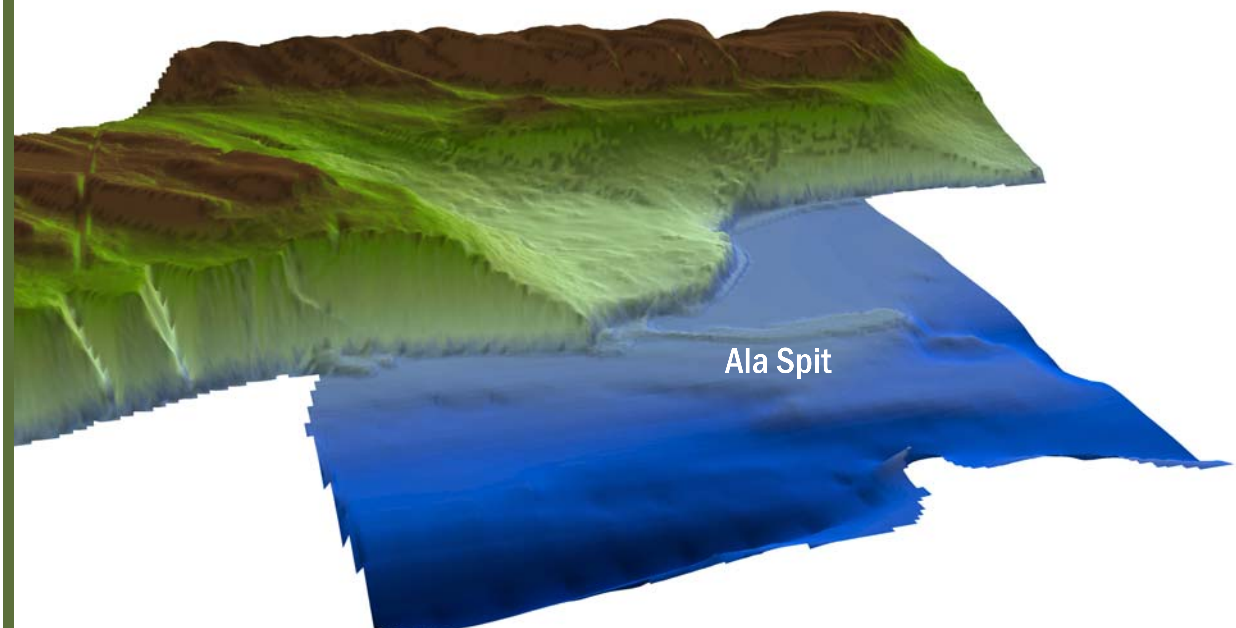
Feasibility Study for Restoration of Ala Spit



Ala Spit County Park

Island County Planning and Community Development Department

September 2008

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FEASIBILITY STUDY FOR RESTORATION OF ALA SPIT

Ala Spit County Park

Prepared for

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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). To characterize habitat use, fish surveys were performed by the Skagit River System Cooperative (SRSC) in collaboration with Herrera. Beach profiles were performed by BlueWater Engineering. The following people provided helpful comments regarding the conclusions made in this document and also provided nonreadily available data relevant to this project: David Finlayson and Eric Grossman, United States Geological Survey, and David Montgomery, University of Washington. In addition, local residents Larry Frostad and Ed Koetje provided key historical and background information regarding the conditions of Ala Spit.

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Executive Summary

Herrera Environmental Consultants, Inc. (Herrera) has prepared this feasibility study for Island County to explore potential restoration and preservation alternatives at Ala Spit County Park, on the northeastern shore of Whidbey Island. These restoration and preservation investigations were partially funded by a grant from the Salmon Recovery Funding Board (SRFB). The SRFB grant application noted that Ala Spit may be in jeopardy of being breached at its base (the "neck" of the spit), thereby endangering a pocket estuary adjacent to the spit. The pocket estuary includes a lagoon, marshlands, and mudflats and provides vital rearing and cover habitat for juvenile salmonids as they transition from their upstream freshwater habitats to the Pacific Ocean. The primary goals of the project are to maximize the recovery of salmon species through the preservation and restoration of their local habitat, while continuing to maintain the current recreational use of Ala Spit County Park by the public.

The grant application identified several anthropogenic features having the potential to create a future breach of the spit. These features include a small rock groin (i.e., the rock "jetty") immediately south of the spit, as well as a bulkhead extending between the groin and the spit. Both of these features are located within the Ala Spit County Park. Another feature identified in the grant application is a private bulkhead located approximately 1,200 feet south of the park. In addition, and although not identified in the grant application, a riprap revetment is located along the neck of the spit and is associated with the existing access trail along the spit.

This feasibility study was developed to test the following general hypotheses: Ala Spit is close to being breached at the neck, thereby endangering an existing pocket estuary associated with the spit; and both the small rock groin and the park bulkhead are inducing the thinning and eventually breaching of the neck of the spit.

To achieve the project goals and test the above hypotheses, this feasibility study addressed several factors:

- The ecologic, geomorphic, and physiographic environment in the vicinity of Ala Spit, including both historic and existing conditions

- The evaluation of alternative strategies to restore and preserve Ala Spit.

The assessment of the ecologic, geomorphic, and physiographic environment in the vicinity of Ala Spit was developed based on a year-long study, which involved collaboration among geologists, engineers, and fisheries ecologists. The assessment included a characterization of the following elements:

- Coastal geomorphology
- Substrate and wood
- Bathymetry
- Oceanographic conditions

- Sediment budget
- Morphodynamics
- Watershed conditions
- Human modifications
- Vegetation present in the dune and salt marsh habitats
- Fish habitat use.

Based on the results of this assessment, several alternatives were developed and analyzed in coordination with the staff of the Island County Planning and Community Development Department (PCDD). The alternatives are intended to restore and preserve important habitat components present in the existing pocket estuary, and in particular to provide crucial rearing habitat for juvenile salmonid species that rely on the estuary for part of their lifecycle.

Results of the historic and existing conditions assessment indicate that geomorphic conditions at the spit are significantly affected by the riprap revetment associated with the trail present along the spit. While the rock groin inhibits some longshore transport from the sediment-producing shoreline bluffs to the south, these effects are not as significant as those posed by the presence of the riprap revetment. The riprap revetment artificially holds in place the lower third of the spit and cuts off the supply of sediment and large woody debris to the southern end of the pocket estuary. This occurs because the natural transport of sediment over the berm of the beach during storms is interrupted by the riprap revetment. Over time, this has resulted in sediment starvation in the pocket estuary, degrading the habitat quality.

The loss of the overwash sediment supply has caused the pocket estuary (west side) and the associated trail to erode, triggering the conversion of marshlands to intertidal mudflats on the periphery of the pocket estuary. As this erosion and coarse sediment starvation occurs, the pocket estuary area (edge) along the spit neck has become lowered, and is now subject to an increased frequency of tidal inundation. The lowering in elevation and increased tidal inundation frequency precludes wood accumulation in this portion of the pocket estuary. This loss of wood further degrades the topographic complexity of the pocket estuary habitat and compromises its stability.

To address the degradation of habitat, Herrera (in coordination with Island County PCDD) developed and analyzed a range of alternatives that will restore and protect future habitat values at Ala Spit. Based on the alternatives analysis and the results of the existing and historic spit and estuary assessment, the recommended restoration alternative is to remove the riprap revetment along the southern third of the spit. Removal of the revetment would result in substantial long-term benefits to habitat quality in the pocket estuary. The existing mudflats immediately west of the removed revetment would likely convert to marsh and backshore, once the natural sediment supply is restored. In this case, breaching of the neck would occur intermittently during and after large storms, as this is a natural process. While this may limit public access to parts of the spit during extreme high tides, the breaching events will supply coarse-grained sediment to the southern end of the pocket estuary, providing structure to the backshore area. Meanwhile, the neck of the spit would be rebuilt in between storms, similar to those areas near the north end of the spit. Other anticipated benefits include the long-term improvement in large woody debris recruitment, an increase in spawning habitat for forage fish, and improved conditions for juvenile salmon rearing habitat. In general, more natural geomorphic conditions would be restored to the spit and estuary that are currently being interrupted by the presence of the riprap revetment, which is artificially constraining natural processes that contribute to habitat-forming features.

Introduction

The Island County Planning and Community Development Department (Island County PCDD) retained Herrera Environmental Consultants, Inc. (Herrera) to assist with a feasibility study for potential restoration and preservation activities at Ala Spit County Park. Ala Spit lies on the northeastern shore of Whidbey Island, immediately across from Hope Island, Washington (Figure 1). This study has been partially funded by a grant from the Salmon Recovery Funding Board (SRFB). The potential for significant alteration of existing habitat conditions at Ala Spit exists due to a possible breaching at the "neck" of the spit. Such a breach would endanger the adjacent pocket estuary (comprised of a lagoon, marshlands, and mudflats).

The SRFB grant application identified several anthropogenic features as potentially responsible for a possible future breach. These features include a small rock groin (i.e., the rock "jetty") located immediately to the south of the spit, as well as a bulkhead extending between the groin and the spit (referred to in this report as the park bulkhead). Both of these features are located within Ala Spit County Park (see Figure 2). Another feature of concern is a private bulkhead located approximately 1,200 feet to the south (referred to in this report as the private bulkhead). In addition, a riprap revetment (and associated fill) is located along the neck of the spit. Although not identified previously, this riprap revetment was noted during a field assessment performed on March 22, 2007. The riprap revetment supports an existing dirt and gravel trail that provides access to the northern portion of the spit. In addition, the presence of partially buried concrete debris (slats) was also identified along the east portion of the spit, primarily on the upper beach area. Natural features of importance include the nearby steep shorelines that potentially deliver sediment to the nearshore area; these features are referred to as feeder bluffs in this report.

This feasibility study includes two main components:

- An assessment of the ecologic, geomorphic, and physiographic environment in the vicinity of Ala Spit, examining both historic and existing conditions
- An analysis of alternative strategies developed to restore and preserve Ala Spit.

The assessment of the ecologic, geomorphic, and physiographic environment in the vicinity of Ala Spit was developed based on a year-long study, which involved collaboration among geologists, engineers, and fisheries ecologists. The assessment included a characterization of the following:

- Coastal geomorphology
- Substrate and wood
- Bathymetry
- Oceanographic conditions
- Sediment budget

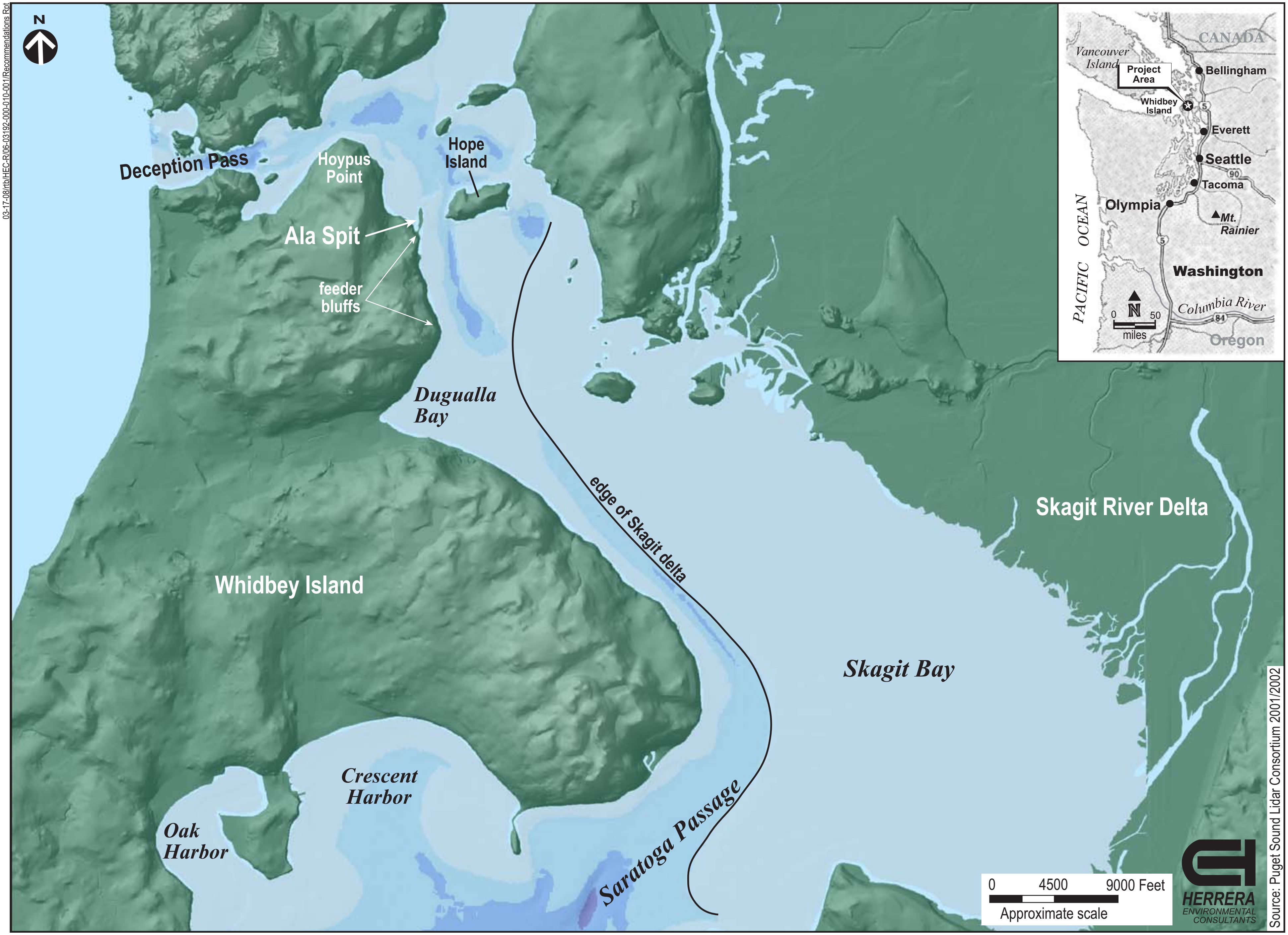

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Figure 1. Vicinity map of Ala Spit on Whidbey Island, Washington.

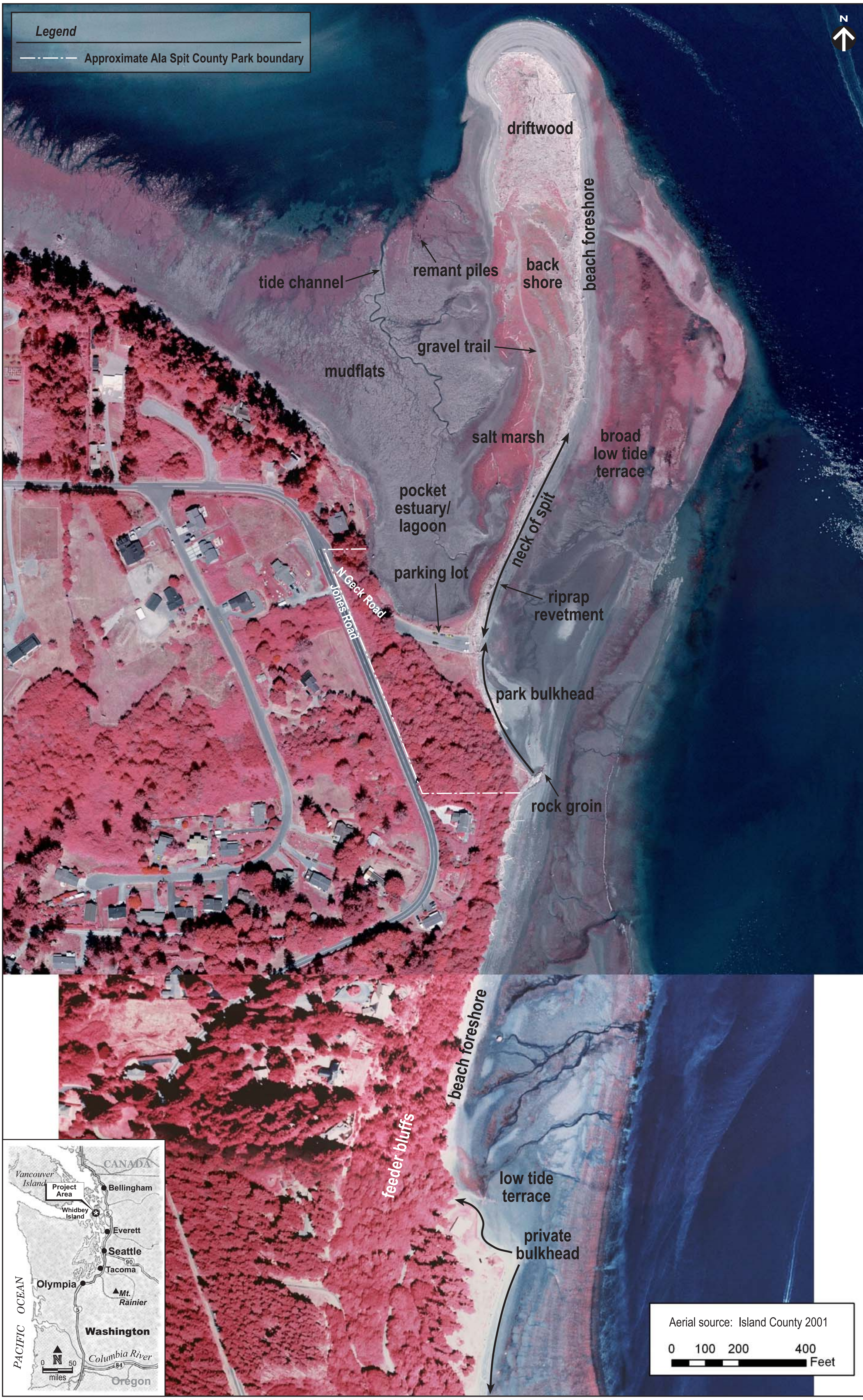

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Figure 2. Geomorphic characteristics, related habitat and manmade features found at Ala Spit, Whidbey Island, Washington.

- Morphodynamics Watershed conditions
- Human modifications
- Vegetation present in the dune and salt marsh habitats
- Fish habitat use.

Based on the results of this assessment, several alternatives were developed and analyzed in coordination with the staff of the Island County Planning and Community Development Department (PCDD). The alternatives are intended to restore and preserve important habitat components present in the existing pocket estuary, and in particular to provide crucial rearing habitat for juvenile salmonid species that rely on the estuary for part of their lifecycle.

The results of this feasibility study, including the historic and existing conditions assessment, the alternatives analysis, a discussion of the preferred alternative, conclusions, and restoration recommendations are presented in the following sections of this report.

Methodology

The methodology used in this feasibility study incorporated various restoration elements described in a series of recent documents addressing habitat restoration in Puget Sound (e.g., Fresh et al. 2004; Redman et al. 2005; Simenstad et al. 2006; Beechie et al. in press). Each of these studies suggests that nearshore restoration goals should be clarified early on for a project. Once the project goals are established, a quantitative, process-based analysis of the cost effectiveness of each of the alternatives should follow, if possible. In particular, Simenstad et al. (2006) suggested that alternatives should be selected to the extent that they fit within the "landscape context" of the location of the planned restoration activities.

Project Goals

The goals for the Ala Spit restoration and preservation project are derived directly from the mission statement of the SRFB, with added goal from Island County that specifically applies to Ala Spit as an Island County Park:

> *To maximize the recovery of salmon species, through the preservation and restoration of their habitat, while maintaining the current use of Ala Spit County Park by the public.*

General Hypotheses

The SRFB grant application for this project identified several anthropogenic features as potentially responsible for a possible breach at the neck of Ala Spit. Based on this premise, the following working hypotheses were developed and tested (i.e., examined) to guide the feasibility study:

- Ala Spit is close to being breached at the neck, thereby endangering an existing pocket estuary associated with the spit.

- The small rock groin immediately south of the spit and the park bulkhead are inducing thinning of the neck of the spit (potentially resulting in a breach).

To meet the goals established for the project and to test the above hypotheses, the approach focused on: (1) an assessment of historical and existing physical and ecologic conditions in the vicinity of Ala Spit, and (2) an alternatives analysis conducted to develop and evaluate potential alternatives to restore and preserve those habitat features associated with the spit. The specific methodology for each of these components is described below.

Assessment of Historical and Existing Physical and Ecologic Conditions

The historical and existing physical and ecologic conditions assessment was a collaborative year-long study that involved geologists, engineers, and fisheries ecologists. The natural and anthropogenic forces that have shaped (and continue to shape) Ala Spit are dynamic and complex. To adequately characterize the factors that influence the spit and its associated habitat features, the following processes and conditions were considered as part of the multidisciplinary assessment:

- Coastal geomorphology
- Substrate and wood
- Bathymetry
- Oceanographic conditions
- Sediment budget
- Morphodynamics
- Watershed conditions (performed by Island County PCDD)
- Human modifications
- Dune and marsh habitat
- Fish habitat
- Fish habitat use (performed by the Skagit River System Cooperative [SRSC] in collaboration with Herrera).

This assessment involved the review and analysis of existing data sources and information relevant to the project, as well as data collected in the field during site visits. Field data were often compared with the available information sources and also provided more site-specific information than available from the existing sources, which were generally more regional in scale.

Conditions of the spit were initially identified during a site visit to the county park site on March 22, 2007. On this day, daytime spring tides occurred at +12.05 feet above mean lower-low water (MLLW) at 7:12 a.m. and -1.59 feet MLLW at 2:12 p.m. (estimated from a Seattle National Oceanic and Atmospheric Administration [NOAA] gauge), allowing for the full tidal range to be observed during daylight hours. A subsequent site visit on June 6, 2007, helped confirm the observations made on the first site visit and allowed for examination of the beach during the more quiescent summer weather.

In addition to the site visits, local residents with a close, historical association with the site and general area were contacted. These included the following people: Larry Frostad, Evelyne Koetje, and Ed Koetje. Because all of these individuals have visited Ala Spit repeatedly and consistently since the 1940s, they were able to provide insight into the timing and motivation for human modifications made since 1940, and in some cases they were able to provide detailed information regarding the design of those modifications. In addition, photographs (prior to 1990) from neighbors of the park (supplied by Island County) were reviewed and are included in

Appendix A. Recognized experts in the fields of nearshore ecology and geomorphology were also contacted to review the conclusions and recommendations made in this report, as well as to provide nonreadily available data relevant to this project. These experts included David Finlayson and Eric Grossman of the United States Geological Survey (USGS), and David Montgomery of the University of Washington.

The methodology is described below for each of the primary components of the historical and existing physical and ecologic conditions assessment.

Geomorphic, Substrate, and Wood Characterization

Key physical elements examined as part of the feasibility study included geomorphic conditions on the site, the distribution and type of substrate, and the presence of habitat-forming wood features. A 1:100,000 scale state geologic map (DGER 2005) and 7.5-minute regional geologic map (Dragovich et al. 2000) were consulted and used for baseline information regarding the surficial geology of the area. Other recent work on the geomorphology of Whidbey Island (Herrera 2007) provided detailed information regarding the recent geologic history of the area, including a list of references related to the subject. These resources included the following: a detailed (7.5-minute) geologic map of the Ebey's Landing National Historical Reserve (Polenz et al. 2005); a master's thesis describing the surficial sediment deposits of central and northern Whidbey Island (Carlstad 1992); and a reference regarding the Everson Interstade, an important geologic time period in the area (Armstrong et al. 1965). Finally, observations and photographs taken of the feeder bluffs on the site visits were used to field-verify information presented in these resources, as well as to detect small-scale variability in the study area not captured in these broader, regional studies.

Substrate was cataloged with photographs on the site visits and compared to recent aerial photographs (specifically, 1956, 1965, 1971, and 1981). These observations of the substrate were used to field-verify existing information provided by SRSC (SRSC 2007). Soil pits were also dug at grain-size breaks along the beach foreshore. These soil pits were interpreted on site, often with adjacent shallow pits farther landward or seaward of the primary test pit to determine local variability in surface geology.

As with substrate, woody debris was evaluated in several ways. Large woody debris (LWD) was measured at four locations in a 50-foot radius from established center points along Ala Spit (Appendix E). Woody debris was classified into four diameter classes (less than 6 inches, 6 inches to 1 foot, 1 foot to 2 feet, and greater than 2 feet) and three length classes (less than 10 feet, 10 to 15 feet, and greater than 15 feet). Transects were established in the four cardinal directions, and the total pieces of wood within each age class were identified along each transect. The width of driftwood accumulation was also measured at various points along the spit by taking a measurement of the driftwood in a straight line from the western edge of the spit to the eastern edge. The measured width of driftwood accumulation was used to update a geographic information system (GIS) shapefile specifically documenting the areal coverage of driftwood, which was obtained from SRSC (2007). For the purposes of the alternatives analysis, the data were simplified into a total area of driftwood accumulation (i.e., surface coverage) by combining like categories of the first four transects. This was done, in part, to make the analysis consistent with previous fish habitat analyses performed by SRSC (Beamer et al. 2005). The areas densely covered by LWD were delineated as “driftwood.”

Characterization of Bathymetry

Bathymetry (that is, characterization of the underwater depth) is an important feature of site conditions, as it is a primary indicator of available habitat. A bathymetric survey was performed as a part of this study to determine the geomorphologic context of Ala Spit. In particular, the survey clarified the shape of the shallow subtidal bench to the southwest of the spit. This survey was referenced to a National Geodetic Survey (NGS) monument on Ala Spit (NGS PID TR0390). The bathymetric survey was performed using sonar technology to obtain distances to the seabed from a boat, which were then referenced to the Ala Spit NGS monument. Profiles of the beach elevation (slope) were also obtained (Appendix B).

Bathymetric data were also obtained (Finlayson 2008) as a part of an unrelated project survey sponsored by the USGS in Skagit Bay (Appendix C). This survey included information on the acoustic reflectance of the seabed, which provided information about substrate and age. When the bed is older or comprised of lithified (i.e., bedrock, not sediments) material, it reflects more acoustic energy than surfaces covered in recently deposited sediments and mud.

Characterization of Oceanographic Conditions

Ala Spit is profoundly influenced by tidal circulation and offshore wave patterns in the area. Therefore, the characterization of these physical processes is important in understanding historical ecological conditions and future changes that may be produced by proposed modifications.

Ala Spit is located at the northern end of Skagit Bay. Skagit Bay is a primary site of estuarine exchange between the Pacific Ocean and the Skagit River. As a result, the bay is often highly stratified and can have high concentrations of surficial sediment. Because salinity and sediment concentration gradients can influence the circulation and mixing at a river mouth (McCool and Parsons 2004), predicting flows based on existing numerical hydrographic models is extremely difficult, if not impossible. Direct observation of flows in the bay and the narrow channel between Ala Spit and the opposite shore (see Figure 1) with modern oceanographic equipment (e.g., bottom-mounted tripods, shipboard acoustic Doppler current profilers) is possible but cost prohibitive. Therefore, the characterization performed as part of this feasibility study is primarily qualitative in nature and based on existing literature that addresses circulation in the study area. Limited quantitative flow estimates were made based on simple approximations to flow velocity directly measured during the site visits.

A number of studies have investigated general circulation in Skagit Bay, as well as the Puget Sound at large (Collias et al. 1973; Babson et al. 2006). In particular, Collias et al. (1973)

provided basic information about the hydrography of the waters surrounding Ala Spit and emphasized the complexity of currents in the study area. Because of this complexity, basic methods of characterization, such as general-circulation numerical models, cannot accurately capture the near-bed mechanics associated with nearshore sediment transport. Therefore, velocity measurements of flotsam made on site were determined to be the most reliable estimate of nearshore geomorphic forces. Stokes drift can influence surficial transport of floating debris, but given the strength of the tidal currents in the area, this effect was deemed to be small. In addition, because flow is hydraulically controlled (Collias et al. 1973), near-bed shear stresses can be predicted directly from these observations. Finally, the initial site visit was scheduled to occur at a time of maximum shear stress (i.e., spring tides and high Skagit River flow). Therefore, the velocity measured during the site visits provides an upper limit to tide-current-induced shear stresses found in the study area.

Waves are likely the dominant physical process transporting sediment on the beach foreshore in the study area. Waves in Puget Sound are fetch-limited and generated almost exclusively by local winds. Because fetch is the dominant variable regulating wave height, it is straightforward to estimate the size of wave incident on a beach given the basin geometry using simple algebraic wind-induced wave estimation formulas (USACE 1984; Finlayson 2006). The most common and widely accepted of these formulas, USACE (1984), uses fetch and wind speed to predict wave period and wave height. At Ala Spit, high-wind-speed events were determined from wind data collected at the Arlington Airport (the nearest source of hourly wind data to Ala Spit). Fetch was determined from the GIS analyses conducted as a part of this study.

Characterization of the Sediment Budget

Sediment budget refers to the balance between sediment added to and removed from a coastal system; one of the key objectives of this feasibility study is to better understand how sediment transport rates have contributed, and will continue to contribute into the future, to conditions at Ala Spit and its associated pocket estuary. Sediment transport rates, particularly on the steep, coarse-grained beaches of Puget Sound, are extremely difficult to measure directly (Finlayson 2006). Even when transport rates can be measured, they are often only applicable at a single location and do not provide an understanding of how a beach may be evolving in a more holistic sense (Finlayson 2006). However, knowledge of the sedimentology of the littoral system can lead to basic conclusions about how Ala Spit is changing over time. The first step in developing a sediment budget is to define the geomorphic transport zones by examining the pattern of substrate and topography in a particular drift cell. At Ala Spit, littoral transport is fairly simple. Because of large fetches to the south (the dominant direction of strong winds) and limited fetches to the north, the flow of sediment (at least on the east side of the spit) is constrained to be overwhelmingly northward (Collias et al. 1973). The private bulkhead at the southern end of the project area precludes sediment input from further south and artificially disconnects the drift cell that contributes sediment to Ala Spit. As the source of sediment to the spit is also nearby (i.e., the Skagit River and the feeder bluffs), Ala Spit provides an ideal place to perform a sediment budget using sedimentological methods because the transport system is virtually limited to these sources.

The majority of sediment transport on Puget Sound beaches occurs on the beach foreshore (Finlayson 2006). On most Puget Sound beaches, there is substantial vertical variability in the substrate present. Often, an active veneer of substrate is underlain by a more consolidated layer of sediments (e.g., at Cama Beach on Camano Island [Finlayson 2006], and at Camano Island State Park [Gendron 2006]). These sediments are often coated with a layer of coarse shell hash. Similar conditions were observed at Ala Spit during the site visits for this study. Therefore, it is possible to determine the depth of the active veneer on the beach using relatively shallow (1 to 3 feet) soil pits. Although this method likely underestimates the sediment transport rate to some degree (that is, because some of the material likely migrates on the low-tide terrace), it provides a reasonable approximation of the total amount of sediment in transport during the last storm season. This can lend insight into the timescales involved with the existing geomorphic processes. In the case of Ala Spit, the veneer is predominantly coarse-grained (i.e., gravel in excess of 1/8 inch in diameter) coated with a layer of coarse shell hash on some areas.

Assessment of Morphodynamics at Ala Spit

Morphodynamics refers to the study of seafloor topography and sea current hydrodynamic processes, and subsequent changes involving the motion of sediment. As with the sediment budget, these are crucial concepts to consider when assessing the future habitat conditions of Ala Spit. Using an aerial photograph and early topographic sheet (T-Sheet) survey (United States Coast & Geodetic Survey 1908), an analysis was completed to assess the morphodynamic characteristics of Ala Spit. This analysis was performed by overlaying historic and current georeferenced photographs and the georeferenced T-Sheet on lidar-derived hillshade data from 2002 (PSLC 2001 and 2002) using GIS resources. An objective of this analysis was to determine the evolution of the shoreline from 1908 to 2006 using aerial photographs and available topographic data. For the purpose of this analysis, the shoreline was defined by markers typically used to denote the ordinary high water (OHW), as determined by the presence of riparian vegetation, wrack, and other indicators.

In addition, a conceptual model of the natural processes responsible for spit formation was constructed using the results of the characterizations of physical and geomorphic conditions. This model was developed to estimate future change(s) on the spit. The model is essentially a description of the dominant physical processes shaping the spit over time.

Characterization of Watershed Conditions

Habitat features and their quality at Ala Spit are influenced by physical and hydrological conditions in the watershed. In 2007, Island County conducted a watershed characterization of the drainage areas contributing to Ala Spit and the surrounding nearshore environment (Island County 2007). 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 Ala Spit nearshore environment (Island County 2007). This 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 system draining to the pocket estuary. The findings of this watershed characterization are summarized in this feasibility study as appropriate.

In addition to the information obtained from the Island County watershed characterization, other watershed features were assessed in subsequent field work and during the interpretation of aerial photographs and GIS data. Any features relevant to current and future habitat conditions in the Ala Spit nearshore environment and/or the evaluation of alternatives are described in this document.

Assessment of Human Modifications

In addition to the physical and ecological processes described above, conditions at Ala Spit are also influenced by anthropogenic features. Human modifications were identified and mapped during the site visits and from an analysis of aerial photographs. Aerial photographs taken in 1956, 1965, 1971, and 1981, together with a nautical chart dating from 1908, were used to estimate the location of the shoreline over time. Although both T-sheet and historic sheet (H-sheet) surveys were available from the University of Washington (UW) Puget Sound River History Project (University of Washington 2007), they provided little in the way of useful data for this feasibility study. The H-sheet data were generally of poor quality, provided little new information, and were excluded from this analysis. The T-sheet was also of limited value because it is unclear what was defined as the shoreline, particularly in the pocket estuary (i.e., the west side of the spit). Because the northern tip of the spit is and has been steep, the T-sheet is accurate and useful for determining the rate of historical growth of the spit.

In addition to the aerial photographic analysis, Herrera contacted various local residents who have had a close historical association with Ala Spit. These people include the following: Larry Frostad, Evelyne Koetje, and Ed Koetje. These individuals had substantial contact with Ala Spit as early as the 1940s. Therefore, they were able to provide insight into the timing and motivation for human modifications made since 1940 and, in some cases, provided detailed information regarding the design of those human modifications.

The impact of the modifications was assessed by applying the conceptual model developed in the morphodynamics section to the historical aerial photograph time series. The impact of these modifications serves as a test of the conceptual model for current conditions, as well as provides a means to estimate future shoreline change given the observed changes subsequent to individual human modifications.

Characterization of Dune and Salt Marsh Vegetation

Dune and salt marsh vegetation at Ala Spit were characterized and mapped using information collected during the site visits and using aerial photographs. In addition, GIS shapefiles containing data on existing habitat features obtained from SRSC (2007) were verified and updated based on field observations performed during the site visits. New GIS shapefiles were created to map habitat features not previously mapped by SRSC (2007).

Characterization of Fish Habitat

Ala Spit provides valuable nearshore habitat for salmonids. In particular, the pocket estuary on the west side of the spit represents important holding habitat and cover for juvenile salmonid smolts as they transition from their natal freshwater streams to their adult life in the Pacific Ocean. Fish habitat in Ala Spit was characterized and mapped during the site visits and using recent aerial photographs. General habitat areas included the Ala Spit pocket estuary; and nearshore shallow intertidal habitat along the outside of the spit (the west and east sides, respectively). Within these general habitat areas, fish habitats were characterized by type (listed below). For each type, the existing habitat area was calculated. In addition, existing habitat feature GIS shapefiles obtained from SRSC (2007) were verified and updated based on field observations performed during the site visits. New GIS shapefiles were created to map habitat features not previously mapped by SRSC (2007). Habitat features were mapped as the following three types: macroalgae, eelgrass beds, and salt marsh vegetation. Additional habitat characterization was completed as part of the geomorphic, substrate, and wood assessment, as well as the dune and salt marsh vegetation assessment (as described above).

Assessment of Fish Habitat Use

Fish habitat use along Ala Spit was assessed, in collaboration with the SRSC and volunteers from the Washington State University Island County Beach Watcher program. This fish habitat use assessment was performed twice per month from February through June 2007. To assess fish abundance, species composition, and size, beach seines were used to sample (i.e., catch) fish at 10 locations along the western and eastern sides of Ala Spit. Beach seining occurred on flood tides or neap low tide stage, typically at tidal stages lower than +4 feet, or higher than +9 feet above mean lower-low water (MLLW).

Seining sampling events were conducted using a small hand-operated net (6 feet by 80 feet), according to the sampling methodology described in detail in Beamer et al. (2005) and Beamer (2007). Two different habitat locations were sampled: the lagoon habitat in the Ala Spit pocket estuary, and the shallow intertidal habitat area along the outside of the spit. Five sites were sampled in each habitat location during each event. The 10 locations were spaced relatively evenly along the shoreline; however, the precise location of sampling varied from event to event depending on site-specific conditions at the time. The western side of the pocket estuary was not sampled because it is privately owned shoreline. The tip of the spit also was not sampled because it marks the transition between the pocket estuary and outside shallow intertidal habitat.

All fish species captured during sampling were identified to species (where practicable) and counted. Length measurements were recorded for a subsample of up to 20 representative individuals for each species (i.e., for catches of 20 or less, all individuals were measured; for catches of greater than 20, a representative subsample of 20 individuals was measured).

Analysis of catch data consisted of paired (lagoon versus outside shallow intertidal) comparisons of average density by species for each sampling date, using numbers per hectare units. The methods used to calculate catch density are described by Beamer et al. (2005) and Beamer (2007). An aggregate comparison of fish density by habitat location provides a general indication of the use of lagoon versus outside shallow intertidal habitat.

To provide an understanding of the environmental conditions at the time of the sampling events, salinity and temperature measurements were recorded at the apex of each seine setting at middepth using a Model 60 YSI meter. These data were averaged by habitat location (pocket estuary and outside shallow intertidal) by sampling date. In addition to these parameters, substrate and vegetation types within the seined area were recorded using categories developed by McBride et al. (2006).

Alternatives Analysis

As part of this feasibility study, several alternatives were developed and evaluated in terms of their effectiveness for providing long-term restoration and preservation benefits to Ala Spit and its associated pocket estuary. These alternatives, which were developed in coordination with Island County PCDD, included the following:

- Alternative A – "Do nothing."
- Alternative B – Remove the existing riprap revetment along the southern one-third of the spit.
- Alternative C – As in Alternative B, remove the existing riprap revetment; in addition, acquire properties near or adjacent to Ala Spit to facilitate long-term protection of the valuable habitats provided by the spit.

The alternatives analysis considers a 50-year timeframe. For each alternative, the cost effectiveness was assessed by determining the cost per acre of area (expected to result from each alternative) that supports salmonid habitat as well as use of the park by the general public. The cost effectiveness of each alternative considered the cost per acre of "use," with use broadly defined as areas of different attributes required for salmonid species and the general public using the park. The area of each of the alternatives was added arithmetically so as not to favor (or "weight") one attribute or alternative over another.

Results and Discussion

Results of the historical and existing conditions assessment indicate that geomorphic characteristics at the spit are most profoundly affected by the riprap revetment associated with the trail along the spit. While the rock groin does inhibit some longshore transport from the feeder bluffs to the south and the park bulkhead interrupts the connection between the beach and backshore, these effects are not as significant as those posed by the presence of the riprap revetment. The riprap revetment (located along the neck of the spit) artificially holds in place the lower one-third of the spit and cuts off the supply of sediment and LWD to the southern end of the pocket estuary. This occurs because the natural transport of sediment over the berm of the beach (through an overwash process during storms) is interrupted by the riprap revetment. Over time, this has resulted in sediment starvation in the pocket estuary.

The only other major supply of sediment to the pocket estuary is very fine sediment (silt) in suspension from the Skagit River. The loss of overwash sediment supply has caused the pocket estuary side of the riprap revetment and associated trail to erode, triggering the conversion of marshlands to intertidal mudflats on the periphery of the pocket estuary. As this erosion and coarse sediment starvation occurs, the pocket estuary area (edge) along the spit neck has decreased in elevation, and is now subject to an increased frequency of tidal inundation. The lower elevation and increased tidal inundation frequency precludes wood accumulation in this portion of the pocket estuary (because of wood buoyancy). This loss of wood further degrades the quality of the pocket estuary habitat and compromises its stability. As discussed in more detail in the *Alternatives Analysis* section (below), if the riprap revetment is removed, the supply of sediment and LWD will be restored to the pocket estuary. However, the trail (as it exists today) is likely to be occasionally obliterated through the natural process of overwash during high tide events and associated wave energy. This obliteration will be likely to remove only the fill associated with the trail; new, informal trails or access paths will likely be established by users of the park, given the nature of uncontrolled access in this recreational area. Consequently, access limitation may occur only during extreme high tide events in the wintertime, which likely would have been the case historically, before the riprap revetment was constructed.

In testing the two general hypotheses (as presented in the *Methodology* section, above), the following was found:

- *Ala Spit is close to being breached at the neck, thereby endangering an existing associated pocket estuary*: Based on the analysis conducted as part of this feasibility study, the neck of the spit is not about to be breached. However, the riprap revetment is being undermined as the pocket estuary is slowly eroding due to the loss in sediment supply and the increase in wave energy. The loss of sediment supply has been caused by the elimination of overwash by the riprap revetment.

- *The small rock groin located immediately to the south of the spit and the park bulkhead are inducing the thinning and eventual breaching of the* *spit neck*: Results of the feasibility study indicate that the small rock groin and the park bulkhead are not responsible for the changes observed at the neck of Ala Spit. Instead, the riprap revetment has precluded sediment accretion on the spit by preventing overwash and splay formation.

The supporting analyses and technical details associated with these hypotheses are presented below.

Geomorphic, Substrate, and Wood Characterization

Ala Spit, formerly known as Ben Ure Spit (USGS 1978), is a beach spit that lies on the northeastern shore of Whidbey Island, immediately across a deep, narrow channel from Hope Island (see Figure 1). Its formation started as sea level stabilized in western Washington, about 6,000 years ago (Shipman 1989).

The Ala Spit County Park includes salt marsh and dune areas located on the western and central portions of the spit, respectively. The park also includes a pocket estuary on the western side of the spit, which is characterized by central mudflat areas surrounded by salt marshes. Pocket estuaries are partially enclosed bodies of marine water that are connected to a larger estuary (such as Puget Sound) at least part of the time, and are diluted by fresh water from stream tributaries or springs at least part of the year (Fetherston et al. 2001). Pocket estuaries are an important habitat for wild Chinook salmon juveniles early in the year once they leave their natal estuary (e.g., Skagit River estuary) and enter the nearshore areas of Whidbey Island (Beamer et al. 2003, 2006). It should be noted that the Ala Spit pocket estuary lacks some of the characteristics of other estuarine settings and, therefore, could also be described as a barrier lagoon landform. Nonetheless, for the purpose of this feasibility study, the inner portion of the spit is considered a pocket estuary.

Part of the Ala Spit County Park is considered a nearshore area. This nearshore area is composed of upper, intertidal, and shallow subtidal beach areas located along the eastern shoreline of the spit. From a coastal geomorphic perspective, the nearshore area includes a foreshore area.

Surface sediments of the spit are primarily comprised of gravel and sand accumulated from feeder bluffs to the south. The park lies in a drift cell identified as WHID-22, as mapped by Johannessen and Chase (2005). Sediment on the spit could also represent a lag deposit from earlier erosion of offshore features (i.e., eroded drumlins, as described below in the *Characterization of Bathymetry* section). Finally, some fine-grained material (sand and finer) on the spit is likely also derived from the Skagit River. The spit has a gravel foreshore (that is, a steep beach face in the upper portion of the intertidal zone) on its southern and eastern shore, which wraps around the north end of the point. Beyond the northernmost point of the spit, the foreshore becomes predominantly sandy. An extensive low-tide terrace is present between 4 feet North American Vertical Datum of 1988 (NAVD88) and the roll-over point of the beach platform, which occurs at roughly -3 feet NAVD88. The low-tide terrace is widest and most pronounced on the east side of the spit. On the west side of the spit, an intertidal marsh is present. Driftwood accumulations are significant behind and on the foreshore berm and near the tip of the spit. Figures 2 and 3, respectively, depict the geomorphic and substrate characteristics of Ala Spit.

The feeder bluffs to the south of the spit are composed primarily of glacial outwash deposits from the Vashon stade (the last ice age). There is a thin cap of glacial till on these bluffs, which thickens to the south, away from the spit (DGER 2005).

Light detection and ranging (lidar) data, which were used primarily to characterize geomorphic conditions at the site, are available for the entire supratidal portion of the study site. The existing lidar data are sufficient for characterizing these portions of the spit. In particular, the highest part of the neck of the spit is well resolved. The elevation of the highest point on the neck of the spit is 13.0 feet NAVD88, with most of the riprap located at greater than 11.5 feet NAVD88 in elevation. On unmodified areas of the outer (northern) portions of the spit, the berm is generally less than 12.0 feet NAVD88 in elevation. In nearshore areas, it is crucial that lidar be flown at low tide to resolve all of the intertidal landforms. Unfortunately, the lidar data available for Ala Spit were collected at a relatively high tide, and only the uppermost portions of the foreshore were resolved. Therefore, it was necessary to collect additional data using marine survey methods. The results of this survey are summarized in the next section (*Characterization* of *Bathymetry*).

Characterization of Bathymetry

Bathymetric survey results and data available from the USGS indicate that several topographic benches run north to south and underlie the spit (Figures 2 and 4). The USGS survey observed extremely high acoustic backscatter from these features, indicating that the benches are most likely erosional (Appendix B). Because all of this area was completely reworked during the last glaciation (Booth 1994), the observation that the benches are erosional indicates that there are only two likely possibilities for their origin: they could be eroded drumlins, or they could be remnants of ancient spits that formed at lower sea levels. Eroded drumlins are common features in the bathymetry of Puget Sound, particularly in areas where tidal currents are significant. These features are often oriented north to south and are linear, like the ridges that help to protect Ala Spit. Although somewhat unusual, drumlins can be found below sea level because of the past variation in relative sea level.

It is also possible that the benches are the remnants of ancient spits that formed during periods of lower sea level. Evidence supporting this hypothesis is the large amount of gravel present on the benches. While some gravel could migrate offshore to these benches from bluff sources, it is more likely that most of this material may be a lag deposit left over from the partial erosion of an ancient spit. In addition, the aerial photographic analysis (see the *Assessment of Human Modifications* section, below) indicates that the spit has generally been migrating north-

northwestward. Because these bench features lie to the south and east of the modern spit, the location of these features is consistent with earlier expressions of the spit (see the *Assessment of Human Modifications* section, below). Regardless of their origin, these benches likely play a role in reducing wave energy from the south by break, enhancing the retention of sediment on the spit, particularly on the low-tide terrace.

Characterization of Oceanographic Conditions

On the March 22, 2007, site visit, daytime spring tides occurred at +12.05 feet above MLLW at 7:12 a.m. and -1.59 feet MLLW at 2:12 p.m. The high water that occurred in the early morning hours, approximately 1 hour before arrival, inundated much of the northern portion of the spit. This was not an unusually high tide, but was certainly as high as the highest spring high tides occurring in Ala Spit.

To consider the effects of ocean waves on sediment delivery (or removal) to Ala Spit, the oceanographic conditions analysis examined circulation (hydrography), wave height, wind speed, and water-level extremes. Collias et al. (1973) provides an excellent summary of hydrographic conditions in the vicinity of Ala Spit. The following conclusions of that work are particularly relevant to the Ala Spit project.

- Tidal currents in the area are significant and controlled by hydraulic flow at Deception Pass.
- Tidal currents on the ebb flow northwards, and flood currents flow south.
- High flow rates in the Skagit River intensify tidal currents in the channel between Ala Spit and Hope Island.
- Net transport is northward for surface waters and southward for deeper waters near Ala Spit.
- Surface water salinities are strongly related to the Skagit River flow rate, while salinity of deeper water is nearly constant.
- The pocket estuary west of Ala Spit is protected from ebb currents by the spit itself and from flood currents by Hoypus Point (Figure 1).

Circulation

Most of the information regarding circulation from Collias et al. (1973) was derived from a physical laboratory model of Puget Sound constructed at the University of Washington. As a result, Collias et al. (1973) does not provide insight into the magnitude of currents, particularly near the bed at the shoreline. Therefore, on the initial site visit, surface currents were measured

Figure 3. Substrate characteristics observed at Ala Spit.

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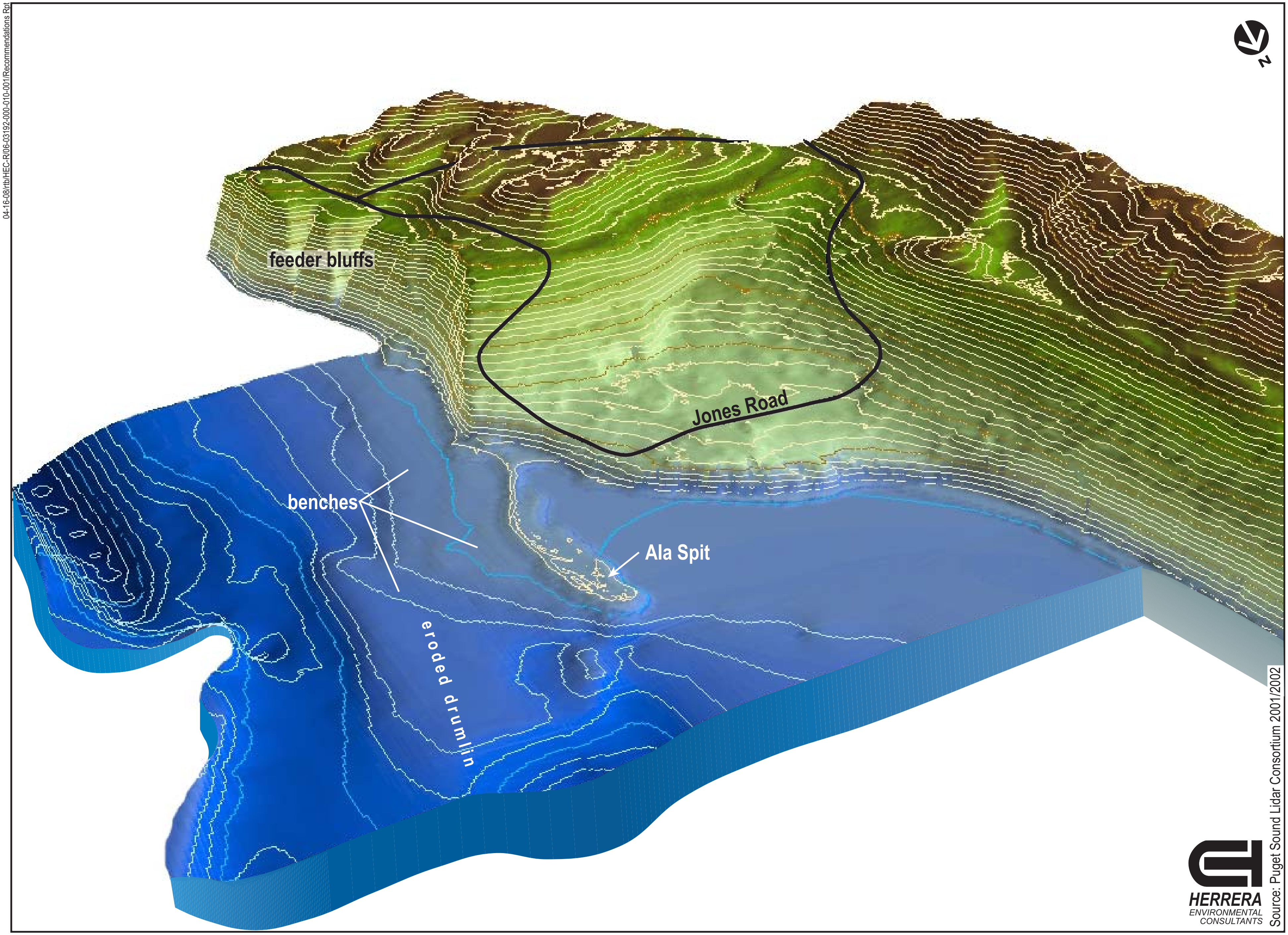

Figure 4. **Combined topographic-bathymetric map for Ala Spit created from merged lidar data and bathymetric data collected during the course of this study.**

by tracking flotsam. Surface current velocities of approximately 1 foot per second were observed in water depths of 2 feet near the shore. Assuming that the tidal current was a unidirectional boundary layer (a good assumption based on the hydraulic flow described by Collias et al. 1973), the following expression is valid:

$$\frac{U}{u_*} = \frac{1}{\kappa} \ln \frac{h - D}{D} + 8.5$$

Where: u_* = the shear velocity

D = the size of sediment on the bed

κ = the von Karman constant (equal to 0.4)

U = the surface velocity

h = the water depth (Batchelor 1967).

This expression estimates the ability of the flow to mobilize sediment via the shear velocity. Calculated shear velocities (approximately 1 inch per second), based on the conditions observed during peak ebb tide, are sufficient to resuspend unconsolidated mud, silt, and fine sand (Miller et al. 1977). However, this shear velocity is not sufficient to mobilize coarse sand and gravel on the foreshore. For example, if the equation by Batchelor (1967) above is used to solve for the surface velocity required to mobilize gravel-size sediment, results indicate that surface velocities of 5 feet per second would be necessary to mobilize this material. Because the initial site visit was on a spring tide during peak ebb and high flows on the Skagit River (when currents are likely greater than any other time), it is unlikely that tidal currents alone are ever sufficient to transport gravel on the foreshore. However, tidal currents might help transport sediment (even gravel) northward, if that material was first mobilized by wave action. Tidal currents also likely inhibit the deposition of mobilized material on the easternmost portions of the spit.

Wave Action

Waves are likely the dominant physical process transporting sediment on the beach foreshore, even near the tip of the spit where tidal currents are greatest. Waves in Puget Sound are fetch-limited and generated almost exclusively by local winds. Because fetch is the dominant variable regulating wave height, it is straightforward to estimate the size of waves incident on a beach given the basin geometry (Finlayson 2006). Because of the orientation of Ala Spit, southerly waves are dominant due to the relative strength of southerly winds and the long fetch to the south. Some minor transport likely occurs from north to south associated with northerly winds, but the size of these waves will be limited by the somewhat limited fetch in that direction and lack of sizeable feeder bluffs (Johannessen and Chase 2005). Northerly winds are also generally less strong than winter-storm southerly winds (Finlayson 2006).

The nearest publicly available meteorological (wind) data are from the Arlington Airport, approximately 30 miles southeast of Ala Spit. Although wind patterns on Whidbey Island are somewhat unusual, with winds blowing into and out of the Strait of Juan de Fuca, as well as north and south winds confined by the Olympic and Cascade ranges, the Arlington data are considered to provide a reasonable estimate of the strongest events that originate from the south. Using these data, the average strongest annual sustained wind recorded at Arlington is approximately 38 knots. Annual events are generally considered to have the largest geomorphic impact (Finlayson 2006). Because winds are guided by the topography of Puget Sound channels, the maximum possible fetch is assumed to extend to the south end of Dugualla Bay (3 miles distant). Using the Sverdrup-Munk-Bretschneider (SMB) wave model (a simple and well-established algebraic model of locally produced waves; USACE 1984), the significant wave height of this annual storm was predicted to be 3 feet high in deep water. Although such waves are large for Puget Sound, they are small in comparison to other more exposed coasts (e.g., on the outer Washington coast, where 10-foot waves are common). These 3-foot waves would be able to mobilize all of the material derived from the feeder bluffs to the south of the spit (i.e., anything smaller than boulder size: <20 cm), but they would be unable the move the riprap in the revetment along the southwestern shore of the spit. To mobilize the 3-foot riprap, waves at least 6 feet high in deep water would be required.

Water Level

Water level extremes are controlled by atmospheric disturbances, particularly large winter storms during El Niño/Southern Oscillation (ENSO) events (Schonher and Nicholson 1989). Strong ENSO events have occurred in 1982–1983, 1991–1992, 1997–1998, and 2005–2006. In Seattle, six of the ten of the highest water levels on record occurred in these years, during intense winter storms. The other four occurred during winter storms in moderate ENSO years (i.e., 1987, 2003).

The record of water-level observations at Seattle also provides an estimate of the extent of inundation at Ala Spit during high-water events (NOAA 2007a). Because the tide range (the difference between mean lower low tide and mean higher high tide) is muted somewhat in Skagit Bay as compared to Seattle, NOAA provides an adjustment for tidal extremes at temporary gauges. (The reference marker used in the bathymetric survey is identical to the site of a temporary NOAA gauge.) The NOAA elevation adjustments use mean lower low water (MLLW) as the reference elevation; therefore, the tidal elevations recorded at the Seattle gauge must be expressed relative to MLLW before the continuous data can be converted to feet above MLLW on Ala Spit. The elevations in feet above MLLW were multiplied by the adjustment factor that NOAA recommends (i.e., 0.96) to account for the reduction of high tide range from Seattle to Ala Spit (NOAA 2007b). These adjusted elevations are converted from MLLW to NAVD88 using the conversion supplied by the NOAA Vdatum program (Spargo et al. 2006). Based on this conversion, the water level at Ala Spit was 12.2 feet NAVD88 on January 27, 1983 (the highest water level in the Seattle record), which would completely inundate the entire spit, with the exception of a few isolated points along the riprap revetment. There have been eight other high-water events that exceeded 11.7 feet NAVD88 within the last 30 years, three of which occurred in the last 5 years. These water levels would inundate most of the spit, including some areas that have been artificially raised around the riprap revetment.

The predicted inundation of the entire spit during extreme high-water conditions is consistent with direct observations on the day of the site visit. One hour prior to the site visit, observations made in Seattle by NOAA indicate that the water level was 10.0 feet NAVD88 (NOAA 2007a). Although this is significantly less than the extreme high waters noted above, this water level would top the berm in a particularly low spot on the northern portion of spit. Evidence of this inundation is shown in Figure 5. The photograph shows fresh, wet flotsam that was found behind the wood-laden berm in the area where the overtopping occurred.

Figure 5. Fresh flotsam and driftwood behind the natural berm on the northern end of Ala Spit (March 22, 2007).

Characterization of the Sediment Budget

A sediment budget represents a quantified estimate of sediment transport processes and is therefore a useful tool for describing geomorphic conditions. At Ala Spit, a sediment budget is more straightforward than most locations because of the distinct boundaries of the drift cell (i.e., the spit collects most of the material sourced from a limited set of shoreline bluffs) and the short distance between source and sink (i.e., bluffs and spit, respectively).

The pattern of substrate derived from existing data (SRSC 2007) allows for the assignment of sedimentary facies (a collection of like sediments that reflect a depositional environment). Sedimentary facies reflect the depositional environment, with each facies being a distinct kind of sediment for that area or environment. The two facies most important for the sediment budget are the sand and gravel area on the foreshore on the periphery the spit, and the low-tide terrace, which consists primarily of fine sand and relict coarser material. The foreshore has been shown to be the active transport zone for coarser material on Puget Sound beaches (Finlayson 2006). In addition to the beach foreshore, the elevation of the low-tide terrace can provide insight into the relative significance of sediment supply in the vicinity of the beach. Finlayson (2006) has shown that alluvial sediment supply from adjacent rivers to the nearshore raises the low-tide terrace. Therefore, the low-tide terrace elevation can provide a qualitative estimate of the importance of alluvial sediment supply.

Foreshore

The feeder bluffs immediately south of the spit are actively supplying gravel and sand to the foreshore surrounding the spit (Johannessen and Chase 2005). On the initial site visit, several fresh slide deposits were observed, photographed, and estimated for total volume (Table 1). These seven slide events have provided, within the last year, an estimated 9,900 cubic feet of new sediment to the beach. The eroded bluff material is predominantly till and outwash sand.

Table 1. Landslides in the Ala Spit drift cell as observed on March 22, 2007.

Landslide [a]	Northing	Easting	Estimated Volume (cubic feet)	Mode of Failure
1	48° 23.451"	122° 35.172"	3,000	slide
2	48° 23.431"	122° 35.179"	2,000	slide
3	48° 23.429"	122° 35.180"	500	shallow slump
4	48° 23.401"	122° 35.194"	1,000	shallow slump
5	48° 23.376"	122° 35.200"	3,000	slide
6	48° 23.356"	122° 35.206"	200	surface erosion
7	48° 23.345"	122° 35.210"	200	surface erosion
Total			**9,900**	

[a] Photographs of some of the landslides are included in Appendix A.

As a result, about one-quarter of that volume is coarse enough to remain in the active foreshore transport (i.e., not removed by gravity-driven suspension to deeper water). The remainder escapes to the low-tide terrace or to deeper portions of Skagit Bay. Some limited amount of material may come from beyond the survey area (i.e., south of the southern bulkhead, described in the *Assessment of Human Modifications* section below), although it is most likely that the southern bulkhead blocks much of this material or directs it offshore via a series of shore-perpendicular channels. The winter of 2006–2007 was somewhat wetter than average and triggered more slope failures than other recent winters. (Such slope failures are usually caused by oversaturation of the ground surface.) However, since the delivery of sediment to the drift zone is highly intermittent and dominated by the most severe conditions, the amount of sediment supplied in the winter of 2006–2007 could be considered equivalent to a typical or average year. This would mean that 2,000 to 3,000 cubic feet of new sediment are delivered to the Ala Spit drift cell each year.

On the initial site visit, six test pits were dug to determine the volume of sediment recently deposited on the spit. Recently deposited material was identified as loose sandy to gravelly material above a harder, more compact layer of gravel and shell hash. This uppermost “active layer” was easily identifiable in all of the test pits in the foreshore area. The depth of the active layer ranged between 1 and 30 inches, as illustrated in Figure 6. Because depths were selected in the middle of the foreshore where recent deposition is the greatest, it is possible to estimate the total volume of this material if a triangular prism of newly deposited sediment across the shore is assumed. The assumption was made that the depth of the active layer along an isobath (a line of similar elevation below sea level) between pits for the entire length of the foreshore peaked at the test pit site and tapered in both directions across shore (seaward and shoreward) (i.e., the sediment thickness was assumed to be zero at the top of the berm and at the foreshore-low-tide-terrace transition). This estimate yielded a volume of 440,000 cubic feet in the active layer on the Ala Spit foreshore. This indicates that the volume of sediment derived from the drift cell is much smaller than the total volume in active transport. The discrepancy could arise from two mechanisms. First the volume of sediment in the active layer could be derived from other sources (i.e., other than the feeder bluffs), which provide the additional volume. Or, secondly, the volume of sediment in the Ala Spit foreshore may not be made up of sediment from a single year of bluff erosion. If this second scenario were the only explanation for the difference in volume, the residence time would need to be approximately 200 years (i.e., the volume of sediment in the active layer divided by the rate of delivery of sediment to that layer from the adjacent bluffs). This would mean that the rate of change in the dynamics of spit modifications would be slow (i.e., decades).

To summarize, there are three potential scenarios that can be used to explain the foreshore sediment budget data for Ala Spit:

1. The difference in volume of active foreshore sediment as compared to that originating from the drift cell originates from the erosion of older spit deposits.

2. The difference in volume of active foreshore sediment as compared to that originating from the drift cell originates from the Skagit River.

3. The residence time of sediment on the spit is long (approximately 200 years).

These scenarios are not mutually exclusive, and each one could play a role to some degree, particularly since each has some evidence to support it. For example, it is likely that the

Figure 6. Deposit thickness of recent sediments on spit foreshore.

coarse-grained benches described in the *Characterization of Bathymetry* section are relict spit features that have been eroded away by modern wave action. This would require only a few inches of erosion per year along the entire spit to accommodate this volume. Because migration of the spit is significant (as described in the *Assessment of Morphodynamics at Ala Spit* section), this rate of change can easily be accounted for.

In terms of accounting for the difference in the volume of sand engaged in transport every year and the volume supplied to the drift cell, the Skagit River produces a tremendous amount of sediment—more than 1 million tons per year (Downing 1983). Sand can be transported some distance from the surface plume (Hill et al. 2000). Even if only a small fraction of this sand resides in the Ala Spit foreshore, it could represent an important contribution to the sediment budget, and could help make up for the difference in the transport and supply volumes. However, this is the sand portion only, which is less than 50 percent of the total material. The gravel portion must be accounted for by other mechanisms.

Finally, it is most likely that the residence time of sediment in the active layer is long. Ala Spit is a large feature, and it likely takes several years for sediment to be transported the length of the spit. In addition, Finlayson (2006) showed that transport reversals on Island County beaches are common due to the seasonal variation in dominant wind/wave direction, and can result in negligible net transport. However, in the case of Ala Spit, it is unlikely that southward (summer) transport can compensate the large northward transport that occurs in the winter months.

Based on the three sediment budget scenarios presented here, the implications for Ala Spit and its preservation are as follows:

- *The active transport volume of sediment on Ala Spit comes primarily from the erosion of older spit deposits.* Ala Spit will continue to be an active, viable spit, with sufficient material available for transport and habitat support, provided that erosion and migration of the spit is allowed to continue unabated. Shore protection structures on the spit could compromise the ability of the spit to migrate and inhibit its natural geomorphic function.

- *The Skagit River may supply a significant fraction of the sand that is building the spit over time.* Major alterations in land use in the Skagit basin (e.g., dam installation) could have deleterious effects on the geomorphic functioning of Ala Spit. These changes could overwhelm any shoreline modifications made within the drift cell.

- *The timescale associated with geomorphic change on the spit is large (on the order of 200 years).* Any alterations in sediment supply and wave environment will induce changes only over the course of many years. However, the inverse will also be true. A loss of sediment supply to the drift cell will be expressed for many years, even if the supply is restored.

Low-tide Terrace

It has recently been observed that the elevation of the gravel-sand transition (which closely approximates the foreshore-low-tide-terrace transition) is correlated with proximity to riverine sediment sources (Finlayson 2006). This work demonstrated that for beaches where the transition was above 2 feet MLLW, there was always a nearby source of alluvial sediment. Although there are small streams near Ala Spit, none deliver sufficient quantities of sediment required to raise the low-tide terrace. The relatively high elevation of the low-tide terrace at Ala Spit (4 feet NAVD88; 2.5 feet MLLW) is most likely due to sand derived from the Skagit River. This conclusion is corroborated by numerous fresh, ephemeral deposits of mud found on the site visit at low tide. Although the contribution of sand from the Skagit River is small relative to mud, it is not uncommon for a small amount of sand to be transported several miles in the surface plumes of Cordilleran (west coast) rivers in flood (Hill et al. 2000). In addition, although most of the load may be mud, the sand will be left behind once the mud is remobilized from wave action and tidal currents (see the *Characterization of Oceanographic Conditions* section above) and deposited in deeper waters. The elevated low-tide terrace directly supports the second scenario noted above in the *Foreshore* subsection (i.e., the missing sand comes from the Skagit River).

Assessment of Morphodynamics at Ala Spit

The shoreline at Ala Spit is dynamic, and various sources of sediment interact with oceanographic forces to change the spit over time. To understand the past changes in the spit and the effects of any proposed changes, an analysis of aerial photographs and early surveys was conducted, and a conceptual model was formulated to account for the dynamic forces and processes acting on the spit.

Analysis of Aerial Photographs and Early Survey (T-Sheet)

Figure 7 illustrates the evolution of the shoreline from 1908 to 2006. The shoreline was defined by markers typically used to denote OHW, including the presence of riparian vegetation, wrack, and other indicators. In the case of the 1956 and 1965 photographs, the shoreline along the neck of the spit was ill-defined due to the poor quality of the photographs and the lack of obvious OHW markers. In 1956, there was no vegetated fill (the primary marker used in later aerial photographs) to indicate the presence of a shoreline in the neck area of the spit. The neck vegetation at that time was likely limited and sparse due to intermittent inundation and therefore imperceptible due to the poor quality of the image. As a result, the shoreline in this area for 1956 was estimated using a dotted line (Figure 7).

The early survey (T-Sheet) and historic photographs illustrate the evolution of the spit. Since 1908, the spit has moved approximately 100 feet to the west, displaying a westerly curvature. It has also lengthened by more than 200 feet. Movement away from the direction of incoming wave energy (originating from the southeast) is typical for active, mobile spits. It is also typical that a spit grows with time, so long as the sediment supply remains intact. The rate of movement

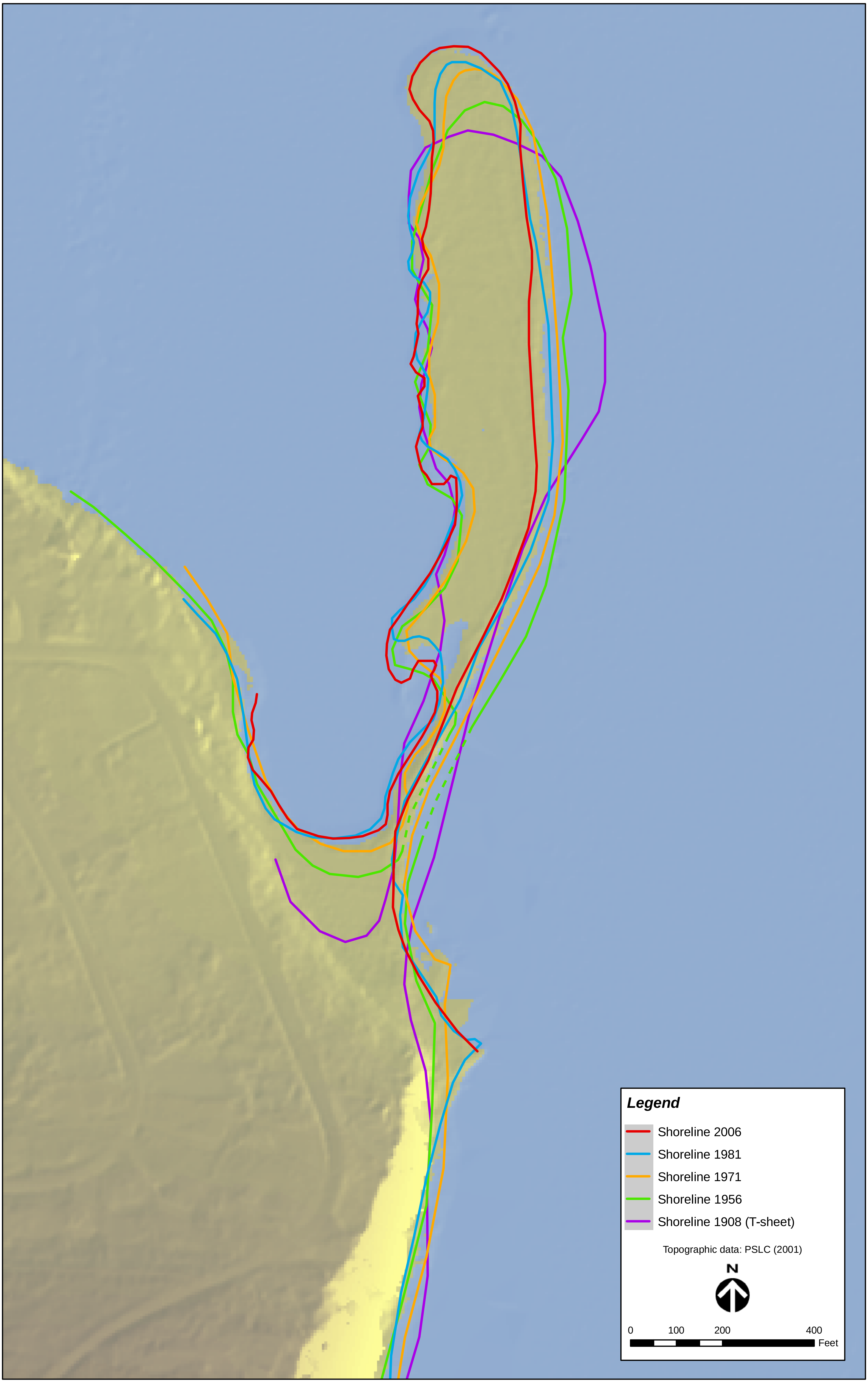

Figure 7. Historic shoreline map developed from earlier surveys and aerial orthophotographs.

also provides constraints on the sedimentation estimates used in the sediment budget. The growth and extension of the spit at the observed rate (approximately 200 feet in 100 years; see Figure 7) would require an average of 2 feet of accumulation per year. As stated before, the relatively high elevation of the low-tide terrace at Ala Spit is 2.5 feet MLLW (4 feet NAVD88). The presence of 2.5 feet of sand deposited on the northwest end of the spit indicates that most, if not all, of the sediment near the tip of the spit (the area growing) remains in place. It also indicates that sediment delivery to the tip of the spit during the winter of 2006–2007 was typical of the last 100 years, including many years prior to the modifications currently on site. Movement of the spit westward (depicted on Figure 7) indicates that the new gravel on the east foreshore is ephemeral, or eroded from the underlying gravel-shell-hash layer (i.e., scenario #1 of the *Foreshore* subsection of the *Characterization of the Sediment Budget* section above). Figure 8 is a plot of the northing (in feet) of the northernmost point of the spit from the aerial photographs over time. This plot shows that with time, the tip of Ala Spit is growing in a northerly direction.

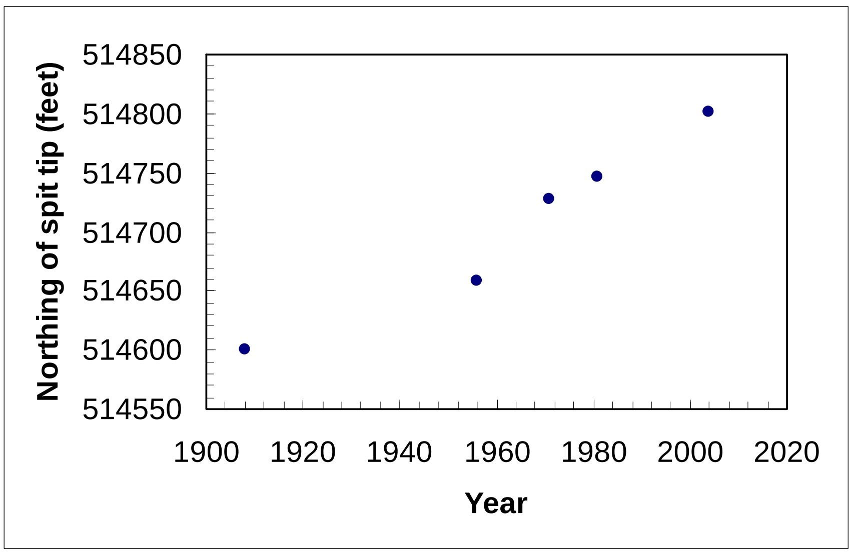

Figure 8. Plot of northerly growth of the tip of Ala Spit with time.

Ala Spit represents a complex balance between transport and deposition of feeder bluff and riverine sediments. As with many geologic features, particularly those in the Puget Sound nearshore, the shape and character of the spit is controlled primarily by extreme events (Finlayson 2006), namely high-water, wind-storm events. Because these events have simultaneous high-water levels and large waves, sediment transport above normal sea levels is significant.

Conceptual Model

Based on knowledge of these dominant forces, a conceptual model of spit evolution can be developed (Figure 9). The process-based model accounts for both seasonal variability and

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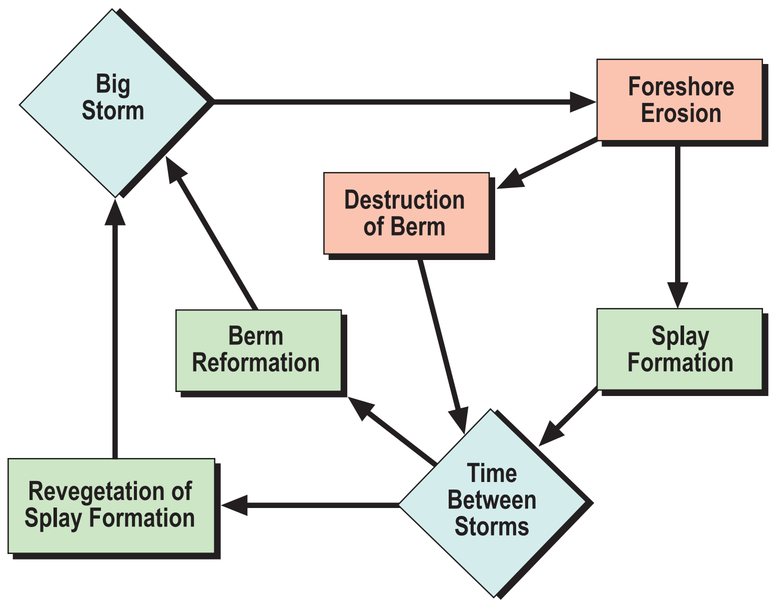
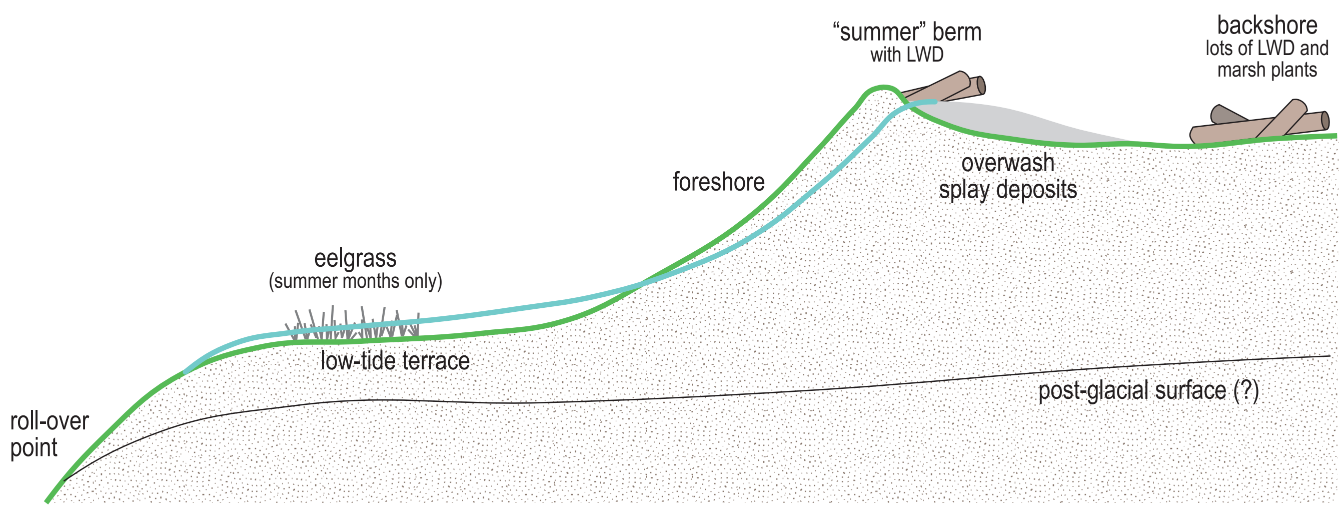


Cycle of Spit Formation and Migration



Seasonal Variability

Figure 9. Conceptual model of Ala Spit morphodynamics.

long-term, systematic change. The processes can produce morphologic changes in both planform (along-shore) and along the beach profile (across-shore). In the transport corridor on the foreshore, erosion due to large water and wind events is common (Finlayson 2006). The sediment located there is transported higher onto the beach, to form high storm berms or backshore splay deposits depending on the topography behind the primary berm. The topography is often complex due to the depositional patterns from previous splays. Sediment also can move offshore to form small temporary bars on or near the low-tide terrace. During times of relative quiescence, the material deposited on these lower bars gradually moves up the beach to form lower berms immediately above MHHW. Meanwhile, the high-storm features (i.e., the splay deposits and storm berms) are not inundated by seawater and can sometimes be revegetated by terrestrial (e.g., dune) vegetation (Figure 9).

A dynamic balance between quiescent (or “summer”) berm formation and large winter storms that remobilize and redistribute these deposits is reached over time (Figure 9). The net effect is the maintenance of a mobile berm which is overtopped during rare events, similar to the way a floodplain accommodates unusually large flood events. This berm can migrate with time, approximately in the same direction that the dominant wave forces move, due to continual formation and revegetation of splay deposits. For Ala Spit, this migration is generally northwesterly. Crucial to this process is the exchange of sediment and other debris with the pocket estuary. In addition to ensuring that the spit can migrate farther to the northwest, this exchange provides nutrients and a diversity of substrate to the pocket estuary. The spatial complexity of the substrate is essential in providing the framework for a properly functioning nearshore ecosystem, which will sustain juvenile salmonid rearing habitat in the immediate area.

The splay deposits consist of large quantities of sediment in the backshore, which provide substrate for the recruitment of LWD and flotsam. For Ala Spit, the splay deposits widen the spit (in the east-west direction) and generate substrate complexity. Sediment is also preferentially accumulated at the north end of the spit, just beyond the influence of strong southerly storms. Because there is some limited transport southward on the northwest side of the spit due weaker northerly events, the north end is curved (see Figure 7). Based on the results of the morphodynamic assessment and as illustrated in the conceptual model, the neck of the spit can be maintained by natural physical processes.

Characterization of Watershed Conditions

In 2007, Island County conducted a watershed characterization of the drainage areas contributing to Ala Spit and the surrounding nearshore environment (Island County 2007). This characterization addressed the physical, hydrologic, and habitat features of the watershed, with an emphasis on current and potential future zoning, land use, and surface water quality conditions potentially affecting habitat conditions in the Ala Spit nearshore environment.

The characterization identified two distinct subbasin watersheds associated with the Ala Spit nearshore environment: watershed #005, which influences conditions in the pocket estuary, and an unnamed watershed adjacent to the southeastern side of watershed #005, which drains to the beach to the south side of Ala Spit (Figure Watershed #005, in Appendix A). A summary of findings for these two watersheds is provided below.

Watershed #005

Watershed #005 is the larger of these two subbasin drainage areas, approximately 605 acres in size. Agricultural activities typical of hobby farmers occur within this watershed. These agricultural activities have affected wetland and stream buffers. This watershed contains the only identifiable surface stream draining to the Ala Spit vicinity. This small stream system is characterized by a relatively simple channel network that drains via a culvert under Troxell Road into a channel on private property that drains to the southwest side of the pocket estuary. This system includes approximately 3,373 feet of identifiable channel, split between a 1,053-foot roadside ditch tributary and a mainstem channel of approximately 2,220 feet. The system is ephemeral in nature, carrying water predominantly during winter months when soils are saturated, or during and following large storm events. Watershed #005 contains eight forested wetlands covering a total of approximately 50 acres. These wetlands range in size from 0.2 to 22 acres. Three of these wetlands contain identifiable surface water pools. There is no apparent surface water connectivity between these wetland features, but the watershed is characterized by abundant seeps and springs, indicating likely groundwater connectivity. The mainstem channel originates in a wetland in the lower portion of the watershed.

A possibility not considered in the Island County watershed characterization is the probability that the stream channel feature in watershed #005 is artificial in nature. The following characteristics suggest this possibility: (1) the U.S. Coast and Geodetic Survey sheet for north Skagit Bay shows no evidence of this feature; however, streams of similar size are shown elsewhere (United States Coast & Geodetic Survey 1908); (2) the channel is relatively short and linear, with a trapezoidal cross-section (visible in site photos) that is unusually large for an ephemeral stream of this nature; (3) the mainstem originates in a wetland pasture, wrapping around the outer edge of the feature, while the tributary portion essentially functions as a roadside ditch; and (4) there are no other channel features in the watershed despite abundant similar wetlands distributed at different elevations.

Given these characteristics, it is highly likely that the channel was created to drain the wetland for pasture or agricultural uses, and then adopted to convey stormwater runoff from Troxell Road. If this is an artificially created channel, this point source of freshwater input to the pocket estuary most likely did not exist historically.

An additional source of freshwater input to the pocket estuary from watershed #005 was identified during field observations and by aerial photograph interpretation. There is a visible input of freshwater inflow to the pocket estuary from a ponded wetland habitat on the south side of the park via a culvert underneath the access road and parking lot. This wetland is in turn fed by groundwater seepage from the base of the bluff. The bulk of this groundwater likely originates as rainfall in watershed #005. However, groundwater dynamics in the surrounding area were not investigated, and it is possible that some portion of groundwater inflow may arise from other upland areas (e.g., the unnamed watershed immediately to the south).

Unnamed Watershed

The unnamed watershed is approximately 160 acres in size. It contains no identified drainage features, and the wetland area is limited to a single 1.5-acre forested wetland in the western portion of the watershed. There are no apparent surface water features in this drainage. The Island County (2007) watershed characterization suggested that runoff reaches the nearshore environment as overland sheet flow. This is likely the case to a major extent, but it is possible that runoff also infiltrates and reaches the nearshore environment as groundwater seepage. Much of the eastern portion of this watershed is bounded by vegetated bluffs above the beach to the south of Ala Spit, which will play a role in the routing and delivery of groundwater to the beach.

Zoning

Both watersheds are currently zoned for rural residential, agricultural and forest uses, and county-owned park zones. Development in both watersheds is sparse, with several undeveloped parcels interspersed between residential homes, hobby farms, and small forestry operations. The unnamed watershed includes several view properties with development at the top of the bluffs. Future land uses are projected to trend toward single-family residences limited to larger lot sizes which, in combination with critical areas ordinance requirements and other protections, are expected to limit many of the adverse effects that typically accompany dense development.

Habitat/Resources of Concern

In each watershed, the primary issues of concern include the potential for increased development to impact the following:

- Marine native riparian vegetation
- Feeder bluffs
- Groundwater recharge that provides freshwater inflow to the nearshore environment via seeps
- Water quality of surface waters delivered to the pocket estuary by the stream system draining watershed #005.

Marine riparian native vegetation and freshwater seeps are important habitat characteristics in the inland marine waters of the Pacific Northwest (EnviroVision et al. 2007). Bluff vegetation provides shade, inputs of allochthonous nutrients, and LWD, controls erosion, and moderates the delivery of fresh water to the nearshore environment. While a number of studies have documented the importance of marine riparian vegetation to the health of the nearshore environment, the ecological functions provided are still poorly understood.

Feeder bluffs are important sources of sediment to the nearshore environment, particularly beaches. For example, the feeder bluffs immediately south of Ala Spit are actively supplying gravel and sand to the spit (Johannessen and Chase 2005). Sediment recruited from the feeder bluffs supports and maintains important nearshore habitat such as spawning habitat for forage fish (in the upper beach area) and eelgrass beds (in the intertidal/subtidal area).

Freshwater seeps are also associated with a variety of habitat characteristics that are selectively used by species of concern, particularly forage fish and other organisms preyed upon by salmonids. As with riparian vegetation, the specific roles that freshwater seeps play in the nearshore marine environment remains poorly understood. Any increase in impervious surface that results in decreased infiltration, or that increases the channel network density and speeds surface water runoff, could produce adverse water quality and quantity effects on the shoreline environment. As the scientific basis for regulatory guidance evolves, a precautionary approach toward the conservation of these resources is highly recommended. Enforcement of measures in place to protect wetland habitat and groundwater recharge zones; implementation of state-of-the-art measures to reclaim water and control and infiltrate stormwater runoff; and the use of regulation, education, and incentives as necessary to protect marine riparian vegetation are all recommended.

Surface water quality conditions do not appear to be an immediate concern; however, the available data are currently too limited to be conclusive. In 2006 and 2007, Island County tested surface water runoff in the watershed #005 channel feature; testing took place as long as water was present (Island County 2007). In total, 16 water quality samples were collected during discrete sampling events beginning in October 2006 through winter 2007. Each sample was tested for electrochemical parameters (pH, alkalinity, and conductivity), temperature, turbidity, dissolved oxygen (DO), and fecal coliform bacteria. Samples from alternating events were also tested for nitrates, organic phosphorous, and hardness.

Water Quality

With the exception of turbidity, no significant water quality concerns were identified in the watershed #005 stream. Measured turbidity levels ranged between 30 and 52 nephelometric turbidity units (NTU). These levels exceed the currently defined threshold of 23 NTU for “typical and expected” turbidity in Island County surface waters. However, Island County is in the process of collecting new data on baseline sediment conditions in freshwater streams, so it is possible that different “typical and expected” turbidity thresholds may be defined once these data are available. In addition, it is important to note that these sampling events were limited in nature and not systematic and that data from the first year of sampling showed lower background levels (17 NTU) that the defined threshold of 23 NTU. Sampling occurred during periods when water was flowing in this ephemeral channel system; although the rate of flow could be generally characterized as a consistent “trickle.”

It is also important to note that the stream in watershed #005 appears to be artificial in nature. This means that fine sediment inputs from this stream to the pocket estuary may be higher than would normally occur with a natural system. Historically, most freshwater input likely occurred in the form of groundwater-fed shoreline seeps. The creation of this drainage feature has likely altered the pattern of freshwater inflow to the pocket estuary, with a larger portion occurring in the form of surface water runoff during storm events. This has likely increased the volume of delivery of fine sediments during and following storm events. This also suggests the potential for some decrease in inputs from seepage, which would occur over a more extended period if originated from groundwater (as supposed to surface runoff).

The effect of fine sediment inputs from this tributary is difficult to fully ascertain without additional data collection, but it is insignificant in comparison to the contribution from the Skagit River. The geomorphic features present both inside and outside the spit indicate that the Skagit River is a dominant source of fine sediments present in the nearshore. The watershed #005 drainage feature is a minor source in comparison. Other water quality parameters, such as inputs of nutrients and pollutants that impact salmon, are of greater concern.

Because this surface water feature is delivering stormwater runoff to the pocket estuary and will continue to do so, some potential for undesirable water quality impacts are expected in the future under full build-out conditions in the watershed. Measures to control nonpoint source pollution from stormwater runoff and other sources should be considered to avoid these potential impacts.

Assessment of Human Modifications

A number of human modifications are evident on Ala Spit, most of which have occurred since the first aerial photograph was taken in 1956. No significant modifications have occurred at the county park since Island County acquired the site in the mid 1990s. Although local citizens with a detailed knowledge of the site were interviewed (both directly, as well as indirectly through county officials), limited information was collected about the site prior to the county acquiring the property. Most of the information for this feasibility study was obtained indirectly from interpretation of the aerial photographs and during the site visits.

Analysis of the aerial photographs indicates that the spit has continued to grow since human modifications were implemented (Figures 7 and 8). This suggests that whatever the geomorphic ramifications of human activities may be, they do not affect the longitudinal growth of the spit, at least on relatively short-term timescales (i.e., decadal).

Human modifications to the area in and around Ala Spit County Park, illustrated in Figure 10, include the following:

1. Riprap revetment – A mix of placed rock exists north of the north edge of the parking lot for approximately 800 feet along the outer (eastern) shoreline of the spit. The rock was placed with associated fill behind it

sometime after a rock groin (as described below) was installed, but prior to 1965 (Koetje 2008). The riprap revetment was placed to prevent "washing through at a high tide" (Koetje 2008). Quarried rock is the dominant material in the revetment, which is usually greater than 1 foot in diameter. The revetment also includes a limited amount of construction debris, although it comprises less than 10 percent of the placed material (Koetje 2008). Some of the debris is unusually large, with one of the largest pieces measured at 45 cubic feet and weighing an estimated 2 tons.

2. Southern private bulkhead and associated creosote pilings – A private bulkhead protrudes approximately 100 feet into Skagit Bay and well below mean tide level. This bulkhead is located approximately 1,200 feet south of the rock groin (southern park boundary). The bulkhead is not apparent on the 1956 aerial photograph, but some alteration of the area is evident in the 1971 photograph (although not necessarily in its current form). Based on the aerial photograph analysis, by 1981 the bulkhead appeared similar to current conditions. Although on private land outside of the county park, the bulkhead (protecting an associated residence) protrudes out into the foreshore and disrupts littoral transport from the south. The bulkhead also includes a number of old creosoted-treated wood pilings that extend onto the low-tide terrace.

3. Rock groin – A large rock (2-foot+ diameter) groin was placed approximately 500 feet south of the neck of Ala Spit in 1960 to encourage shoreline accretion for a planned, but never constructed, shoreline development project (Koetje 2008). Currently, the groin extends down to 1 foot NAVD88, which is above the base of the foreshore. Analysis of historical aerial photographs verified anecdotal accounts that the groin was installed sometime between 1956 and 1965.

4. Park bulkhead – A concrete bulkhead, approximately 800 feet in length, extends north from the groin, past the parking area to the beginning of the riprap revetment. It was designed by Ed Koetje in 1960 as part of a planned development, and constructed soon after. When constructed, the bulkhead was 7 feet tall and had fill placed behind it to provide a level surface for parking. Today, the bulkhead is 3 to 4 feet tall, as sediment (sand) has accumulated in front of this structure.

5. Road fill and parking area – The access road to the spit is paved, along with a 100-foot wide parking lot which also serves as the trailhead for the gravel path that runs along the length of the spit. The road and parking area appear in the earliest aerial photograph and therefore predate 1956. Anecdotal evidence also indicates that they existed prior to World War II (Frostad 2008).

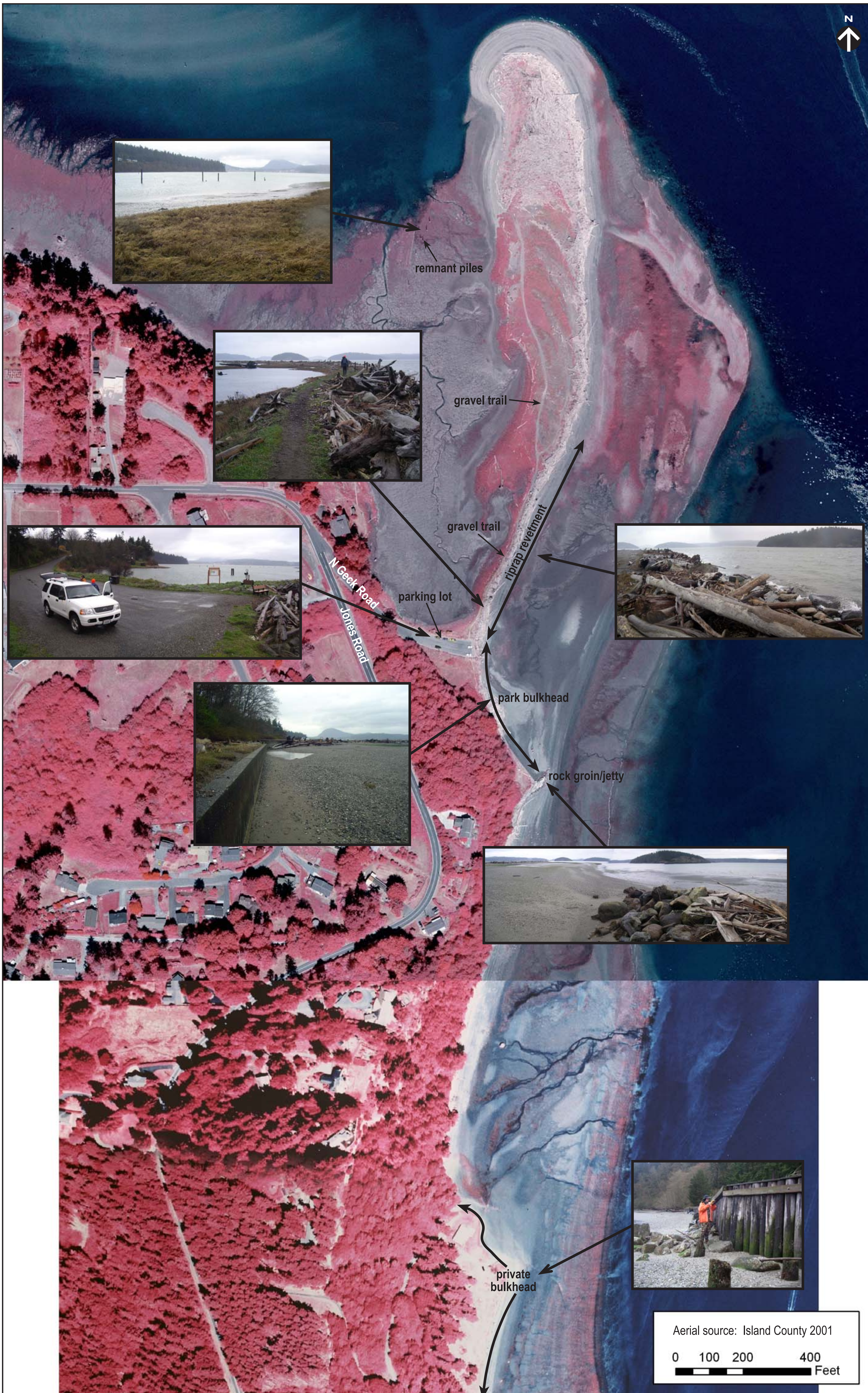


Figure 10. **Human modifications in the vicinity of Ala Spit and its pocket estuary, Whidbey Island, Washington.**

6. Remnant piles – A line of piles remaining from log booms and other logging infrastructure is present within the pocket estuary. Log booms were present at Ala Spit as late as the 1940s but have since been removed (Frostad 2008). Direct observation of the piles was not possible on the site visits because the piles are all in relatively soft mud. However, from their appearance at a distance, they appear to be made of creosote-treated wood.

Impacts on Morphodynamics

Disruptive modifications at the spit include the groin, the southern bulkhead, the riprap revetment, the park bulkhead, and the road fill and parking lot. The impacts associated with these modifications are discussed below in order of significance, with the most significant modification (i.e., the installation of the riprap revetment along the neck of the spit) discussed first.

1. Riprap revetment – The riprap revetment along the neck of Ala Spit has steepened the shoreline in front of it, as most revetments tend to do. The riprap at Ala Spit is somewhat unusual in that it only protects a thin trail no more than 5 feet wide in places. The riprap revetment has also steepened the western side of the spit, along the pocket estuary. Under normal conditions, the neck (i.e., the berm along the neck) would behave like undisturbed areas farther north, which would be intermittently eroded during large storm events and rebuilt during more quiescent times (as described above in the *Assessment of Morphodynamics at Ala Spit* and illustrated in Figure 9). This is most dramatically depicted in a comparison of cross-spit profiles showing the riprap revetment and the unaltered northern portion of the spit (Figure 11). The loss of sediment to the pocket estuary side of the revetment, as well as the corresponding habitat type shift, is also evident in the highly unusual barnacled-covered gravel (Figure 12). These gravels were deposited in the pocket estuary prior to the installation of the revetment. Most of the gravel has likely been buried by intermittent erosion and subsequent deposition of mud. However, the remaining gravel on the deflated surface along the pocket estuary edge is often inundated by quiescent seawater. These conditions are ideal for barnacle recruitment on the gravel. The extent of barnacle formation (multiyear layers) suggests that the area along the pocket estuary edge where the gravel occurs has been in these conditions for many years. The revetment also prohibits the historic, natural migration of the spit to the northwest, which can be seen as the development of a westerly curvature in the spit with time (see Figure 7).

2. Southern private bulkhead and associated creosote pilings – This bulkhead protrudes into Puget Sound and creates a strong gradient in foreshore grain size, with cobbles dominating the foreshore immediately north of the

bulkhead, while the southern foreshore is dominated by fine gravel. This gradient in grain-size indicates that the bulkhead is intercepting much of the sediment coming from farther south and may cause erosion farther north over long periods of time (i.e., greater than 10 years). In addition to the blockage, the wood used in the bulkhead has been treated with creosote, which can degrade water quality and discourage fish use (Vines et al. 2000).

3. <u>Rock groin</u> – Groins can be harmful to nearshore ecosystems because they interrupt alongshore sediment transport and cause both anomalous erosion (on the downdrift side) and deposition (on the updrift side) (Meadows et al. 2005). However, the groin at Ala Spit does not completely intercept sand and gravel moving through the foreshore active transport zone between 0 and 6 feet NAVD88. More than 1 foot of loose gravel was found on the foreshore immediately north (downdrift) of the groin, indicating that the transport zone is still partially intact. This occurs because the groin terminates at a relatively high elevation. However, because of its orientation to the shoreline, the groin also reduces the wave energy in front of the park bulkhead and minimizes its geomorphic impact.

4. <u>Park bulkhead</u> – Bulkheads typically reflect wave energy and coarsen and erode the beach in front of them (Herrera 2005; Williams and Thom 2001). However, the park bulkhead at Ala Spit is not reflecting significant amounts of wave energy or causing erosion immediately seaward of it. In fact, there has been at least 3 feet of accretion in front of the park bulkhead since it was constructed. Additional evidence of the relative lack of wave reflection is the large amount of accumulated driftwood, gravel, and sand accumulating in front of the bulkhead along most of its length. In one location, unidentified marsh vascular plants are beginning to colonize the substrate on the seaward side of the bulkhead. Deposition of mobile material and colonization of marsh plants in front of a bulkhead is only possible when wave reflection is small. The presence of such material indicates that waves are substantially attenuated before they reach the seawall. The primary disruption caused by an inactive bulkhead such as this is the physical separation of the backshore from the beach foreshore.

5. <u>Road fill and parking area</u> – The parking lot and North Geck Road (i.e., the road leading to the parking lot from Jones Road) block seepage from the bluff bounding the west edge of the spit. Although there is a culvert underneath North Geck Road, the distributed nature of the groundwater emanating from the bluff causes water to be intercepted landward of the road and parking lot, thus creating an isolated low area. The parking lot, North Geck Road, and the park bulkhead disconnect this low area from marine influence. The intercepted water accumulates in what appears to be a freshwater wetland. However, according to the analysis of aerial

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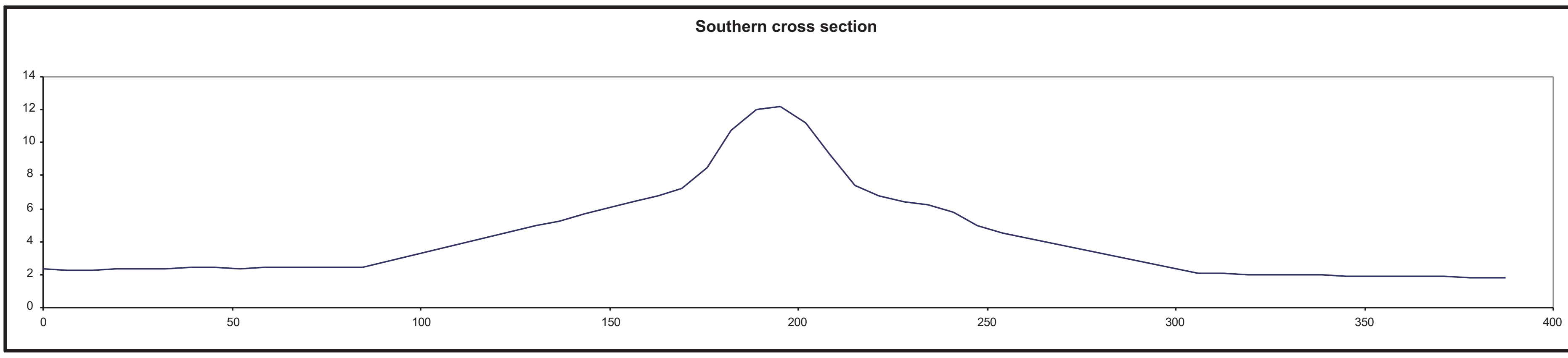
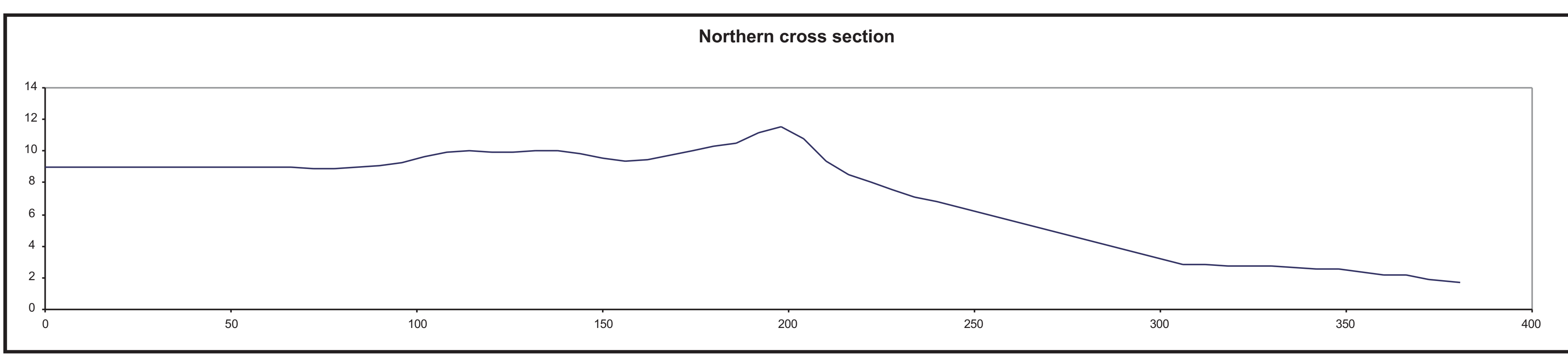


View looking south along Ala Spit



View looking north along Ala Spit

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Note: As can be seen, the unaltered portion of the spit is characterized by a wider backshore area, which is maintained by overwash process.

Figure 11. Photographic comparison of altered (riprap revetment) and unaltered cross-spit profiles.

photographs and the early survey (T-Sheet), this area was originally likely to have been the southernmost portion of the pocket estuary. This area may also have been filled and cut off by the construction of North Geck Road and the parking lot. This area was identified in 2005 as a restorable marsh (Beamer et al. 2005).

6. Remnant piles – The limited number and extent of the remnant piles make them of no geomorphic consequence. However, they appear to be creosote-treated piles and therefore a likely source of pollutants to the pocket estuary ecosystem.

Figure 12. Barnacle-covered gravel found in the pocket estuary. The specimen is approximately 0.4 inches in diameter.

Characterization of Dune and Salt Marsh Vegetation

Plant community development on pocket estuary landforms, as in other estuarine systems, is guided by the interaction of natural disturbance, salinity, and hydrologic gradients based on tidal, riverine, and coastal geomorphic processes and influences (Bird 2000; Fetherston and Abbe 2001; Mitsch and Gosselink 2000). Fore dune areas (the beginning on the landward side of MHHW) often exhibit steep elevation gradients on the seaward side and are limited to plant species highly adapted to the harsh conditions and heavy disturbance caused by wind and occasional wave energy (Fetherston and Abbe 2001; Weidemann 1984). The leeward dune-marsh transition community comprises a combination of dune and salt marsh vegetation, with the distribution of species determined by nature of the elevation and salinity gradients that extend between the fore dune and marsh habitats (Ewing 2008; Fetherston and Abbe 2001). The intertidal marsh plant community on the leeward side of the landform defining the pocket estuary is influenced by a more gentle elevation gradient, with sediment deposition that occurs primarily via overwash during winter storm events or fall-out of suspended fines and a plant community that develops under semiprotected conditions (Fetherston and Abbe 2001; Mitsch and Gosselink 2000). The structure and function of these plant communities are, as mentioned, a product of the environmental and geomorphic conditions under which they have developed. However, it is imperative to understand that the plant communities themselves play an integral role in the engineering of their physical environment (Bird 2000; Mitsch and Gosselink 2000). The following discussion explores these plant–environment interactions within the context of dune and tidal marsh plant communities of coastal pocket estuaries.

In terms of influence on geomorphic processes, tidal marsh vegetation provides sediment stabilization, thereby preventing erosion, and it also slows water velocities, which facilitates the deposition of suspended sediments (Bird 2000; Mitsch and Gosselink 2000). This feedback loop mechanism, whereby plant community characteristics influence physical processes and resulting changes in physical processes and in turn affects the composition and structure of the plant community, comprises a widely accepted model of wetland development (Mitsch and Gosselink 2000). The capacity of the vegetation to provide these functions is largely determined by species composition and associated growth habits (Ewing 2008; Mitsch and Gosselink 2000). Species with considerable aboveground biomass and extensive root systems, such as *Carex lyngbyei* (Lyngby sedge), will provide greater soil-binding and water-slowing functions than more demure species, such as *Lilaeopsis occidentalis* (Western lilaeopsis), which would likely only provide modest surface sediment stabilization (Ewing 2008).

Tidal salt marsh plant community structure and function in the Puget Sound area and elsewhere have been shown to be overwhelmingly influenced by a combination of elevation, which determines degree, duration, and frequency of tidal inundation, and salinity gradients (Mitsch and Gosselink 2000; Ewing 1986; Hutchinson 1982). Plant community composition and distribution are driven mainly by the interaction of species tolerance ranges with a combination of environmental conditions, which results in the development of a variety of spatial zonation patterns (Mitsch and Gosselink 2000; Hutchinson 1982).

Depending on both the steepness of the elevation and salinity gradients and the width of the tolerance ranges of the resident plant species, transitions between zones in tidal marshes can be abrupt or gradual (Hutchinson 1982; Ewing 1986). This can lead to the development of a distinct mosaic spatial pattern including high marsh and low marsh community types, a vegetation assemblage characterized by subtle shifts in species composition along environmental gradients, or a situation that resembles a midspectrum representation of these two concepts (Ewing 2008; Thom et al. 2002; Mitsch and Gosselink 2000).

Microscale topographic variation also contributes to plant community structure; in keeping with the feedback loop discussed above, marsh vegetation plays an important role in engineering and maintaining this topographic diversity (Stribling et al. 2007). LWD input and activity also play an important role in marsh development and diversification, both by creating disturbance in existing stands of marsh vegetation and corresponding opportunities for colonization and by creation of microsites (growth platforms for reducing flooding stress, microgeomorphologic changes, etc.) to facilitate the establishment of a greater diversity of species (Ewing 2008; Hood 2007).

Over time, the combination of sediment stabilization and accretion results in changes in tidal marsh elevation, and therefore alters the exposure of the plant community to tidal inundation and salinity (Thom et al. 2002; Mitsch and Gosselink 2000). As elevations within a tidal marsh increase and gain complexity, the vegetation community matures and diversifies through successional processes (Mitsch and Gosselink 2000; Hutchinson 1982). Once the elevation of the marsh approaches the highest excursion of the tide, sediment deposition slows and equilibrium is reached between deposition and erosion, with high marsh vegetation becoming increasingly dominant as succession proceeds (Mitsch and Gosselink 2000; Thom et al. 2002; Hutchinson 1982).

The existing salt marsh plant community at Ala Spit follows the generally accepted model of distribution along elevation and salinity gradients as discussed above (Mitsch and Gosselink 2000; Ewing 1986). In the area of the spit where overwash is not impeded by the riprap revetment (i.e., northern portion of the spit beyond the extent of the riprap revetment) and marsh development has been allowed to proceed naturally, the intertidal zone is relatively broad, and the transition between high and low plant communities is subtle, with a relatively even distribution of *Distichlis spicata* (saltgrass) and *Salicornia virginica* (pickleweed) in the lower elevations gradually giving way to a pickleweed-dominated community accompanied by Western lilaeopsis in the higher elevations. Microtopographic diversity in this area is also common, with observed spatial variation in plant community composition coinciding markedly with slight topographic depressions and rises (Hood 2007). In contrast, at the neck of the spit, where overwash has been precluded by the riprap revetment, the elevation gradient is much steeper, resulting in a narrow band of vegetation where the subtle transition between high marsh and low marsh communities is difficult to discern.

As with wetland vegetation, dune vegetation plays an important role in the shaping of the backshore landscape via the feedback loop discussed above, whereby plants engineer their physical environment (Bird 2000; Mitsch and Gosselink 2000; Weidemann 1984). These plants initiate dune formation by reducing wind velocity, thereby facilitating deposition of wind-suspended sediments, as well as by functioning to physically trap and deposit sediment transported in both wind and water (Bird 2000; Weidemann 1984). They also serve to stabilize dune features and prevent erosion by providing shelter to existing sediment from the erosive force of the wind (reducing shear stress) and by the soil-binding capacity of their root or rhizome systems (Bird 2000; Weidemann 1984).

Similar to the discussion of wetland plants, the function of dune vegetation in engineering landforms also depends on the species, which must be adapted to harsh wind disturbance, wave energy (during winter storm tides), soils with low available nutrients, and saline conditions (Weidemann 1984). In Puget Sound, one of the most common species tolerant of such conditions is *Leymus mollis* (American dunegrass), a robust perennial grass growing 0.5 to 1.5 m tall (Ewing 2008; Weidemann 1984). This species has been shown to play an important role in the capture and deposition of sediment, and anecdotal evidence suggests that the resulting sand accumulation at its base actually triggers growth, thereby increasing the plant's ability to trap more sediment (Bennett 2005). This serves as yet another example of the feedback mechanisms that exist between coastal vegetation and geomorphic processes.

Characterization of Fish Habitat

Fish habitat in the vicinity of Ala Spit includes the pocket estuary on the west side of the spit, as well as shallow intertidal areas along the east site of the spit. Within the pocket estuary, fish habitat includes a lagoon, marshland, and mudflat areas. Along the shallow intertidal area, fish habitat includes the upper beach, tidal areas, and shallow subtidal areas. Primary habitat features within these physical habitats include macroalgae (e.g., *Ulva* sp., *Enteromorpha* sp., and *Fucus* sp.), eelgrass beds, and dune and salt marsh vegetation (Figure 13).

During the field visits, habitat zones as originally defined and mapped by Beamer et al. (2005) were field verified, with the results presented in Table 2. Disconnected habitat zones were summed to derive the totals presented in the table. Therefore, the areas presented by habitat type should not be considered to be contiguous. In a few cases, similar habitat types were lumped to simplify the subsequent alternatives analysis.

Table 2. Habitat type acreage at Ala Spit County Park.

Habitat Type	Area (acres)
Backshore	5.4
Beach (foreshore)	4.93
Channel	0.02
Large Woody Debris	2.8
Salt marsh	1.78
Fill/Isolated Backshore	0.89
Mudflat	34.06

Additional habitat characterization was completed as part of the geomorphic, substrate, and wood assessment (see the *Geomorphic, Substrate, and Wood Characterization* section as well as the *Characterization of Dune and Salt Marsh Vegetation* section above).

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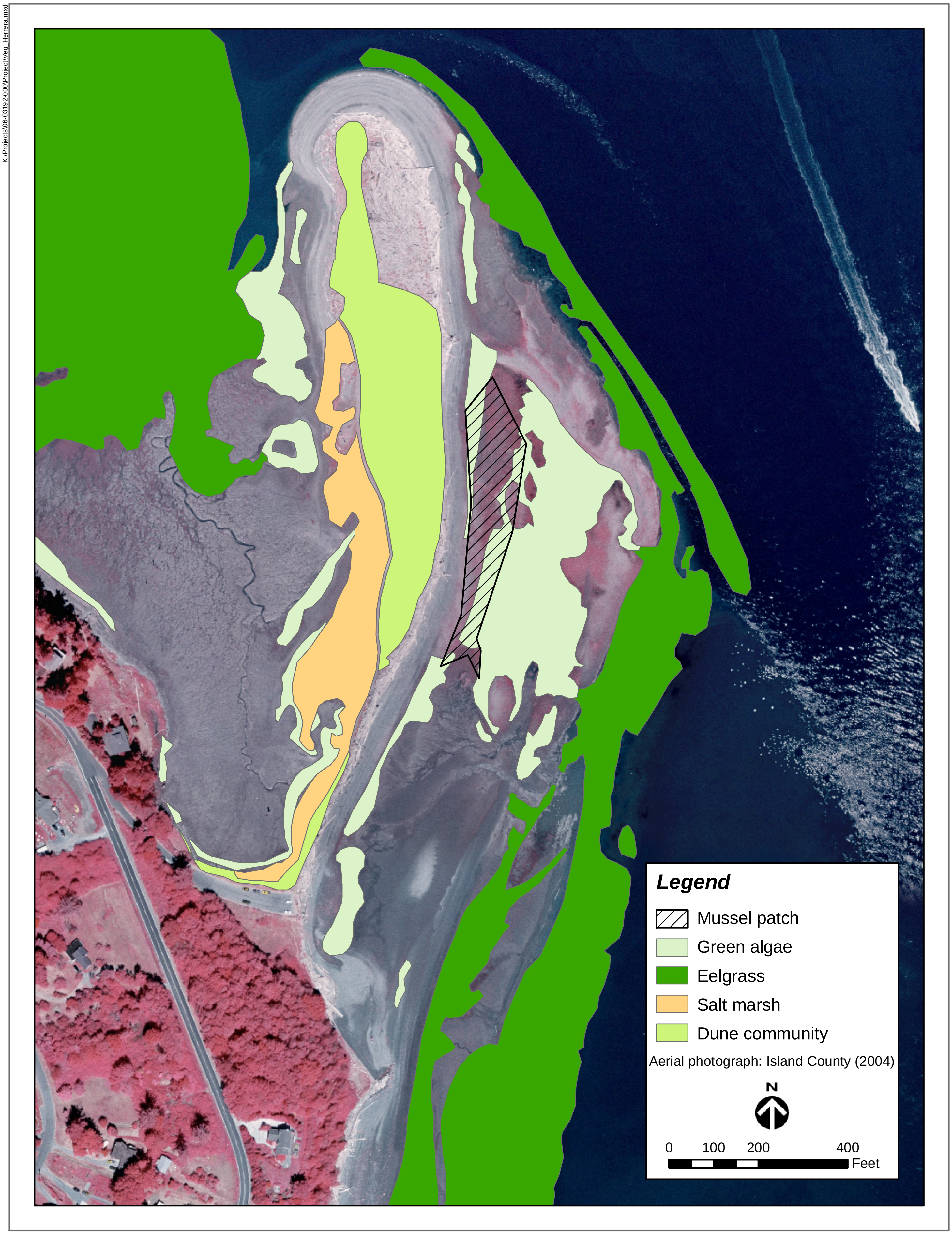

Figure 13. Habitat features observed at Ala Spit.

Assessment of Fish Habitat Use

To assess fish abundance, species composition, and size, beach seines were used to sample fish at 10 locations along Ala Spit (Beamer 2007). In sampling events conducted between February and June 2007, 5,948 fish representing 17 species were captured. The sampling occurred over the course of 100 beach seine sets and was conducted in two different locations representing different habitat: the outside of the spit (representing shallow intertidal habitat), and the pocket estuary (representing lagoon habitat). Wild juvenile Chinook and chum salmon, sand lance, shiner perch, stickleback, staghorn sculpin, starry flounder, and gunnel were the dominant species captured. Except for the sampling events in April, the lagoon habitat samples generally produced larger numbers and greater diversity of fish over the 5-month period than the shallow intertidal habitat on the outside of the spit. Fish captured in the lagoon habitats were also larger than those captured on the outside of the spit during the same sampling event. This suggests that the lagoon habitat is more productive and supports higher growth rates. These findings are consistent with current understanding regarding the importance of pocket estuary habitats (Beamer et al. 2005), and demonstrate the importance of the lagoon habitat for juvenile salmonid rearing.

Chum salmon were an exception to these general findings. Juvenile chum salmon dominated the samples collected in the intertidal habitat on the outside of the spit. The aggregate calculated density of chum salmon captured in the outside intertidal habitat was greater than the density calculated for the lagoon habitat, and in fact greater than the density of all other species combined. However, this discrepancy may be explained by the likelihood that the samples collected in the outside intertidal habitat were not representative of actual habitat use. These results were skewed by the capture of schools of juvenile chum salmon smolts during the two sampling events in April. These schools were most likely migrating along this shoreline habitat, following outmigration from the Skagit River system and seeking suitable rearing habitat. The following evidence is provided to support this assertion:

- Beamer et al. (2005) observed that juvenile chum salmon density consistently peaks in Skagit Bay and the surrounding marine shoreline areas in April.
- The largest numbers of chum salmon collected from the outside intertidal habitat were captured at sampling locations with limited cover.
- Chum abundance levels at these locations were well above average for index sites in other areas in Skagit Bay in April 2007.
- The largest school of chum was captured in swifter current conditions than average, during sampling in an area with limited suitable cover.
- Observed chum density in the lagoon habitat increased during the sampling events. This occurred 2 weeks after the highest chum densities were observed at the sampling locations on the outside of the spit.

Collectively, these observations suggest that the density calculations for the outside intertidal habitat were skewed by schools of juvenile chum salmon that were migrating through, but not necessarily inhabiting, the sampling area. Specifically, the April 12 sampling event at one location on the outside of the spit captured a school of 1,308 juvenile chum, more fish than most other sampling events combined on any given date. This event also exceeded the average catch per unit effort rate (CPUE) for seining events at sampling index locations throughout Skagit Bay in April 2007 (164.1 CPUE, using a range of net sizes), and the highest average CPUE during 1999, a high abundance year (734.2 CPUE). These results suggest that this sample is an outlier and not representative of actual habitat use. The April 12 event coincides with the known peak outmigration period for chum smolts from the Skagit River into Skagit Bay (Beamer 2007), indicating that large numbers of juveniles are likely to be encountered migrating along the nearshore environment seeking suitable areas for rearing.

Seine net sampling at the same outside location occurred over mixed coarse substrate with relatively swift current (approximately 1 to 2 feet per second). Due to the lack of cover, this location does not provide suitable habitat for long-term residence by rearing juvenile salmonids. This, in combination with the likelihood of large numbers of outmigrant chum being present, suggests that this school was migrating along the shoreline in search of suitable habitat.

When evaluating density, it is important to consider that the sampling regime was too limited to produce results with statistical power to clearly detect a difference between these habitat types. When the April 12 CPUE value at the same outside location was discarded as an outlier, average chum salmon densities at lagoon locations over the sampling period were 1.3 times larger. Considering the likelihood that the other April sampling event captured transitory migrant chum in the adjacent nearshore habitat, use of lagoon habitat is probably more extensive.

Fish growth rates inferred from size measurements are an indication of the importance of the lagoon habitat. On average, juvenile chum and Chinook captured in the lagoon were slightly larger than those captured in the adjacent nearshore habitat on the outside of the spit. These differences in length were not compared statistically, so the significance of the results is not clear. Other fish species captured in both the lagoon and adjacent nearshore habitats, such as staghorn sculpin, also showed a clear tendency toward larger size in the lagoon. These findings are consistent with the understanding that pocket estuaries provide cover, forage, and other habitat features conducive to increased growth rates and greater overall survival.

Alternatives Analysis

Three alternatives were developed and analyzed as part of the Ala Spit restoration and preservation project. The objectives of the alternatives development process were to improve habitat conditions along Ala Spit by implementing viable enhancement or restoration actions. These actions are focused on improving rearing habitat conditions for juvenile salmonids that occur along Ala Spit, in particular in the pocket estuary. Additional habitat improvement features were also considered, including the backshore area, beach habitat, spawning habitat for forage fish, large woody debris, and riparian vegetation. In addition, maintaining public access in the county park and along the spit was also considered.

The alternatives developed and analyzed as part of the project included the following:

- Alternative A – "Do nothing."
- Alternative B – Removal of the existing riprap revetment the southern third of the spit.
- Alternative C – As in Alternative B, remove the existing riprap revetment; in addition, acquire properties near or adjacent to Ala Spit to offer additional shoreline protection over the long-term.

Based on the findings described above in the *Results and Discussion* section, it was determined that the park bulkhead and the rock groin are not responsible for the existing conditions of the eroding neck along Ala Spit. While the rock groin does inhibit some longshore transport from the feeder bluffs to the south and the park bulkhead interrupts the connection between the beach and backshore, these effects are not as significant as those posed by the presence of the riprap revetment. The riprap revetment (located along the neck of the spit) artificially holds in place the lower one-third of the spit and cuts off the supply of sediment and LWD to the southern end of the pocket estuary. This occurs because the natural transport of sediment over the berm of the beach (through an overwash process during storms) is interrupted by the riprap revetment. Over time, this has resulted in sediment starvation in the pocket estuary. Therefore, the park bulkhead and the rock groin were not specifically included in the alternatives developed and analyzed for the project.

The results of the alternatives analysis conducted for the project are presented below, including an assessment of the potential impacts on habitat types and other features should each alternative be implemented. In addition, estimated costs associated with each alternative are presented, followed by a discussion of the recommended alternative based on the analysis conducted as part of this project.

Alternative A

Alternative A is the "do nothing" alternative. Even without implementing any activities to restore Ala Spit, there would be costs associated with maintaining the existing trail and riprap revetment. The riprap revetment would likely fail in the future, as a result of ongoing erosion within the pocket estuary edge (along the spit neck) due to the complete elimination of sediment supply to this area that was originally replenished by overwash. Erosion would further undermine the riprap revetment, resulting in the continued ongoing failure of this structure. Indeed, undermining of the riprap revetment has already occurred in the past, mobilizing pieces of the riprap (see Figure 14). Wave energy could accumulate in the area of the existing failure and subject it to enhanced erosion, similar to breaks in an armored shoreline (Komar 1998). To maintain access to the northern end of the spit along the trail, future maintenance would be required along the revetment.

Figure 14. Riprap that has failed and fallen from the revetment onto the pocket estuary side of Ala Spit. (Photograph taken on March 22, 2007.)

Pocket Estuary Habitat

Under existing conditions, the pocket estuary exhibits a mix of marsh communities with muddy tide channels landward (i.e., on the spit) of a large area of intertidal mudflats. The intertidal mudflat area is expanding due to two different processes. The lower intertidal area is prograding (advancing) northward due to the accretion of fine sediment (fine sand, silt, and clay). This sediment is derived primarily from the Skagit River and transported alongshore around the tip of the spit. In addition, a small portion of the fine sediment likely originates from the active erosion of fill associated with the trail, as well as the road prism of the park's access road. Through habitat transitioning, the mudflats are encroaching on the marsh areas immediately west of the trail and riprap revetment. As the area immediately west of the riprap revetment continues to be cut off from overwash replenishment, the transition from marshlands north and west of the revetment to mudflats will continue to occur, albeit slowly, over the next 50 years. Although it has been suggested that the anthropogenic-induced transition from marsh to mudflat can be detrimental to juvenile salmonid populations (Simenstad and Cordell 2000), there is no evidence in the data collected at Ala Spit (Beamer 2007) to suggest that the mudflat areas near the revetment will be utilized any less than the less altered marsh areas.

The future habitat transformations in the pocket estuary are anticipated to be a continuation of the changes described by Beamer et al. (2005) between 1956 and 2004. Over the next 50 years, this transformation is expected to include a further northerly expansion of mudflats for approximately 200 feet at the north end of the pocket estuary. This will also include a conversion of a 50- to150-foot swath of marsh and backshore areas to mudflats immediately west and north of the riprap revetment.

The predicted change in area over the next 50 years of the two habitat types that comprise the pocket estuary (i.e., salt marsh and mudflat) is identified below.

Salt Marsh

Predicted area change: A loss of 0.22 acres

Mudflat

Predicted area change: A gain of 2.26 acres

Backshore

The backshore in the vicinity of the riprap revetment is being slowly lost as it is eroded due to the loss in sediment supply and the increase in wave energy in the pocket estuary during high tides. This process will continue until virtually no backshore remains behind the riprap revetment. It is estimated that the area of backshore lost westward of the riprap revetment between 1956 and the present will be approximately equivalent to the area of backshore lost between now and the year 2058. However, new backshore is being created on the west end of the tip of the spit as it grows northward, such that net area change is reduced (offset) somewhat.

Predicted area change: A loss of 0.03 acres

Beach Habitat

Beach habitat on the east side of the spit is changing very slowly with time due to the continuity of the sediment supply along the beach. However, over time, the spit has developed a curvature starting where shoreline to the north of the riprap revetment has migrated northward, while the shoreline to the south associated with the riprap revetment remains fixed in the same location (see Figure 7). The bend will become more pronounced with time, as the unmodified beach migrates farther northward in response southerly wave attack. In 50 years, it is anticipated that some percentage of the foreshore would be lost, as the northern tip forms a coarsened promontory. This will cause the foreshore to be eroded (lowered) in a wholesale manner, similar to other armored shoreline locations in Puget Sound (Herrera 2005; Finlayson 2006). However, a net gain in the length of beach would be expected, as the tip of the spit advances northward (~150 feet). The changes at the northern end of the riprap revetment are assumed to be consistent with the loss of 1 foot of sediment; given the width of the foreshore (~30 feet) and its slope (7:1), 20 percent of the foreshore is expected to be lost. This loss and beach lowering is likely to be comparable to erosion observed on analogous armored shorelines in Puget Sound (Herrera 2005).

<u>Predicted area change</u>: A gain of 0.05 acres

Forage Fish Spawning Habitat

Over the entire length of the east side and portions of the west side of Ala Spit, the existing substrates are appropriate for spawning habitat for both sand lance and surf smelt spawning (WDFW 1997). Given these substrate characteristics and the spawning habitat requirements of the species, surf smelt likely prefer the exposed “beach” portion of the spit on the east side. In contrast, sand lance are likely to preferentially spawn in front of the bulkhead at the southern end of the spit, near the northern tip of the spit, and at the northern, seaward portion of the pocket estuary. Currently, only the footprint of the riprap revetment in the uppermost foreshore lacks suitable spawning habitat for forage fish. In addition, partially buried concrete slats (debris) occupy portions of the upper beach, thereby precluding forage fish spawning in those areas.

The loss of sediment and lowering of the beach described in the *Beach Habitat* subsection above will cause the surface substrate to coarsen. Near the northern end of the riprap revetment, the beach will eventually coarsen to the point where it no longer supports surf smelt spawning. The preclusion of spawning behavior due to sediment coarsening will likely be short lived during those periods dominated by large waves (typically during the winter). Even in the most impacted areas, finer gravel will coat the coarsened beach, enabling surf smelt spawning to occur during more quiescent periods. In this analysis, it is assumed that the width of the spawning area (between 7 feet above MLLW and MHHW) for the entire front of the riprap revetment will narrow to what now occurs in the front, near the neck of the spit. However, the area of forage fish spawning habitat is likely to expand at the northern tip of the spit, as the spit continues to grow. In sum, there will be a slight decrease in forage fish habitat area.

<u>Predicted area change</u>: A loss of 0.06 acres

Large Woody Debris (LWD)

Currently, there is a considerable amount of LWD on Ala Spit, even on top of the riprap revetment (although only on the east/beach side). However, the storage of wood is limited near the riprap revetment (along the neck of the spit) due to its narrow width and relatively steep slope. With time, it is expected that the beach will continue to erode at the base of the revetment, and wood will be gradually lost from the beach side. This will occur as a result of the lowering of the beach elevation and wood loss from natural processes. To estimate the loss in LWD, the current minimum width of LWD (~10 feet) (i.e., in the location where the shoreline is now most influenced by the riprap revetment) is assumed to be the dominant width of LWD by the year 2058 along the entire length of the riprap revetment (800 feet). The spit will lengthen by approximately 150 feet, assuming that the supply of sediment from the drift cell and from the Skagit River is not interrupted. This estimate also represents the rate of extension measured during the last 50 years.

LWD will continue to accumulate near the north end of the spit. The Skagit River produces an enormous amount of LWD and is assumed to be the source of most of the driftwood found on Ala Spit. Some small amount of wood comes from the Ala Spit drift cell. However, for this analysis, it is assumed that the shoreline will remain intact (as will the LWD recruitment potential) due to the existing strict enforcement of logging within the nearshore zone (Island County 2001). Therefore, the total area of LWD coverage on the spit is expected to increase with time, even in the absence of habitat enhancement activities.

Predicated area change: A gain of 0.2 acres

Riparian Vegetation

Using a recent aerial photograph, it was determined that 65,000 square feet of the shoreline zone (defined as that area within 200 feet of the ordinary high-water mark) has been deforested in the Ala Spit drift cell. Because of strict regulations on tree cutting within the shoreline zone (Island County 2001), it is assumed that no further deforestation will occur. Therefore, the area in question will remain intact regardless of habitat enhancement activities on Ala Spit.

Predicted area change: 0 (No gain or loss)

Public Accessibility

The primary access to the county park from the parking lot at the end of Geck Road is a small dirt and gravel trail that leads to the north end of the spit. The trail provides marginal access to the spit because it is not Americans with Disabilities Act (ADA) accessible, and does not allow for infant strollers. A fundamental assumption of Alternative A is that the county will maintain the trail in roughly the same condition for the next 50 years. This is important not only for use of the park, but also to prevent deleterious environmental impacts associated with the failed revetment (i.e., severe erosion in any failed section). The existing access conditions have also been considered below in the analysis of Alternatives B and C.

Predicted area change: 0 (No gain or loss)

Alternative B

In Alternative B, the riprap revetment on the southern one-third of the spit would be removed. The park bulkhead would remain. The rock and other construction debris that comprise the revetment would be hauled off site and sold to a local quarry. This would allow for a natural berm to reform where the trail currently exists. The berm would likely support considerably more LWD than the current riprap revetment. However, the presence of LWD and the new berm would be dynamic features, meaning that any trail that is passively formed between the parking lot and the tip of the spit might be inundated and/or "damaged" during large storms, and LWD would likely be transported in and out of the area of the berm.

Pocket Estuary Habitat

The pocket estuary (i.e., the brackish intertidal area) west of the spit proper is defined by the marsh and mudflat zones in Beamer et al. (2005). It would expand as the low-tide terrace continues to accrete northward (as described in Alternative A). With removal of the riprap revetment, mudflats immediately west of the removed revetment would likely convert to marsh and backshore once the sediment supply is restored (via overwash splays) to the pocket estuary side of the spit. As the sediment supply returns, the northward advance of mudflats in this area due to erosion of the marsh would be halted. The conversion to salt marsh and backshore would occur over time, as the elevation of the land surface recovers and the area is recolonized by marsh plants. Deposition of sediment through overwash is expected to occur rapidly due to the artificially low elevation of the existing land surface. Recolonization by marsh vegetation is also expected to occur rapidly due to the large quantity of local seed stock.

The conversion of mudflats to marsh and backshore is expected to occur only at high topographic elevations, where the existing mudflats are barren. The areas of eelgrass at lower elevations are expected to be unaffected by processes occurring at marsh elevations, as is typically the case throughout Puget Sound (Finlayson 2006). By the year 2058, the marsh and backshore areas would likely return to the conditions that existed prior to 1956, as interpreted by Beamer et al. (2005).

The predicted change in area of the two habitat types that comprise the pocket estuary (i.e., salt marsh and mudflat) is identified below.

Salt Marsh

Predicted area change: A gain of 0.04 acres

Mudflat

Predicted area change: A gain of 1.51 acres

Backshore

With the removal of the riprap revetment, the supply of coarse-grained sediment would be restored to the southern end of the pocket estuary. This process would begin to build a backshore west of the area where the trail now exists. This process would begin with the construction of a “summer berm” shortly after the removal of the riprap (as conceptually illustrated in Figure 9). Summer berms are ridges of material formed near the mean higher-high tide elevation and are formed during quieter times, as mobile sediment migrates up the beach (Komar 1998). This berm would accumulate wrack material such as LWD and flotsam, as well as beach sediments (i.e., sand and gravel). The berm would be remobilized in the winter, with some of the sediment in the berm driven westward, accumulating farther beyond each successive year’s berm. This process would continue until the elevation of the land surface is sufficient to maintain salt-tolerant upland vegetation (e.g., dune grasses). By the year 2058, the neck spit would likely widen to the thickness identified by Beamer et al. (2005) as observed in 1956. This future backshore area would be substantially lower than the current trail prism. The predicted process described here implicitly assumes that the existing sediment supply remains intact.

<u>Predicted area change</u>: Gain of 0.2 acres

Beach Habitat

Removing the riprap revetment would allow the spit to equilibrate relative to the surrounding wave environment. This would widen the beach, most likely to the 1956 width described by Beamer et al. (2005). Most of the widening would occur to the north and west of the riprap revetment, including the area covered by the existing trail prism. In addition, the beach would lengthen due to the accumulation of new sediment on the northern tip. This lengthening process is considered to be independent of other changes on the spit (e.g., the formation of a backshore in the existing mudflat).

<u>Predicted area change</u>: A gain of 0.08 acres

Forage Fish Spawning Habitat

Alternative B would result in an increase in forage fish spawning habitat area relative to Alternative A because there would be no loss of spawning area near the northern tip of the riprap revetment. There would also be an expansion of suitable spawning habitat (the width of the beach near the neck), as the berm becomes more muted and mobile. It is assumed that this width would be comparable to that of the beach near the northern tip of the riprap revetment under existing conditions. Continued lengthening of the spit would also result in an expansion of spawning habitat relative to existing conditions.

<u>Predicted area change</u>: A gain of 0.17 acres

Large Woody Debris (LWD)

The area covered by LWD would increase relative to both existing conditions and Alternative A. If the riprap revetment is removed, the spit will likely widen at its neck and expand its capability to harbor wood on the new beach berm. The accumulation of wood is assumed to be limited by geomorphic processes, not by the supply of wood to the nearshore. On the initial site visit, numerous pieces of LWD were observed floating offshore, likely from the Skagit River. This debris was fresh (i.e., not weathered) and often had squared ends indicative of logging activity (no recent logging was observed in the area adjacent to Ala Spit). These observations, as well as previous observations along the shorelines of Skagit Bay, indicate that there is a large volume of large woody debris available for deposition on Ala Spit from the Skagit River. For this analysis, it is assumed that the width of LWD recovered on the berm of the spit equals the width of LWD observed in the 1956 aerial photograph (~30 feet). The spit is also estimated to lengthen by approximately the same distance noted in Alternative A (~150 feet).

<u>Predicted area change</u>: A gain of 0.37 acres

Riparian Vegetation

Under this alternative, there would be no change in riparian vegetation relative to that described for Alternative A. Therefore, the same area calculation applies for both alternatives.

<u>Predicted area change</u>: 0 (No gain or loss)

Public Accessibility

By removing the existing riprap revetment, the primary protection of the narrow trail would be lost. The removal would also lower the elevation of what remains of the trail prism. During a large storm event, the trail could be obliterated or washed away in sections. In such an event, the storm would likely replace the trail prism with a loose berm of interlocking woody debris, as currently exists on the northern end of the spit. During lower water-level periods, the northern end of the spit can still be accessed via the foreshore. This would likely be the case along the neck of the spit if the trail is obliterated.

<u>Predicted area change</u>: A loss of 0.06 acres

Alternative C

Like Alternative B, Alternative C includes the removal of the riprap revetment along the southern third of the spit. However, Alternative C also includes the acquisition of properties where private land use practices have encroached on and impaired the ecological functions of the Ala Spit drift cell. Because these alterations compromise the adjacent shoreline in terms of both the juvenile migration corridor and as a source of LWD and sediment, acquiring these properties represents an attractive option for long-term salmon restoration. This action would also help to ameliorate the relative loss of access to Ala Spit due to the partial loss of the trail (as described below) by providing additional access to the shoreline. In addition, it would expand the Cascadia Marine Trail, a federally supported kayak trail, which may qualify the land acquisition for federal grant matching funds.

Several nearby properties have reduced vegetation coverage within the riparian zone and installed shoreline hardening infrastructure. Restoring the riparian buffer and removing existing shoreline armoring would enhance the transport capacity of the Ala Spit drift cell. The beneficial impact of this restoration might be significant, because most of the rest of the drift cell is intact, and because the number of salmonids currently using this area is extremely large (Beamer 2007). However, for the purposes of this analysis, these restorative activities (i.e., removal of bulkheads on newly acquired properties) are not included.

Pocket Estuary Habitat

Because Alternative C does not provide additional benefits as compared to Alternative B for the protection of pocket estuary habitat (other than to ease the passage of juvenile salmon alongshore outside of the park site), the predicted pocket habitat area would remain the same as in Alternative B.

Salt Marsh

<u>Predicted area change</u>: A gain of 0.04 acres

Mudflat

<u>Predicted area change</u>: A gain of 1.51 acres

Backshore

As in Alternative B, the riprap would be removed and the backshore would eventually reform westward of the existing trail prism. Because the sediment supply is assumed to remain intact, there is no additional benefit as compared to Alternative B of acquiring the properties. Although there are obstructions in the Ala Spit drift cell, none of these obstructions preclude new sediment from being delivered to the spit area. Therefore, the predicted area change is the same as described for Alternative B.

<u>Predicted area change</u>: Gain of 0.2 acres

Beach Habitat

Under Alternative C, beach habitat would not increase more than that identified for Alternative B. Because sediment sources would be better protected, it is less likely that erosion (e.g., at the northern end of the park bulkhead) would represent the same level of risk as described for Alternative B. However, there are several factors that suggest that the sediment supply to the spit would remain intact in the future (regardless of additional property acquisition): (1) the existing sediment supply is sufficient for the spit to grow; (2) existing laws already restrict the interruption of sediment from human activities; (3) the amount of sediment in active transport would be significantly greater than what is supplied from the drift cell; and (4) under existing conditions, sediment recruitment into the drift cell is possible along the shoreline between the private bulkhead (Figure 10) and the park bulkhead (i.e., the removal of the private bulkhead would not significantly affect sediment accretion at Ala Spit as there is a large feeder bluff updrift from this structure).

Predicted area change: A gain of 0.08 acres

Forage Fish Spawning Habitat

Relative to Alternative B, Alternative C could increase forage fish spawning habitat if the bulkheads on the acquired properties were removed. However, this would include additional construction costs associated with removing the bulkheads on these properties, and these gains would occur off site; therefore, these gains are not included in this analysis. The predicted forage fish spawning habitat area would remain the same as in Alternative B.

Predicted area change: A gain of 0.17 acres

Large Woody Debris (LWD)

With additional protection of the riparian corridor and restoration of the existing affected areas, the littoral supply of LWD would be preserved. However, most (if not all) of the wood on Ala Spit comes from the Skagit River or from adjacent intact riparian areas. As noted for the estimates in Alternatives A and B, limited enhancements to the supply of LWD from the drift cell would not significantly affect the area supporting LWD on the spit. Therefore, it is unlikely that the LWD coverage in Alternative C would expand more than the estimate provided for Alternative B.

Predicted area change: A gain of 0.37 acres

Riparian Vegetation

Although Alternative C would place two parcels in the drift cell under permanent protection, it would not increase riparian vegetation on the spit itself.

Predicted area change: 0 (No gain or loss)

Public Accessibility

Although the purchased lands would expand access to Ala Spit and its drift cell, accounting for public accessibility areas is limited in this analysis to access on the spit itself. However, it is important to note that acquisition of these properties would increase the recreational value of Ala Spit County Park. For example, these additions would expand the use of the Cascade Marine Trail by providing alternative access points to the nearshore, as well as the opportunity for short, one-way or round trips to the park.

Predicted area change: A loss of 0.06 acres

Cost Analysis

A cost analysis for a 50-year timeframe was performed for each of the alternatives and is summarized in Table 3. The cost effectiveness of each alternative was assessed by the cost per acre of "use," where use is broadly defined as areas of different attributes required for salmonid species and the general public using the park. As demonstrated in Table 3, Alternative B (riprap removal) is the most cost-effective alternative.

Table 3. Cost analysis summary table.

Attribute	Alternative A Do Nothing Average[a] Acreage	Alternative B Riprap Removal Average[a] Acreage	Alternative C Riprap Removal and Property Acquisition Average[a] Acreage
Pocket Estuary Habitat			
Salt Marsh	-0.22	0.04	0.04
Mudflat	2.26	1.51	1.51
Backshore	-0.03	0.20	0.20
Beach Habitat	0.05	0.08	0.08
Forage Fish Spawning Habitat	-0.06	0.17	0.35
Large Woody Debris	0.20	0.37	0.37
Riparian Vegetation	0	0	0
Public Accessibility	0	-0.06	-0.06
Cost	$120,892	$79,457	$1,823,457
Cost per Average Change in Acreage of Use	$56,563/acre	$34,397/acre	$840,355/acre

[a] Average is a temporal average of change in use assumed over a 50-year time period. For additional details, see Appendix D.

A detailed cost estimate of the construction and permitting consultation in association with riprap revetment removal or repairs to that revetment is provided in Appendix D.

Alternative A

The cost of this alternative is primarily associated with continued maintenance of the trail leading from the parking lot to the end of the spit. As erosion continues on both sides of the riprap revetment that protects the trail, small portions of the riprap from this revetment would likely be undermined and collapse onto the beach at times of intense wave activity. This has already occurred, although it has not yet compromised the trail such that significant repairs have been required during Island County's ownership of the park (since approximately 1995). Given the age of the riprap (placed sometime in the 1960s), its uncertain maintenance history and current precarious state, it is assumed that at least two maintenance efforts will occur within the next 50 years. The cost estimate includes repair and replacement of the existing riprap revetment of two 20-foot sections, assumed on the pocket estuary side of the revetment. Because this is a repair only, permitting costs are limited (see Appendix D for details).

Total cost: $120,892

Alternative B

The cost of this alternative is primarily associated with removal of the riprap revetment (see Appendix D for details). It is assumed that the southern end of the spit will be returned to a natural state, and no further maintenance of the area will be required. However, coastal geomorphic settings exhibit natural changes through some of the natural physical processes described earlier in this document (e.g., sediment replenishment through overwash). Removing the riprap revetment would alter current geomorphic conditions by restoring those physical processes. These alterations would restore the salt marsh area that has eroded as a result of the cutoff of sediment supply by the riprap revetment. However, unforeseen environmental effects (e.g., infestations of invasive species) may occur and may require additional measures to protect salmonid use of the spit as well as the site's natural beauty. The alterations may also modify the existing access conditions of the park. Therefore, it is recommended that annual physical monitoring be performed to learn from implementation of this project and to execute alternative measures if needed to ensure continued public access to the park, based on adaptive management principles. In addition, some limited monitoring should be performed to ensure that excessive erosion does not occur at the northern end of the park bulkhead. Some beach nourishment could be required to prevent the northern end of the park bulkhead from impeding sediment transport around it as the spit migrates northward.

Total cost: $79,457

Alternative C

The total cost of Alternative C would include all costs associated with Alternative B, plus the costs associated with the purchase of two waterfront properties. For the purpose of this estimate, one of these properties is assumed to be a large (approximately 1 to 5 acres) waterfront estate, while the other is a smaller (less than 0.5 acre) bluff property. Costs associated with maintenance and revegetation of these properties are not included in this analysis. According to Windermere listings of comparable properties on north Whidbey Island and Fidalgo Island on December 5, 2007, there were 21 large waterfront estates listed between $2,395,000 and $279,000, with a median price of $995,000. There were 10 small bluff properties varying between $1,595,000 and $275,000, with the median price being $749,000. Therefore, the combined market value of these properties (assuming the median value for each) is estimated to be $1,744,000. It is important to note that the purchase of these properties by Island County could occur regardless of whether any other alternatives are implemented and would create an excellent opportunity to increase public access along the shoreline.

Total cost: $1,823,457

Recommended Alternative

Based on the findings of the feasibility study (in particular, the alternatives analysis), Alternative B was identified as the preferred alternative and recommended for further analysis and consideration. The results of the alternatives analysis were presented to Island County for the selection of the recommended alternative in a technical memorandum dated February 6, 2008 (Herrera 2008).

Conclusions and Recommendations

Based on the findings of this feasibility study and the analysis of restoration and preservation alternatives for Ala Spit, Island County has selected Alternative B as the preferred alternative. In Alternative B, the riprap revetment on the southern one-third of the spit would be removed. The park bulkhead would remain. The rock and other construction debris that comprise the revetment would be hauled off site and sold to a local quarry. This would allow for a natural berm to reform where the trail currently exists. The berm would likely support considerably more LWD than the current riprap revetment.

Following removal of the riprap revetment, the initial response of the salt marsh plant community on the periphery of the pocket estuary to anticipated sudden changes in the hydrologic regime and sediment deposition may be a reduction in productivity and vegetative coverage. Although this may initially appear to be a short-term negative impact on the plant community, new sediment input through the restoration of tidal overwash at the spit is expected to have a significant long-term positive effect on the marsh habitat. An increase in sediment deposition and accretion in this area is expected to reverse the current trend of marsh retreat by increasing the elevation of the existing mudflats, thereby broadening the elevation gradient of the intertidal zone and increasing the area of suitable habitat for the existing salt marsh species. These species are expected to recolonize quickly by both vegetative propagation and seeding. The process of marsh succession will occur as the elevation of the marsh increases. Finally, the sediment budget is expected to eventually reach the deposition-erosion equilibrium representative of mature marsh systems (Mitsch and Gosselink 2000). In addition, the development of microtopographic diversity and LWD-facilitated microsites found in naturally functioning tidal marsh habitats is also expected to occur in this system (Hood 2007; Stribling et al. 2007).

Given the current composition of resident plant species, the brackish conditions in the pocket estuary would most likely be characterized as falling into the upper polyhaline range (18–30 parts per thousand) (Ewing 2008; Dethier 1990). With this level of salinity, the semiprotected nature of the pocket estuary, the expected increase in unvegetated sediment due to post-restoration accretion, the imminent development of greater topographic complexity, and the existence of seasonally consistent storm events to deliver water-transported propagules, there will be the perpetual potential for colonization by locally common plant species not currently found at the site (Ewing 2008). These species may include *Atriplex patula* (orache), a broadleaf annual, and *Jaumea carnosa* (marsh jaumea), a succulent perennial, which have been observed in significant densities in other Whidbey Island salt marsh habitats (Ewing 2008). Consideration also needs to be given to the potential colonization by *Spartina alterniflora*, an aggressive invasive species, following removal of the riprap revetment and subsequent exposure of unvegetated areas in the leeward tidal marsh (Ewing 2008). Because the establishment of this opportunistic species would greatly challenge the restoration success, it is recommended that the site be monitored closely until native species have become successfully established.

At Ala Spit, the backshore area behind the riprap revetment is currently dominated by nonnative annual and perennial grasses that flank the access trail, with the potential presence of American dunegrass (Ewing 2008). Removal of the riprap revetment is expected to result in the exposure of these grasses to increased salt stress, flooding stress, and physical disturbance through overwash processes, which would most likely weaken their presence at the site. With the expected accumulation of sand and gravel and establishment of summer berms, locally abundant native dune grasses adapted to the harsh conditions of the backshore environment, such as *Leymus mollis* (American dunegrass), will most likely recolonize the area quickly (Ewing 2008; Bennett 2005). Likely associates may include *Cakile edentula* (American searocket) and *Grindelia integrifolia* (gumweed). The establishment of dune vegetation will both stabilize soils and accumulate sediment, thereby facilitating the salt marsh/dune stabilization feedback loop. Dune formations, although dynamic in nature, are expected to become a permanent feature in the area behind the riprap revetment, separated by a gradual elevation gradient (characterizing the leeward dune-marsh transition community) from the salt marsh on the leeward side of the spit.

In conclusion, removal of the riprap revetment and reintroduction of natural hydrology and disturbances to pocket estuary habitats at Ala Spit are expected to result in the restoration of distinct, dynamic, and sustainable native dune and salt marsh vegetation communities that will influence and be influenced by key geomorphic processes. In turn, these changes are expected to benefit juvenile salmon habitat utilization.

In addition to implementing the preferred alternative, other restoration and preservation opportunities exist at Ala Spit. The following sections describe potential restoration and preservation activities that could also be considered and implemented in concert with the preferred alternative, followed by general recommendations based on the findings of this feasibility study.

Restoration and Preservation Actions to Consider

- **Removal of the rock groin (i.e., the jetty)**. Removal of the rock groin would completely restore littoral transport to the Ala Spit drift cell, as well as add to the aesthetic value of the park as a natural place. However, as described in depth earlier in this document, the groin is not significantly prohibiting the transport of sediment alongshore. As a result, the main benefits of removing the groin would be aesthetic and recovery of forage fish habitat over the footprint of the groin (approximately 10,000 square feet).

- **Removal of the park bulkhead**. Removing the park bulkhead would reconnect the beach in front of the seawall to the backshore behind it and possibly reengage the small wetland east of the existing parking lot. This would expand and improve forage fish habitat over the length of the current bulkhead footprint. However, removing the park bulkhead would endanger the parking lot area. Hence, the gain in forage fish habitat needs to be evaluated against the potential loss of access to the park (see details below).

- **Removal of the parking lot and access road.** The parking lot and access road to the park are located on fill that was placed on a former marsh. Removing the parking lot and associated fill could enable recovery of the adjacent wetland to an estuarine salt marsh, as well as expand the pocket estuary area (Beamer et al. 2005). The road fill also artificially bounds the north end of the wetland and inhibits a more natural connection to the rest of the landscape. However, this would disable vehicle access to the park itself both by visitors and maintenance personnel. The removal of the parking lot and access road could discourage use of the park and make maintenance of the facilities at the park extremely difficult.

- **Removal of creosote piles.** The pocket estuary contains a line of several (5 to 10) creosote piles. These piles are primarily located in the middle of the mudflats. There would be a benefit to removing these piles as they represent a source of water and sediment pollutants to aquatic organisms and their habitat within the pocket estuary.

- **Property acquisition.** Property acquisition was considered as one of the alternatives (Alternative C). However, as discussed in the *Results and Discussion* section, property acquisition without deconstruction of existing infrastructure (i.e., bulkheads and groin) would not have benefits from the perspective of preventing a breach at the neck of the spit. Nonetheless, the acquisition of the properties identified in Alternative C would create an excellent opportunity to increase public access along the shoreline.

General Recommendations

Conservation of watershed-scale resources is highly recommended. Enforcement of measures in place to protect wetland habitat and groundwater recharge zones; implementation of state-of-the art measures to reclaim water; control and infiltration of stormwater runoff; and the use of regulation, education, and incentives as necessary to protect marine riparian vegetation are all recommended.

Water quality monitoring performed in the lowest point of watershed #005 (on the south side of Troxell Road) found high concentration of fecal coliform bacteria during a number of monitoring events. Although the samples contained high concentrations during a number of events, the high variability of fecal coliform bacteria concentrations from sample to sample does not appear to support the presence of a significant, chronic pollution problem. Island County should implement actions to reduce concentrations of fecal coliform bacteria.

In the characterization of the conditions in watershed #005, turbidity was found to be the parameter of most concern (Island County 2007). Education and public outreach, additional water quality monitoring, and enhancement/restoration of existing altered stream buffers may help maintain or improve the water quality conditions in these watersheds and in the habitats associated with Ala Spit.

Education and public outreach will likely produce the largest, most sustained improvements in water quality. Education helps people to make informed land-use decisions regarding their own private property as well as common open areas, such the Ala Spit County Park. Outreach efforts should focus on agricultural activities, with an emphasis on actions that are relevant to typical hobby farmers. An outreach campaign that describes appropriate logging or forest practices may serve to preserve existing water quality conditions in the watersheds draining to Ala Spit and its environs.

As identified by Island County (2007), continued water quality monitoring can ensure that future land uses are not contributing to water quality degradation. Future water quality monitoring and trend analysis should begin by analyzing existing versus future land-use activities within the watersheds draining to Ala Spit and the analysis of future versus current nitrate, turbidity, and fecal coliform bacteria concentrations. Correlations between current and future pollutant bacteria concentrations will allow decision-makers to modify land-use requirements and management practices for the protection of water quality and habitat over time.

Enhancement of altered buffer areas within the watersheds draining to Ala Spit would ensure continued protection and improvement of water quality conditions, as well as habitats. Vegetative buffers can filter various pollutants and provide valuable habitats for species. A significant amount of buffer area in the watersheds associated with Ala Spit has been altered overtime (Island County 2007). Enhancing these buffers by removing invasive, nonnative vegetation and replanting with native species would lead to healthy habitat and improved water quality.

Based on existing and future water quality conditions, current and future land uses, and existing regulatory protections, the above strategies are likely the most cost-effective, long-term strategies for maintaining and improving water quality conditions in these watersheds.

Glossary

Allochthonous nutrients – Nutrients that arrive from outside of the medium/environment in question.

Backshore – The flat area behind the berm of a beach that can be inundated during extreme high water events. Often backshores, like those at Ala Spit, possess a large amount of LWD (large woody debris).

Drift cell – The length of shoreline along which sediment is transported. At Ala Spit, the drift cell is comprised of the shoreline from the feeder bluffs to the south to the northern tip of the spit.

Drumlin – A ridge of glacial sediments (usually till) that are formed underneath a glacier. The axis of a drumlin is oriented in the direction of glacial movement.

Facies – A collection of like sediments that reflect a depositional environment, each facies being a distinct kind of sediment for that area or environment.

Feeder bluffs – Steep, unstable, eroding shorelines that deliver large quantities of sediment to the nearshore via landsliding landslides and other similar geologic processes.

Foreshore – The steep portion of a beach that extends from a few feet above mean lower-low water up to mean higher-high water.

Grain-size – The diameter of sediment on the shoreline.

Groin – A shore-perpendicular shoreline structure intended to accumulate sediment in alongshore transport. A groin typically accumulates sediment on the updrift sides, and erodes the shoreline on the down-drift side. Groins are sometimes called jetties.

Intertidal (zone) – The range of elevations along the shoreline generally between mean lower-low water and mean higher-high water. This area undergoes daily wetting and drying and is where the water line intersects the shore.

Isobath – A line of similar elevation below sea level.

Large woody debris (LWD) – Large woody debris can originate from autochthonous (from adjacent hillslopes) and allochthonous (drift that originated elsewhere) sources. The primary source of LWD on Ala Spit is from the Skagit River. Woody debris is classified here into four diameter classes (less than 6 inches, 6 inches to 1 foot, 1 foot to 2 feet, and greater than 2 feet) and three length classes (less than 10 feet, 10 to 15 feet, and greater than 15 feet).

Lithified material/lithification – The process by which sediment turns into solid rock due to burial, pressure, and heat. This process also describes the relative strength of sediments and sedimentary material that is acquired during the process of lithification.

Low-tide terrace – A large, flat area of limited slope offshore of a beach, typically occurring at an elevation near mean lower-low water. Low-tide terraces can arise from either erosion or deposition. At Ala Spit, the low tide terrace on the west side of the spit is depositional, while the east side is erosional and coincident with a topographic bench.

Mean higher-high water (MHHW) **–** The average of all of the higher of the two high tides that occur in a given day. This elevation is sometimes used as the ordinary high-water mark on marine shorelines and typically defines the upper limit of the intertidal zone.

Mean lower-low water (MLLW) – The average of all of the lower of the two low tides that occur in a given day. This elevation typically defines the lower limit of the intertidal zone.

Morphodynamics – The general term that describes the suite of physical processes responsible for transporting sediment and (trans)forming the land surface.

Mudflats – A geomorphic feature that occurs in intertidal and subtidal areas of high sediment supply and significant sedimentation. In this report, it also refers to a habitat type that corresponds to muddy bottom, unvegetated, intertidal areas.

Near-bed mechanics – The physical processes and forces occurring extremely near the bed (within inches).

Nearshore – The area from the top of shoreline bluffs to the depth offshore where light penetrating the Sound's 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.

North American Vertical Datum of 1988 (NAVD88) – This is the most common datum used for topographic surveys. Although its origins are loosely based on mean sea level, it is referenced to the center of the Earth and not dependent on local sea level. At Ala Spit, NAVD88 is approximately 0.4 feet above mean lower-low water.

Pocket estuary – A generic term that refers to a protected shallow-water habitat area that is influenced by both freshwater and saltwater sources. In this report, it refers more generally to the shallow intertidal area west of Ala Spit.

Salt marsh – An area in the intertidal zone that contains emergent, salt-tolerant vegetation. Pickleweed (*Salicornia virginica*) dominates the salt marsh at Ala Spit.

Sediment budget – An accounting of the sources and sinks of sediment within a given area.

Shear stress – The shear force applied to the bed, which has commonly been related to the volumetric sediment transport rate.

Shell hash – Crushed calcareous (shells) that is formed initially during energetic events and transported upwards on the beach during more quiescent periods.

Splay deposit – A deposit formed from storm-induced inundation of water and sediment.

Stokes drift – An interactive process that transports solid material in the direction of wave propagation in a fluid.

Summer berm – A mound of sediment and LWD large woody debris accumulated near mean higher-high water constructed by waves during quiescent periods (summer). Summer berms can either be eroded entirely in the winter time or precipitate the formation of a storm berm above ordinary high water in the backshore.

Topographic benches – These are flat areas found in this study that appear to be eroded (by wave action) promontories that now occur at or below mean lower-low water.

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APPENDIX A

Photo Log and Watershed Characterization

Photo 1. Fish sampling within the pocket estuary. Looking toward the southwest from the salt marsh edge. February 26, 2007.

Photo 2. Fish sampling along the nearshore on the east side of Ala Spit. Looking south. February 26, 2007.

Photo 3. High tide conditions on Ala Spit, looking north from the parking area. March 22, 2007

Photo 4. High tide conditions on Ala Spit, looking south from the parking area. Note wood accumulation in front of the bulkhead. March 22, 2007.

Photo 5. Low tide conditions on Ala Spit, looking north. Note wood accumulation along the neck. March 22, 2007

Photo 6. Wood accumulation along the neck of Ala Spit, looking south. Note riprap along the trail prism. March 22, 2007

Photo 7. Wood area coverage on the northern portion of Ala Spit. March 22, 2007

Photo 8. Recently recruited wood along the east side of Ala Spit. March 22, 2007

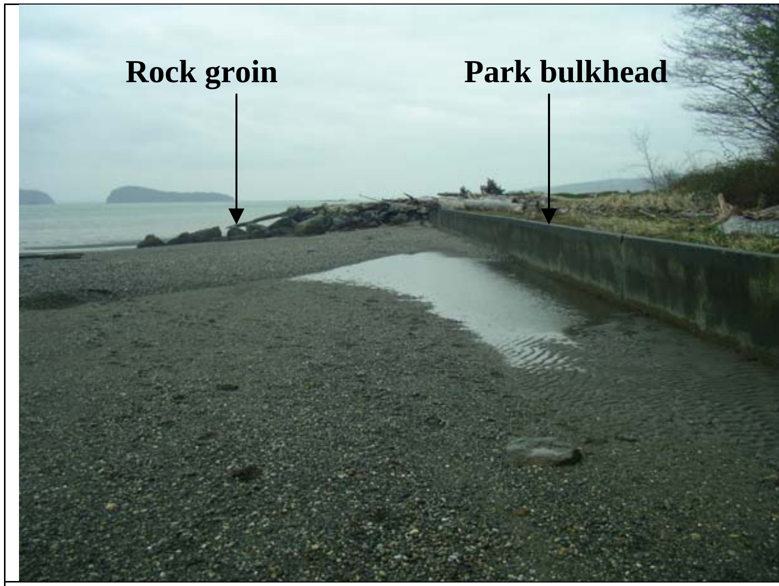


Photo 9. Rock groin and bulkhead at the Ala Spit County Park looking south during low tide conditions. March 22, 2007

Photo 10. Rock groin and bulkhead at the Ala Spit County Park looking west during low-tide conditions. March 22, 2007

Photo 11. Backfill behind the southern portion of the park bulkhead, looking north. March 22, 2007

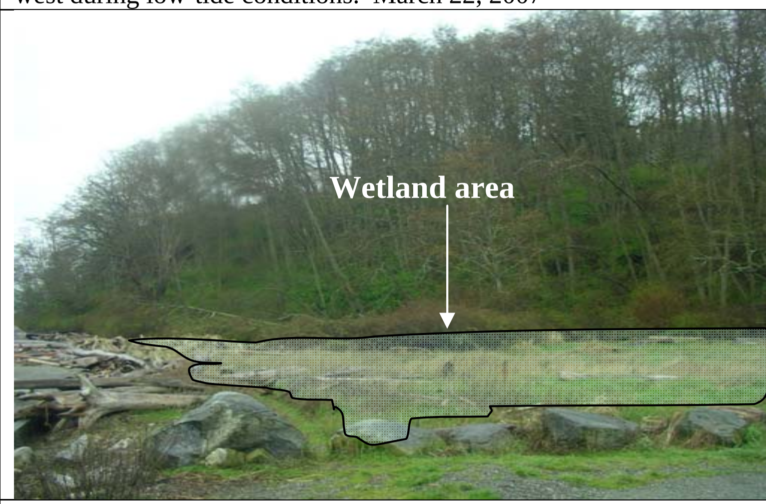


Photo 12. Wetland area located between the park bulkhead and the parking area. Looking south from the Ala Spit County Park's parking area.

Photo 13. Ala Spit pocket estuary, looking north. Note the salt marsh vegetation during low-tide conditions. March 22, 2007

Photo 14. Ala Spit pocket estuary, looking south. Note the salt marsh vegetation during low-tide conditions. March 22, 2007

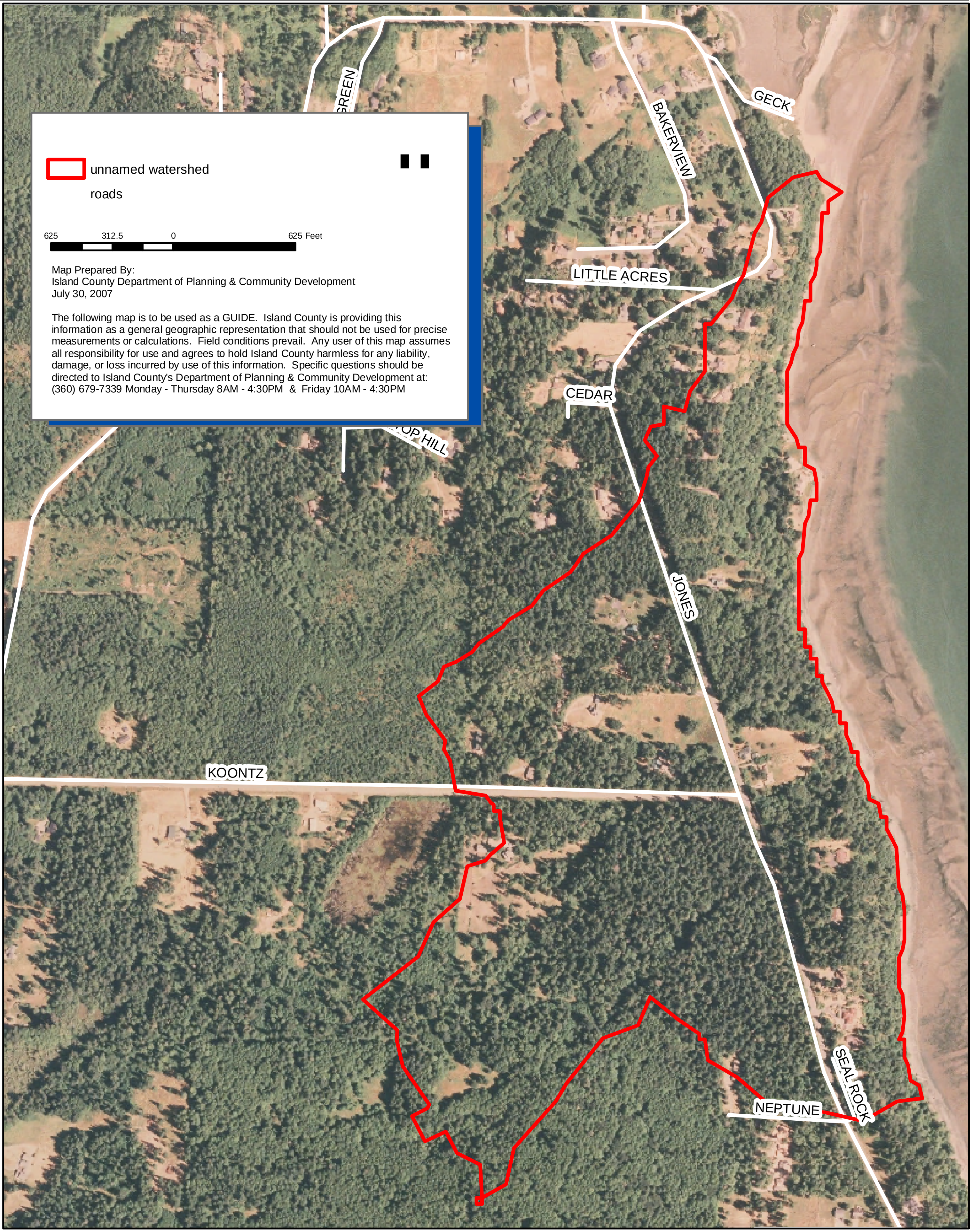
Photo 15. Wood fire at Ala Spit County Park, looking to the southeast from the spit. North Whidbey Fire and Rescue (Fire District No. 2) responded to a fire at Ala Spit at about 8:30 pm on August 15, 2007.

Photo 16. Test pit excavation for sediment thickness determination during the field assessment performed on March 22, 2007.

Island County

Department of Planning & Community Development

Ala Spit Watershed Characterization



unnamed watershed

roads

625 312.5 0 625 Feet

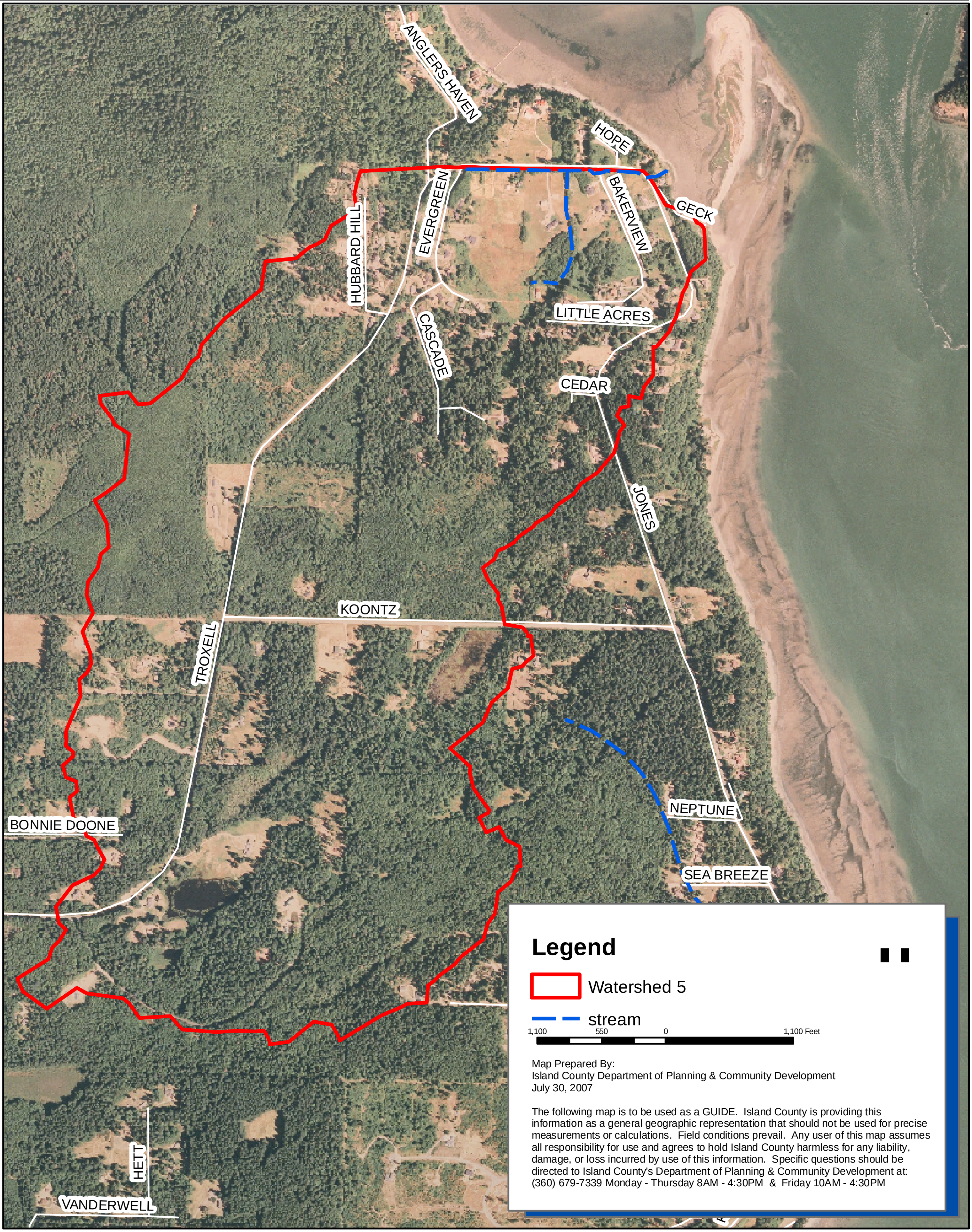
Map Prepared By:
Island County Department of Planning & Community Development
July 30, 2007

The following map is to be used as a GUIDE. Island County is providing this information as a general geographic representation that should not be used for precise measurements or calculations. Field conditions prevail. Any user of this map assumes all responsibility for use and agrees to hold Island County harmless for any liability, damage, or loss incurred by use of this information. Specific questions should be directed to Island County's Department of Planning & Community Development at: (360) 679-7339 Monday - Thursday 8AM - 4:30PM & Friday 10AM - 4:30PM

Island County

Department of Planning & Community Development

Ala Spit Watershed Characterization



APPENDIX B

Beach Profiles Along the East Side of Ala Spit

Beach Profiles Along the East Side of Ala Spit

Beach profiles were collected at the ends of the bathymetric survey lines used to create Figure 4 of the main body of the report. Because the shoreward end of the profiles was not georeferenced, the bearing of the profiles could not be obtained. However, because the gap between the extent of the terrestrial lidar and bathymetric survey was small and the slope of the foreshore is linear, the slope of the foreshore obtained from the profiles below was used to stitch the lidar data and the bathymetric into a single map and create a smooth, accurate final product (Figure 4).

Table B-1. Beach profiles along the north and east side of Ala Spit.

No.		Distance	Raw Elevation	Water on Staff	Staff Offset	NAVD Tide	Inst Ht Above Water	Water Elev – HI	NAVD Elevation
1	**Northern tip of Ala Spit**								
	Top of Bank	0	2.87	2.19	3.48	5.67	7.89	5.02	10.69
		10	4.77	2.19	3.48	5.67	7.89	3.12	8.79
		20	5.43	2.19	3.48	5.67	7.89	2.46	8.13
		30	6.03	2.19	3.48	5.67	7.89	1.86	7.53
		40	6.72	2.19	3.48	5.67	7.89	1.17	6.84
	Water's Edge	48	7.89	2.19	3.48	5.67	7.89	0.00	5.67
	Time=1518								
2	**Track Line 20**								
	Top of Bank	0	3.04	2.15	3.48	5.63	7.51	4.47	10.10
		10	5.03	2.15	3.48	5.63	7.51	2.48	8.11
		20	5.88	2.15	3.48	5.63	7.51	1.63	7.26
		30	6.85	2.15	3.48	5.63	7.51	0.66	6.29
	Water's Edge	37	7.51	2.15	3.48	5.63	7.51	0.00	5.63
	Time=1525								
	Alignment	X	Y						
	East	1216961	514643						
	West	1211664	514643						
3	**Track Line 19**								
	Top of Bank	0	1.67	2.1	3.48	5.58	6.33	4.66	10.24
		10	3.51	2.1	3.48	5.58	6.33	2.82	8.40
		20	4.69	2.1	3.48	5.58	6.33	1.64	7.22
		30	5.70	2.1	3.48	5.58	6.33	0.63	6.21
	Water's Edge	37	6.33	2.1	3.48	5.58	6.33	0.00	5.58
	Time= 1534								
	Alignment	X	Y						
	East	1216961	514293						
	West	1211664	514293						

Table B-1 (continued). Beach profiles along the north and east side of Ala Spit.

No.		Distance	Raw Elevation	Water on Staff	Staff Offset	NAVD Tide	Inst Ht Above Water	Water Elev – HI	NAVD Elevation
4	**Track Line 18**								
	Top of Bank	0	2.29	1.96	3.48	5.44	7.24	4.95	10.39
		10	3.84	1.96	3.48	5.44	7.24	3.40	8.84
		20	4.90	1.96	3.48	5.44	7.24	2.34	7.78
		30	5.69	1.96	3.48	5.44	7.24	1.55	6.99
		40	6.48	1.96	3.48	5.44	7.24	0.76	6.20
	Water's Edge	49	7.24	1.96	3.48	5.44	7.24	0.00	5.44
	Time=1541								
	Alignment	X	Y						
	East	1216961	513943						
	West	1211664	513943						
5	**Track Line 17**								
	Top of Bank	0	1.50	1.82	3.48	5.3	6.38	4.88	10.18
		10	2.70	1.82	3.48	5.3	6.38	3.68	8.98
		20	3.65	1.82	3.48	5.3	6.38	2.73	8.03
		30	4.44	1.82	3.48	5.3	6.38	1.94	7.24
		40	5.30	1.82	3.48	5.3	6.38	1.08	6.38
		50	6.19	1.82	3.48	5.3	6.38	0.19	5.49
	Water's Edge	52	6.38	1.82	3.48	5.3	6.38	0.00	5.30
	Time=1548								
	Alignment	X	Y						
	East	1216961	513593						
	West	1211664	513593						

Table B-1 (continued). Beach profiles along the north and east side of Ala Spit.

No.		Distance	Raw Elevation	Water on Staff	Staff Offset	NAVD Tide	Inst Ht Above Water	Water Elev – HI	NAVD Elevation
6	**Track Line 16**								
	Top of Bank	0	2.42	1.71	3.48	5.19	5.57	3.15	8.34
		10	4.16	1.71	3.48	5.19	5.57	1.41	6.60
		20	5.28	1.71	3.48	5.19	5.57	0.29	5.48
	Water's Edge	22	5.57	1.71	3.48	5.19	5.57	0.00	5.19
	Time=1554								
	Alignment	X	Y						
	East	1216961	513243						
	West	1211664	513243						
7	**Track Line 15**								
	Top of Bank	0	1.7	1.52	3.48	5	5.79	4.09	9.09
		10	2.75	1.52	3.48	5	5.79	3.04	8.04
		20	3.3	1.52	3.48	5	5.79	2.49	7.49
		30	3.48	1.52	3.48	5	5.79	2.31	7.31
		40	3.89	1.52	3.48	5	5.79	1.90	6.90
		50	4.21	1.52	3.48	5	5.79	1.58	6.58
		60	4.59	1.52	3.48	5	5.79	1.20	6.20
		70	4.86	1.52	3.48	5	5.79	0.93	5.93
		80	5.11	1.52	3.48	5	5.79	0.68	5.68
		90	5.5	1.52	3.48	5	5.79	0.29	5.29
	Water's Edge	97	5.79	1.52	3.48	5	5.79	0.00	5.00
	Time=1604								
	Alignment	X	Y						
	East	1216961	512893						
	West	1211664	512893						

Table B-1 (continued). Beach profiles along the north and east side of Ala Spit.

No.		Distance	Raw Elevation	Water on Staff	Staff Offset	NAVD Tide	Inst Ht Above Water	Water Elev – HI	NAVD Elevation
8	**Track Line 14**								
	Top of Bank	0	3.32	1.41	3.48	4.89	5.82	2.50	7.39
		10	4.65	1.41	3.48	4.89	5.82	1.17	6.06
	Water's Edge	19	5.82	1.41	3.48	4.89	5.82	0.00	4.89
	Time=1610								
	Alignment	X	Y						
	East	1216961	512543						
	West	1211664	512543						
9	**Track Line 13**								
	Top of Bank	0	1	1.29	3.48	4.77	5.91	4.91	9.68
		10	2.55	1.29	3.48	4.77	5.91	3.36	8.13
		20	3.42	1.29	3.48	4.77	5.91	2.49	7.26
		30	4.59	1.29	3.48	4.77	5.91	1.32	6.09
		40	5.6	1.29	3.48	4.77	5.91	0.31	5.08
	Water's Edge	42	5.91	1.29	3.48	4.77	5.91	0.00	4.77
	Time=1616								
	Alignment	X	Y						
	East	1216961	512193						
	West	1211664	512193						
10	**Track Line 12**								
	Top of Bank	0	1.1	1.17	3.48	4.65	5.46	4.36	9.01
		10	2.69	1.17	3.48	4.65	5.46	2.77	7.42
		20	3.48	1.17	3.48	4.65	5.46	1.98	6.63
		30	4.51	1.17	3.48	4.65	5.46	0.95	5.60
	Water's Edge	39	5.46	1.17	3.48	4.65	5.46	0.00	4.65
	Time=1622								
	Alignment	X	Y						
	East	1216961	511843						
	West	1211664	511843						

Table B-1 (continued). Beach profiles along the north and east side of Ala Spit.

No.		Distance	Raw Elevation	Water on Staff	Staff Offset	NAVD Tide	Inst Ht Above Water	Water Elev – HI	NAVD Elevation
11	**Track Line 11**								
	Top of Bank	0	2.3	1.04	3.48	4.52	6.73	4.43	8.95
		10	4.25	1.04	3.48	4.52	6.73	2.48	7.00
		20	5.36	1.04	3.48	4.52	6.73	1.37	5.89
		30	6.19	1.04	3.48	4.52	6.73	0.54	5.06
	Water's Edge	37	6.73	1.04	3.48	4.52	6.73	0.00	4.52
	Time=1629								
	Alignment	X	Y						
	East	1216961	511493						
	West	1211664	511493						
12	**Track Line 10**								
	Top of Bank	0	3.2	0.9	3.48	4.38	6.04	2.84	7.22
		10	4.88	0.9	3.48	4.38	6.04	1.16	5.54
	Water's Edge	19	6.04	0.9	3.48	4.38	6.04	0.00	4.38
	Time=1636								
	Alignment	X	Y						
	East	1216961	511143						
	West	1211664	511143						
13	**Track Line 9**								
	Top of Bank	0	2.28	0.8	3.48	4.28	6.31	4.03	8.31
		10	4.06	0.8	3.48	4.28	6.31	2.25	6.53
		20	5.27	0.8	3.48	4.28	6.31	1.04	5.32
	Water's Edge	30	6.31	0.8	3.48	4.28	6.31	0.00	4.28
	Time=1641								
	Alignment	X	Y						
	East	1216961	510793						
	West	1211664	510793						

NOTES:
1. Beach profiles are aligned with (1) the fall line of the beach and, except for the profile at the tip of the spit, (2) with track lines of the open water bathymetry.
2. All units are in feet. State plane coordinates are in US survey feet.

3. Horizontal datum is WA state plane – north zone (NAD83).
4. Vertical datum is North American Vertical Datum 1988 (NAVD88).
5. Alignment provides the approximate north-south orientation of the track line.
6 . Time is in Pacific Daylight Time.
7. Top of Bank is the practical top of bank. It does not include piles of logs. For all intents and purposes, it is the top of the open beach.
8. Final survey data are in the boxes. All other data are interim data.

APPENDIX C

USGS Seabed Data

USGS Seabed Data

In February 2007, the USGS tested a SWATHplus-M phase-differencing sidescan sonar system in an area near Ala Spit (USGS Cruise ID #K-1-07-PS; Finlayson [2008]). Included below is a map of bed reflectance developed from the data collected in this study. Sidescan sonar can capture both information about the reflectance of the bed and the depth of the water column. Of particular relevance to the Ala Spit project is the high reflectance of the benches fringing Ala Spit (Figure 4 of the main body of the report). The reflectance of these benches is comparable to rock outcroppings in Deception Pass, which are known to be basalt. These areas indicate that there is no deposition of recent Skagit River sediments on the benches fringing Ala Spit and that the material comprising the benches is either bedrock or well-consolidated, previously glaciated sediments (i.e., till). The following is a description of the sonar system from USGS technical staff, along with the instrument's strengths and weaknesses compared to comparable technologies.

A 234.5 kHz SEA (AP) Ltd. SWATHplus-M phase-differencing sidescan sonar was deployed on the *R/V Frontier f*or swath mapping. The SWATHplus measures the depth and sonar reflectivity of the sea floor below and to the side of the sonar transducers to a range of about five times the water depth (on each side). As the vessel progresses down the trackline, continuous pinging progressively builds an image of the sea floor one row at a time.

The system works by transmitting on one stave and receiving data on two or more staves (a conventional sidescan system transmits and receives on one stave only). The instantaneous geometry of any pair of reception staves and the currently insonified patch on the sea floor results in a phase difference in the received sonar signal from which an elevation angle is determined. Multiple pairs of staves at different spacings resolve angular ambiguities and provide redundancy in the measurements. Combined with range information (a function of sound speed and time) and other position and orientation sensors aboard the vessel, a 3D position of the insonified patch on the sea floor is determined.

Advantages: The two main advantages of bathymetric sidescan over conventional shallow-water multibeam systems is the wide swath width in shallow water (up to 8x water depth versus 3x water depth) and the lower cost (from an engineering point of view, the transducers are a much simpler design with fewer components). Also, since it is a real sidescan system, the backscatter is excellent.

Disadvantages: It does not appear to be as precise as a multibeam (larger standard deviations), although survey accuracy is comparable (mean values are close to the same). In addition, it has the classic problem of sidescan geometry: a wide nadir blind spot and angular ambiguity problems if two targets are located at the same range.

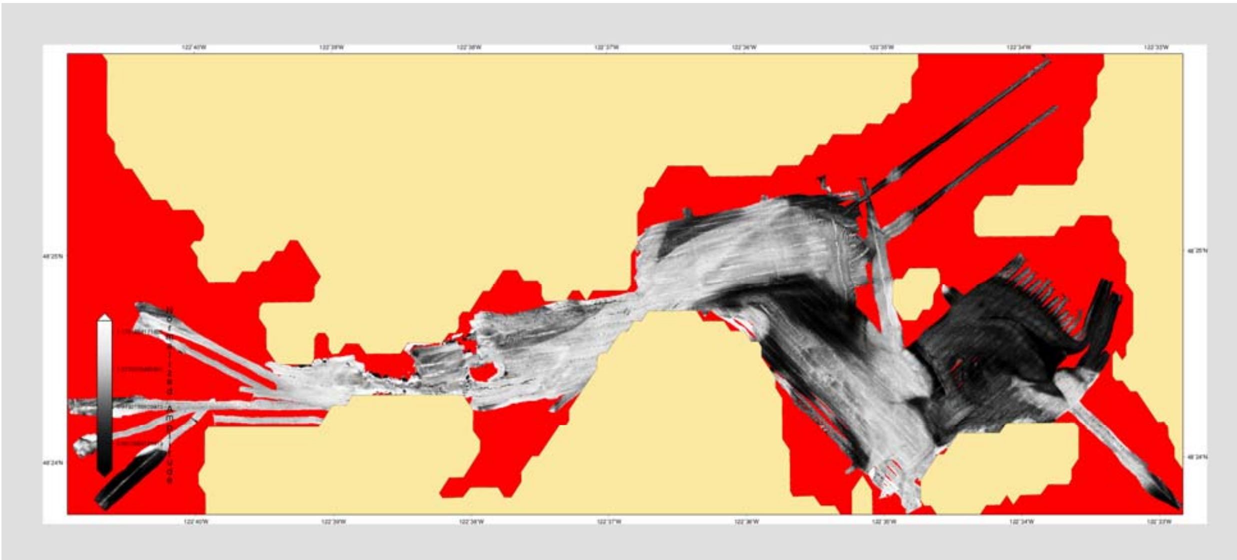


Figure C-1. Map of backscatter from the SWATHplus-M phase-differencing sidescan sonar system between Deception Pass and Ala Spit (Finlayson 2008). White areas are areas of high backscatter, while darker areas indicate lower reflectance.

Reference:

Finlayson, D. 2008. Personal communication (with Jeff Parsons, Coastal Geomorphologist, Herrera Environmental Consultants, Inc., Seattle, Washington, regarding USGS seabed data collected in the Ala Spit area). January 28, 2008.

APPENDIX D

Draft Engineering Estimate of Probable Construction Cost

Draft Engineering Estimate of Probable Construction Cost

Repair of Riprap Revetment (Alternative A)

Project: Ala Spit
Proj #: 06-03192-000
Client: Island County

Date Modified: 7/30/2007
Spread shee by: GK
Checked by:
Checked Date:

Assumptions

1 Assumes repair occures midway along 800' riprap prism
2 Assumes water does not overtop construciton access (top of existing riprap prism during repair)

Option Description and Assumptions:								
			Quantity	Unit	Unit Cost	Price	Total Price	Comments
1	**Mobilization**		1	LS	$910.00		$910	4% of all other items
2	**Stabilized Construction Entrance**		1	EA	$2,000.00		$2,000	Typical BMP, w/quarry spalls
3	**Construction Fencing**		150	LF	$2.40		$360	Installed, Discretionary use by Engineer for construction site isolation
4	**Erosion Control Blanket**		0	SY	$2.00		$0	Discretionary use by Engineer
5	**Silt Fence**		800	LF	$1.20		$960	Discretionary use by Engineer (400' on either side)
6	**Silt Curtian**		0	LF	$20.00		$0	Northwest Linings Quote (150' for ELJ 1 and 2 plus 100' for discretionary use)
7	**Straw Mulch**		0	SF	$0.20		$0	Discretionary use by Engineer
8	**Plastic Sheeting**		0	SF	$0.80		$0	Engineer's Discrection as needed
9	**Straw Wattles**		0	EA	$24.65		$0	Discretionary use by Engineer
10	**TESC O&M**		2	WK	$300.00		$600	Includes submittals, wkly report and O&M
11	**Clearing and Grubbing**		0.2	AC	$5,000.00		$964	Clearing of wood debris and tops soils
12	**Temporary Access**		200	CY	$40.00		$8,000	Quarry Spaull road (.5' deep 12' wide 800' long. Includes removal
13	**RipRap**		1	LS	$5,500.00		$5,500	Estimate
	a	Riprap	100	CY	$55.00	$5,500.00		Assumes 1-3' dia. riprap: 1/2 Trapizoidal Prism 5' wide at top 21' wide at bottom and 4' tall. Cost includes placment (end dump).
14	Restoration of Access Disturbance		1	LS	$4,340.00		$4,340	Assumed 400 lf, 21' wide
	a	Finish Grade	940	SY	$1.00	$940.00		Finish grading, gentle slopes, no survey staking/grade control assumes 21' wide by 400' long
	b	Pedestrian trail gravel	40	CY	$35.00	$1,400.00		Estimate (cost includes placment along alignment and minimal compaction)
	b	Plantings	200	SY	$10.00	$2,000		Premium seed mix w/mulch & tackifier applied at 1800lbs/acre. North West Errosion Control qoute ($1200/acre for hydro and compost additional $42/yd blown in)

15	Contingency at 30%	$7,091
Construction Subtotal		**$30,725**
16	**Consulting Sevices for Pemitting Exemption**	**$5,000**
17	**TAX (8.4%)**	**$2,581**
Total Construction Cost Subtotal		**$38,306**
18	**First repair in 2020 (6% per year inflator)**	**$81,704**
19	**Second repair in 2040 (6% per year inflator)**	**$262,036**
20	**Net present value of first repair (4% deflator)**	**$49,069**
21	**Net present value of second repair (4% deflator)**	**$71,823**
TOTAL NET PRESENT VALUE		**$120,892**

Draft Engineering Estimate of Probable Construction Cost

Removal of Riprap Revetment (Alternatives B & C)

Project: Ala Spit
Proj #: 06-03192-000
Client: Island County

Date Modified: 7/30/2007
Spread shee by: GK
Checked by:
Checked Date:

Assumptions

1 Assumes 800' long riprap prism 5' wide at the top and 21' wide at bottom (2:1 side slopes)
2 Assumes water does not overtop construciton access (top of existing riprap prism during removal) and riprap removed from outer point towards parking lot.

Option Description and Assumptions:

			Quantity	Unit	Unit Cost	Price	Total Price	Comments
1	**Mobilization**		1	LS	$2,170.00		$2,170	4% of all other items
2	**Stabilized Construction Entrance**		1	EA	$2,000.00		$2,000	Typical BMP, w/quarry spalls
3	**Construction Fencing**		150	LF	$2.40		$360	Installed, Discretionary use by Engineer for construction site isolation
4	**Erosion Control Blanket**		0	SY	$2.00		$0	Discretionary use by Engineer
5	**Silt Fence**		1600	LF	$1.20		$1,920	Discretionary use by Engineer
6	**Silt Curtian**		0	LF	$20.00		$0	Northwest Linings Quote (150' for ELJ 1 and 2 plus 100' for discretionary use)
7	**Straw Mulch**		0	SF	$0.20		$0	Discretionary use by Engineer
8	**Plastic Sheeting**		0	SF	$0.80		$0	Engineer's Discrection as needed
9	**Straw Wattles**		0	EA	$24.65		$0	Discretionary use by Engineer
10	**TESC O&M**		2	WK	$300.00		$600	Includes submittals, wkly report and O&M
11	**Clearing and Grubbing**		0.2	AC	$5,000.00		$964	Clearing of wood debris and tops soils
11	**Temporary Access**		200	CY	$40.00		$8,000	Quarry Spaull road (.5' deep 12' wide 800' long. Includes removal
12	**Excavation/Haul**		1	LS	$38,500.00		$38,500	Estimate
	a	Riprap Excavation	1100	CY	$15.00	$16,500.00		Assumes 1-3' dia. riprap: Trapizoidal Prism 5' wide at top 21' wide at bottom and 4' tall. Assumes 2/3 volume is riprap?Included loading in dump truck
	b	Concrete Debris Excavation	600	CY	$15.00	$9,000.00		Assumes Trapizoidal Prism 5' wide at top 21' wide at bottom and 4' tall. Assumes 1/3 volume is Concrete Debris?Included loading in dump truck
	d	Haul, rt, 12 CY dump	1700	CY	$5.00	$8,500.00		12yd drop axel truck/ Includes sorting of Concrete and Riprap and 30 minute rt.
	e	Disposal	900	TN	$5.00	$4,500.00		(Disposal of riprap free at Boulder Pit, Concrete $5/ton at batch plant with or without rebar: Nor'West Concrete (Ron Vandam 360-708-1326). (Boulder Pit approx 3-4 miles from site: Batch Plant 30 minutes RT)
13	Restoration of Excavatioin Disturbance		1	LS	$1,870.00		$1,870	Assumed 800 lf, 21' wide
	a	Finish Grade	1870	SY	$1.00	$1,870.00		Finish grading, gentle slopes, no survey staking/grade control assumes 21' wide by 800' long
	b	Plantings	0	SY	$10.00	$0		Premium seed mix w/mulch & tackifier applied at 1800lbs/acre. North West Errosion Control qoute ($1200/acre for hydro and compost additional $42/yd blown in)

14	Contingency at 30%	$16,916
Construction Subtotal		**$73,300**
15	**Oversight**	$0
16	**TAX (8.4%)**	**$6,157**
TOTAL		**$79,457**

APPENDIX E

Large Woody Debris Data

Woody Debris Point Counts

Point	Diameter	Total	Anchored	Non-anchored	Length <10'	Length > 10'
Point 1	< 6"	92		92		
	6" - 1'	9		9		
	1' - 2'	5		5		
	> 2'	5	2	3		

Point	Diameter	Total	Anchored	Non-anchored	Length <10'	Length > 10'
Point 2	< 6"	27		27	27	
	6" - 1'	7		7		7
	1' - 2'	7		7		7
	> 2'	3		3	3	

Point	Diameter	Total	Anchored	Non-anchored	Length <10'	Length > 10'
Point 3	< 6"	80		80	80	
	6" - 1'	8		8	4	4
	1' - 2'	5	3	2	2	3
	> 2'	4		4		4

Point	Diameter	Total	Anchored	Non-anchored	Length <10'	Length > 10'
Point 4	< 6"	53		53	53	
	6" - 1'	14		14	12	2
	1' - 2'	7		7	4	3
	> 2'	3		3	1	2

Notes:

1 - Points are not the same as wrack width measurements

Wood Wrack Width Point #	Width*
1	13' 4"
2	10' 6"
3	15' 0"
4	24' 7"
5	16' 5"
6	20' 5"
7	36' 0"
8	38' 0"
9	77' 5"
10	10' 6"
11	26' 11"
12	11' 0"
13	18' 8"

Notes:

* Width is distance cross-shore from berm to end of wracked debris

1 - Points are not the same as point counts