watershed basis.

Watershed Characterization

Habitat features and their quality along Strawberry Point are influenced by physical and hydrological conditions in the surrounding watersheds. Between 2006 and 2008, Island County conducted a watershed characterization of the Strawberry Point drainage areas (Island County 2008a). This characterization focused on the physical, hydrologic, and habitat features of the watershed, with emphasis on the zoning, land use, and surface water quality conditions. The intent of this characterization was to identify land use and water quality parameters that could potentially affect habitat conditions in the Strawberry Point nearshore environment (Island County 2008a). The watershed characterization was conducted using a combination of methods, including field and windshield surveys, interpretation of aerial photographs, GIS analysis, and preliminary collection and testing of water quality samples from the tributary stream systems draining to the Strawberry Point nearshore environment. The findings of Island County's watershed characterization (Island County 2008a) are summarized here as appropriate.

Develop Protection Recommendations

Results of the analyses described above (i.e., coastal geologic and geomorphic conditions, nearshore habitat environment, shoreline vegetation conditions, and watershed characterization) were evaluated and synthesized by the Herrera project team, in coordination with Island County, to develop specific implementation actions designed to protect the nearshore processes and aquatic habitats at Strawberry Point for the benefit of both salmonids and forage fish. Protection recommendations were developed in consideration of the stated goals of the WRIA 6 SRP. Recommendations were developed for the project area as a whole, as well as by individual watershed or coastal drainage area.

Results and Discussion

Geologic and Geomorphic Conditions

The following section provides an overview of the geologic and geomorphic conditions of the Strawberry Point project area, including a description of geologic conditions, the relevance of these conditions to the existing nearshore environment, historic and current geomorphic conditions, oceanographic conditions, and human modifications.

Geologic Conditions

Whidbey Island, and Strawberry Point in particular, is a glacial feature in the Puget Lowland, which occupies a basin bounded on the west by the Olympic mountains and on the east by the Cascade mountains. It is a region of active tectonic stresses driven by the northeastward subduction of the Juan de Fuca (oceanic) plate and the northward migration of the Mendocino Triple Junction (Wells et al. 1998; Finlayson 2006). These tectonic stresses occur as a series of faults, some of which pass through the project area. Throughout the last one million years, the Puget Lowland has been inundated by the Cordilleran Ice Sheet, the continental ice sheet formed during ice ages on the west side of the Rocky Mountains (Bretz 1913; Armstrong et al. 1965). As many as six distinct glacial advances filled the basin with sediment to an elevation of more than 400 feet above present sea level (Booth 1994). However, the sediments of the last advance, the Vashon Stade, dominate the landscape throughout the project area.

The Vashon Stade

The entire landscape in the vicinity of Strawberry Point was "reset" by the Puget Lobe during the Vashon Stade. Therefore, it is useful to understand the sequence of events that occurred during the advance and retreat of the Vashon Stade. Nearly all of the sediments that comprise the land surface above sea level on northern Whidbey Island were delivered from farther north by this ice sheet or events that followed it.

Approximately 20,000 years ago, the Cordilleran ice sheet, fed by snow accumulation in inland British Columbia, advanced past Admiralty Inlet and cut off the Puget Lowland from marine influence. This caused the formation of a large lake in the Puget Lowland. The dammed lake caused the deposition of all of the fine-grained sediments that would normally be flushed out to sea. The sediment deposits remaining from this event are known as Lawton Clay, the first of the three layers of sediment commonly associated with the Vashon Stade. As the Puget Lobe of the Cordilleran ice sheet continued to advance for the next approximately 5,000 years, it released at its terminus large amounts of sand and gravel. This material is often referred to as outwash. In Puget Sound, the sedimentary deposit associated with (advance) outwash during the Vashon Stade is called the Esperance Sand. The final major deposit left by the ice sheet was a till, usually called the Vashon Till. These series of deposits are seen throughout Puget Sound, with

the Lawton Clay on the bottom, the Esperance Sand above that, and capped by the Vashon Till. The reason that the Vashon Till is often the most surficial deposit throughout the Puget Lowland is because the Puget Lobe is thought to have collapsed quickly. Because much of the Puget Lowland is relatively flat and above seawater influence, the processes that followed these events did not produce significant sedimentary deposits, except near modern rivers and shorelines.

The Everson Interstade and Local Sea-Level History

In many places throughout Puget Sound, no substantial geomorphic alteration has occurred since the collapse of Puget Lobe and the formation of the three deposits described above. On northern Whidbey Island, however, significant deposits of material occur as a result of the Everson Interstade, a time period immediately following the collapse of the Puget Lobe (Carlstad 1992; WDNR 2005a). Once the Puget Lobe collapsed, the edge of the Cordilleran Ice Sheet stabilized somewhere near the modern-day town of Coupeville (WDNR 2005b). At this time, seawater flooded the Puget Lowland. Because the land near the ice edge (including the project area) remained depressed by the weight of the ice, many areas near it were held well below sea level. Ice continued to flow from northeast to southwest during this time, as evidenced by the drumlins seen in lidar (Figure 2). This period of time after the collapse of the Puget Lobe, but before ice left the project area completely, is referred to as the Everson Interstade.

During the Everson Interstade, the preexisting glacial sediments delivered during the Vashon Stade were redistributed by both seawater and the advancing ice sheet (Figure 2). For areas lower than about 300 feet above modern sea level (then the local sea level), flow of newly returned seawater quickly remobilized the previously deposited Vashon Stade sediments. This inundation created a smooth landscape below this elevation, often comprised of relatively fine-grained sediments (WDNR 2005a, 2005b).

Once the glacier began to retreat again north of the project area, the land gradually rebounded (uplifted) and the local sea level fell (WDNR 2004). During this time, Strawberry Point gradually emerged from the sea. This gradual emergence is recorded as a series of terraces along the Strawberry Point shoreline (WDNR 2005a) (Figure 2). These terraces are common and segment the coastal bluffs into active and inactive (previously active) portions, particularly near the western edge of the project area.

Relevance of Geologic History to the Modern Nearshore

Since the formation of Everson Interstade deposits, sea level has remained relatively stable, at least as compared to the variability experienced at the end of the last glaciation. This stability, along with sediment delivery from the advancing Skagit River delta, has caused the formation of a broad, low-tide terrace with elevations ranging from a few feet above to a few feet below MLLW. Low-tide terraces are common throughout Puget Sound (Finlayson 2006). However, the low-tide terraces in the project area, particularly near its western end, are muddier than most.

K:\Projects\07-03638-000\Project\Geologic.mxd

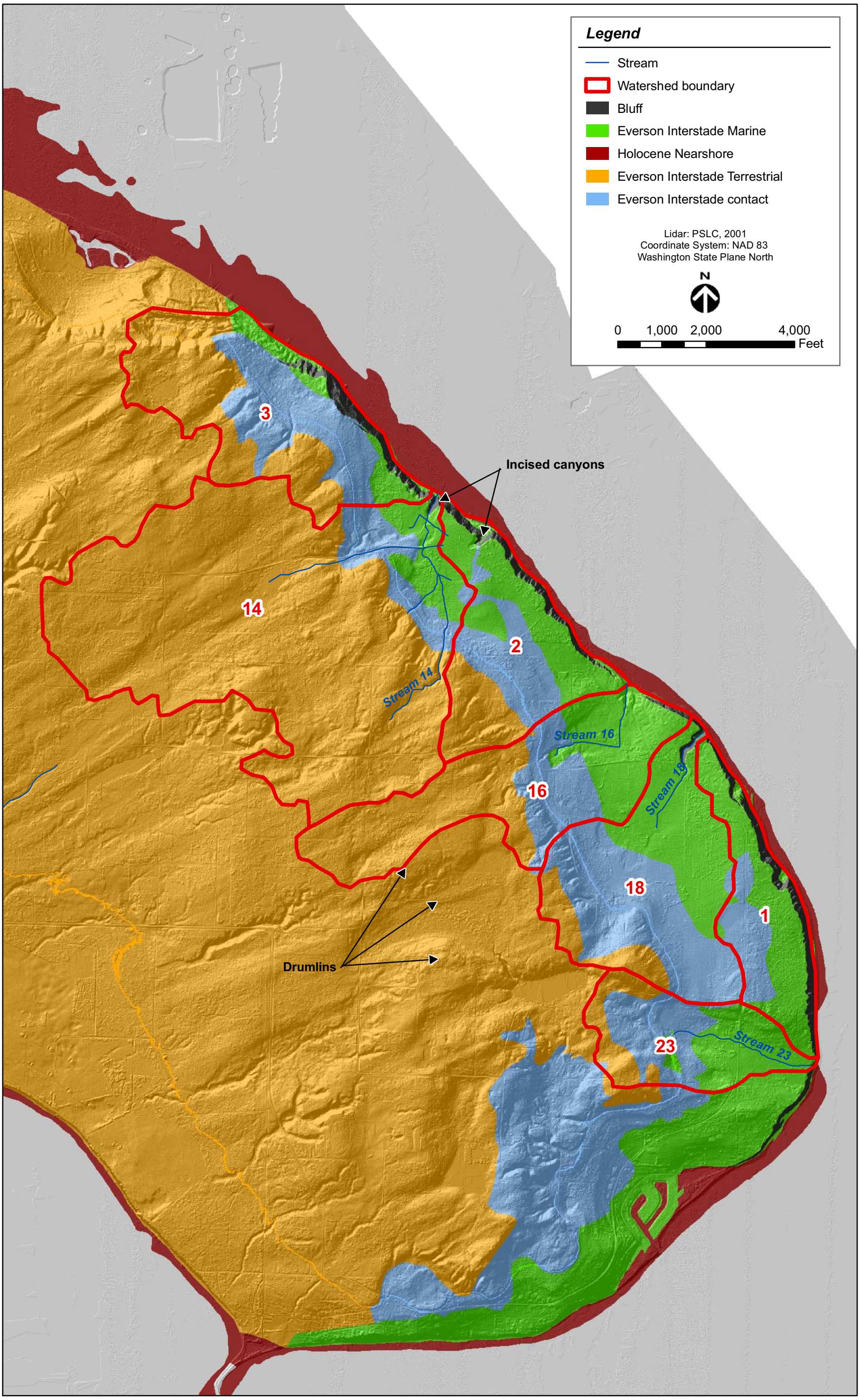


Figure 2. Geologic and geomorphic map of Strawberry Point overlain on a lidar hillshade of the area. Watershed numbers and boundaries are also shown.

Landward of the low-tide terrace is a steeper beach foreshore. The foreshore is the most sedimentologically active portion of the nearshore (Finlayson 2006). Because the foreshore derives most of its material from the erosion of adjacent coastal bluffs, it reflects the type of sediment that comprises those bluffs, ranging in size from sand to boulders. Because northern Whidbey Island has also been subject to tectonic deformation (mostly via the Strawberry Point Fault Complex) and glacially derived material is heterogeneous, the composition of the beach foreshore varies dramatically throughout the project area.

Geomorphic Conditions Prior to European Settlement

Four unnamed stream systems drain to the nearshore marine environment in the Strawberry Point project area (Island County 2008a; see Figure 2 for stream locations). These streams are identified by the Island County designation for the watersheds in which they occur (i.e., Streams 14, 16, 18, and 23).

The undisturbed reach of shoreline in Deception Pass State Park provides an excellent example of geomorphic conditions found prior to European settlement. Figure 3 illustrates many of the features common to the nearshore prior to development. Here, large trees extend down to the beach foreshore. In many instances, these trees, both deciduous and conifer, shade the beach and accumulate woody debris. Large woody debris is also extensive along the shore, often suspended in overhanging trees. Near the larger stream mouths (e.g., Stream 18) in the project area, marshes could have potentially existed. Freshwater input to these marshes was likely substantially less than under existing conditions; most of the existing streamflow is associated with runoff from roads and other developed (deforested) areas. Aside from Stream 18, it is likely that concentrated (channelized) surface water flow is an artifact of development.

Existing Geomorphic Conditions

Although the entire shoreline in the project area is in the same drift cell (identified as WHID-20 in Johannessen and Chase [2005]), the activity and nature of the sediment supply and transport do change along shore. The watersheds and drainage areas delineated in the Strawberry Point Watershed Characterization (Island County 2008a) provide a useful framework by dividing the project area into discrete geomorphic subunits. As mentioned in the Watershed Characterization, these watersheds do not represent the only pathway for water to enter the nearshore environment. Several other outlets of freshwater were found across the shoreline during the site visit. These varied from small (less than 1-foot diameter) corrugated plastic pipe outlets, likely draining single residences, to larger municipal road drains. Where observed during the site visit, these outlets are identified on the geologic conditions maps prepared for this study.

Figure 3. Photograph of the shoreline in Deception Pass State Park, which was likely typical of predevelopment conditions at Strawberry Point.

Each watershed, coastal drainage area, and associated stream is described below in the order they appear, moving along the shoreline from southeast to northwest:

- Watershed 23 – The geologic characteristics of this watershed are depicted on Figure 4. The small, channelized stream associated with this watershed drains developed land and enters Skagit Bay via a deeply incised slot canyon. However, there is no geomorphic manifestation of the stream outlet on the nearshore (i.e., no delta or outlet channel through the beach), indicating that expression of the stream may be anthropogenic, particularly given its relatively deforested drainage area. Substantial wave erosion of the adjacent bluffs is evident, and there is evidence of shoreline protection structures (i.e., placed rock) near the stream outlet (see the *Human Modifications* section, below). The foreshore associated with this watershed/stream is predominantly cobble with occasional boulders. The low-tide terrace, if it exists, was not observed due to the timing of the visit to this area (i.e., this watershed was visited at a time prior to low tide).

- Coastal Drainage Area 1 – The geologic characteristics of this coastal drainage area are depicted on Figure 4. The shoreline in this coastal drainage area faces east and has been identified as a source of sediment for the rest of the drift cell and project area (Johannessen and Chase 2005). The shoreline is simple (featureless), with the exception of a riprap revetment described in detail in the *Human Modifications* subsection. Bluffs in the area are generally steep and actively supply material for much of their height to the nearshore. Two landslides have been previously mapped in this area (Figure 4), and an additional small landslide was observed on the April 2008 site visit (see the *Coastal Bluffs and Landslides* subsection, below). The nearshore is typified by a steep gravel to cobble foreshore with a narrow, sandy low-tide terrace (Figure 5). Large woody debris and wood wrack are common, except near the riprap revetment in the middle of the area.

- Watershed 18 – The geologic characteristics of this watershed are depicted on Figure 6. The small stream associated with this watershed flows through a residential parcel that currently maintains a conservation easement (Hilton 2008). A small delta has formed on the foreshore, although there was no surface-water expression of the stream at the shoreline at the time of the site visit (Figure 7). However, the presence of the delta indicates a likely hydraulic connection of the stream to Puget Sound during times of higher flow. The beach foreshore in this reach is finer grained than on adjacent shorelines, indicating that the stream may have supplied a large amount of sediment during times of high flow in the past. A relatively narrow, sandy low-tide terrace is associated with this watershed/stream.

- Watershed 16 – The geologic characteristics of this watershed are depicted on Figure 6. The shoreline segment along this watershed has been cleared and bulkheads installed (Figure 8). The land surface is unusually flat, with distinct terraces associated with the residences. Although the land surface was likely relatively flat prior to development due to seawater inundation during the Everson Interstade, the land surface may have been further modified (graded) when the area was developed. Recession of the foreshore has been caused by the presence of the bulkheads, particularly where they protrude onto the beach foreshore (Figure 8). The foreshore is generally finer grained than the adjacent areas (Coastal Drainage Area 1 and 2). It is uncertain whether this is associated with the bluff substrate, or whether it reflects the sediment supply from the two small streams associated with Watersheds 16 and 18. Watershed 16 also marks the beginning of a dramatic expansion of the low-tide terrace width (>200 feet). It also corresponds to distinct fining in the sediment present on the low-tide terrace. The extensive mud deposits are consistent with sediment delivery from the Skagit River, which was partially confirmed by the presence of tidal fronts observed during the site visit (see the *Oceanographic Characterization* section, below, for details).

- Coastal Drainage Area 2 – The geologic characteristics of this coastal drainage area are depicted on Figure 9. The shoreline along this coastal drainage area is dominantly cuspate, as evident when the shore is viewed from Deception Pass State Park (Figure 10). Cuspate forelands are geomorphic features found on coastlines and created by longshore drift. Composed of sand and small gravel, and typically later stabilized by vegetation, cuspate forelands are triangular-shaped accretions that extend seaward. The cusps are generally erosional on the east side and depositional on the west side, consistent with along shore transport to the west. In the depositional shadow of one of these cusps at Coastal Drainage Area 2, a small sandy spit has begun to form (Figure 11). The shoreline in the pocket estuary associated with the spit has been developed, modified, and armored with a treated-wood bulkhead, although it is unclear to what extent this has occurred (see the *Culvert-Induced Incision* subsection, below). One landslide is associated with an area between two of the cusps, with instances of raveling and soil creep on the updrift (east) sides of all of the other cusps (see the *Coastal Bluffs and Landslides* subsection). The foreshore in this reach is generally coarse grained but varies significantly from gravel-bedded to cobble-bedded with intermittent boulders. The entire area has a broad (>400 feet), muddy low-tide terrace.

- Watershed 14 – The geologic characteristics of this watershed are depicted on Figure 12. Watershed 14 is the largest watershed by area; however, like the other smaller watersheds with streams, there was no evidence of a

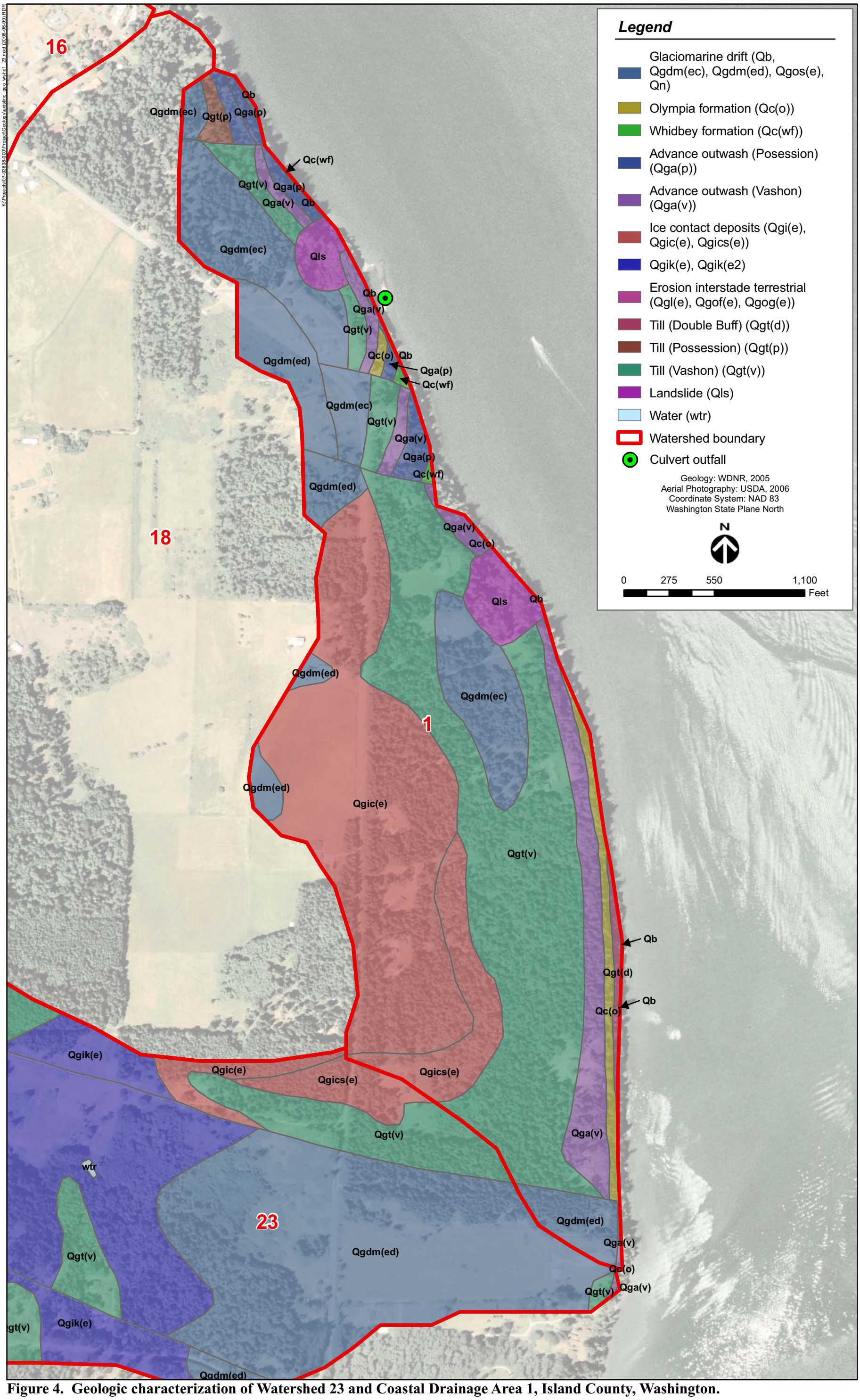


Figure 4. Geologic characterization of Watershed 23 and Coastal Drainage Area 1, Island County, Washington.

Figure 5. Photograph of a typical shoreline in Coastal Drainage Area 1.

K:\Projects\07-03638-000\Project\Geology\existing_geo_wshd16_18.mxd (2008-06-09) RDR

Legend

- Glaciomarine drift (Qb, Qgdm(ec), Qgdm(ed), Qgos(e), Qn)
- Whidbey formation (Qc(wf))
- Advance outwash (Vashon) (Qga(v))
- Ice contact deposits (Qgi(e), Qgic(e), Qgics(e))
- Qgik(e), Qgik(e2)
- Erosion interstade terrestrial (Qgl(e), Qgof(e), Qgog(e))
- Till (Possession) (Qgt(p))
- Till (Vashon) (Qgt(v))
- Landslide (Qls)
- Water (wtr)
- Watershed boundary

Geology: WDNR, 2005
Aerial Photography: USDA, 2006
Coordinate System: NAD 83
Washington State Plane North

N

0 225 450 900 Feet

2
16
18
1
Qb
Qc(wf)
Qgdm(ec)
Qgog(e)
Qga(v)
Qgt(p)
Qgt(v)
Qgik(e)
Qga(p)
Qls
Qgic(e)
Qgdm(ed)
wtr
Qgl(e)

Figure 6. Geologic characterization of Watersheds 16 and 18, Island County, Washington.

Figure 7. Small delta formed on the beach foreshore at the outlet of the stream associated with Watershed 18.

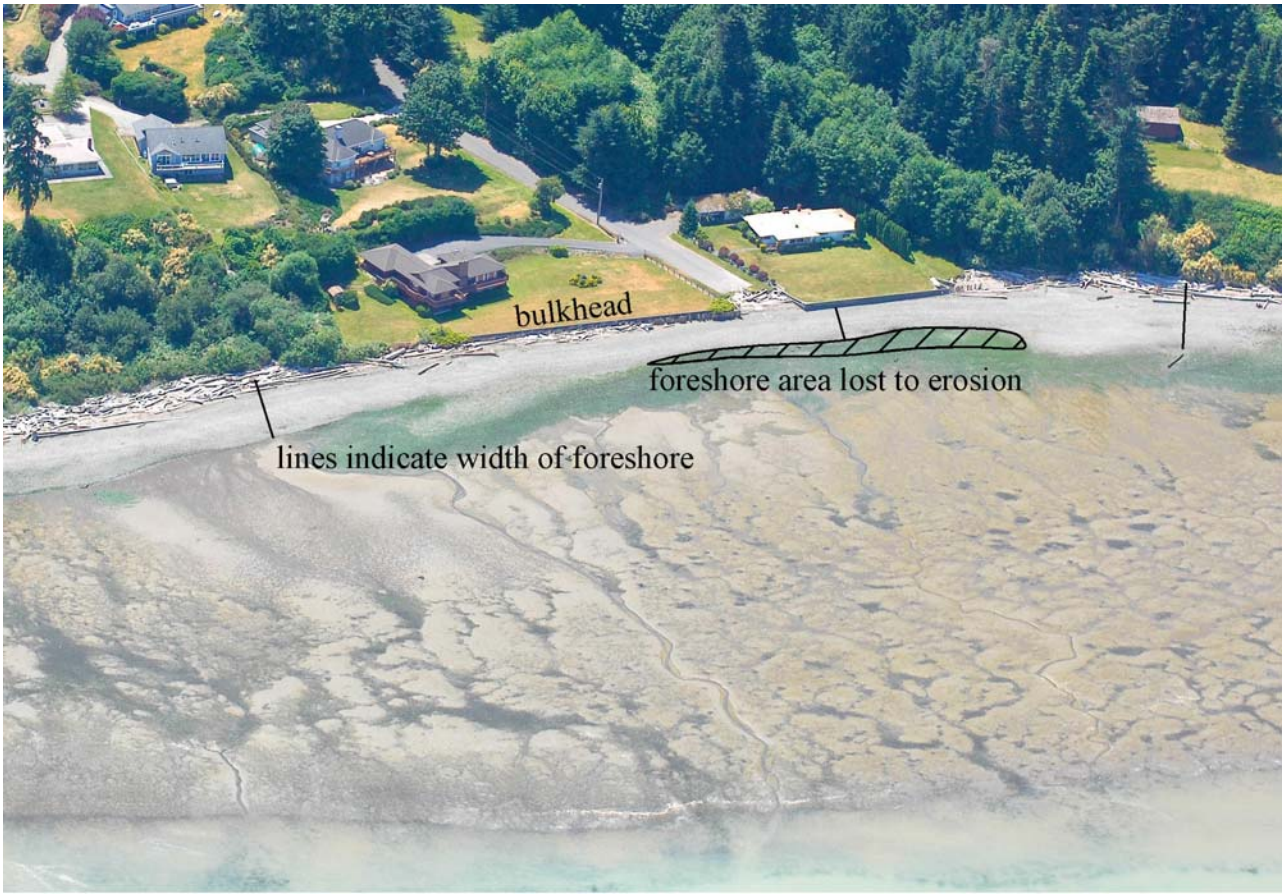


Figure 8. Oblique aerial photograph of the outlet of the unnamed stream that drains Watershed 16. Note that the section of the beach is lower in front of the bulkheads than on adjacent shorelines, indicating that the protective structures have caused erosion and shortened the foreshore. Narrowed foreshores are a common impact of bulkhead installation (Herrera 2005; NRC 2007).

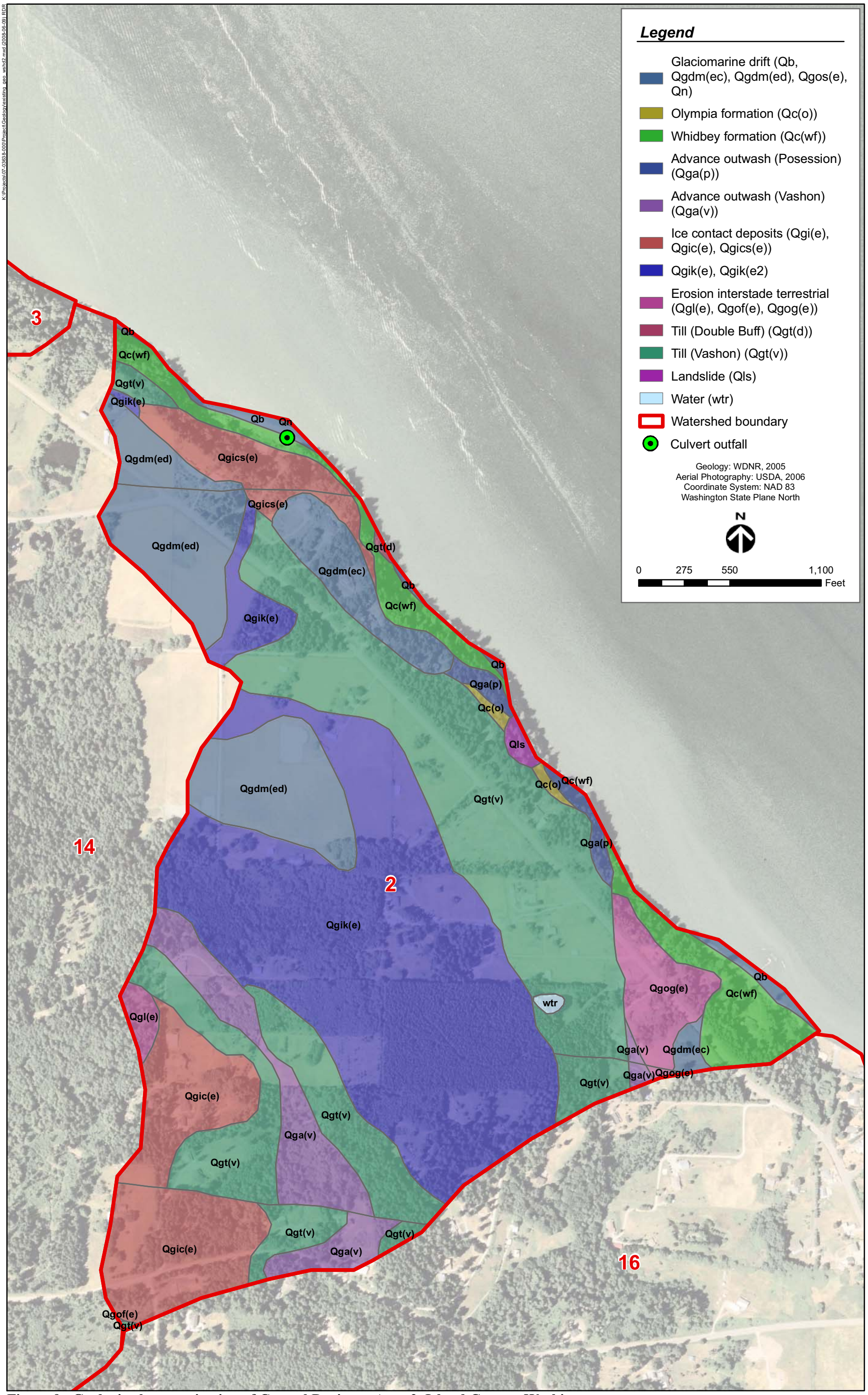


Figure 9. Geologic characterization of Coastal Drainage Area 2, Island County, Washington.

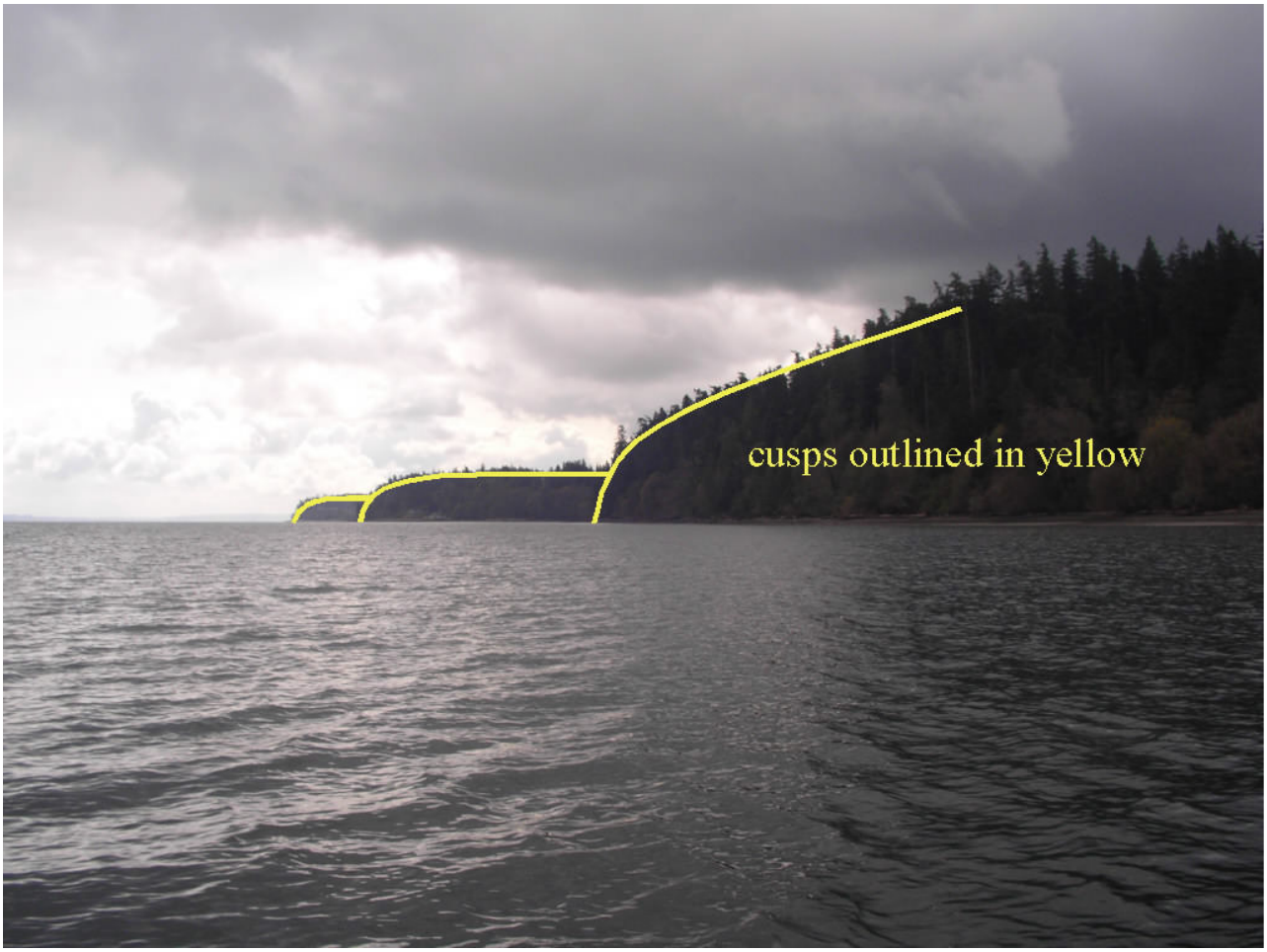


Figure 10. Looking east toward Strawberry Point from Deception Pass State Park. Note the several headlands, or cusps, that protrude into Skagit Bay (outlined in yellow).

Figure 11. Developing spit at Coastal Drainage Area 2, viewed in the most recent oblique aerial (taken in 2006) available from the Washington Coastal Atlas (Ecology 2008).

K:\Projects\07-03638-000\Project\Geology\existing_geo_wshd3_14.mxd (2008-07-01) RDR

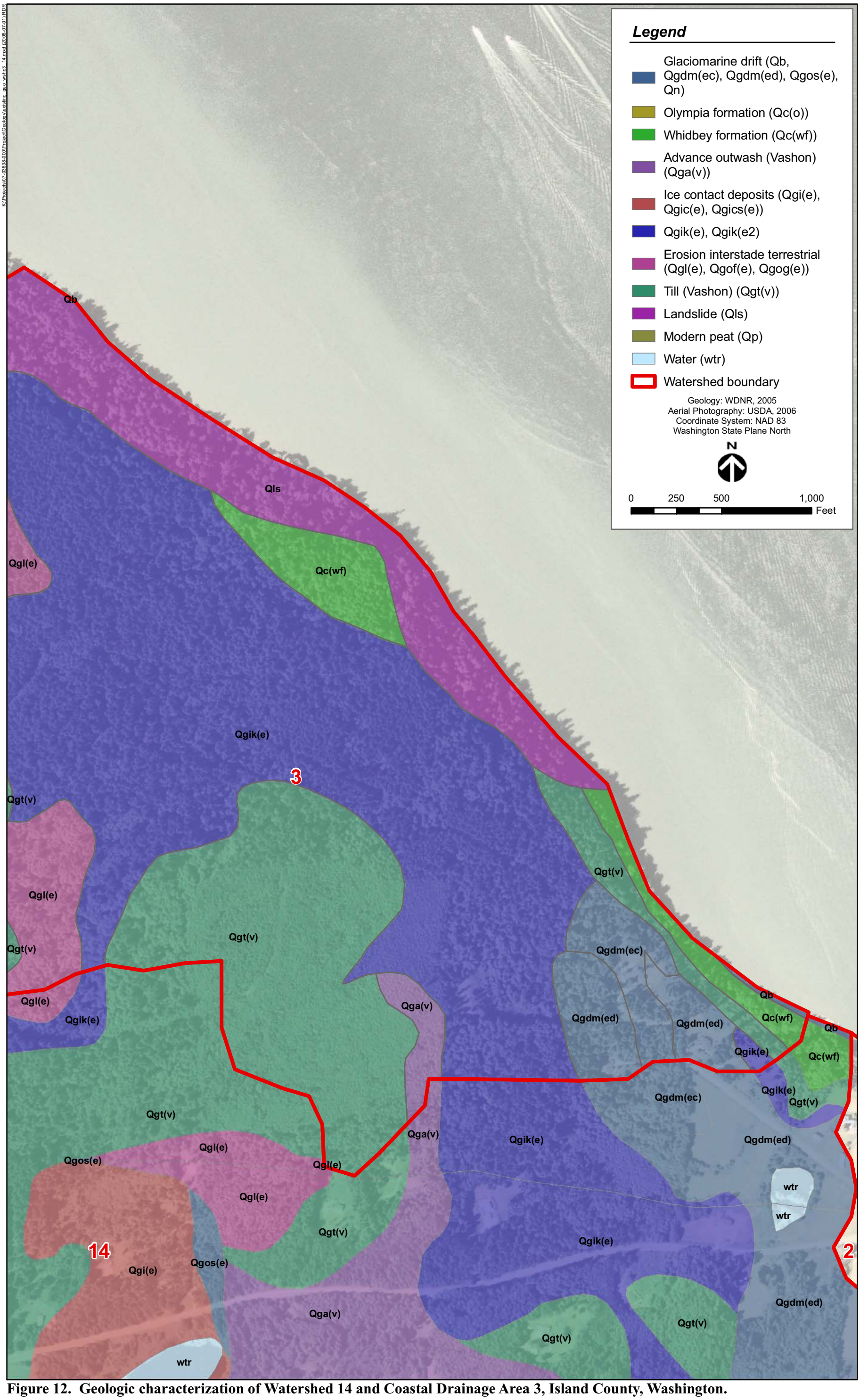


Figure 12. Geologic characterization of Watershed 14 and Coastal Drainage Area 3, Island County, Washington.

delta formed at the stream outlet. Oblique aerial photographs taken at low tide indicate that there is a mound of sediment at the stream outlet, and the substrate is somewhat more fine-grained than on the adjacent shorelines. However, the expression of the stream mouth is a very subtle feature (Figure 13). The stream has also recently incised, possibly a result of the concentration of surface water runoff from a culvert at Green Road (see the *Culvert-Induced Incision* subsection, below). Aside from these aspects, the nearshore in this watershed closely resembles the neighboring coastal drainage areas.

- Coastal Drainage Area 3 – The geologic characteristics of this coastal drainage area are depicted on Figure 12. This shoreline is almost exclusively within the Deception Pass State Park and serves as a proxy for predevelopment conditions (Figure 3). At the west end of the area, an ancient landslide dominates the coastal bluff (Figure 12). The landslide does not appear to be active and could be a relict from the large local sea level variations during the Everson Interstade. The upper foreshore throughout the area is comprised of fine-grained sediments, ranging from sandy to pebbly in size. The lower foreshore is coarser, generally up to cobble size, but devoid of boulders. The low-tide terrace is wide (up to 500 feet) and mud rich.

Coastal Bluffs and Landslides

Coastal bluffs along Puget Sound are extremely variable because of their diverse geologic composition (Shipman 2004). Coastal bluffs along Strawberry Point demonstrate this variability and range in height from zero at the stream outlet (Watersheds 18 and 16) to more than 200 feet in Coastal Drainage Area 3. The bluffs are often segmented, with their upper portions often relict from higher local sea levels. In some places, these terraces are identifiable (Figure 2), while others are obscured by vegetation and subsequent mass wasting. Truly active bluffs, where the entire height of the bluff is engaged in delivering sediment to the beach, are rare and generally confined to Coastal Drainage Area 1.

Shipman (2004) identified four hillslope sediment transport processes that are present along Puget Sound coastal bluffs: (1) raveling, (2) soil creep, (3) hydrology, and (4) block failures. All of these processes occur along the shoreline in the project area, although hydrologic transport is limited. Raveling occurs when erosion of the bluff toe causes progressive failure further up the slope, and is common along steeper bluffs throughout the project area (particularly in Coastal Drainage Area 2). An example of raveling is shown in Figure 14. Soil creep occurs when a vegetated mat that covers the bluff face slowly migrates downslope. It is most common in Coastal Drainage Areas 2 and 3.

Five landslides in the project area may be considered to fit into the block failure category. Four of these landslides were identified by previous studies (WDNR 2005a; Johannessen and Chase 2005) and are described in the *Existing Geomorphic Conditions* section earlier in this report. All

Figure 13. Oblique aerial photograph of the mouth of the unnamed stream that drains Watershed 14. Note the small (dry) mound on the beach foreshore near the creek mouth.

Figure 14. An example of raveling at the toe of the bluff in Coastal Drainage Area 2.

of these previously identified landslides are evident on the lidar mapping. They are of varying age, with the large landslide in Coastal Drainage Area 3 possibly being several thousand years old, while the two landslides in Coastal Drainage Area 1 have occurred since European settlement. In addition, a recent landslide was observed behind a private residence in Coastal Drainage Area 1 (Figure 15). However, none of these areas coincide with significant migration of the shoreline, as determined by comparing the shorelines shown on the T-sheet with the existing shoreline. This would indicate that significant retreat of the shoreline predates European settlement, and modern retreat is not rapid enough to be measured with traditional techniques (i.e., comparison of the shoreline position in historical documents) throughout the project area.

Culvert-Induced Incision

In several instances, dramatic incision has occurred recently (in a geologic sense) in small streams between Green Road and the Skagit Bay shoreline. Based on past work in the area and other informal accounts (Montgomery 2003), deeply incised canyons beginning with road culverts are relatively common throughout Island County. It is often uncertain whether the incision is ongoing and primarily associated with large rainfall events being passed through existing culverts, or whether the deeply incised canyons are relict features from initial settlement and deforestation. However, in the case of the canyon shown in Figure 16 (Coastal Drainage Area 2), incision can be documented in a time series of aerial photographs. The canyon is not apparent on the 1944 aerial photograph, and only emerges as a major feature within the last 30 years.

Where these incised canyons are found, they are noted on the maps illustrating existing geologic conditions (e.g., Figure 2). The most dramatic instance of this type of feature is within Coastal Drainage Area 2, where Bultman Lane runs between Green Road and the shoreline of Skagit Bay (Figure 16). It is unclear whether the incision is the result of splash-damming, grading associated with residential development, or ongoing culvert-induced incision. However, the amount of eroded material is large (estimated at 67,000 cubic yards). There is also evidence that much of this material may have inadvertently formed a spit that now protects the small developed area at the end of Bultman Lane (Figure 11). This hypothesis is supported by the coincidence of the neck of the spit with the most probable discharge of the eroded sediments and the similarity of the grain size associated with the spit and the eroded geology (i.e., the Whidbey Formation). A further indication that this sediment supply is either ongoing or recent past sediment input that has not been fully distributed along shore is the elevated low-tide terrace near these residences (see the *Human Modifications* section, below). Elevated low-tide terraces in Puget Sound have been shown to be related to nearby littoral inputs of sediment (Finlayson 2006).

Oceanographic Characterization

Sediment transport in the subtidal zone (i.e., seaward of the intertidal zone) in the project area is dominated by tidal currents. These currents, strongly affected by freshwater discharge from the Skagit River, are significant in the area. The currents are primarily confined to a channel (approximately 50 feet deep and 2,000 to 3,000 feet wide) that separates the Whidbey Island

Figure 15. Landslide on privately owned bluff segment in Coastal Drainage Area 1. Note that the downed tree is still green, indicating that the landslide occurred within the past few months (photograph taken on April 9, 2008).

nearshore from the Skagit River delta. The project area is near the boundary between the influence of Deception Pass and Admiralty Inlet, but currents generally flow north on the ebb tide and south on the flood tide, consistent with the dominance of the Deception Pass exchange. However, as Collias et al. (1973) have noted, the magnitude (and potentially the direction) of these flows are highly dependent on the discharge from the two forks of the Skagit River.

Several oceanographic fronts were observed in this area during the site visit (Figure 17). This is somewhat surprising; because of the cold weather (which minimized snowmelt) preceding the site visit on April 9, 2008, flow in the Skagit River was reduced from a historical average of approximately 15,000 cfs to 8,000 cfs (~8,000 cubic feet per second [cfs]; USGS 2008). Fronts were observed concurrently with the presence of an extensive (>200 feet wide) muddy low-tide terrace near the boundary between Watersheds 18 and 16 (see the *Existing Geomorphic Conditions* section for details). The mud-rich low-tide terrace is identified as a distinct feature on all recent nautical charts. The combination of fine sediment supply and protection from waves likely causes fine sediment from the Skagit River to accumulate on the low-tide terrace in areas north and west of the presence of the fronts, while shorelines farther south and east (e.g., Coastal Drainage Area 1) are energetic enough to prevent such accumulations of sediment.

Waves are likely the dominant physical process transporting sediment on the beach foreshore in the project area. Waves in Puget Sound are fetch-limited and generated almost exclusively by local winds. Because fetch is the dominant variable regulating wave height, the size of waves along a beach can be calculated with formulas that incorporate the basin geometry (Finlayson 2006).

For most of the project area (i.e., with the exception of Watershed 23 and Coastal Drainage Area 1), the dominant waves (and winds) originate from the northeast. An estimate of storm wave height was calculated using wind data recorded at the Arlington Airport. According to these data, the maximum annual wind speed originating from the northeast for the 2006–2007 water year was 13 knots. Annual events such as these are generally considered to produce the largest geomorphic impact (Finlayson 2006). The fetch is assumed to extend from Strawberry Point to Goat Island (about 3 miles at high tides). Based on the Sverdrup-Munk-Bretschneider (SMB) wave model, recommended by the U.S. Army Corps of Engineers (USACE 1984), predicted significant wave height of this annual storm would be 1 foot in deep water with a period of 2.1 seconds. Although Skagit Bay northeast of the project area shoreline is shallow, this estimate does not need to be modified to account for shallow-water conditions because of the extremely short period of the waves compared to the water depth. One-foot high waves would potentially move gravel, but not cobble, on the foreshore where the waves would break and swash. However, these waves would have difficulty mobilizing even a muddy bed on a flat low-tide terrace if the mud was consolidated, which is again consistent with observations of mud accumulation in these areas.

Unlike the rest of the project area, the shoreline in Coastal Drainage Area 1 and Watershed 23 is dominated by refracted wave energy originating from the south (Figure 2). These waves originate in Saratoga Passage, a deep body of water that separates Whidbey and Camano Islands. Refraction of waves around Strawberry Point in this area was observed on the site visit (during a

K:\Projects\07-03638-000\Prop\rtispit.mxd

Figure 16. Close-up view of a recent aerial photograph overlain on a lidar hillshade in the area of the nascent spit in Coastal Drainage Area 2.

Figure 17. Oceanographic fronts observed at the eastern end of the fine sediment, muddy low-tide terrace along the shoreline of Watershed 16.

period of southerly winds), and is likely common during winter storms when strong prevailing winds are also from the south. To provide a useful comparison to the waves calculated on the western portion of the site, the same calculation employing USACE (1984) method was performed, using the peak southerly wind recorded at Arlington Airport (38 knots), along with the fetch that spans the length of Saratoga Passage (approximately 18 miles). Based on these calculations, these waves would be 6.9 feet high with a period of 5.8 seconds in the annual peak storm event. The wave incident on the shoreline in Coastal Drainage Area 1 and Watershed 23 would be less than this, as refraction reduces the wave height as the waves interact with the seabed. However, it is likely that some significant fraction (more than 10 percent) of this energy would impact the nearshore. This is consistent with the sharp change in shoreline characteristics (i.e., deeper, coarser low-tide terrace, with a coarser foreshore), where refracted wave energy from Saratoga Passage is encountered in Watershed 23 and Coastal Drainage Area 1.

Human Modifications

Although the Strawberry Point nearshore is relatively unaltered compared to many Puget Sound shorelines, a number of human alterations do exist in the project area. These features generally have the original purpose of shoreline protection, even though the shoreline is mostly stable and wave-induced erosion is extremely low or nonexistent. Unnecessary shoreline modification is common throughout Puget Sound (Shipman 2004). The most profound modifications to the nearshore are often related to structures and rock placed below the mean higher-high water (MHHW). Although bulkheads, which are broadly defined as immobile shoreline protection structures, are relatively rare in the project area and serve little practical purpose, they are actively changing the geomorphic character of the shoreline. Figure 18 illustrates all of the major human modifications in the project area identified during the site visit. Each identified shoreline modification is described below, along with its geomorphic implications and its approximate date of installation.

1. Riprap near stream mouth (Watershed 23) – Riprap revetment has been placed at the toe of the bluff beneath a home near the outlet of the stream associated with this watershed (Stream 23). A concrete block may or may not be set into the foundation behind the placed riprap. Because of the small footprint of the modification, it is not evident in older aerial photographs. However, the feature can be seen in the high-resolution 2006 oblique aerial photographs obtained from the Washington Coastal Atlas (Ecology 2008). It also appears that the riprap did not exist in the 1993 oblique photograph (the home above the riprap was not constructed at that time), although the coarser resolution of that photograph makes definitive determination difficult.

2. Riprap revetment and associated "lagoon" in Coastal Drainage Area 1 – This modification has produced the largest geomorphic impact of any human modification along the Strawberry Point shoreline. Although the rationale for placing the riprap revetment is unknown, it protects a small lagoon and the adjacent bluff which was subject to mass wasting in the

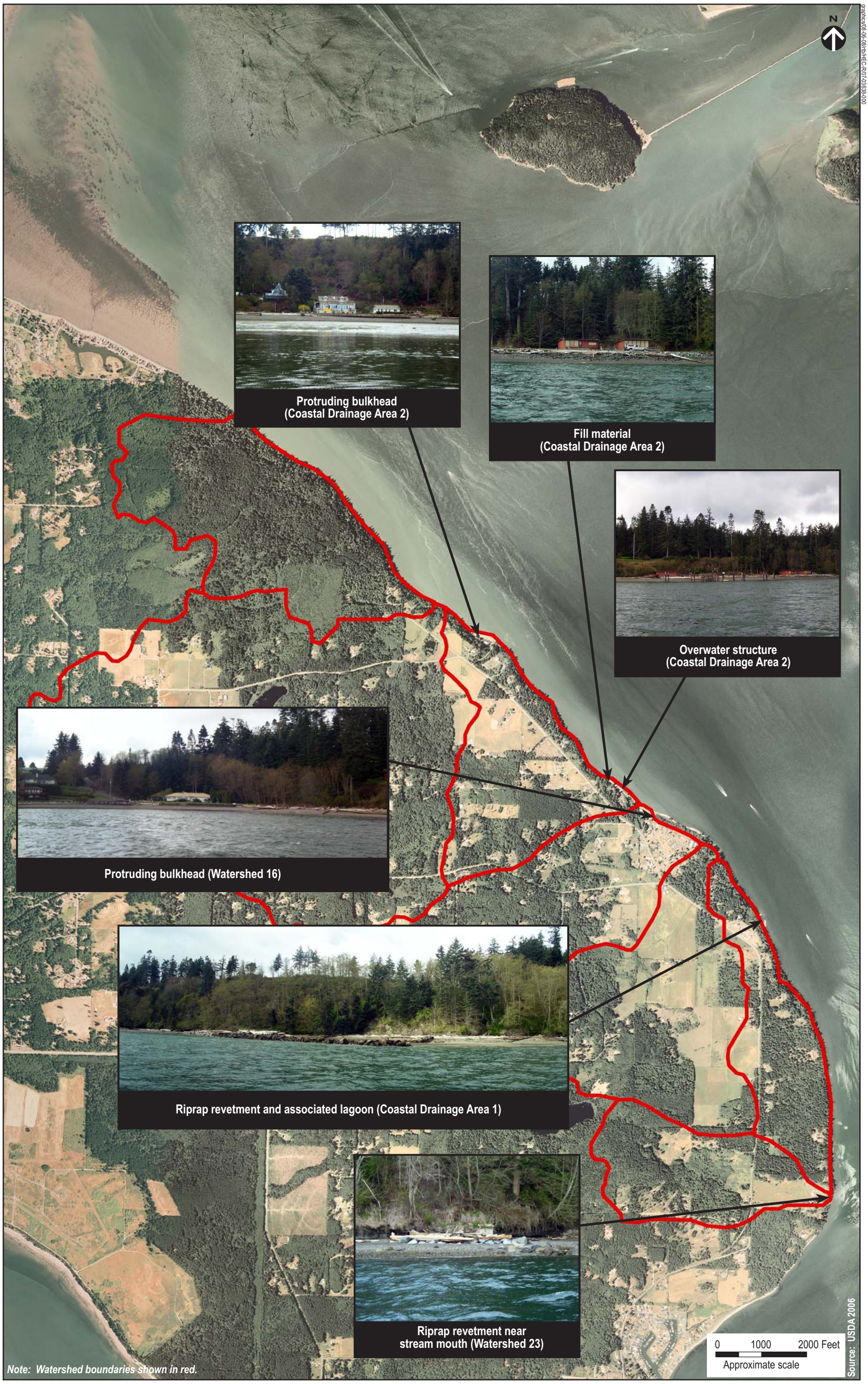


Figure 18. Shoreline human modifications along the Strawberry Point project area.

geologically recent past (see the *Coastal Bluffs and Landslides* subsection). The structure protrudes approximately 160 feet into the nearshore. Its presence is sufficient to rob the foreshore on the downdrift (west) side of the revetment, which has resulted in denuding and armoring of the beach substrate. It has also deepened and almost eliminated the low-tide terrace on the downdrift (west) side of the structure. Based on an analysis of the aerial photographs, this modification was likely constructed sometime between 1944 and 1965.

3. Protruding bulkhead in Watershed 16 – Several homes in this area have manicured lawns protected by a concrete-treated-wood bulkhead (see Figure 8). There are signs of net beach erosion in front of the bulkhead, indicating that it is producing the same adverse impacts that shoreline hardening measures have been shown to cause in Puget Sound (Herrera 2005; Finlayson 2006), elsewhere (NRC 2007), and in this study (see Human Modification 6, below). These impacts can affect native fish and wildlife in numerous ways as a recent literature review has shown (Herrera 2008b), including a net loss of foreshore area and a reduction in the time that the water surface intersects mobile substrate (Herrera 2005). These impacts can also compromise the capacity of the beach to support spawning by forage fishes (see the *Nearshore Habitat Conditions and Fish Utilization* section for details). Based on the analysis of aerial photographs, this modification was likely constructed sometime before 1965.

4. Overwater structure in Coastal Drainage Area 2 – A large pier with adjacent wooden rafts protrudes onto the low-tide terrace. The pier was constructed with creosote-treated wood. Although it is obvious that the structure serves as a pier, it is unknown who uses the pier and for what purpose. Because of the relatively narrow footprint of the structure and the lack of structural fill, it has no significant geomorphic impact on the adjacent shoreline. Based on the aerial photograph analysis, this modification was likely constructed sometime before 1965.

5. Fill in Coastal Drainage Area 2 – On one property, the upper beach has been filled with native material and protected with riprap. Despite the incursion of the fill material into the nearshore, there seems to be little geomorphic impact from this shoreline modification. Based on the aerial photographic analysis, this modification was likely constructed sometime before 1977.

6. Protruding bulkhead in Coastal Drainage Area 2 – One property (for sale during the site visit) located in front of the pocket estuary has a treated-wood bulkhead. Based on the aerial photograph analysis, this modification was likely constructed sometime between 1971 and 1980.

Figure 19 illustrates the geomorphic changes that have resulted from the placement of the bulkhead, where a profile taken at the bulkhead is compared to a relatively undisturbed transect on an adjacent shoreline. The most significant difference between the two profiles is the dramatic lowering of the foreshore (by more than 4 feet) in front of the bulkhead. There is a minor increase in beach slope in the case of the bulkhead, but the most conspicuous difference between the bulkhead and unmodified transect is the overall lowering of the shoreline. This observation is consistent with other studies examining the geomorphic effects of bulkheads in Puget Sound (Herrera 2005; Finlayson 2006). In combination with the slight increase in the height of the low-tide terrace, the foreshore is one-half as wide as in the case of the unmodified shoreline. This produces a number of significant impacts, as detailed in the *Nearshore Habitat Conditions and Fish Utilization* section later in this report.

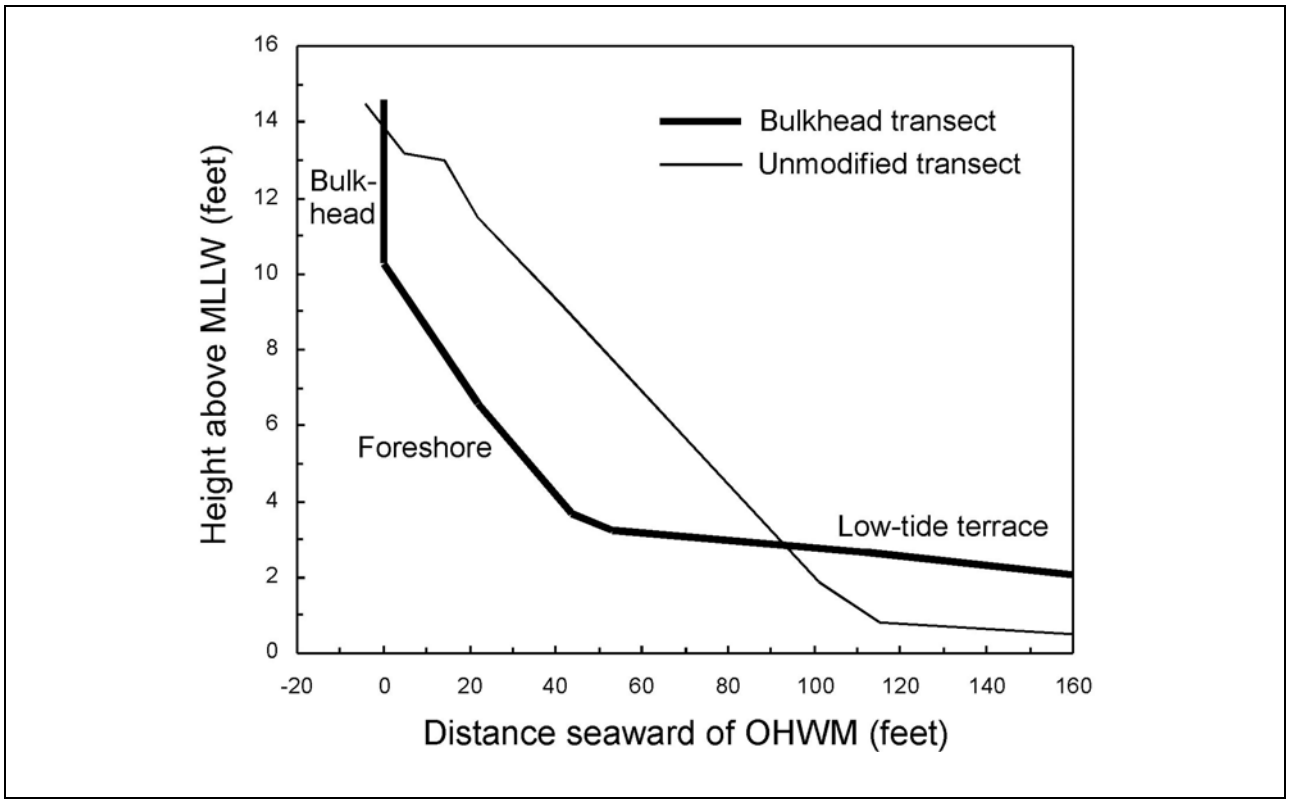


Figure 19. Comparison of beach transects from Coastal Drainage Area 2. The unmodified shoreline transect was recorded in the midst of the unmodified portion of Coastal Drainage Area 2, while the bulkhead transect was recorded at Human Modification 6 (see Appendix A for details).

7. Removal of coastal bluff vegetation – Throughout Coastal Drainage Areas 1 and 2, woody vegetation has been removed from the coastal bluffs. This has contributed to enhanced erosion along the bluffs and limited the propensity of the shoreline to accumulate rafted woody debris. The exception to this is in Coastal Drainage Area 3 in Deception Pass State Park, where geomorphic conditions characteristic of pre-European settlement are remarkably intact. Note: this human modification is not illustrated in Figure 18.

Nearshore Habitat Conditions and Fish Utilization

Analysis of the available sources of information indicates that the Strawberry Point shoreline provides critical nearshore marine habitat for a range of species of interest, including multiple salmonid populations and several species of forage fish. Eelgrass occurs continuously along the Strawberry Point shoreline, concentrated in sandy depressions throughout the lower portion of the low-tide terrace. In general, the eelgrass beds along the Strawberry Point shoreline were not densely populated on the date of the site visit.

A small patch of pickleweed (salt marsh vegetation) was observed on the back side of the spit at the edge of the lagoon associated with Coastal Drainage Area 1. This was the only continuous patch of salt marsh vegetation observed during the April 2008 site visit.

Watershed processes in the adjacent upland areas on the Strawberry Point project area strongly influence these marine nearshore habitat conditions. In contrast, freshwater habitats within the project area exert a more limited influence. The four streams within the Strawberry Point project area are small, ephemeral systems with little or no capacity to provide fish habitat. However, they are sources of freshwater, sediment, allochthonous nutrients (i.e., external in origin), and (potentially) pollutants, all of which can affect nearshore habitat conditions. The nearest Whidbey Island stream system with the potential to support anadromous fish is Dugualla Creek, approximately 1.5 miles to the north of the northern boundary of the project area.

In the WRIA 6 Salmon Recover Plan, the Strawberry Point shoreline qualifies as a Tier 1, high priority area for habitat preservation and restoration (Island County 2005). The rationale for this ranking includes the following:

- The shoreline provides a number of features that provide high-quality habitat for salmonid rearing, as well as for several other marine species, and connectivity between current and potential rearing “hotspots” in the vicinity.
- The Strawberry Point shoreline is located on a dispersal pathway for juvenile salmonid migrants exiting the Skagit River system.
- The shoreline provides documented spawning habitat for three forage fish species (Pacific herring, surf smelt, and Pacific sand lance).

Additional details on these elements and their relationship to fish habitat utilization are provided in the following sections.

Stream Habitat Use and Influence of the Streams on Marine Nearshore Habitat Conditions

The Strawberry Point project area includes four unnamed stream systems that drain to nearshore marine habitats, as well as several wetland-associated ponds that are drained by these stream systems (Island County 2008a). These stream systems are identified by the Island County designation for the watershed or coastal drainage area in which they occur: stream 14, 16, 18, and 23. Water quality parameters were monitored periodically in these streams under Island County's Surface Water Monitoring Program, which was initiated in these systems in 2006 and 2007 (Island County 2008a). This information provides a useful perspective on both the potential for these systems to provide freshwater habitat and their likely influence on marine habitat conditions.

These streams are ephemeral, lacking flows for extended periods during the summer dry season and generally providing limited discharge during wet periods. All of these systems show evidence of historic hydromodification (Island County 2008a), most likely conducted in order to drain wetlands in the area. The limited flow conditions and relatively steep topography of the lower reaches of these streams indicate that these drainages provide no existing or potential habitat for anadromous fish species. However, these stream systems do contribute freshwater runoff to marine nearshore habitat. Some of the stream mouths are associated with or are in the vicinity of predicted historic pocket estuaries (Beamer et al. 2005; also see the *Geologic and Geomorphic Conditions* section earlier in this report) and could support potentially valuable pocket estuary habitats in the future. Therefore, water quality conditions within these systems are important.

The Watershed 14 drainage illustrates the lack of freshwater habitat for migratory salmonids and is characteristic of the other watersheds within the Strawberry Point project area. This stream system and its associated watershed are the largest of the seven watersheds or coastal drainage areas in the project area, covering approximately 1,095 acres. The drainage network consists of a main channel approximately 6,200 feet in length, a large tributary approximately 3,660 feet in length, and a number of smaller tributary channels. This system drains 17 mapped wetlands ranging in size from 0.2 to 14 acres. The wetlands provide sufficient groundwater inflow to support summer base flows into July, but the system runs dry in the August and September dry period (Island County 2008a).

Flow conditions observed during winter sampling in Stream 14 indicate that the area of wetted habitat is limited. Under typical winter conditions, the observed active channel width was approximately 1 foot, with depths ranging from 3 to 4 inches (Island County 2008a). Given these flow conditions, the potential for this system to provide anadromous fish habitat is negligible. A review of the available data on fish habitat use in this stream also supports this conclusion (WDFW 2008a). No records of current or historical use of this system as fish habitat were identified. The remaining stream systems in the project area are smaller and are dry over

longer periods of time (several months). This indicates that the potential for these systems to provide anadromous fish habitat is similarly negligible. Available water quality and flow data (Island County 2005) also support this conclusion.

Marine Habitat Utilization

The Strawberry Point shoreline provides documented habitat for several species of concern, specifically marine forage fish and anadromous salmonid species, as well as several other marine fish species common in the Whidbey/Saratoga basin. These habitats include eelgrass, salt marsh, and beach habitats. Use of these habitats by forage fish and salmonids is described below.

Forage fish species play a critical role in the functioning of nearshore marine ecosystems in Washington state. These species feed on phytoplankton and zooplankton, converting this biomass into a preferred prey resource for many predatory species, including marine mammals, seabirds, juvenile and adult salmonids, and many other fish species. The Strawberry Point shoreline provides known spawning and rearing habitat for three important forage fish species. Documented spawning habitat for Pacific herring, surf smelt, and Pacific sand lance occurs within the project area (Bargmann 1998; WDFW 2008a, 2008b, 2008c; Island County et al. 2003).

The Skagit Bay stock of Pacific herring, currently one of the larger herring stocks in Washington state, is known to spawn within the project area (Stick 2005). Herring rely on submerged aquatic vegetation in the intertidal zone, specifically eelgrass and a variety of algae species, as spawning substrate. Accordingly, the preservation and enhancement of physical processes and conditions that support and maintain these habitats are important considerations for shoreline management. This type of vegetation is present throughout the project area, and herring spawn has been documented along the entire length of shoreline when this herring stock is abundant.

Surf smelt and sand lance spawning habitat has also been documented along the Strawberry Point shoreline (WDFW 2008b, 2008c); however, recent surveys have only documented surf smelt spawning (Island County et al. 2003). Sand lance spawning was not observed during surveys conducted in the project area between 2001 and 2003; however, this does not indicate that this type of habitat use does not occur. Sand lance spawning was documented during these surveys on beaches to the north of the project area and to the west at Point Polnell (WDFW 2008b; Island County et al. 2003), and was documented in the project area adjacent to the Deception Pass Park annex during surveys conducted by WDFW in 1994 (WDFW 2008b).

Both surf smelt and sand lance use similar sandy and gravelly substrate high in the intertidal zone. Accordingly, the recruitment and transport of substrate along this shoreline habitat strongly influence the quality and quantity of available spawning habitat. These processes also influence the distribution of spawning substrate, as well as submerged aquatic vegetation used by herring. Preservation of marine vegetation is also important to the maintenance of high-quality rearing habitat for forage fish. In addition to the role that vegetation plays in moderating

sediment recruitment and transport, shoreline shade is positively correlated with improved incubation survival for summer spawning surf smelt and sand lance eggs (Rice 2006).

The presence of high-quality habitat features (e.g., eelgrass beds) and abundant prey resources is indicative of the importance of the Strawberry Point shoreline for anadromous salmonid species. This area provides both rearing and migratory habitat and, importantly, a corridor providing ecological connectivity between the Skagit River and high-quality rearing habitats in the project vicinity (e.g., Ala Spit to the north). Although undocumented, it is possible that fish species use the habitats in the small salt marsh and lagoon associated with Coastal Drainage Area 1 during high and low tidal conditions, respectively.

Nearshore Vegetation Conditions

As described in the *Assessment Methodology* section above, the study area for the characterization of shoreline conditions was 200 feet from the Strawberry Point shoreline, within all watersheds and coastal drainage areas. This area is referred to as the "coastal shoreline study area." Land cover types within the coastal shoreline study area varied from unaltered, mature coniferous forest to manicured lawns (Appendix B). Land cover types appear to be most influenced by historic and current land use practices and by their position on the landscape with respect to the bluff environment and geologic characteristics. Given the difficulty of capturing land cover type characteristics on the bluff face and other steep slopes when digitizing aerial photographs, these areas were digitized and analyzed separately using GIS resources. Appendix C provides an example of the results of this GIS analysis. It depicts the bluff face polygon on an oblique aerial photograph taken from one location within the project area and indicates the areas within the polygon that are occupied by different land cover types.

The following sections describe the land cover types observed within the coastal shoreline study area at Strawberry Point, followed by the land cover type distribution within each watershed and coastal drainage area to identify watershed-specific shoreline vegetation characterizations.

Strawberry Point Shoreline Land Cover Types

Land cover types found along the shoreline of the Strawberry Point study area are listed and described below.

Coniferous Forest

This land cover type occupies approximately 15 percent (15.48 acres) of the entire coastal shoreline study area. The largest continuous tract of this habitat type was found in Coastal Drainage Area 3, Deception Pass State Park. Smaller patches (<5 acres) of coniferous forest were observed in undeveloped areas of Coastal Drainage Areas 1 and 2. This habitat type is usually confined/restricted to the top of bluff areas because the bluff face is often actively erosive, thereby precluding the establishment of a mature conifer forest. In some areas, characterized by high bluff stability, this habitat type extends down the bluff face.

This habitat type is characterized by a >50 percent dominance of conifer species, namely Douglas fir. Western hemlock, western red cedar, and grand fir are common subordinate species, with younger individuals often comprising the subcanopy layer. Most stands appear to be mature (90 to 200 years) with old (200+ years) trees found mainly within the state park. Structural diversity is high, with a well-established understory of deciduous shrub and groundcover species. Common shrub species include Indian plum, snowberry, beaked hazelnut, Oregon grape, sword fern, salmonberry, and oceanspray. Herbaceous cover is also dense, with trillium and stinging nettle being representative species in this layer. High-quality snags and large trees with a high degree of apical branching or brooming are found here (grand fir with their round tops provide especially good nesting sites for bald eagles), especially along the bluff face and toe where they have survived as relicts from historic landslides.

Mixed Forest

This is the most common land cover type in the study area, occupying approximately 48 percent (49.56 acres) of the total area. It commonly occupies bluff tops and areas landward, and it also extends down bluff faces and on terraces in areas exhibiting low sediment mobility.

This habitat type is dominated by Douglas-fir, big leaf maple, and red alder, with coniferous and deciduous species occurring in approximately even distribution. Western red cedar was a commonly observed subordinate species. Resident Douglas-fir trees tended to vary from young (<90 years) to mature (90 to 200 years), with some old trees present as relicts on the bluff face and toe. Deciduous species also vary in age from young to mature, with old big leaf maple and red alder occupying areas of historic disturbance, and younger trees occupying areas of more recent slide activity. Structural diversity is also high in the mixed forest areas, often with a dense understory composed of Indian plum, snowberry, beaked hazelnut, Oregon grape, sword fern, lady fern, salmonberry, elderberry, and oceanspray. In wetter areas, salmonberry is often the dominant understory shrub species, whereas in drier areas, snowberry, oceanspray, and Oregon grape are more common. Pacific madrone was observed on the drier sites, including some bluff faces and bluff tops.

Deciduous Forest

This land cover type is common in all seven watersheds (approximately 24 percent of the total study area; 24.51 acres), and it often occupies bluff faces and toes and also gaps in coniferous or mixed forests or landslide tracts. Common dominant species include red alder and big leaf maple. Their presence likely indicates disturbance intervals short enough to preclude the establishment of mature coniferous vegetation, and resident trees are most often very young (<50 years). Some historically active erosion areas that have not experienced landslide activity or other major disturbance in the recent past (e.g., along the shoreline in Coastal Drainage Area 3) are characterized by overhanging, old big leaf maple trees that provide an excellent substrate for the abundant growth of epiphytic plants such as mosses, ferns, and lichens (Figure 20).

Figure 20. Photograph of mature big leaf maples characterized by abundant epiphyte (mosses, licorice ferns, and lichens) growth in Coastal Drainage Area 3. April 9, 2008.

Understory species composition is similar to the mixed forest type but is less stratified here since a conifer canopy component is not present.

Shrub

This land cover type is sparse within the study area (approximately 4 percent of the study area, 3.85 acres total), and it tends to occupy areas of apparently relatively recent disturbance. It consists primarily of shrub species such as Indian plum, oceanspray, willow, and beaked hazelnut, and very young deciduous tree species such as big leaf maple and red alder. Because of its age and composition, the structural diversity of this land cover type is lower (a single canopy layer) compared to the forest land cover types.

Mixed Forest with Manicured Understory

This land cover type is found in two locations in Coastal Drainage Area 1 (part of one polygon crosses over into Watershed 18), occupying approximately <1 percent (0.92 acres) of the entire study area.

These areas are characterized by an open mixed canopy and a manicured/maintained lawn understory.

Field

This land cover type is sparse and scattered throughout the study area (<1 percent of the entire study area; 0.42 acres). It is characterized by areas of continuous (not necessarily homogeneous) graminoid land cover that does not appear to be maintained as a manicured lawn. This land cover type encompasses areas that appear to be used for agricultural purposes.

Lawn

This land cover type is sparsely distributed throughout the study area and is associated with residential development (approximately 7 percent of the study area; 7.19 total acres). It includes manicured lawns and landscaping surrounding residences with a contiguous, cumulative area that meets the minimum mapping unit criteria (see the *Assessment Methodology* section), but with individual areas that do not meet the minimum mapping unit criteria (and are therefore not mapped separately).

Impervious

This land cover type is also sparsely distributed throughout the study area. It occurs primarily in areas of residential development (approximately 1 percent of the study area; 1.36 acres) and includes the footprint of residences, driveways, parking areas, and roads.

Large Woody Debris

This land cover type was mapped in one location in Coastal Drainage Area 2 (<1 percent of the total study area; 0.15 acres) where the accumulation of logs on the beach was of sufficient extent to meet the minimum mapping unit (see the *Assessment Methodology* section).

Watershed-specific Land Cover Types

Watershed 23

Land cover types in the study area of Watershed Area 23 are listed in Table 1 and mapped in Appendix B. This watershed contains only a narrow portion (197 feet) of the shoreline. The top of the bluff is characterized by a narrow band of young to mature (>50 years) Douglas-fir. The area behind this narrow band of conifers is occupied by residences with surrounding lawns. A small, incised stream channel that has cut a short ravine down the bluff face is also present.

Table 1. Land cover type in the study area of Watershed 23, represented as cumulative area and percentage of total shoreline land cover.

Land Cover Type	Area (acres)	Percent of Total
Coniferous forest	0.27	20
Mixed forest	0.08	6
Deciduous forest	0.36	27
Shrub	0.10	8
Mixed forest with manicured understory	0	0
Field	0.29	22
Lawn	0.09	7
Impervious	0.13	10

The steep bluff face is characterized by young, deciduous forest dominated by young deciduous tree species, including big leaf maple and red alder. Very young (<50 years) Douglas-fir and scattered Pacific madrone are also present. Shrub species observed include Indian plum, snowberry, and beaked hazelnut. The riparian zone of the incised stream channel is vegetated at a moderate density with deciduous species and is characterized by a higher cover of young Douglas-fir than found elsewhere on the bluff face. Unvegetated areas (exposed sediment) were also observed, with an estimated cover of <5 percent. The young vegetation and the presence of bare ground on the bluff face indicate that this is an area of relatively recent/active erosion.

The toe of the bluff abruptly transitions into backshore, with the bluff face vegetation ending abruptly at a sizable cut bank above the beach.

Coastal Drainage Area 1

Land cover types in the study area of Coastal Drainage Area 1 are listed in Table 2 and mapped in Appendix B. This coastal drainage area occupies a long stretch of marine shoreline

(7,415 feet) and is characterized by undisturbed mixed forest with diffuse areas of residential development.

Table 2. Land cover type in the study area of Coastal Drainage Area 1, represented as cumulative area and percentage of total shoreline land cover.

Land Cover Type	Area (acres)	Percent of Total
Coniferous forest	4.61	13
Mixed forest	18.56	52
Deciduous forest	9.42	27
Shrub	0	0
Mixed forest with manicured understory	0.92	3
Field	0.13	<1
Lawn	1.44	4
Impervious	0.30	<1

The southern upland portion of this coastal drainage area is characterized by high-quality, intact, mature coniferous forest dominated by Douglas-fir that extends from behind the top of the bluff to midbluff face (in some cases extending to the bluff toe). The lower and more recently active portion of the bluff face in this area is deciduous forest, dominated by mature to young deciduous species including big leaf maple and red alder. The understory is dense and well established; shrub species present include sword fern, Indian plum, and snowberry. This more mature vegetation structure indicates a lower level of bluff mobilization than in Watershed 23. A number of old (200+ years), relict Douglas-fir snags that have survived previous landslides and other disturbances reside on the toe and face of the bluff, providing bald eagle nesting and perch sites (Figure 21).

The middle section of the nearshore of Coastal Drainage Area 1 has been only sparsely developed, with all residences set back from the top of the bluff, which has not been cleared extensively for view purposes. This portion of Coastal Drainage Area 1 is dominated mainly by mixed forest from the top of the bluff landward and mixed and deciduous forest areas on the bluff face. One of the significant landslide areas mentioned in the *Geologic and Geomorphic Conditions* section is characterized by a dense canopy of deciduous forest species, including >50-year-old big leaf maple and red alder. One area is characterized by mixed forest with manicured understory, in which regular understory maintenance has greatly altered the canopy characteristics, likely by precluding tree seedling and shrub establishment.

The northern portion of Coastal Drainage Area 1 is characterized by a greater density of residential development. While most impacts are confined to areas set back from the bluff, a contiguous cleared area occupied by four new homes abuts the bluff edge. The area on the bluff face directly below this development is characterized by deciduous forest that is likely the product of historic tree clearing for view improvement. (Compared to the surrounding area, conifer cover is greatly reduced on the bluff face in this area.) An old road grade (now

Figure 21. Photograph of large relict conifer on bluff face providing bald eagle nesting site in Coastal Drainage Area 1. April 9, 2008.

grass-covered) meanders down from the developed area to a manmade spit feature (described in the *Geologic and Geomorphic Conditions* section) with a lagoon. A small patch of pickleweed was observed on the back side of the spit at the edge of the lagoon (Figure 22). This was the only continuous patch of salt marsh vegetation observed during the April 2008 site visit.

Just north of this development lies another small tract of intact mature coniferous forest that extends down the bluff face to the shoreline, one of the few occurrences of this land cover type occupying this landscape position outside of the state park. Farther north, there is another area of mixed forest with manicured understory. The conifer canopy here appears to be more closed than at the occurrence of this land cover type farther south, which potentially suggests a lower level of maintenance (by landowners) than in the previously noted instance of this land cover type.

Watershed 18

Land cover types in the study area of Watershed 18 are listed in Table 3 and mapped in Appendix B. This watershed contains only a narrow portion (596 feet) of shoreline. It is characterized by a small stream that empties through a broad, mixed forest ravine. There is an open grassy area that appears to be regularly maintained at the stream mouth directly below the proximate residence. (A small boat storage and bridge were also observed here.)

Table 3. Land cover type in the study area of Watershed 18, represented as cumulative area and percentage of total shoreline land cover.

Land Cover Type	Area (acres)	Percent of Total
Coniferous forest	0.69	28
Mixed forest	1.33	54
Deciduous forest	0.44	18
Shrub	0	0
Mixed forest with manicured understory	0	0
Field	0	0
Lawn	0	0
Impervious	0.01	<1

The bluff face and steep slopes of the ravine are characterized by mixed and deciduous forest. Some areas of active erosion and bare soil were observed on the bluff face.

Watershed 16

Land cover types in the study area of Watershed 16 are listed in Table 4 and mapped in Appendix B. This watershed contains 1,612 feet of shoreline and has the most densely developed nearshore (and the highest impervious surface area) within the study area, with a relatively dense residential development with extensive landscaping downslope of Green Road.

Figure 22. Photograph of pickleweed patch on the edge of the artificial coastal lagoon created as a result of the manmade spit feature in Coastal Drainage Area 1. April 9, 2008.

This development abuts the bluff above the shoreline, and the bluff face in front of it was recently cleared of trees, as it is now dominated by shrubs and young alder and big leaf maple.

Table 4. Land cover type in the study area of Watershed 16, represented as cumulative area and percentage of total shoreline land cover.

Land Cover Type	Area (acres)	Percent of Total
Coniferous forest	0.11	1
Mixed forest	0.25	3
Deciduous forest	1.29	17
Shrub	2.67	36
Mixed forest with manicured understory	0	0
Field	0	0
Lawn	2.63	35
Impervious	0.56	8

Just north of the shrub-dominated slope, two residences with large bulkheads and large lawns occupy the shoreline at the end of Borgman Road. Just north of these bulkheads, the stream enters Puget Sound through a deciduous forested ravine.

Costal Drainage Area 2

Land cover types in the study area of Coastal Drainage Area 2 are listed in Table 5 and mapped in Appendix B. Coastal Drainage Area 2 contains 6,273 feet of shoreline, and its nearshore is characterized by mixed forest land cover type but also exhibits sporadic residential development with some extensive areas of landscaping, areas of field, and two continuous tracts of coniferous forest that extend down the bluff face. Areas of deciduous forest occupy old landslide scars and the more active erosion areas on the bluff face and toe.

Table 5. Land cover type in the study area of Coastal Drainage Area 2, represented as cumulative area and percentage of total shoreline land cover.

Land Cover Type	Area (acres)	Percent of Total
Coniferous forest	4.39	16
Mixed forest	10.93	40
Deciduous forest	7.45	27
Shrub	1.07	3
Mixed forest with manicured understory	0	0
Field	0	0
Lawn	3.03	11
Impervious	0.36	1

The southern portion of this coastal drainage area is characterized by a small but highly developed area on the shoreline with a clubhouse building and significant areas of impervious surface that are associated with the highly visible dock and overwater structures. Above this area lies a residence characterized by a significant amount of landscaping. Two lawn areas to the north appear to be regularly maintained, and one exhibits a large area of bare ground in a cul-de-sac formation.

Unusual land cover types in the central portion of Coastal Drainage Area 2 include two areas of continuous coniferous forest and areas of deciduous forest in old landslide scars and cleared areas.

The northern portion of this coastal drainage area is characterized by a few large residences with extensive landscaping. In one area where homes and shoreline armoring (reinforced pilings) have been built below the bluff, there is a broad backshore area and some sparse patches of dune vegetation mixed with upland grasses. Dune vegetation is also present, growing sparsely amidst the accumulated large woody debris in the area (Figure 23).

English ivy was also observed growing on the slope below the southernmost house on this terrace.

Watershed 14

Land cover types in the study area of Watershed 14 are listed in Table 6 and mapped in Appendix B. This watershed contains 256 feet of the narrowest shoreline in the study area of any of the watersheds. No development within the nearshore is present in this watershed. It is characterized by deciduous forest, dominated by red alder at the stream mouth, as well as a small mixed forest component.

Table 6. Land cover type in the study area of Watershed 14, represented as cumulative area and percentage of total shoreline land cover.

Land Cover Type	Area (acres)	Percent of Total
Coniferous forest	0	0
Mixed forest	0.19	13
Deciduous forest	1.28	87
Shrub	0	0
Mixed Forest with manicured understory	0	0
Field	0	0
Lawn	0	0
Impervious	0	0

Land cover types in the study area of Coastal Drainage Area 3 are listed in Table 7 and mapped in Appendix B. Except for two minimally developed home sites at its southern extent, the nearshore zone of this coastal drainage area lies within the boundaries of Deception Pass State Park. As noted previously, this area provides an excellent reference for pre-European settlement land cover conditions.

Figure 23. Photograph of sparse dune vegetation amidst accumulated large woody debris in Coastal Drainage Area 2. April 9, 2008.

Table 7. Land cover type in the study area of Coastal Drainage Area 3, represented as cumulative area and percentage of total shoreline land cover.

Land Cover Type	Area (acres)	Percent of Total
Coniferous forest	5.41	19.4
Mixed forest	18.22	65.3
Deciduous forest	4.27	15.3
Shrub	0.01	<1
Mixed forest with manicured understory	0	0
Field	0	0
Lawn	0	0
Impervious	0	0

Coastal Drainage Area 3

Larger continuous stands of old trees (200+ years) are found here, with mixed forest tracts also being common. In most areas, the bluff face is characterized by mixed or deciduous forest, with some areas of low bluff activity and terraces providing an opportunity for coniferous forest to extend down the bluff face. As in most other locations in the project area, deciduous forest occupies the bluff toe. As in Coastal Drainage Area 1 (but in greater quantity), a number of snags that have survived previous landslides and other disturbances occur on the toe and face of the bluff, providing bald eagle nesting and perch sites. Other plant species more characteristic of mature Pacific Northwest forests were observed here, including Pacific yew, red huckleberry, and trillium.

Old big leaf maple trees at the toe of the bluff that show scars from survival of landslides provide substrate for the abundant growth of epiphytic plants such as mosses, ferns, and lichens. These trees often overhang the foreshore, providing shade and roughness to the shoreline environment.

Freshwater wetlands were observed in two locations, characterized by a terrace that creates a broader transition from the bluff toe to the beach (Figure 24). These wetlands reside in depressions within the terrace at the bluff toe behind a back-beach berm. Small streams were observed flowing through and into the wetland, and resident vegetation consisted of hydrophytic plant species such as skunk cabbage and wetland sedges.

Summary of Findings on the Assessment of Shoreline Vegetation Conditions

The shoreline environments of watersheds and coastal drainage areas in the project area are characterized by steep, vegetated bluffs, often exhibiting an abrupt transition to the backshore at the bluff base. In some cases, especially in drainage areas and landslide scars, there is a slightly broader transition from bluff toe to backshore. In a few cases, these areas are occupied by small freshwater wetlands fed by groundwater seeps or bluff runoff. Rarely, a small back-beach area is

Figure 24. Photograph of freshwater wetland on bluff toe terrace in Coastal Drainage Area 3. April 9, 2008.

present behind accumulated large woody debris exhibiting minimal establishment of dune vegetation, but these areas are extremely small, where present, and quite patchy.

Although characterized by a diversity of upland habitat types, the entire study area is dominated by Douglas-fir. Invasive species did not appear to have a strong presence, although investigation was limited in scope. Scattered occurrences of English ivy were, however, observed, such as on the slopes of Coastal Drainage Area 2. Management techniques for invasive species serving as groundcover on steep slope areas will require careful planning and consideration since they currently provide slope stabilization functions.

The bluff areas represent unusual environments, with land cover types that are influenced by the mobility of soils on the bluff and by land use practices. In areas of low bluff activity, vegetation at the top of the bluff often reflects the same vegetation type as that found behind the bluff (as long as land use practices have not involved the removal of vegetation), with a subtle shift in subordinate species composition from species with lower drought tolerance (e.g., western red cedar) behind the bluff to species of higher drought tolerance (e.g., Pacific madrone) at the edge of the bluff. Vegetation on the bluff face and toe also appears to vary based on the degree of bluff activity and/or land use practices. In highly active areas and recent landslide tracts, these zones often support young, deciduous (seral) tree species (such as red alder) and a dense shrub layer because the high frequency of disturbance precludes the establishment of more mature forest types. Similarly, land use practices that have involved the clearing of trees on bluff faces for view improvements have resulted in the establishment of shrub or deciduous land cover types (e.g., on the bluff face in front of the large residential development in Coastal Drainage Area 1). In areas of lower bluff mobility, on terraces, and older landslide tracts, the bluff face is often characterized by mixed forest, and in areas that are virtually stable, coniferous forest may extend down the bluff face. The bluff toe is almost always characterized by deciduous forest species, likely because of the frequency of disturbance and erosion in this area. Large relict conifer trees that have survived previous landslides often stand out on bluff faces and toes and provide high-quality nesting sites for bald eagles and osprey.

Finally, land cover types vary significantly throughout the study area and appear to be most influenced by historic and current land use practices and by their position on the landscape with respect to the bluff environment and geologic activity. Structurally diverse habitats such as coniferous and mixed forests are found in areas of lower disturbance (low bluff activity or no-to-minimal human alteration), and more homogeneous, less complex habitats such as shrub or lawn areas are, as expected, found in areas of greater disturbance (i.e., with a high degree of human alteration or high bluff activity).

Watershed Characterization

As stated earlier, the Strawberry Point Watershed Characterization report (Island County 2008a) divided the project area into seven discrete watersheds or coastal drainage areas. The landmass of Whidbey Island at Strawberry Point is small, only 3 to 4 miles across; therefore, the stream

tributaries to the nearshore are relatively short in length. Four of these watersheds (i.e., Watershed 23, Watershed 18, Watershed 16, and Watershed 14) cover more than 100 acres and are defined by a single defined discharge (i.e., flow outlet); the remaining three watersheds are grouped into three coastal drainage areas (i.e., Coastal Drainage Area 1, Coastal Drainage Area 2, and Coastal Drainage Area 3) with no defined discharge. Because of the short length of stream tributaries and coastal drainages, nonpoint pollutants and sediment will move quickly across the landscape during storm events. In those watersheds with a defined discharge point to the marine shoreline, pollutants will be delivered quickly through channels and concentrate along the shoreline at the stream mouth. In the coastal drainage areas, water will typically move as sheet flow across the land and distribute any pollutants diffusely along the shoreline, or will infiltrate into the ground and reach the shoreline more slowly.

The seven watersheds in the Strawberry Point project area contain 421 parcels that are governed by the various zoning requirements of Island County. Zoning requirements affect the potential to segment and develop existing parcels, as well as guide which land uses are suitable for individual parcels. The land in the project area is zoned Rural, Rural Agriculture, Rural Forest, and Commercial Agriculture, as well as State Park.

As stated previously, four unnamed stream systems within the Strawberry Point project area drain to the nearshore marine environment (see Figure 2 for stream locations). In addition, several wetlands drain through these stream systems (Island County 2008a). These stream systems are identified by the Island County designation for the watersheds in which they occur (i.e., streams 14, 16, 18, and 23). Water quality parameters were monitored in these streams under Island County's Surface Water Monitoring Program, which was initiated in these systems over 2006 and 2007 (Island County 2008a).

These streams are ephemeral, lacking flows for extended periods during the summer dry season and generally providing limited discharge during wet periods. Island County conducted water quality sampling for multiple parameters during 2006 and 2007 (Island County 2008a). The intensity of sampling varied between drainages, with the number of sampling events being dependent upon the size of the drainage and streamflows present. Water quality parameters analyzed in all systems included general flow conditions (e.g., flow present, wetted width, depth), temperature, pH, dissolved oxygen (DO), nitrates, phosphates, turbidity, and fecal coliform bacteria. With the exception of turbidity and phosphorus, all parameters were within state standards in all watersheds during the monitoring period (Island County 2008a).

With regard to turbidity, Island County has established 16 nephelometric turbidity units (NTU) as a provisional threshold level (Island County 2008a). This threshold is based on observed background levels in relatively undisturbed Island County watersheds (6 NTU), and state turbidity standards requiring that turbidity levels not exceed 10 NTU over background levels. Observed turbidity levels were generally below this threshold, except during the fall when exceedences were observed in each system. These exceedences ranged from 20 to as high as 80 NTU in some cases. This effect was identified as being associated with seasonal "scraping" (vegetation clearing) from roadside ditches to improve conveyance (Island County 2008a).

Currently, there is no applicable state standard for phosphorus in streams, but the mean of levels observed in undeveloped stream drainages on Island County provides a useful basis for comparison. The timing and frequency of peak orthophosphate levels varied by stream system, but the Island County mean was exceeded on multiple occasions in every stream system, most commonly during the early fall runoff period. This suggests some potential for elevated delivery of nutrients to nearshore marine waters; however, observed nitrate levels were all below the state regulatory threshold for freshwater systems. Because nitrogen is the primary limiting nutrient in marine systems, this suggests that elevated phosphorus inputs are not likely to be a concern (Island County 2008a).

Of the seven watersheds sampled by Island County, the Watershed 14 drainage was sampled the most intensively because this system is the largest and supports streamflows over the longest period of time (Island County 2008a).

A summary of findings for these watersheds is provided below, based on the Strawberry Point Watershed Characterization report prepared by Island County (2008a).

Watershed 23

This watershed is 203 acres in size and is drained by a small, seasonal stream with its headwaters in a wetland. Island County conducted an assessment of high-resolution aerial photography, quantifying the observable land cover and land uses in the watershed and revealing that the vast majority of this watershed consists of natural vegetation (Island County 2008a).

Residential development and field-maintenance are the dominant activities occurring in this watershed. Each of the 11 residential dwellings and accessory structures in this watershed are surrounded by a small area of residential landscaping and garden, and there are several barns that do not appear to currently house animals. Fields have been cleared in the upper and lower portion of the watershed, but only the lower field appears to be mowed/hayed. Neither aerial photo analysis nor field-verification revealed that these fields are being used for livestock grazing. However, the barns in the lower portion of the watershed indicate historic agricultural use, and there is the potential that landowners may raise livestock in the future. Some forested areas on smaller lots on the southwest border of the watershed have been recently cleared. The remainder of the watershed is undeveloped forest and shrub land (Island County 2008a).

For the purpose of this assessment, surface water quality was monitored between October 2 and December 18, 2007 (Island County 2008a). The sampling took place at the inlet to the culvert located under Strawberry Point Road, at a point along the channel about 1,800 feet from the shoreline. The water was analyzed six times for fecal coliform bacteria and three times for nutrients (nitrate and orthophosphate). Routine parameters (including temperature, pH, conductivity, turbidity, dissolved oxygen, and water level) were measured seven times.

Turbidity exceeded the County standard of 16 NTU on all occasions between October 24 and December 18, 2007. Turbidity was highest on October 24, when all other Strawberry Point sites

had high turbidity, attributed to the recent scraping of roadside ditches by Island County road crews.

Compared to the mean orthophosphate levels for other Island County streams during 2006-2007 water year (0.14 mg/L), levels in this watershed were higher on two occasions during the monitoring period. The other measured water quality parameters were within state standards during all sampling events (Island County 2008a).

Coastal Drainage Area 1

Costal Drainage Area 1 is 192 acres in size. There is no monitorable surface water feature in this coastal drainage area; hence, no monitoring was conducted (Island County 2008a). This watershed is mostly forested. Mixed coniferous-deciduous forest makes up a contiguous track of approximately 100 acres on the downslope side of Strawberry Point Road. Single-family residences intersperse the area, mostly in the northern portion of the drainage area. The upslope side of Strawberry Point Road is dominated by grass fields and forest. The grass fields appear to be used for grazing but are perhaps occasionally mowed or hayed (Island County 2008a).

Watershed 18

This watershed is 399 acres in size and is drained by a small, seasonal stream. Approximately one-third of this watershed is mixed coniferous-deciduous forest, some of which appears to have been logged in the past half-century. Of the 60 acres of deciduous forest, about 78 percent appears to have grown up within an old timber harvest. Another one-third of the watershed is field—either used for pasture or hay production—making it the watershed with the greatest percentage of land identified as field in the project area. Rural residences are dispersed throughout the forest in the southwest portion of the watershed. A large percentage of this watershed is zoned for agriculture, either Commercial or Rural, and the land use that characterizes this zoning is pasture for cattle or livestock. It is the only watershed in the project area with land zoned as Commercial Agriculture (Island County 2008a).

Surface water quality was monitored between October 24 and December 18, 2007. The sampling station was located at the inlet to the culvert running under Strawberry Point Road, a location along the channel about 1,400 feet from the shoreline. The water was analyzed four times for fecal coliform bacteria and twice for nutrients (nitrate and orthophosphorus). Routine parameters (including temperature, pH, conductivity, turbidity, and dissolved oxygen) were measured five times (Island County 2008a).

Turbidity exceeded the County standard of 16 NTU on October 24, 2007. As with the other sites on this date, the high turbidity was likely attributed to the recent scraping of roadside ditches by Island County road crews.

Compared to the mean orthophosphorus levels for other Island County streams during the 2006-2007 water year (0.14 mg/L), the concentration of orthophosphorus in Stream 18 exceeded this level twice during the monitoring period.

The other measured water quality parameters were within state standards during all sampling events (Island County 2008a).

Watershed 16

This watershed is 380 acres in size and is drained by a small, seasonal stream. The watershed is mostly forested with residences on large, forested lots. A majority of the residences in the upper two-thirds of the watershed have lawn or cleared areas around them, but the rest of the parcel remains forested. The lower one-third of the watershed consists of fields and dense rural development with more extensive landscaping. This development is concentrated on the downslope side of Green Road, near the bluff above the shoreline (Island County 2008a).

One channel drains this watershed. A defined channel about 1,100 feet long drains a manmade pond just south of Green Road. Above the pond, the channel is less defined, although it probably continues about 2,000 feet up to Silver Lake Road. The stream may have been artificially channelized at some point, as evidenced by the deep, relatively straight channel running through the fields. However, the stream drains to the marine shoreline through a deep ravine, evidence that this stream has occupied this channel for a long period of time. The stream is shallow through its course and contributes only small volumes of freshwater to the marine environment (Island County 2008a).

Surface water quality was monitored between October 24 and December 18, 2007. The sampling location was the outlet of the culvert under Green Road, at a point about 500 feet from the shoreline. The water was analyzed four times for fecal coliform bacteria and twice for nutrients (nitrate and orthophosphorus). Routine parameters (including temperature, pH, conductivity, turbidity, and dissolved oxygen) were measured five times (Island County 2008a).

The measured water quality parameters were within state standards during all sampling events. Turbidity exceeded the County standard of 16 NTU on October 24. As within the other watersheds, this high turbidity was likely attributable to the recent scraping of roadside ditches by Island County road crews (Island County 2008a).

Coastal Drainage Area 2

Coastal Drainage Area 2 is 283 acres in size. It has no streams, and its shoreline is characterized by steep bluffs. Thirteen percent of this drainage area is zoned Rural Agriculture and these lands are used for pasture by a few horses and cows. The remaining Rural lands consist of single residences in forest or field—some of which also appear to be used for pasture. Six acres near Green Road have been cleared of vegetation in the past year, leaving bare exposed soil. One 20-acre and one 10-acre parcel are entirely forested. One road bisects this drainage area near the coastline, and another occurs in the upper part of the drainage (Island County 2008a).

Although no stream or principal channel is present in this drainage area, a culvert crossing with a steady flow of water was monitored between October 24 and December 18, 2007. The sampling

location was at the inlet to the culvert under Green Road, approximately 2,300 feet south of the intersection with Rose Lane. This point captures about 4,000 feet of roadside ditch. The sampling location was about 300 feet from the shoreline (Island County 2008a).

The water was analyzed three times for fecal coliform bacteria and twice for nutrients (nitrate and orthophosphorus). Routine parameters (including temperature, pH, conductivity, turbidity, and dissolved oxygen) were measured four times.

Turbidity exceeded the proposed Island County baseline turbidity level (16 NTU) during all sampling events. Elevated turbidity is presumed to be attributable to the recent scraping of roadside ditches by Island County Public Works Department (Island County 2008a).

Fecal coliform bacteria levels measured at this site were high during two of the three sampling events. State standards for these bacteria are as follows: "secondary contact recreation fecal coliform levels must not exceed a geometric mean value of 200 colonies (CFU)/100 mL, and no more than 10 percent of all samples (or any single sample when less than 10 sample points exist) shall exceed 400 CFU/100 mL." The bacteria count was 830 cfu/100 mL during one of the events, so an exceedence occurred. Further study may illuminate the question of whether fecal coliform persists in surface water here or not (Island County 2008a).

The other water quality parameters were within state standards during all sampling events.

Watershed 14

At 1,095 acres, this watershed is the largest in the project area and is drained by a small, seasonal stream. Several short tributaries feed this stream. A large tributary, 3,660 feet long, flows in from the west and runs between a series of ponds and along a road. Water flows into a series of constructed ponds at the corner of DeVries and Green roads. The ponds detain the streamflow but allow enough of it to flow out, with flow present in the stream nearly year round.

The watershed is largely forested, with rural development interspersed among the forest. There are fewer fields in this watershed than in the rest of the project area, with only a few fields at the most downstream point in the watershed and a few higher up. The fields in the land zoned Rural Agriculture are used for pasture by cattle. Forests are mixed deciduous-conifer or purely deciduous. All appear to be in various stages of postlogging succession.

This watershed was monitored as part of Island County's Surface Water Monitoring Program. Samples were collected upstream of the culvert crossing under Green Road between December 5, 2006, and January 3, 2008. The sampling location captured water flowing from the series of ponds above this point, as well as water from several roadside ditches. The sampling station is 700 feet from the shoreline. This sampling location continues to be monitored because it is a baseline site.

The water was analyzed 25 times for fecal coliform bacteria and 13 times for nutrients (nitrate-nitrogen and orthophosphorus). Routine parameters (including temperature, pH, conductivity, turbidity and dissolved oxygen) were measured 26 times. Flow was noted as being absent during a routine visit on August 16 but was present again on October 2, suggesting a maximum of 8 weeks when the stream did not flow (Island County 2008a).

When analyzed following state standards, 8 percent of the fecal coliform bacteria samples exhibited concentrations of more than 400 CFU, and the geometric mean was less than 200 CFU. Thus, an exceedence of the state standard did not occur.

Turbidity was higher than 16 NTU on four occasions over the 2006-2007 monitoring year. During the period when the other Strawberry Point watersheds were monitored, turbidity exceeded this value once, on October 24. As with the other watersheds, this high turbidity is presumed to be attributable to the scraping of roadside ditches.

Compared to the mean orthophosphorus levels for other Island County streams during the 2006-2007 water year (0.14 mg/L), the concentration of orthophosphorus in Stream 14 exceeded this level four times during the monitoring period.

The other water quality parameters were within state standards during all sampling events (Island County 2008a).

Coastal Drainage Area 3

This watershed is 408 acres in size. The area is physically unique in Island County because part of the area does not drain to the shoreline, but to a bog. There are no streams in the rest of the area, and water infiltrates into the soil or drains diffusely to Puget Sound.

Because 90 percent of the drainage area is park, the dominant land use is passive recreation, such as hiking and horseback riding through the few trails in the park. The remaining 10 percent of the drainage area is forested, with a few rural residences at the very edge (Island County 2008a).

Water quality was monitored in the bog between October 30, 2006, and January 3, 2008. Water from this wetland does not drain to the nearshore and so is not considered relevant to the Strawberry Point project. This wetland is included in the County's general monitoring program because it is a relatively unusual feature. Results from the 2006-2007 monitoring show acidic, low-oxygen conditions typical of this type of wetland. Between June 19, 2007, and January 3, 2008, no water was present (Island County 2008a). This sampling location continues to be monitored because it is also a baseline site.

Conclusions

Geologic and Geomorphic Conditions

Based on the observations and analysis of coastal geology and geomorphology, three aspects of the existing conditions at Strawberry Point could influence the identification and implementation of habitat protection activities in the area:

- *Diversity of shoreline sediments* – Because of the high levels of tectonic activity, shoreline and bluff sediments are generally diverse in grain size, making project-wide prescriptions difficult and potentially inappropriate. Therefore, shoreline projects (for example habitat restoration projects) should consider existing physical conditions and processes that are unique to the Strawberry Point environment (see the *Recommendations for Habitat Protection* section).

- *Primary impacts are associated with fixed structures and riprap that have been placed seaward of MHHW* – Although shoreline structures are relatively rare in the project area, where they do occur they have significantly disturbed the natural form of the shoreline. In most instances, they have little practical use and serve primarily as aesthetic landscape elements. Where possible, actions to reduce the geomorphic impact of these structures should be pursued. The actions considered should include removal (see the *Recommendations for Habitat Protection* section).

- *Relative inactivity of the shorelines* – With the exception of Coastal Drainage Area 1 and Watershed 23, most of the shorelines and coastal bluffs are at least marginally stable, especially if they are forested. Deforestation and placement of shoreline structures are the primary sources of bluff and beach erosion, respectively, in the rest of the project area (see the *Recommendations for Habitat Protection* section).

Nearshore Habitat Conditions and Fish Utilization

Of particular interest, the project area is the initial nearshore habitat experienced by a large proportion of migrating Chinook salmon fry and pink and chum salmon smolts arising from the North and South Forks of the Skagit River. The Skagit River System Cooperative (SRSC) has studied the dispersal pathways from the mouth of the Skagit River using drift buoys (Beamer et al. 2005). They found that the current plumes discharged from several distributary channel systems travel directly across Skagit Bay toward the Strawberry Point shoreline. This indicates

that under high river flows, weak-swimming fry and smolts are likely to be transported directly to this nearshore environment. This also suggests that the initial feeding and refuge functions provided by these habitats are important to early marine survival, as fry migrants and smolts transported into the marine environment on high streamflows must undergo a relatively rapid physiological and behavioral transition to the marine environment.

The Strawberry Point shoreline also provides ecological connectivity between other highly productive salmonid rearing areas. Notably, this shoreline functions as a migratory corridor between existing and former pocket estuary habitats with the potential for restoration (Beamer et al. 2005). Pocket estuaries are small estuary systems fed by tributaries or groundwater inflow that provide highly productive transitional and rearing habitats for juvenile salmonids as they adapt to the marine environment. The gradual loss of these habitats to shoreline development has been identified as a limiting factor in the early marine survival of several salmon species, including chum and Chinook salmon (Beamer et al. 2003; Herrera 2008a).

A number of existing and former pocket estuaries in the vicinity have been targeted as priorities for restoration and enhancement, with Ala Spit, Dugualla Bay, Dugualla Bay Heights, Mariners Cove, and Crescent Harbor identified as high-priority sites (Beamer et al. 2005). The Dugualla sites and Mariners Cove lie immediately to the north and south of the Strawberry Point project area boundary, respectively, while Crescent Harbor lies to the west of Mariners Cove.

Shoreline Vegetation Conditions

Shoreline vegetation in the upland areas along the Strawberry Point shoreline likely provide some of the same functions provided by freshwater riparian areas (Desbonnet et al. 1995) as well as additional functions unique to nearshore marine systems (Brennan and Culverwell 2004; Williams and Thom 2001; Williams et al. 2001). Shoreline vegetation moderates the quality of aquatic habitats by increasing slope stability, providing erosion protection (Myers 1993; Manashe 1993; Broadhurst 1998), and buffering against pollution and sediment runoff (Federal Interagency Stream Restoration Working Group 1998). Overhanging vegetation provides shade that regulates microclimates important to surf smelt spawning (Penttila 2001), and solar radiation/desiccation limits the distribution of intertidal invertebrates in the upper beach area (Foster et al. 1986). Large woody debris sourced from these shoreline areas can stabilize beaches and help build berms and backshore areas (Brennan and Culverwell 2004). Intact, diverse shoreline vegetation provides high-quality habitat for birds, mammals, amphibians, and invertebrates. (At least eight bald eagles and five great blue herons were observed using shoreline vegetation within the project area on Herrera's April 9, 2008 site visit.)

Given the critical role that trees play in these functions, structurally and compositionally complex land cover types of the upland shoreline environment (e.g., coniferous forest, mixed forest) likely provide greater functions for the nearshore than do the structurally homogeneous land cover types (e.g., lawn, shrub). These functions include the support of higher nearshore

invertebrate abundance and diversity, greater habitat diversity, input of large woody debris, and increased shade.

As expected, the shoreline area of Coastal Drainage Area 3, with its large tracts of intact, native coniferous forest, exceptional abundance of large trees, high snag density, and proliferate overhanging vegetation, provides the greatest contribution of the aforementioned functions within the project area. The relatively limited amount of development throughout most other areas of Strawberry Point has allowed for the retention of many of these functions on a smaller scale. Overhanging vegetation along the shoreline is common, and some sections where conifers extend down to the bluff toe were also observed. In addition, although many areas have been previously cleared of large trees (or their establishment and persistence have been precluded by high bluff activity), the presence of just a few large relict trees on the bluff face in areas of Coastal Drainage Areas 1 and 2 provides significant terrestrial habitat value, as evidenced by the bald eagle nests observed during the site visit.

Areas of higher density development, such as along the shoreline of Watershed 16, are characterized by low abundance of these high-quality habitat types, both from actual property development and associated lawns and from tree clearing for view enhancement. Other locations with similar land practices include properties in the southern and northern extents of Coastal Drainage Area 2, and the large development with four homes in the northern extent of Coastal Drainage Area 1. The habitat functions described above are reduced in these areas because of the lack of a tree canopy and minimal species diversity.

Vegetation Removal

Shoreline vegetation has been removed at various locations throughout the project area. Although this has had no obvious significant geomorphic consequence, it can make preexisting steep slopes more unstable, thus increasing their rate of retreat and erosion (see the *Recommendations for Habitat Protection* section). In areas of low bluff activity, vegetation at the top of the bluff often reflects the same vegetation type as that found behind the bluff as long as land use practices have not involved vegetation removal. Vegetation on the bluff face and toe also appears to vary based on the degree of bluff activity and/or land use practices. In highly active erosion areas and recent landslide tracts, these zones often support young, deciduous tree species (such as red alder) and a dense shrub layer because the high frequency of disturbance precludes the establishment of more mature forest types. Similarly, land use practices that involved the clearing of trees on bluff faces (e.g., for view improvements) have resulted in the establishment of shrub or deciduous land cover types. In areas of lower bluff mobility, on terraces, and older landslide tracts, the bluff face is often characterized by mixed forest; in areas that are virtually stable, coniferous forest may extend down the bluff face. From a management perspective and consideration for future habitat preservation strategies, it is important to note that land cover types vary significantly throughout the Strawberry Point project area. Land cover types appear to be most influenced by historic and current land use practices and by their position on the landscape with respect to the bluff environment and geologic activity.

Invasive Species

Invasive species do not appear to have a strong presence in the project area, although the scope of this project did not include a substantial investigation of this issue. Scattered occurrences of English ivy were however observed, in one instance on the slopes in Coastal Drainage Area 2. Management techniques for invasive species serving as groundcover on steep slope areas will require careful planning and consideration since they currently provide slope stabilization functions.

Watershed Conditions

Seven watersheds comprise the project area, consisting of four watersheds having one point of discharge to the shoreline, and three coastal drainage areas. The characterization performed by Island County (Island County 2008a) identified and assessed the current conditions in these watersheds.

The seven watersheds in the Strawberry Point project area contain 421 parcels that are governed by the various zoning requirements of Island County. Zoning requirements affect the potential to segment and develop existing parcels, as well as guide which land uses are suitable for individual parcels. The land in the project area is zoned Rural, Rural Agriculture, Rural Forest, and Commercial Agriculture, as well as State Park.

Four unnamed stream systems within the Strawberry Point project area drain to the nearshore marine environment. These streams are ephemeral, lacking flows for extended periods during the summer dry season and generally providing limited discharge during wet periods. Island County conducted water quality sampling for multiple parameters during 2006 and 2007 (Island County 2008a). This water quality monitoring effort continues today. Water quality parameters analyzed in all systems included general flow conditions, temperature, pH, dissolved oxygen (DO), nitrates, phosphates, turbidity, and fecal coliform bacteria. With the exception of turbidity and phosphorus, all parameters were within state standards in all watersheds during the monitoring period (Island County 2008a).

Recommendations for Habitat Protection

Results of the analyses described above (i.e., coastal geologic and geomorphic conditions, nearshore environment, shoreline conditions, and watershed characterization) were evaluated and synthesized by the Herrera project team, in coordination with Island County, to develop specific implementation actions designed to protect the nearshore processes and aquatic habitats at Strawberry Point for the benefit of both salmonids and forage fish species. Recommendations are presented below for the entire Strawberry Point project area, as well as for each watershed or coastal drainage area.

General Recommendations

Following are the general recommendations applicable to all watersheds and coastal drainage areas within the Strawberry Point project area.

Discourage land use practices that reduce native shoreline vegetation and ecological functions – Given that the degree of function provided by land cover types is so dependent on the degree of structural and compositional diversity, land use practices that reduce habitat complexity (e.g., mowing/manicuring of the forest understory, installation of turf) will significantly decrease the ability of the shoreline environments to provide these benefits. If one of the primary land management objectives for the Strawberry Point project area is preservation and enhancement of nearshore function, it is recommended that land use practices that reduce the diversity of native shoreline vegetation be discouraged and that emphasis be placed on embracing opportunities for enhancement or protection of these important habitat characteristics.

Where maintenance of views is desired, discourage the complete removal of vegetation and encourage "windowing" of large woody vegetation – In numerous locations throughout the project area, shoreline vegetation has been completely removed to create views. This practice not only compromises the stability of shoreline bluffs, often necessitating structural solutions, but it also decreases shade in the nearshore zone and the ability of the shoreline to recruit drifting large woody debris. These conditions negatively affect the quality of nearshore habitat, particularly for forage fish. If views are necessary, windowing the understory can maintain partial views without completely compromising bluff stability and vegetative cover (see Figure 25).

Discourage the installation of new shoreline structures – While little of the shoreline in the project area is currently armored (in comparison to the general shoreline conditions of Puget Sound), future development could include the placement of new revetment structures. However, with the exception of Coastal Drainage Area 1, there is little shoreline erosion in the project area, and protection of property can be accomplished successfully with "softer" means (e.g., addition of stable wood and maintenance or protection of an intact, native bluff and shoreline vegetation). Where possible, these alternative methods should be strongly encouraged over the placement of new structures.

Figure 25. Photograph of two adjacent properties illustrating two different approaches to view preservation. The residence on the right uses a "windowed" approach that is both sustainable and not significantly detrimental to nearshore habitat, while the residence on the left potentially increases shoreline erosion and compromises nearshore habitat by eliminating nearly all vegetation at the top of the bluff.

Watershed-Specific Recommendations

Following are the specific recommendations for each watershed or coastal drainage area in the Strawberry Point project area.

Watershed 23

Protect the riparian corridor of the small stream that defines this watershed – With the potential to create new lots in the now-forested portion of this watershed and to nearly quadruple the population of this watershed, there is a potential for many changes to occur. Initially, forest clearing would lead to an increased potential for erosion and diminishing habitat. The presence of more people, houses, and vehicles would increase the likelihood of nonpoint pollution.

Although the mouth of the stream has not been altered, the banks have been cleared immediately upstream. Because the stream delivers sediment to the rest of the Strawberry Point shoreline, local landowners should be educated to understand that the health of the shoreline depends on maintaining high water quality in the stream that runs through their properties.

Any action in this watershed that maintains the food web, transport system, and water quality will help to protect and maintain nearshore habitat functions. Preserving the habitats in this watershed (forest, open field, and wetlands) will ensure the continued delivery of a diversity of aquatic insects to the nearshore. Limiting the conversion of vegetated areas to bare ground will avoid the introduction of fine sediments to the beach. Reducing the discharge of fines to the beach will serve to maintain the interstices between the beach sands and gravel, which is vital for forage fish spawning.

Additional protection in this watershed can be gained by creating conservation easements on the undeveloped parcels, with special consideration given to those near the shoreline and those in the forested corridor in the upper reaches of the watershed. Other potential actions include educating landowners about proper implementation of best management practices (BMPs), encouraging low impact development (LID), and enhancing riparian buffer by planting native shrubs and trees along the stream channel in the lower reaches of the stream. Education and enhancement efforts related to water quality may start by targeting ways to reduce soil erosion and turbidity, a potential issue in this watershed. Even though water quality problems were minimal during the monitoring performed by Island County (Island County 2008a), any riparian vegetation enhancement and education efforts will maintain water quality and the delivery of nutrients to the nearshore over the long term.

Coastal Drainage Area 1

Protect the intact shoreline corridor – Most of this watershed has an intact shoreline corridor, with adequate setbacks of structures away from the bluff. Where possible, these bluffs should be

put into conservation easements to ensure that the supply of sediment and large woody debris to the rest of the Strawberry Point shoreline remains intact. While this watershed is the most dynamic shoreline in the project area, erosion rates are not rapid in comparison to other locations in Puget Sound, and the existing shoreline vegetation offers modest protection against slope failure. Therefore, clearing on the bluffs should be strongly discouraged, not only to protect the vegetation, but also to avoid detrimental impacts on nearshore habitat.

Although only four new lots can be created in this watershed (Island County 2008a), many of the current lots can still be developed. Therefore, voluntary conservation and education efforts can be used to promote the proper use of BMPs during construction, encourage low impact development, and provide tools for current and new landowners to protect the shoreline.

Watershed 18

Use protection mechanisms already implemented here as a model for other watersheds in the project – A portion of this watershed (16-acre property at the mouth of the associated stream) is already protected by a conservation easement, in cooperation with the landowner and the Whidbey Camano Land Trust. While some disturbance is associated with development, the management of this area has led to a reasonable approximation of predevelopment conditions, protecting existing habitat in the area while maintaining use by residents.

Because the parcels closest to the shoreline (downstream of Strawberry Point Road) are both vulnerable (steep and unstable slopes) and currently undeveloped, these lots should be targeted for voluntary conservation easements and other protective actions such as the use of best management practices during construction and low impact techniques for any new development.

Given the amount of land in this watershed that is zoned for agriculture (Island County 2008a), education and outreach efforts that speak to sustainable agricultural practices would be effective in maintaining the quality of water flowing within through this watershed. Voluntary efforts to enhance riparian buffers by planting native shrubs and trees along the stream channel in its upper reaches will also maintain water quality and delivery of debris, insects, and nutrients to the nearshore over the long term.

Because there is a potential for the creation and development of new lots in this watershed (Island County 2008a), additional protection can be gained by creating conservation easements on the undeveloped parcels, training new landowners about proper implementation of BMPs, and encouraging low impact development. Even though only minor water quality problems were detected during the County's monitoring program, riparian vegetation enhancement and educational efforts are likely to maintain or improve existing water quality.

Watershed 16

Encourage the replacement of existing bulkheads – This watershed is the most heavily armored of all the shorelines in the project area. Ironically, the broad, fine-grained low-tide terrace in this

area indicates a relatively low wave energy environment. There is also essentially no historical shoreline retreat. These bulkheads are serving primarily as aesthetic features only and are not necessary for the protection of property and infrastructure. Because the existing bulkheads have encouraged the loss of foreshore area, it is recommended that these structures be removed where possible and replaced with "softer" techniques of protection, such as beach nourishment and protection of a shoreline buffer (see below).

Encourage replanting of the shoreline vegetation – Much of the shoreline vegetation has been removed to provide views to the residences in this watershed. An intact shoreline buffer would prevent what little erosion would occur from the removal of the existing bulkheads. In addition to enhanced erosion protection, the current vegetation provides little to no shade and likely limits forage fish spawning habitat by elevating summertime temperatures on the beach (Rice 2006).

Coastal Drainage Area 2

Acquire or protect the small development at the end of Bultman Lane – The spit that is beginning to form in this area has created an incipient (i.e., not fully formed) pocket estuary behind it. Pocket estuaries have been shown to be crucial to the protection of salmonids (Beamer et al. 2005). It is unclear whether this feature is natural or a result of the excessive delivery of sediment to the nearshore from nearby grading and disturbance; however, the result is an area that could act as a nursery for juvenile salmonids and a refuge for adult fish. Protection of this area through purchase or conservation easement should be pursued.

In general, because this watershed includes shoreline properties, many of which are undeveloped, education and conservation efforts could be targeted at shoreline protection. Maintaining the vegetation along the bluff will be vital to maintaining nearshore processes.

Conservation easements on the forested lots above the bluff in this watershed would benefit the nearshore environment. Given that some shoreline parcels have armoring, opportunities exist to enhance shoreline processes through voluntary removal of armoring or implementation of other shoreline protection actions. Encouraging the voluntary replanting of exposed areas is another opportunity to protect the shoreline.

Farther inland, land use activities that may contribute to water quality problems should be addressed through education and outreach. Conservation and education efforts should address the proper implementation of BMPs at new construction sites and encourage landowners to use low impact development strategies. Additional surface water monitoring in Stream 2 would help determine the magnitude of the problem with fecal coliform bacteria levels here, and general education about animal waste management and septic system maintenance will ensure that fecal coliform bacteria levels do not increase in Stream 2 in the future.

Watershed 14

Protect the riparian corridor of the small stream that defines this watershed – While the mouth of the stream has not been altered, immediately upstream of the mouth the stream bank has been

cleared. Because the stream eventually delivers both sediment and large woody debris to the intact, predevelopment shoreline of Deception Pass State Park, local landowners should be informed that the health of the shoreline in the park depends on high water quality and woody debris delivered by the stream that runs through their properties.

Additional protection can be gained by creating conservation easements on the undeveloped parcels, as well as educating new landowners about the proper implementation of BMPs and encouraging low impact development. Because some lands in this watershed are zoned Rural Forest, outreach related to proper timber harvest practices could help maintain riparian buffers and water quality. Concentrating protective actions in areas with highly erodible soils may help maintain the low turbidity of freshwaters flowing to the nearshore.

Coastal Drainage Area 3

Use this area as a reference site for future nearshore assessments – This watershed is already protected because it is located predominantly within Deception Pass State Park. The only recommended action for this watershed is to promote its use as a reference site for future nearshore restoration assessments in Island County. The mature vegetation, quantity of racked large woody debris, and dominance of groundwater seeps along the shoreline is unusual in Island County and provides an example of exceptional nearshore habitat.

Glossary

Anthropogenic – Caused either directly or indirectly by human activity.

Beach transect – A profile of elevations perpendicular to the shoreline.

Downdrift – In the direction of dominant along shore sediment transport.

Drumlin – A positive (elevated) glacial feature produced by glaciers that is aligned with the direction of glacial motion.

Everson Interstade – The time period immediately after the collapse of the Puget Lobe when the terminus of the Cordilleran ice sheet was at or near the modern-day town of Coupeville (approximately 10,000 to 13,000 years before present).

Fetch – The distance over which the wind blows to generate a given wave field.

Foreshore – The steep part of the beach that is generally composed of gravel, although it can contain sand or even boulders. The foreshore on the shoreline of Strawberry Point extends from approximately 1 to 3 feet above MLLW to MHHW. It is the most sedimentologically active portion of the nearshore.

(Oceanographic) Front – The sharp boundary between fresher water, associated with a river, and saltier water. These features typically contain floating debris, scum, and/or bubbles on the fresh side of the front. Fronts often migrate with the tide.

Low-tide terrace – A broad, flat portion of the nearshore that extends from a few feet above to a few feet below MLLW. The low-tide terrace is finer grained that the foreshore above it. In Coastal Drainage Areas 2 and 3, the low-tide terraces are composed primarily of mud.

Mean higher-high water (MHHW) – The average elevation of the two high tides in each day over a tidal epoch (19 years).

Mean lower-low water (MLLW) – The average elevation of the two low tides in each day over a tidal epoch (19 years).

Nearshore – In the context of Strawberry Point, the nearshore is the area of marine and estuarine shoreline. It generally extends from the top of shoreline bank or bluff to the depth offshore where light penetrating the water falls below a level supporting plant growth, and upstream in estuaries to the head of tidal influence. It includes bluffs, beaches, mudflats, kelp and eelgrass beds, salt marshes, gravel spits, and estuaries.

Puget Lobe – The southernmost finger of the Cordilleran Ice Sheet that advanced into and fills the Puget Lowland.

Puget Lowland – The low area between the Olympic and Cascade mountain ranges.

Refraction – A process by which wave crests orient parallel to shore owing to wave speed differences once the waves begin to interact with the bed.

Terrace – The linear, flat area that corresponds to a former shoreline or ice-contact point.

Updrift – In the direction opposite of dominant along shore sediment transport.

Vashon Stade – The time period between 20,000 and 13,000 years before present of glacial inundation of the Puget Lowland at the end of the last ice age.

References

Armstrong, J.E., D.R. Crandell, D.J. Easterbrook, and J.B. Noble. 1965. Late Pleistocene Stratigraphy and Chronology in Southwestern British Columbia and Northwestern Washington. Geological Society of America Bulletin 76(3):321-330.

Babson, A.L., A. Kawase, and P. MacCready. 2006. Seasonal and interannual variability in the circulation of Puget Sound, Washington: A box model study. Atmosphere-Ocean 44(1):29-45.

Bargmann, G. 1998. Forage Fish Management Plan—A Plan for Managing the Forage Fish Resources and Fisheries of Washington. Washington Department of Fish and Wildlife, Olympia Washington. September 1998.

Beamer, E., A. McBride, C. Greene, R. Henderson, G. Hood, K. Wolf, K. Larsen, C. Rice, and K. Fresh. 2005. Delta and Nearshore Restoration for the Recovery of Wild Skagit River Chinook Salmon: Linking Estuary Restoration to Wild Chinook Salmon Populations. Skagit Chinook Recovery Plan. LaConner, Washington, Skagit River System Cooperative: 93.

Beamer, E.M., A. McBride, R. Henderson, and K. Wolf. 2003. The importance of non-natal pocket estuaries in Skagit Bay to wild Chinook salmon: an emerging priority for restoration. Skagit River System Cooperative, La Conner, Washington. Available at: <www.skagitcoop.org/>.

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

Brennan, J. and H. Culverwell. 2004. Marine Riparian: An Assessment of Riparian Functions in Marine Ecosystems. Unpublished draft.

Bretz, H. 1913. Glaciation of the Puget Sound region. Washington Geologic Survey Bulletin 8:244.

Broadhurst, G. 1998. Puget Sound Nearshore Habitat Regulatory Perspective: A Review of Issues and Obstacles. Puget Sound/Georgia Basin Environmental Report Series, No. 7. Puget Sound/Georgia Basin International Task Force, Seattle, Washington.

Carlstad, C.A. 1992. Late Pleistocene deglaciation history at Point Partridge, central Whidbey Island, Washington. Geology. Western Washington University, Bellingham, Washington. MS thesis.

Collias, E., C.A. Barnes, and J.A. Lincoln. 1973. Skagit Bay study dynamical oceanography: final report. Department of Oceanography, University of Washington, Seattle, Washington: 186.

Desbonnet, A.V., L.P. Pogue, D. Reiss, J. Boyd, J. Willis, and M. Imperial. 1995. Development of Coastal Vegetated Buffer Programs. Coastal Management 23(2):91–109.

Ecology. 1976-77. Oblique photograph of shoreline. Color orthoimage Washington State Department of Ecology, Shoreline Arial Photos, 1976-77. Obtained April 15, 2008 from the Washington State Department of Ecology website: <https://fortress.wa.gov/ecy/coastalatlas/viewer.htm>.

Ecology. 1992-97. Oblique photograph of shoreline. Color orthoimage Washington State Department of Ecology, Shoreline Arial Photos, 1992-97. Obtained April 15, 2008 from the Washington State Department of Ecology website: <https://fortress.wa.gov/ecy/coastalatlas/viewer.htm.>

Ecology. 2000. Oblique photograph of shoreline. Color orthoimage Washington State Department of Ecology, Shoreline Arial Photos, 2000. Obtained April 15, 2008 from the Washington State Department of Ecology website: <https://fortress.wa.gov/ecy/coastalatlas/viewer.htm>.

Ecology. 2006. Oblique photograph of shoreline. Color orthoimage Washington State Department of Ecology, Shoreline Arial Photos, 2006. Obtained April 15, 2008 from the Washington State Department of Ecology website: <https://fortress.wa.gov/ecy/coastalatlas/viewer.htm>.

Ecology. 2008. Washington Coastal Atlas. Washington State Department of Ecology. Accessed on April 21, 2008, from agency website: <https://fortress.wa.gov/ecy/coastalatlas/viewer.htm>.

Federal Interagency Stream Restoration Working Group. 1998. Stream Corridor Restoration: Principles, Processes, and Practices. National Engineering Handbook, NEH 653.

Finlayson, D. 2006. The Geomorphology of Puget Sound Beaches. Oceanography. University of Washington, Seattle, Washington. PhD thesis.

Foster, M.S., A.P. DeVogelaere, C. Harlod, J.S. Pearse, and A.B. Thum. 1986. Causes of Spatial and Temporal Patterns in Rocky Intertidal Communities of Central and Northern California. Volume 2 of 2. Outer Continental Shelf Study. MMS 85-0049, Contract No. 14-12-0001-30057. U.S. Department of the Interior, Minerals Management Service.

Google Maps. 2008. High resolution aerial photographs of Strawberry Point, Island County, Washington. Website accessed on April 2, 2008. Available at: <http://maps.google.com>.

Herrera. 2005. Marine shoreline sediment survey and assessment, Thurston County, Washington. Thurston Regional Planning Council, Olympia, Washington. Prepared by Herrera Environmental Consultants, Inc., Seattle, Washington.

Herrera. 2007. Functional assessment and historical analysis: Crockett Lake at Ebey's Landing National Historical Reserve. National Park Service, Seattle, Washington. Prepared by Herrera Environmental Consultants, Inc., Seattle, Washington.

Herrera. 2008a. Feasibility analysis for restoration of Ala Spit: Ala Spit County Park. Island County Department of Planning and Community Development. Prepared by Herrera Environmental Consultants, Inc., Seattle, Washington.

Herrera. 2008b. Shoreline Modification White Paper. Washington Department of Fish & Wildlife, Olympia, Washington. Prepared by Herrera Environmental Consultants, Inc., Seattle, Washington.

Hilton, C. 2008. Personal communication (meeting with Jeff Parsons, Herrera Environmental Consultants, Inc., Seattle, Washington, to discuss ongoing protection and restoration activities by the Whidbey Land Trust). Land Protection Specialist, Whidbey-Camano Land Trust. April 9, 2008.

Island County, WDFW, Whatcom County, Skagit County, and Snohomish County. 2003. The Regional Forage Fish Habitat Assessments (2001-2003). Forage fish spawning distribution maps and GIS data. Sponsored by the Washington Salmon Recovery Funding Board, Northwest Straits Commission, and the National Fish and Wildlife Foundation.

Island County. 2005. WRIA 6 (Whidbey & Camano Islands) Multi-Species Salmon Recovery Plan. Board of Island County Commissioners. May 9, 2005.

Island County. 2008a. Strawberry Point Watershed Characterization. Island County Planning and Community Development Resource Enhancement Program, Coupeville, Washington.

Island County. 2008b. Land cover shapefile. Island County Planning & Community Development. Data compiled in 2007. Obtained April 29, 2008, via email from Kirsten Joy Harma, Water Quality Specialist.

Johannessen, J. and M. Chase. 2005. Island County Feeder Bluff and Accretion Shoreform Mapping: Final Report. Island County Marine Resource Committee, Bellingham, Washington.

Manashe, E. 1993. Vegetation Management: A Guide for Puget Sound Bluff Property Owners. Washington State Department of Ecology, Shorelands and Coastal Zone Management Program, Olympia, Washington.

Montgomery, D.R. 2003. King of Fish: The Thousand-Year Run of Salmon. Westview Press, Boulder, Colorado.

Myers, R.D. 1993. Slope Stabilization and Erosion Control Using Vegetation: A Manual of Practice for Coastal Property Owners. Washington Department of Ecology, Shorelands and Coastal Zone Management Program, Olympia, Washington.

NRC. 2007. Mitigating Shore Erosion along Sheltered Coasts. National Research Council. National Academies Press, Washington, D.C.

Penttila, D.E. 2001. Effects of Shading Upland Vegetation on Egg Survival for Summer-Spawning Surf Smelt on Upper Intertidal Beaches in Puget Sound. Washington Department of Fish and Wildlife, Marine Resources Division.

PSLC. 2001. Lidar bare earth digital elevation model ground point returns collected by Terrapoint, January 9, 2001, through February 23, 2002. Vertical accuracy: 30 centimeters. Puget Sound Lidar Consortium. Obtained April 8, 2008, from organization website: <http://pugetsoundlidar.ess.washington.edu/>.

Rice, C.A. 2006. Effects of shoreline modification on a northern Puget Sound beach: microclimate and embryo mortality in surf smelt. Estuaries and Coasts 29(1):63-71.

Shipman, H. 2004. Coastal Bluffs and Sea Cliffs on Puget Sound, Washington. Formation, Evolution, and Stability of Coastal Cliffs–Status and Trends. M.A. Hampton and G.B. Griggs. U.S. Geological Survey, U.S. Department of Interior, Denver, Colorado. USGS Professional Paper #1693.

Stick, K.C. 2005. 2004 Washington State Herring Stock Status Report. Washington Department of Fish and Wildlife, Fish Program, Fish Management Division. Available at: <http://wdfw.wa.gov/fish/papers/herring_status_report/index.htm>.

USACE. 1984. Shore Protection Manual. Waterways Experiment Station, U.S. Army Corps of Engineers, Vicksburg, Mississippi.

USCS. 1909. Skagit Bay, Puget Sound, Washington T-sheet (topographic sheet), U.S. Coast Survey.

USDA. 2006. Aerial photograph of Island County. Color orthoimage. Horizontal Resolution: 1 meter. U.S. States Department of Agriculture, Farm Service Agency, Aerial Photography Field Office. Production date: October 22, 2006. Obtained May 2, 2008, from the University of Washington website: <http://gis.ess.washington.edu/data/raster/doqs_naip.html>.

USGS. 2008. USGS Real-Time Water Data for USGS 12200500 SKAGIT RIVER NEAR MOUNT VERNON, WA. U.S. Geological Survey. Retrieved April 11, 2008, from: <http://waterdata.usgs.gov/nwis/uv?12200500>.

WDFW. 2008a. SalmonScape Database. Documented anadromous fish habitat use in Island County. Website accessed on April 2, 2008. Available at: <http://wdfw.wa.gov/mapping/salmonscape/index.html>.

WDFW. 2008b. SalmonScape Database. Documented sand lance spawning locations in Northern Island County. Website accessed on April 2, 2008. Available at: <http://wdfw.wa.gov/mapping/salmonscape/index.html>.

WDFW. 2008c. SalmonScape Database. Documented surf smelt spawning locations in Northern Island County. Website accessed on April 2, 2008. Available at: <http://wdfw.wa.gov/mapping/salmonscape/index.html>.

WDNR. 1997. Intertidal Habitat Inventory 1996, Skagit County and Northern Whidbey Island. Nearshore Habitat Program, Washington State Department of Natural Resources, Aquatic Resources Division.

WDNR. 2004. Geologic map of the Port Angeles and Ediz Hook 7.5-minute Quadrangles, Clallam County, Washington. Prepared by H.W. Schasse, K.W. Wegmann, and M. Polenz. Division of Geology and Earth Resources, Washington State Department of Natural Resources, Olympia, Washington.

WDNR. 2005a. Geologic Map of the Oak Harbor, Crescent Harbor, and Part of the Smith Island 7.5-minute Quadrangles, Island County, Washington. Prepared by J.D. Dragovich, G.T. Petro, G.W. Thorsen, S.L. Larson, G.R. Foster, and D.K. Norman. Washington State Department of Natural Resources, Olympia, Washington.

WDNR. 2005b. Geologic Map of the Ebey's Landing National Historical Reserve, Island County, Washington. Prepared by M. Polenz, S.L. Slaughter, J.D. Dragovich, and G.W. Thorsen. Washington State Department of Natural Resources, Olympia, Washington.

Wells, R.E., C.S. Weaver, and R.J. Blakely. 1998. Fore-arc migration in Cascadia and its neotectonic significance. Geology 26(8):759-762.

Williams, G. and R. Thom. 2001. Marine and Estuarine Shoreline Modification Issues. Prepared for Washington Department of Fish and Wildlife, Washington Department of Ecology, and Washington Department of Transportation, by Battelle Marine Sciences Laboratory, Pacific Northwest National Laboratory, Sequim, Washington.

Williams, G.D., R.M. Thom, J.E. Starkes, J.S. Brennan, J. P. Houghton, D. Woodruff, P.L. Striplin, M. Miller, M. Pedersen, A. Skillman, R. Kropp, A. Borde, C. Freeland, K. McArthur, V. Fagerness, S. Blanton, and L. Blackmore. 2001. Reconnaissance Assessment of the State of the Nearshore Ecosystem: Eastern Shore of Central Puget Sound, Including Vashon and Maury Islands (WRIAs 8 and 9). J.S. Brennan, Editor. Prepared for King County Department of Natural Resources, Seattle, Washington.

Yang, Z. and T. Khangaonkar. 2009. Modeling Tidal Circulation and Stratification in Skagit River Estuary Using an Unstructured Grid Ocean Model. Ocean Modeling. In press.

APPENDIX A

Beach Foreshore Transects

Transect 1 (Photo 8777 looking toward land)

Linear x (ft)	x (ft)	z (rod, ft)	Z (ft MLLW)	Comments
0.0	0	4.7	15.62	sword fern beginning LWD
6.3	6.5	6.4	13.92	sand and LWD
21.0	21.1	7.9	12.42	end of LWD and sand
25.0	25	8.3	12.02	pebble
45.9	46	11	9.32	small gravel - pebble transition
68.9	69	13.7	6.62	gravel- enteromorpha mix sed transition
91.0	91	14.8	5.52	enteromorpha - find sand over pressured
187.0	187	16.5	3.82	fine sand
242.0	242	16.9	3.42	sand-mud transition
550.0	550	20	0.32	waterline 12:25 pm

Transect 2 (@ house for sale middle of bulkhead)

0.0	0	-0.2	14.57	top of bulkhead
0.0	0	4.1	10.27	bottom bulkhead pebble
21.7	22	7.8	6.57	pebble-gravel transition
43.9	44	10.7	3.67	gravel-mix sed transition foreshore ltt transition
53.0	53	11.1	3.27	mixed sed- sandy mud
112.0	112	11.7	2.67	ltt muddy sand
500.0	GPS from Bret	16.6	-2.23	water level 1:32

Transect 3 (unaltered CW#2)

-4.0	-4	4.2	14.5	base of bluff (60% slope bluff)
4.8	5	5.5	13.2	LWD mixed sed
14.0	14	5.7	13	top of berm in LWD
21.9	22	7.2	11.5	edge of pebble-gravel (gradually varying)
40.9	41	9.5	9.2	gravel to gravel w boulders (x=63 start of mussels)
74.9	75	13.6	5.1	in middle of gravel - cobble with boulders
100.9	101	16.8	1.9	ltt transition begins mix sand with boulders
115.0	115	17.9	0.8	end of coarse clasts
584.0	584	21.2	-2.5	water level @ 3:00

Transect 4 (riprap pond down drift side)

Linear x (ft)	x (ft)	z (rod, ft)	Z (ft MLLW)	Comments
0.0	0	1.7	13.42	base of bluff (bench 15' up 1:1 slope - probable top of old landslide)
26.8	27	4.9	10.22	LWP edge
46.0	46	6.3	8.82	denuded surface - cobble w/ gravel
73.0	73	8.3	6.82	edge of denuded surface to gravel
107.0	107	9.8	5.32	still gravel; poorly sorted
131.0	131	11.4	3.72	still gravel; poorly sorted
152.0	152	13.1	2.02	cleaner gravel
160.0	160	13.9	1.22	clean gravel
172.0	172	15.5	-0.38	begin transition
182.0	182	16.7	-1.58	in mix sed with enteromorpha - edge of coarse clasts; water surface at 3:35 pm
200.0	200	18.1	-2.98	eel grass on ltt
	210	19	-3.88	last one - still in eel grass on ltt

Transect 5 (updrift of riprap revetment, unaltered CW#1)

0.0	0	1.8	8.13	toe bluff
33.8	34	5.8	5.73	edge of LWD
52.9	53	8.2	3.43	mix gravel end
76.0	76	10.5	0.13	coarse gravel
103.9	104	13.8	-1.87	ltt transition - enteromorpha start
124.0	124	15.8	0.13	end of cobbles; water surface 4:28 pm
132.0	132	16	-0.07	ltt sand (clean)
173.0	173	17	-1.07	sand no eel grass

APPENDIX B

Characterization of Nearshore Vegetation Conditions
Detailed Methodology for Digitalization Land Cover Types

Characterization of Nearshore Vegetation Conditions Detailed Methodology for Digitalization Land Cover Types

Shoreline land cover and vegetation types were characterized as part of this study. Study methods included a combination aerial photograph interpretation and site visit observations, using land cover types consistent with those used in Island County's previous mapping efforts. Sources used in this study included the following:

- Strawberry Point Watershed Characterization (Island County 2008)
- High-resolution aerial photography (Google Earth 2008; USDA 2006)
- Oblique aerial photographs from Ecology (Ecology 2006).

Shoreline vegetation conditions were characterized in all areas within 200 feet of the shoreline throughout all Strawberry Point watersheds and coastal drainage areas (described under the *Watershed Characterization* section of this report), referred to in this report as the study area. This study area for the shoreline was selected to be consistent with the regulatory jurisdiction established by the Washington State Shoreline Management Act, which extends from the ordinary high water mark (OHWM) landward 200 feet (Revised Code of Washington [RCW] 90.58.030).

Rectified aerial photographs (USDA 2006) and aerial oblique shoreline photographs (Ecology 2006) were examined to identify robust vegetation assemblage types based on land use, species composition, and habitat structure. The selected land cover categories were based on a combination of: (1) land cover types identified in the Strawberry Point Watershed Characterization (Island County 2008a), and (2) assessment of the level of detection resolution afforded by interpretation of the aerial photographs and Google Earth images. The land cover categories used in the analysis included the following:

- Coniferous forest
- Mixed forest
- Mixed forest, manicured understory
- Deciduous forest
- Shrub
- Bluff face (and other steep slopes)
- Field
- Lawn
- Large woody debris
- Impervious.

Land cover type polygons were digitized over aerial photographs using ArcMap 9.2, with a minimum map unit of approximately 150 feet at an approximate resolution of 1:1500 to 1:2000. To augment the aerial photograph digitizing process, Google Earth imagery was used to provide a higher resolution interpretation of land cover characteristics. (Note: Given their higher level

of resolution, 2008 Google Earth images were used as the default for digitizing when a discrepancy existed between the 2006 and 2008 images [i.e., if it was clear from the 2008 Google Earth image that an area had been cleared and a lawn installed since the 2006 aerial photograph, it was digitized as "lawn," even though this change was not visible on the background 2006 aerial photograph]).

The high level of map resolution used for depicting land cover type distribution within the project area was chosen to allow visualization of polygons that were digitized using a 150-foot minimum mapping unit. A lower level of resolution (i.e., one that would allow for depiction of the entire watershed extent) would not permit visualization of land cover types at this level of detail. Hence, some of the figures included in this appendix may not show the entire boundary of a given watershed.

Effort was made to capture breaks in land cover types along watershed boundaries to further provide watershed-specific land cover descriptions. Given the difficulty of capturing land cover type characteristics on the bluff face and other steep slopes when digitizing the aerial photographs, these areas were digitized separately using the process described below.

National Wetland Inventory (NWI) data provided by the U.S. Fish and Wildlife Service (USFWS) and Island County GIS data for wetlands were reviewed as part of the shoreline land cover analysis. No previously mapped wetlands were identified within the project area. Soil survey GIS data from the Natural Resources Conservation Service (NRCS) were also reviewed, but general soil types did not appear to influence land cover types at the level of resolution used in this study. It is likely that the varied land use history in the project area masks much of the influence that the soil types have on land cover types (at least in nonsedimentologically active areas).

High resolution geologic data were examined to explore any correlation between land cover types and soil stability characteristics (WDNR 2005a). The geologic GIS dataset was first interpreted to identify areas of the bluff characterized by historic landslides and significant soil instability. Digitized land cover types were then overlain onto this dataset to examine how polygon boundaries related to changes in slope type. In many cases, boundaries of old landslides corresponded with forest type transitions, which helped to both refine the polygons and support the hypothesis that land cover types at Strawberry Point appear to represent the interaction of land use practices and geomorphic conditions.

In addition, a land cover dataset for Strawberry Point provided by Island County in April 2008 was used to confirm and refine the digitized land cover polygons developed as part of this study. The Island County dataset covered a significant area of the Strawberry Point watersheds, and Herrera's nearshore study built on this comprehensive mapping effort by providing an enhanced level of detection in subtle shifts in vegetation community types in the shoreline zone and by providing coverage of previously unmapped areas. Originally, impervious areas were purposely incorporated into other land cover polygons in Herrera's dataset because they were not large enough to exceed the minimum mapping unit for this study. After reviewing Island County's dataset, it was apparent that the identification of impervious areas was essential given their

differences with the other land cover types and the significant role they play in exacerbating flashy stormwater flows. Therefore, impervious surface area polygons mapped by Island County were added to Herrera's dataset.

Descriptions of land cover types, polygon attributes (i.e., land cover types assigned to each polygon), and polygon extents were revised following the April 9, 2008, site visit based on direct observations and further assessment and interpretation of Google Earth imagery and the photographs (taken during the site visit, as well as the existing aerial and oblique photographs).

Once land cover polygon extents and attributes were finalized, the resulting shapefile was clipped so that the dataset included only those areas within 200 feet of the shoreline. This was accomplished by applying a buffer operation to a digitized line representing the shoreline, which created a polygon representing the 200-feet-from-shoreline study extent. This polygon was used as the feature class from which the portion of the digitized land cover polygons that fell within the study area was extracted.

Because the topography within the study area comprises flat bluff tops to steep bluff faces and ravines, a combination approach was required to adequately represent the surface area of the various land cover types, both graphically and numerically.

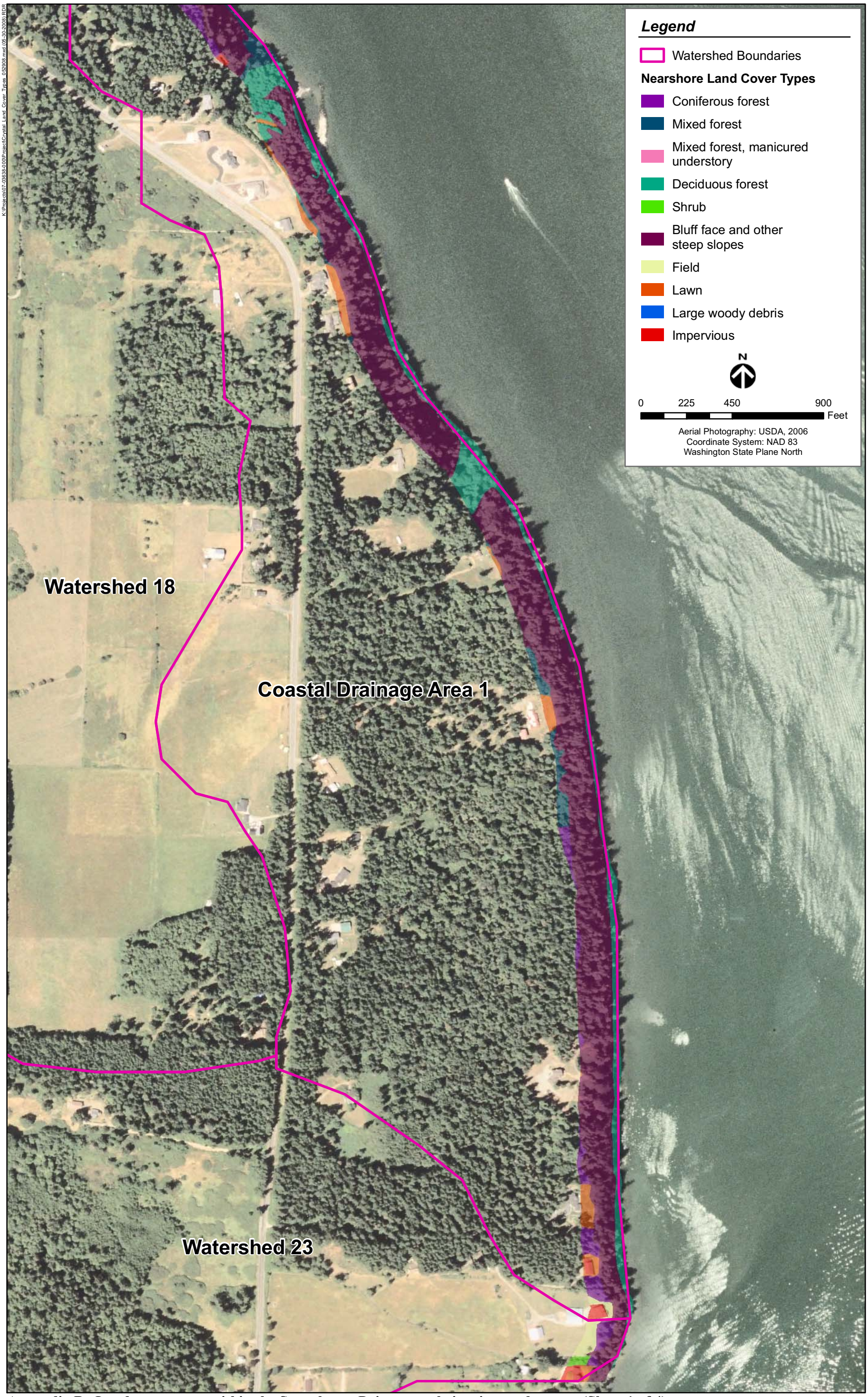
In relatively flat areas, determining the extent of each land cover type was straightforward; surface area was calculated for each watershed using GIS queries and calculations for the digitized polygons described above.

However, since land cover type extents on bluff slopes and other steep slopes would be underrepresented using this technique (aerial coverage is quite lower than actual ground coverage in steep areas), an alternative method was required for land cover type estimation in these areas. The bluff face and other relatively steep slopes were first identified using an analysis of lidar data from the Puget Sound Lidar Consortium (PSLC 2001) to determine portions of the study area characterized by slopes greater than 20 percent. Steep slopes were then isolated and converted to a shapefile, which was smoothed in the ET Geowizards plugin tool using a B-Spline algorithm with a smoothness of 5 and a Freedom of 3. The resulting areas were combined into a single polygon shapefile, named *Bluff face and other steep slopes*.

Areas covered by the *Bluff face and other steep slopes* polygon were clipped from the total land cover type shapefile so that only relatively flat areas would be represented by land cover type polygons and attributes (with the extents calculated as previously described), and the bluff face and steep slopes would be isolated to allow for a separate calculation of land cover types. (Note: Following clipping of the land cover type shapefile, all "slivers" [i.e., existing gaps within the land cover data created by the clipping process] were removed using the Clean Gaps function in the ET Geowizards plugin tool. The Eliminate function was then used where an attribute query was performed on the land cover type shapefile to identify sliver polygons. These polygons were then joined to the neighboring polygon with the largest area.)

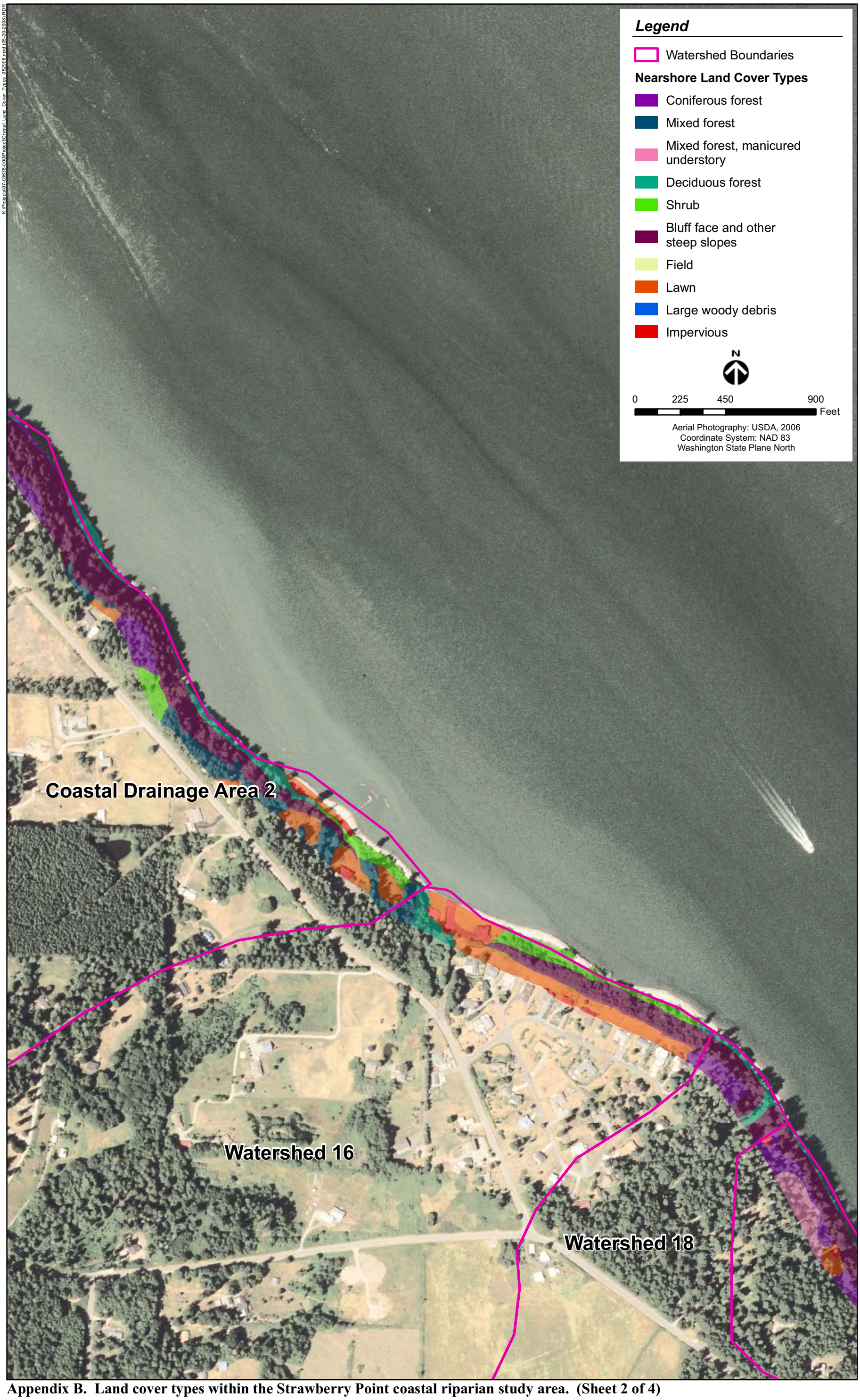
Land cover extents (acreages) on the *bluff face and other steep slope* areas were calculated by the following method: (1) intersecting the *Bluff face and other steep slopes* polygon with the watershed boundaries to determine the total area of this polygon for each watershed, followed by (2) using visual estimation of land cover type extent (percentage) on the bluff face and other steep slopes within each watershed (based on field visit observations and assessment of the oblique and on-site photographs) to calculate the total area occupied by each land cover type per watershed. To determine the total area occupied by each land cover type per watershed, the aforementioned areas were added to the calculated acreages (from the digitized polygons) of land cover types in relatively flat areas, which were determined using the GIS query builder.

Watershed-specific descriptions of land cover types within the Strawberry Point study area were completed based on the compiled map information, site visit observations, and further assessment and interpretation of photographs (site visit and aerial and oblique photographs) and Google Earth imagery.



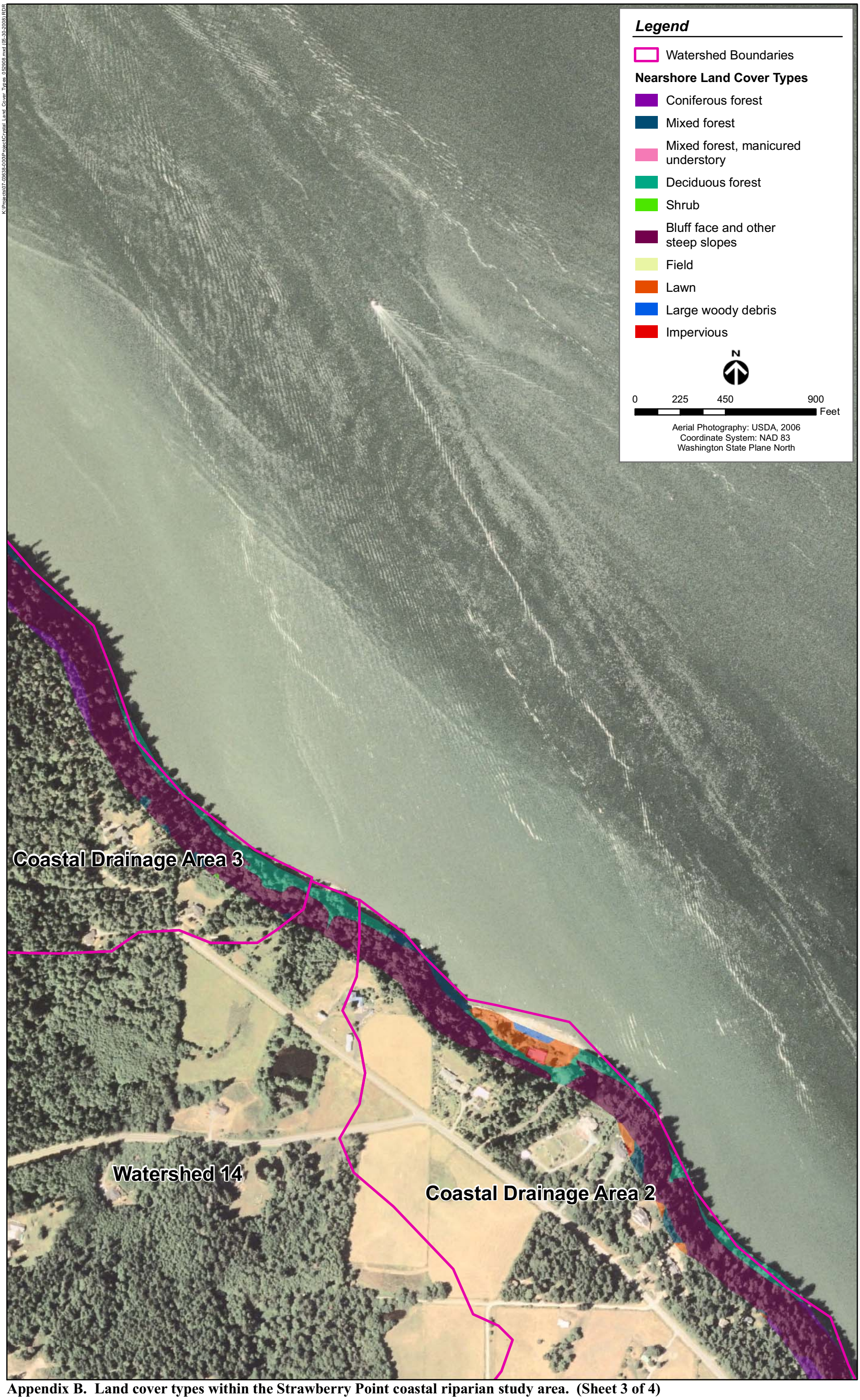
Appendix B. Land cover types within the Strawberry Point coastal riparian study area. (Sheet 1 of 4)

K:\Projects\07-03838-000\Project\Crystal_Land_Cover_Types_052908.mxd (05-30-2008) RDR

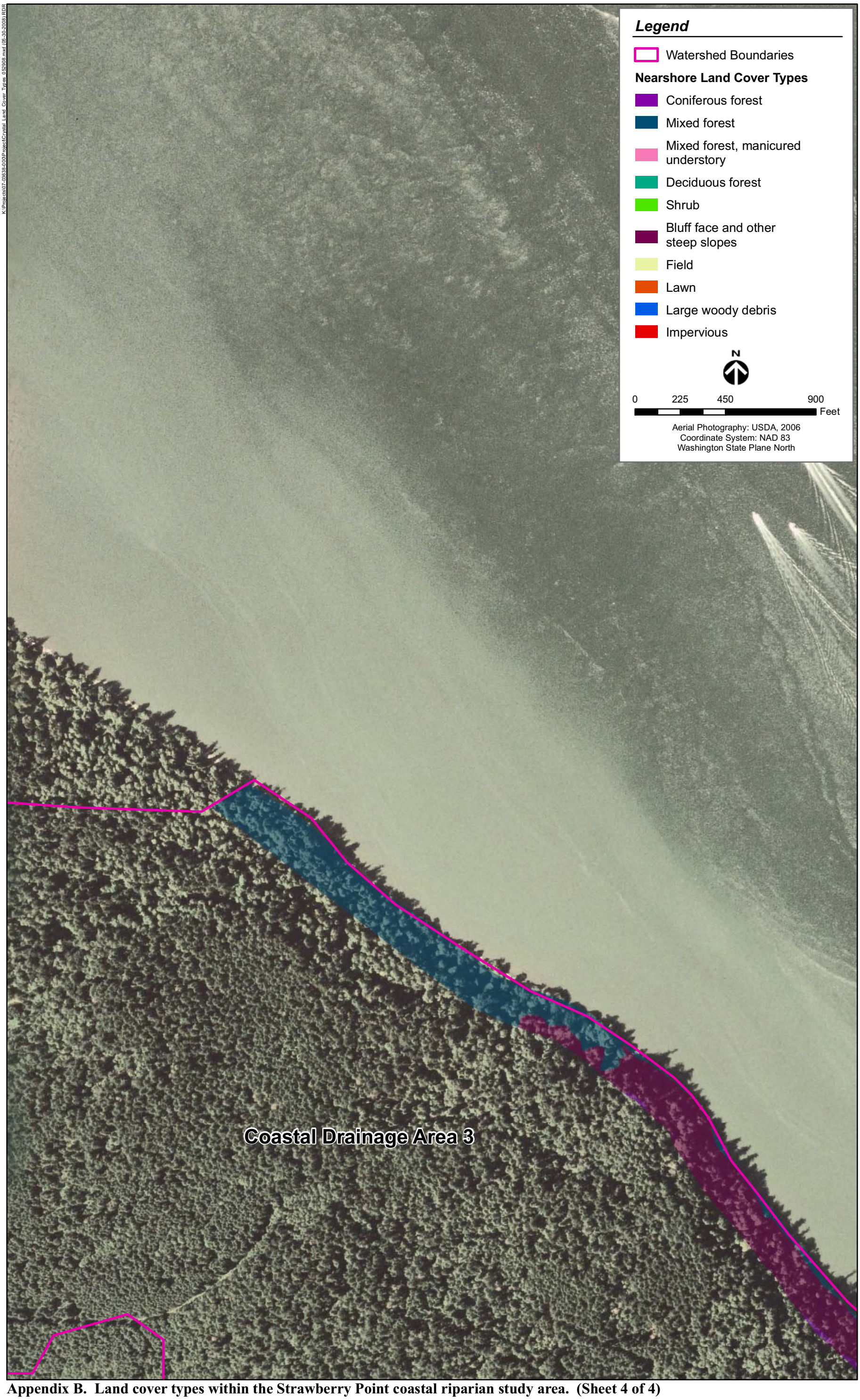


Appendix B. Land cover types within the Strawberry Point coastal riparian study area. (Sheet 2 of 4)

K:\Projects\07-03838-000\Project\Crystal_Land_Cover_Types_052908.mxd (05-30-2008) RDR



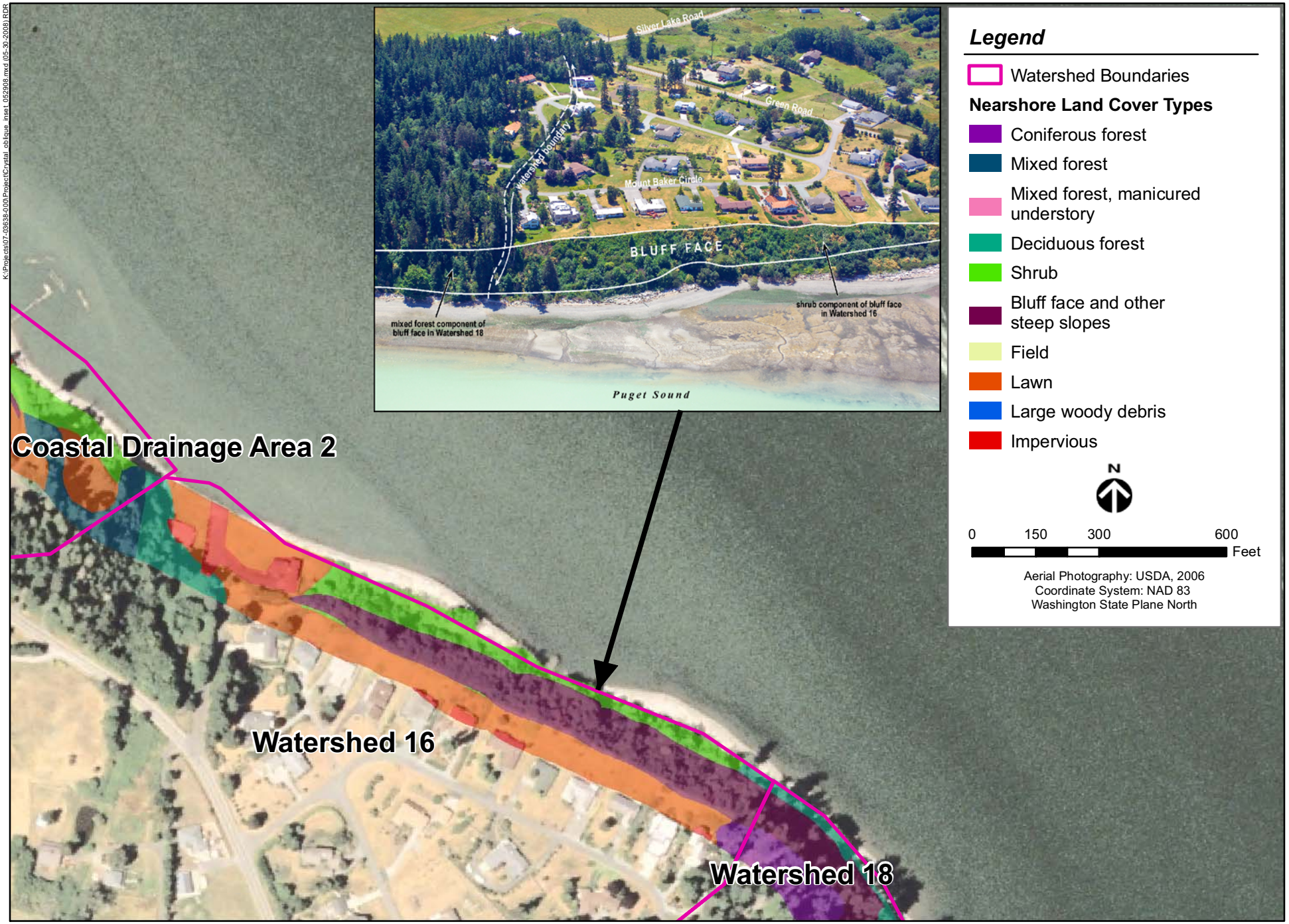
Appendix B. Land cover types within the Strawberry Point coastal riparian study area. (Sheet 3 of 4)



Appendix B. Land cover types within the Strawberry Point coastal riparian study area. (Sheet 4 of 4)

APPENDIX C

Excerpt from Strawberry Point Land Cover Type Map



Appendix C. Excerpt from Strawberry Point land cover type map and corresponding oblique photograph (Ecology 2006) illustrating bluff face extent and land cover components adjacent to the residential development in Watershed 16.