PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION STUDY

DRAFT INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT

October 2014

Prepared In Support of

US Army Corps of Engineers
Seattle District

PUGET SOUND NEARSHORE
ECOSYSTEM RESTORATION PROJECT

Washington Department of
FISH and WILDLIFE

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*These headings and all sub-sections therein are required by the National Environmental Policy Act.

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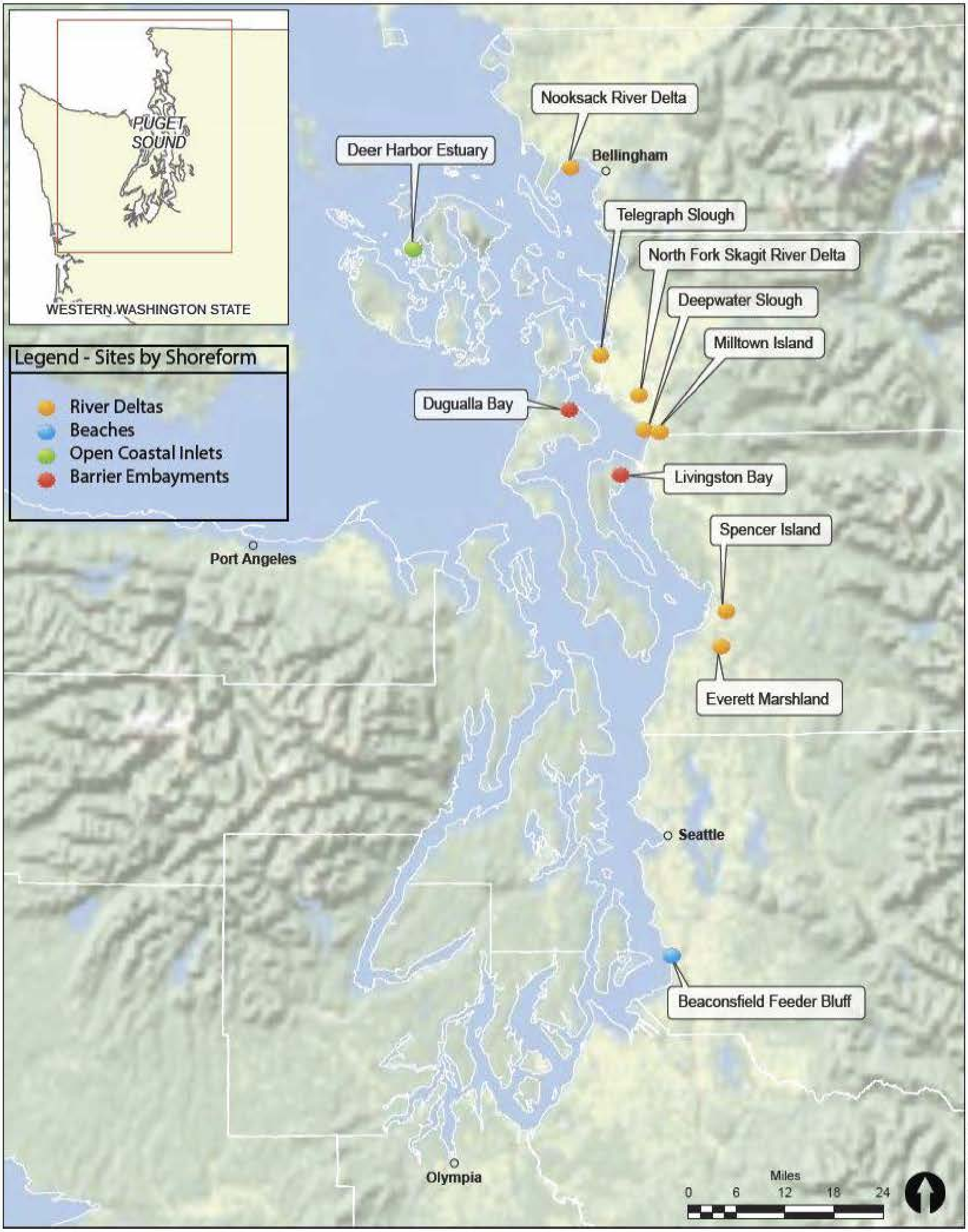
EXECUTIVE SUMMARY

The Seattle District Corps of Engineers (Corps), working collaboratively with the Washington Department of Fish and Wildlife (WDFW) as local sponsor, along with many other regional partners, has conducted a General Investigation (GI) to evaluate problems and potential solutions of ecosystem degradation and habitat loss in Puget Sound, Washington. The Puget Sound Nearshore Study (Nearshore Study) is authorized under Section 209 of the River and Harbor Act of 1962 (Pub. L. 87–874). The Corps and local sponsor are recommending implementation of restoration actions at 11 sites throughout the study area as the outcome of the Nearshore Study. The estimated project first cost to restore these sites is $1.1 billion (October 2014 price level).

The Puget Sound region is generally characterized by steep terrain (mountains, bluffs, etc.), bordered by a relatively narrow band of nearshore shorelines. These shoreline zones transition quickly to the deep waters of Puget Sound. The beaches, embayments, and delta shorelines of Puget Sound's nearshore zone are the most impacted by human changes. These areas are ciritical in providing ecologically important connections between terrestrial, freshwater, and marine ecosystem types. Therefore, the nearshore zone is the strategic focus for Puget Sound recovery and the Puget Sound Nearshore study. The nearshore zone includes beaches and the adjacent top of coastal banks or bluffs, the shallow waters in estuarine deltas, and tidal waters from the head of tide to a depth of approximately 10 meters. This contiguous band around the shoreline of the study area hosts diverse ecosystems that are shaped by coastal geomorphology and local environmental conditions, such as wave energy, salinity, and geology. Analysis of this complex system was based on the scientific guidance provided by the Nearshore Study's interdisciplinary team of scientists. The Nearshore Science Team (NST) has overseen the delivery of a series of peer-reviewed technical reports that provide the foundation of the Nearshore Study. These analyses led to identification of a problem of national significance, and to planning objectives necessary to address identified issues.

The 11 sites included in the tentatively selected plan (TSP) range from six to 1,800 acres; total acreage of the proposed sites is over 5,300 acres. Costs, including final engineering design, environmental compliance, real estate, construction, and post-project monitoring, range from $4 million to over $300 million per site. The sites included in the TSP are geomorphically representative of the entire study area. The TSP includes seven sites in major river deltas, one beach site, one open coastal inlet site, and two barrier embayment sites. All 11 sites of the TSP include critical habitat for Endangered Species Act (ESA) listed species. Geographical locations of the 11 sites of the TSP are included in the figure below.



Restoration Sites Identified by the Nearshore Study for the Tentatively Selected Plan.

Local, state, tribal, and Federal agencies, along with concerned citizens, nonprofit organizations, ports, and businesses recognize the need to identify nearshore ecosystem problems, evaluate potential solutions, and to restore and protect the critical ecosystem services of the nearshore zone. The proposed actions in the Nearshore Study are integral to this comprehensive restoration effort.

The Federal and State plan to accomplish Puget Sound recovery is the Puget Sound Action Agenda. The Action Agenda is prepared by the Puget Sound Partnership (PSP), a state agency, but is endorsed by the U.S. Environmental Protection Agency for this estuary of national significance under the National Estuary Program. In consultation with other state agencies, Federal agencies, tribal governments, industry representatives, and others, the PSP has documented priorities for Puget Sound recovery and implementing the restoration actions proposed by the Nearshore Study is identified in the Action Agenda as a near-term priority for Puget Sound recovery. In addition, authorization and implementation of the sites included in the TSP would significantly contribute to the Action Agenda target of restoring 7,380 acres of estuarine habitat by 2020.

The Nearshore Study is also highlighted in a multi-agency (Federal) Action Plan that addresses the protection and restoration of Puget Sound and the Washington coast. The Action Plan responds to recent concerns raised by Western Washington Treaty Tribes about continued habitat losses and associated diminishment of fishery resources.

As of 2014, 13 fish and marine mammal species in Puget Sound are listed as threatened or endangered or identified as candidate species under the ESA. Within the Study area, there are three listed endangered species and 10 threatened species. Recovery plans for eight of the ESA-listed species have been or are being developed by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Fish and Wildlife Service. Actions proposed by the Nearshore Study support salmon recovery consistent with NOAA's salmon recovery plans.

Based on principles of landscape ecology and ecological restoration, and consistent with Corps planning guidance, the Nearshore Study has identified principles for nearshore restoration that support a process-based approach. Process-based restoration includes intentional changes made to an ecosystem to allow natural processes, including unconstrained tidal hydrology, natural sediment erosion and accretion, and accumulation of driftwood, to occur. Restoration typically involves actions supporting or restoring the dynamic processes that generate and sustain desirable nearshore ecosystem structure (e.g., eelgrass beds) and functions (e.g., salmon production, bivalve production, and clean water). In most cases, this involves removing or modifying human-built structures that have interfered with essential ecosystem processes. Process-based restoration is distinguished from species-based restoration, which aims to improve habitat conditions for a single species or group of species. Nearshore Study objectives seek to benefit the entire ecosystem, with associated improvements in the delivery of broader ecosystem goods and services.

The results of the Nearshore Study are based on a comprehensive analysis of historical and current conditions in the Puget Sound nearshore zone. Technical reports characterize the impacts of shoreline and watershed alterations on nearshore ecosystem processes, identify the fundamental causes of the observed ecosystem degradation, and assess which of the causes most need to be addressed through restoration. The *Change Analysis* "is a comprehensive, spatially-explicit assessment of the extent of change over Puget Sound's shorelines, estuaries, and deltas". The Change Analysis quantified structural and physical change between historical (1850s to 1890s) and current (2000 to 2006) conditions. Building on the results of Change Analysis, the *Strategic Needs Assessment* developed a complementary evaluation tool to investigate the degree of degradation to nearshore ecosystem processes. Evaluation of the Change Analysis and Strategic Needs Assessment results led the NST to identify six major changes to the physical characteristics of nearshore ecosystems of Puget Sound. These changes can be grouped into two broad categories: 1) significant direct changes to the nearshore ecosystems of Puget Sound; and 2) widespread and pervasive changes. These observations support a science-based *Problem Statement*, providing the basis for Nearshore Study planning objectives.

The planning objectives articulate the Nearshore Study's goal to restore the physiographic processes that sustain the Puget Sound nearshore ecosystem and associated diverse nationally and regionally significant resources. The planning objectives include the following:

- Restore the size and quality of large river delta estuaries
- Restore the number and quality of coastal embayments
- Restore the size and quality of beaches
- Increase understanding of natural process restoration in order to improve effectiveness of program actions

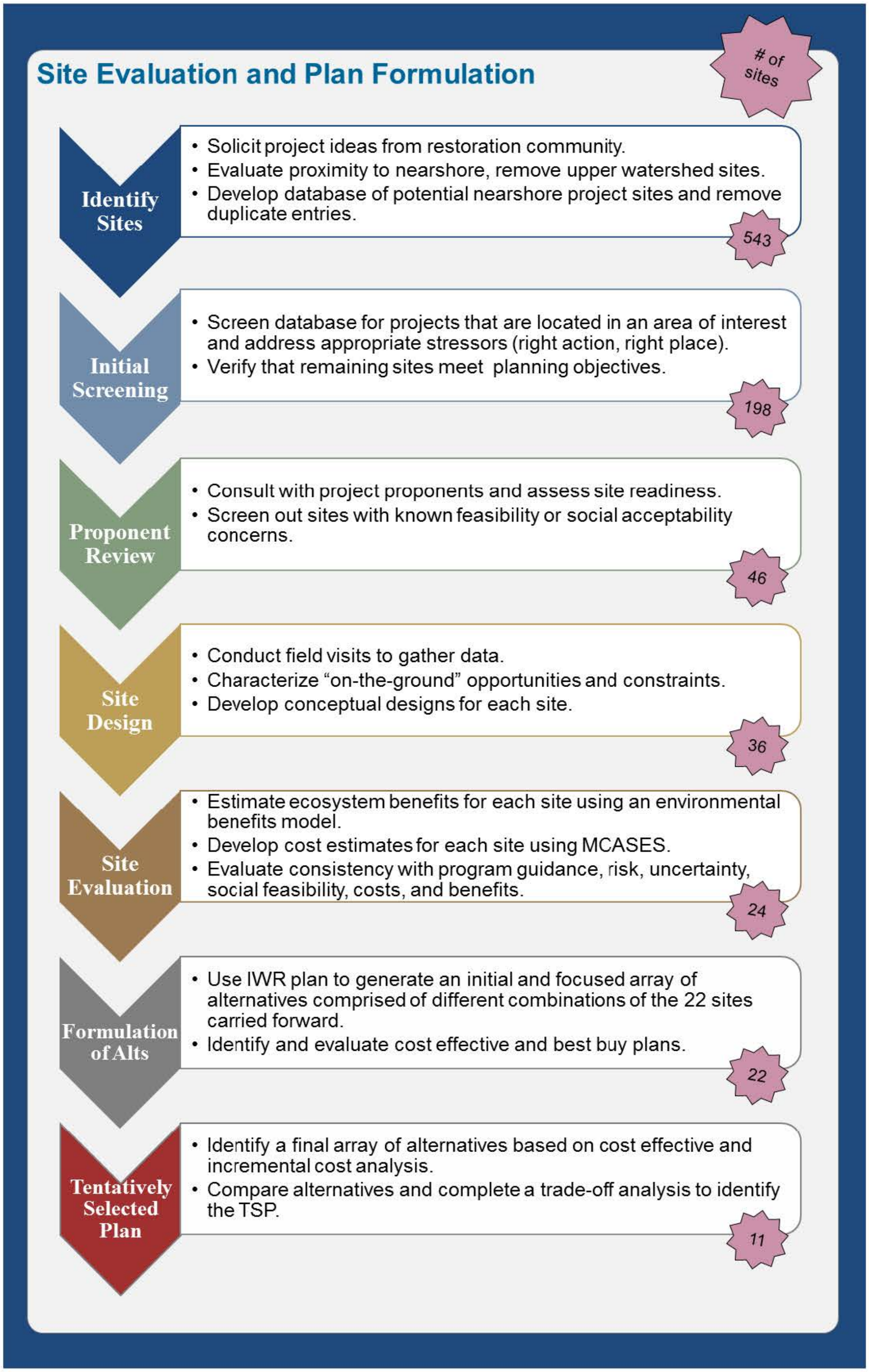
To identify the "right places" for achieving planning objectives, the Study team developed a *strategy* for determining where process-based restoration would have the greatest likelihood of success. The Study team has undertaken a comprehensive plan formulation process; over 500 potential restoration sites initially identified by the diverse group of restoration practitioners in Puget Sound were systematically evaluated using habitat modeling, cost-effectiveness and incremental cost analysis (CE/ICA), and design and cost evaluations. Based on this methodical evaluation, the potential restoration sites were screened and compared to identify the 11 sites included in the Tentatively Selected Plan. The result is a restoration strategy informed by contemporary ecological restoration science and consistent with current and emerging Corps policy for ecosystem restoration.

The 11 sites included in the TSP address planning objectives for all habitat types including seven river deltas, one coastal inlet, two barrier embayments, and one beach system. Sites in the proposed plan include the following:

- Beaconsfield Feeder Bluff
- Deepwater Slough
- Deer Harbor
- Dugualla Bay
- Everett Marshland
- Livingston Bay
- Milltown Island
- Nooksack River Delta
- North Fork Skagit River Delta
- Spencer Island
- Telegraph Slough

The Study team used the process illustrated in the figure below to formulate and evaluate alternatives, ultimately selecting an 11-site TSP.

Benefits from this preferred alternative would derive from removing nearly 75,162 linear feet of shoreline stressors (including tidal barriers, nearshore fill, and shoreline armoring); thereby restoring processes that would create an additional 5,354 acres of tidally influenced wetlands in river deltas and shallow embayments, as well as sustain beach ecosystems. These actions would restore wetlands that have either been lost due to fill or blocked via tidal barriers, and sediment transport and delivery to beaches and embayments. Many of the ESA-listed species in Puget Sound impacted by habitat loss or degradation would benefit from restoration actions, either directly by using the restored habitat (as is the case for listed salmonids) or indirectly via reliance of their prey on the habitat (as is the case for killer whales and murrelets). The Nearshore Study has also identified “valued ecosystem components” (VECs) that are likely to be enhanced by nearshore restoration, have direct or indirect value to humans socially, culturally, or environmentally, and are recognized as emblematic of a healthy Puget Sound. Socially significant VECs include coastal forests, beaches and bluffs, eelgrass and kelp, forage fish, great blue heron, juvenile salmon (including three ESA-listed species), killer whales (ESA-listed), native shellfish (includes one state candidate species), and nearshore birds (including one ESA-listed species). Ultimately, the restoration actions proposed by the Nearshore Study are integral to a comprehensive effort to restore Puget Sound.


Site Evaluation and Plan Formulation
# of sites
Identify Sites
• Solicit project ideas from restoration community.
• Evaluate proximity to nearshore, remove upper watershed sites.
• Develop database of potential nearshore project sites and remove duplicate entries.
543
Initial Screening
• Screen database for projects that are located in an area of interest and address appropriate stressors (right action, right place).
• Verify that remaining sites meet planning objectives.
198
Proponent Review
• Consult with project proponents and assess site readiness.
• Screen out sites with known feasibility or social acceptability concerns.
46
Site Design
• Conduct field visits to gather data.
• Characterize "on-the-ground" opportunities and constraints.
• Develop conceptual designs for each site.
36
Site Evaluation
• Estimate ecosystem benefits for each site using an environmental benefits model.
• Develop cost estimates for each site using MCASES.
• Evaluate consistency with program guidance, risk, uncertainty, social feasibility, costs, and benefits.
24
Formulation of Alts
• Use IWR plan to generate an initial and focused array of alternatives comprised of different combinations of the 22 sites carried forward.
• Identify and evaluate cost effective and best buy plans.
22
Tentatively Selected Plan
• Identify a final array of alternatives based on cost effective and incremental cost analysis.
• Compare alternatives and complete a trade-off analysis to identify the TSP.
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1 INTRODUCTION

This report documents the planning process for ecosystem restoration of the Puget Sound nearshore zone, to demonstrate consistency with U. S. Army Corps of Engineers (Corps) planning policy and to meet National Environmental Policy Act (NEPA) requirements. The study documented herein has been conducted jointly by the Corps and the Washington Department of Fish and Wildlife (WDFW). The following sections provide background information so that the reader can understand the basis for this study. The study is named Puget Sound Nearshore Marine Habitat Restoration, WA, in annual Energy and Water Appropriation Acts. Hereinafter, the study is called the Puget Sound Nearshore Study (Nearshore Study).

1.1 STUDY AUTHORITY*

This Puget Sound Nearshore Study is authorized under Section 209 of the River and Harbor Act of 1962 (Pub. L. 87–874), which states:

"The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which include the following named localities: …Puget Sound, Washington, and adjacent waters, including tributaries, in the interest of flood control, navigation, and other water uses and related land resources."

This authority led to the comprehensive plan documented in the *Comprehensive Study of Water and Related Land Resources: Puget Sound and Adjacent Waters* (Puget Sound Task Force 1971), an effort conducted by state and Federal officials led by the Corps, submitted through the president's Office of Management and Budget in 1974. Recommendations included actions that would increase production of anadromous fish, shellfish, and marine fish; a study of marine beach and shore erosion; a long-term study of sediment production, movement, and its effects to economic and ecologic factors; and a coordinated sea coast resource management program that recognizes the area's combined estuaries and related shorelands as one of the area's most valuable geographic features.

The Puget Sound Nearshore Study was initiated as a Corps Civil, Title 1, general investigation study under Public Law 106-60 (29 September 1999). This authority states:

"The following appropriations shall be expended under the direction of the Secretary of the Army and the supervision of the Chief of Engineers for authorized civil functions of the Department of Army pertaining to rivers and harbors, flood control, beach erosion, and related purposes."

General investigation funds are used for the collection and study of basic information pertaining to rivers and harbors, flood control, shore protection and related projects, restudy of authorized projects, miscellaneous investigations, and, when authorized by laws, surveys and detailed studies, and plans and specifications of projects, prior to construction.

1.2 STUDY AREA AND LOCATION

The waters of Puget Sound receive all of the drainage from surrounding watersheds that cover more than 16,988 square miles, a watershed collectively referred to as the Puget Sound Basin. This basin is bordered on the east by the Cascade Mountains and on the west by the Olympic Mountains. The Puget Sound Nearshore Study area consists of the nearshore zone of the Puget Sound Basin including the Puget Sound, the Strait of Juan de Fuca, and southern portions of the Strait of Georgia that occur within the borders of the United States (Figure 1-1). While the basin occurs largely within northwestern Washington State, two of its headwater drainages originate just across the border in Canada. The study area shoreline has a length of approximately 2,466 miles. The basin is roughly 80 percent land and 20 percent water. The total water area covers nearly 3,090 square miles at mean high water.

For the purpose of this study, the study area has been divided into seven sub-basins based on geographic features including oceanographic sills and bathymetry, common issues and interests of the entities in these areas, and the water flow patterns. These sub-basins are the following:

- Strait of Juan de Fuca
- San Juan Islands – Georgia Strait
- Hood Canal
- North Central Puget Sound
- Whidbey
- South Central Puget Sound
- South Puget Sound

Five of these sub-basins are included within the watershed area of Puget Sound proper. The other two study area sub-basins include areas of the Strait of Juan de Fuca and the Georgia Strait seaward to the international boundary. Within these sub-basins, the study area consists of the entire nearshore zone, which includes beaches and the adjacent tops of coastal banks or bluffs, the shallow waters in estuarine deltas, and tidal waters from the head of tide to a depth of approximately 10 meters (m) relative to the mean lower low water (MLLW) level (Figure 1-2). This contiguous band around the shoreline of the entire study area hosts diverse ecosystems that are shaped by coastal geomorphology and local environmental conditions, such as wave energy and salinity.

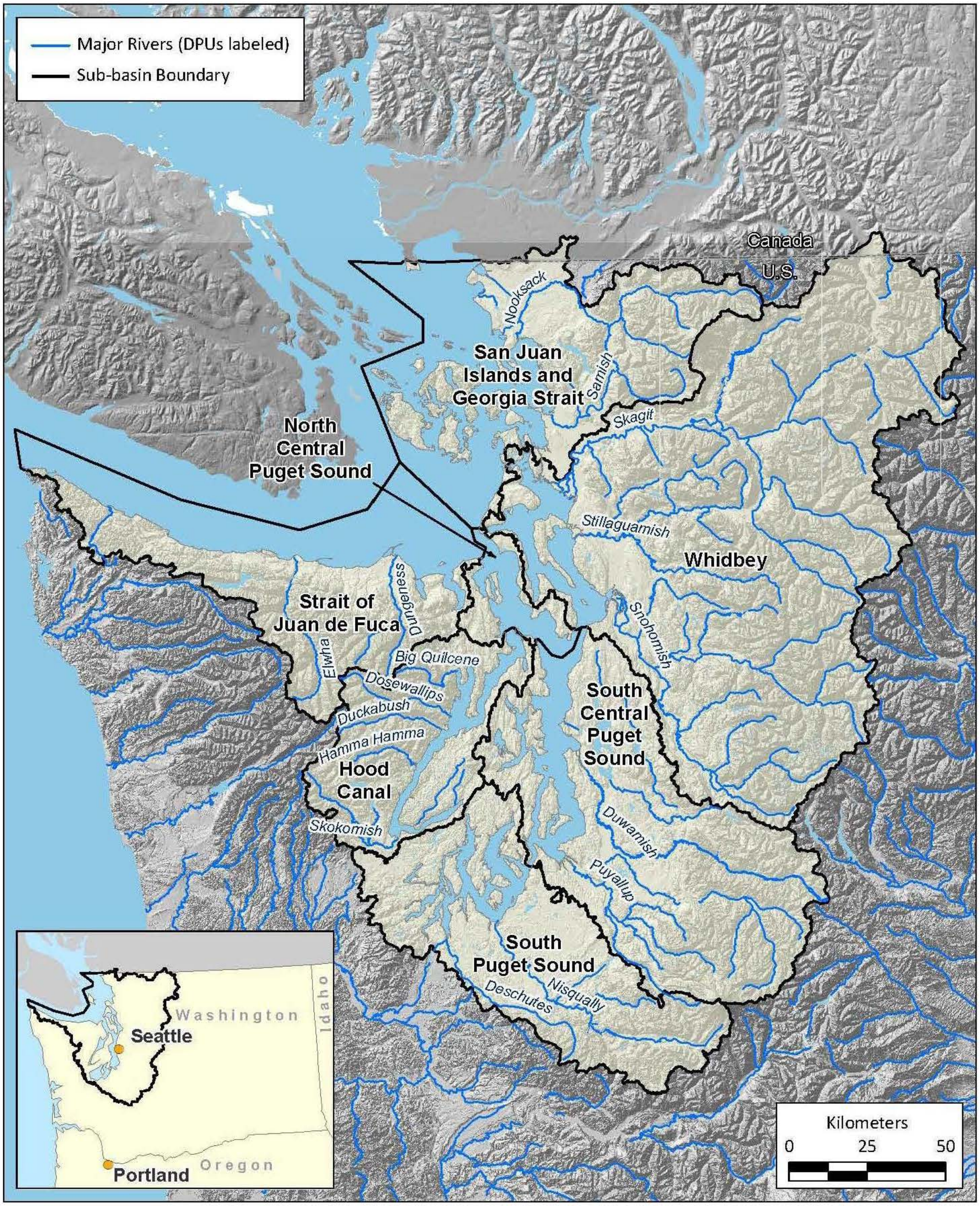


Figure 1-1. Puget Sound Nearshore Study Area with Delineated Sub-basins

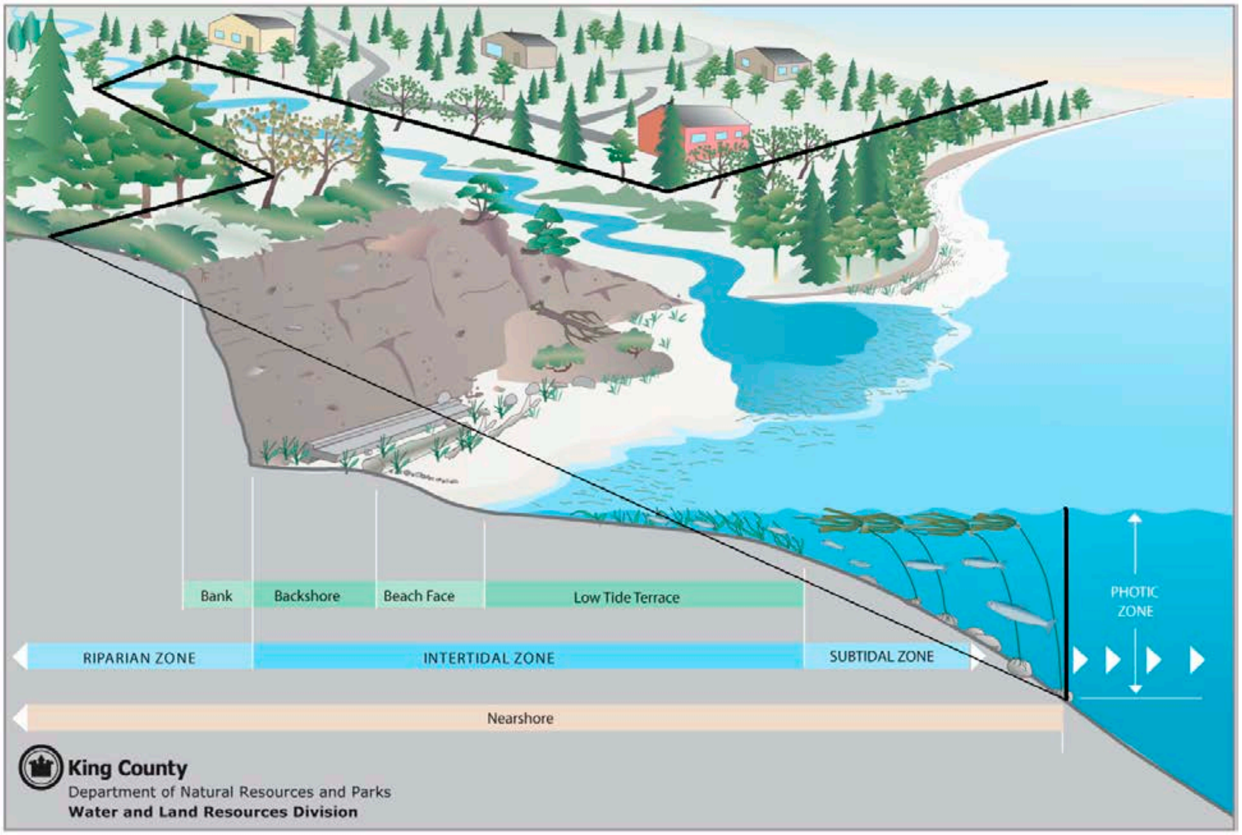


Figure 1-2. Boundaries of Nearshore Ecosystem between Riparian and Subtidal Zones

1.3 STUDY PURPOSE AND SCOPE

The focus of this study is the Puget Sound nearshore zone, the transitional zone between major ecosystem types: terrestrial, freshwater, and marine. Many of the important and unique characteristics of Puget Sound depend upon the nearshore zone, including its high biological productivity, complex food webs, diverse habitats, and large numbers of plants and animals that occupy these habitats (Kozloff 1973; Sound Science 2007). Conditions in Puget Sound provide the context for the nearshore zone issues addressed in this study. The purpose of the Puget Sound Nearshore Study is to evaluate ecosystem degradation in the Puget Sound Basin; to formulate, evaluate, and screen potential solutions to these problems; and to recommend sites that have a Federal interest and the support of a local entity willing to provide necessary local cooperation. Collectively, these restoration actions will be the recommended plan (also referred to as the tentatively selected plan (TSP) or, in the case of NEPA, the preferred alternative).

The Puget Sound Nearshore Study aims to address the continuing degradation of nearshore ecosystems through restoration of natural processes (e.g., sediment movement and tidal hydrodynamics) and restoration and/or re-creation of coastal wetlands and embayments. Scientists have extensively studied the historical character of the marine shoreline to understand the natural processes that sustain the ecosystem. Restoration projects will be designed to advance the natural processes that occur at specific sites working within the constraints of their adjacent landscape. Since other Federal and state initiatives are working to address other aquatic and terrestrial ecosystem degradation throughout the region, the Puget Sound Nearshore Study does not formally consider other types of environmental concerns in Puget Sound, such as those related to water quality, contaminants, stormwater, or land use management. These concerns are taken into consideration during the evaluation of alternatives, as they may affect the success or failure of projects proposed as part of the Nearshore Study, but they are being formally addressed outside of this study. The Project Delivery Team (PDT) is a multi-disciplinary, multi-agency team responsible for the successful development and execution of all aspects of the study. The PDT (also referred to as the Study team) comprises six standing teams, with agency, non-governmental organization and other representatives serving in multiple capacities. Composition of the PDT appears in Chapter 8. The PDT established the following three goals for restoration of the Puget Sound nearshore zone:

- Restore and protect nearshore processes that sustain the ecological health of Puget Sound
- Restore and protect ecosystem functions and structures that support valued ecosystem components (VECs)
- Increase understanding of the Puget Sound nearshore zone to improve restoration and protection actions

The following are Puget Sound Nearshore Study efforts that have been completed in the past few years or are planned in the near future:

- Identify and inventory physical changes to the Puget Sound nearshore zone.
- Identify the most critical physical process needs of the nearshore zone.
- Evaluate conceptual alternatives for meeting these physical process needs.
- Identify near-term (i.e., within 10 years) restoration projects and programs that address the most critical needs in a cost-effective manner.
- Establish priorities among the identified near-term restoration projects and programs.
- Establish a process to implement the near-term restoration projects and programs.
- Identify the key scientific uncertainties and engineering challenges in restoration of nearshore ecosystem processes and propose a strategy for resolving these issues.

The Study has identified and evaluated ecosystem degradation in the Puget Sound Basin, and then formulated, evaluated, and screened potential solutions to these problems. The Study team is recommending a coordinated and feasible series of restoration sites to address the identified physical process needs and restoration opportunities that have a Federal interest and a local entity willing to promote the necessary local cooperation. Implementation of the recommended Puget

Sound Nearshore Study sites will ensure significant progress toward achieving and sustaining nearshore physical processes that are vital to the ecosystem goods and services that human and natural communities have come to rely on and value.

1.4 STUDY BACKGROUND

The reconnaissance phase of the study, initiated on September 29, 1999, found that there was a Federal interest in continuing the study to the feasibility phase, in accordance with guidelines in Section 905(b) of the Water Resources Development Act (WRDA) of 1986. The Washington Department of Fish and Wildlife, as the non-Federal sponsor, and the Corps initiated feasibility phase of the study on September 25, 2001. The feasibility phase cost was shared equally between the Corps and the sponsor. This report presents the results of both phases of study.

1.5 PURPOSE AND NEED FOR PROPOSED ACTION*

The purpose of the proposed action is to restore the natural processes in the nearshore zone that sustain the biological, economic, and aesthetic resources important to the people of the Puget Sound region and the nation in a cost-effective and socially feasible manner with minimal risks, and to facilitate effective monitoring and adaptive management to maximize attainment of restoration objectives.

Puget Sound is home to approximately 4.3 million people, about 70 percent of Washington State's population, and has become the economic hub of the northwestern United States and an American global trade center on the Pacific Rim. Many of the region's natural resources play a major role in the economic well-being and standard of living in the area. A healthy Puget Sound is integral to the regional economy. Chapter 3 of this report provides a detailed account of nearshore ecosystem problems that have given rise to the need for a comprehensive restoration effort requiring the assistance of the Federal government.

The need for the proposed action comes from recognizing that valuable natural resources in Puget Sound have declined to a point that the ecosystem may no longer be self-sustaining without immediate intervention to curtail significant ecological degradation. Impairment of nearshore processes and degradation of ecosystem functions are critical factors in the declining health of Puget Sound. Anthropogenic stressors causing this impairment and degradation include the direct effects of physical alterations to the landscape that have eliminated large expanses of habitat and have disrupted the major ecological processes that create and sustain habitats (see Section 1.8.4 for more information on stressors). The degradation and loss of nearshore ecosystems is of critical importance because the nearshore zone serves as the connection between terrestrial, freshwater, and marine ecosystems. This means that the nearshore zone vitality, resilience, and productivity influence the productivity of the entire Puget Sound Basin. The alterations to the physiographic processes of the nearshore zone directly affect the ecosystem functions, goods, and services upon which humans depend.

As of 2014, 13 fish and marine mammal species in Puget Sound were listed as threatened or endangered or identified as candidate species under the Federal Endangered Species Act (ESA). Within the Study area, there are three listed endangered species and 10 threatened species. Many of the ESA-listed species in Puget Sound impacted by habitat loss or degradation would benefit from restoration actions, either directly by using the restored habitat (as is the case for listed salmonids) or indirectly via reliance of their prey on the habitat (as is the case for killer whales and murrelets).

Many entities are working to address water quality, population and economic growth management, cleanup of toxic substances, and stream restoration; however, there has not been a coordinated effort to restore critical nearshore ecosystems and the natural processes that sustain them. Local, state, tribal, and Federal agencies, along with concerned citizens, nonprofit organizations, port authorities, and other entities recognize the need to identify nearshore ecosystem problems, evaluate potential solutions, and restore and protect the critical ecosystem services of the nearshore zone. Because of the inherent complexities associated with the nearshore zone (varied ownership, mixed land use, etc.), solutions to restoration in the nearshore zone are beyond the capabilities of private entities, non-governmental organizations, or local governments, and are more suited to Federal interests taking the lead and playing a key role in the broader restoration effort. The Corps is well suited to take the lead on this large-scale restoration effort and has the ability to use expertise in water-related resource problems to seek construction authority on restoration efforts in the nearshore zone.

1.6 PROPOSAL FOR FEDERAL ACTION

The proposal to implement ecosystem restoration at sites in the Puget Sound Basin triggered the NEPA process recorded in this document (40 CFR 1501.2). Based on the results of more than 10 years of conducting the Nearshore Study, the Corps is proposing a suite of ecosystem restoration sites around the Puget Sound nearshore zone. The types of nearshore features identified for restoration include freshwater and tidal wetlands, coastal embayments, intertidal mudflats, reconnection of estuarine tidal channels, and sediment delivery from bluff-backed beaches. Restoration of these features and natural processes requires removal of human stressors that have reduced ecosystem functions in the nearshore zone. The proposed restoration measures are to remove stressors such as shoreline armoring and bank stabilization, tidal barriers, wetland fill, overwater structures, and tidal channel restrictions.

Nearshore Study recommendations include ecosystem restoration sites located around Puget Sound. Details on each of the proposed sites are located in Section 4.6. The Corps and WDFW selected the proposed sites based on strategies developed to meet the Nearshore Study’s planning objectives. These sites range from six to 1,800 acres with costs ranging from $4 million to over $300 million per project. The Corps has identified a subset of all proposed sites as the preferred alternative (also known as the recommended or Tentatively Selected Plan), and it is analyzed as one of the alternatives presented in Section 4.7 (40 CFR 1502.14).

In addition to construction projects that restore ecosystem processes, the Corps intends to establish a plan to ensure that monitoring and adaptive management are applied appropriately and efficiently. The purpose of this plan is to maximize attainment of nearshore ecosystem restoration objectives by optimizing efficacy of individual restoration actions, and to facilitate communication among the restoration community regarding successes and challenges. This will provide a mechanism to integrate emerging technologies and best available science into the planning process. The monitoring and adaptive management plan is described in Section 6.6.

1.7 PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

The Corps Seattle District has conducted other general investigations and has implemented other ecosystem restoration projects around Puget Sound prior to initiating the Puget Sound Nearshore Study. Lessons learned and data from these studies have been incorporated into the Puget Sound Nearshore Study where appropriate.

1.7.1 Corps Studies in the Puget Sound Area

General investigation studies underway in the Puget Sound region are listed in Table 1-1.

Table 1-1. General Investigations Underway in the Puget Sound Area

Study Name	Purpose	Description
Skokomish River General Investigation	Ecosystem Restoration	Investigate restoration measures along the Skokomish River, which drains to Hood Canal, a naturally formed fjord of the Puget Sound Basin.
Skagit River General Investigation	Flood Risk Management	Investigate flood risk management measures along the Skagit River, which drains to Skagit Bay, Puget Sound.
Puyallup River General Investigation	Flood Risk Management	Investigate flood risk management measures along the Puyallup River, which drains to Commencement Bay, Puget Sound.
Seattle Harbor General Investigation	Deep Draft Navigation	Investigation navigation improvements to the East and West Waterways of Seattle Harbor.

1.7.2 Corps Ecosystem Restoration Projects in the Puget Sound Area

Authorized and/or completed restoration projects in the Puget Sound area appear in Table 1-2.

Table 1-2. Corps Ecosystem Restoration Projects in the Puget Sound Area

Project Name	Authorization	Description
Puget Sound and Adjacent Waters Restoration Program (PSAW)	WRDA[a] 2000	Restoration studies underway include the Nooksack River Dam Removal and Dungeness River ecosystem restoration.
Qwuloolt Ecosystem Restoration	PSAW - WRDA 2000	Construction underway to restore tidal processes to 400 acres of previously diked pasturelands.

Project Name	Authorization	Description
Seahurst Beach Restoration Phases 1 and 2	PSAW - WRDA 2000	Phase 1 construction was complete in 2005. Phase 2 construction is underway with scheduled completion in August 2014. Both phases restore approximately 1 mile of nearshore habitat through removal of shoreline armoring.
Stillaguamish River Ecosystem Restoration Project	WRDA 2000	Restoration of 10 sites along the Stillaguamish River including three estuary sites.
Green-Duwamish Ecosystem Restoration Project	WRDA 2000	Authorizes 45 site-specific (including 3 estuary sites) and programmatic restoration sites throughout the Green-Duwamish River Basin. Six projects have been completed, one is currently under construction, and one more is nearing the construction phase.
Deepwater Slough Estuarine Restoration Project – Phase I	Section 1135 [b]	Deepwater Slough was the largest estuarine restoration project in Puget Sound when it was implemented, opening 230 acres of intertidal and tidal channel habitat.
Carpenter Creek Estuarine Restoration Project	Section 206 [c]	The project was authorized to improve tidal flushing at two undersized culverts, reduce tidal velocities, remove fish passage barriers, and reduce habitat fragmentation restoring 22 acres of estuarine and salt marsh habitat. The local sponsor constructed this project.
Green/Duwamish River (at Codiga Farms site) Restoration Project	Section 1135	This project created 830 linear feet of side-channel rearing habitat for juvenile salmon, a half-acre estuarine marsh, and 1.6 acres of riparian and upland planting to support wildlife.
Green/Duwamish River Turning Basin (at Hamm Creek) Restoration Project	Section 1135	The project restored a highly degraded tributary to the Duwamish River including a new 1,000-foot channel with soil amendments and plantings.
Lake Washington Ship Canal Smolt Passage Project	Section 1135	The project implemented numerous measures to minimize abrasion injury and mortality to juvenile salmon including installation of smolt flumes over the dam.
Union Slough Restoration Project	Section 1135	The project breached levees and opened 35 acres to tidal influence in the Snohomish River Estuary.

a. WRDA – Water Resources Development Act
b. Section 1135 of the Water Resources Development Act of 1986
c. Section 206 of the Water Resources Development Act of 1996

1.8 PUGET SOUND NEARSHORE STUDY SYSTEMS APPROACH

Corps guidance (Engineer Pamphlet [EP] 1165-2-502 [USACE 1999a]) states, “ecosystem restoration is a primary mission of the [Corps] Civil Works program. … the purpose of Civil Works ecosystem restoration activities is to restore significant ecosystem function, structure, and dynamic processes that have been degraded. Improving the long-term survival of self-sustaining systems delivers improved conditions for fish and wildlife resources.”

The Puget Sound Nearshore Study approach is consistent with Corps policies on ecosystem restoration planning. The study bases its investigation on numerous scientific studies and findings that recognize ecosystem processes as key system drivers that, if degraded, have long-lasting, spatially extensive effects on biological communities. While difficult to assess directly, ecosystem processes are manifested in the natural landforms that they create and maintain. By completing detailed characterizations of marine landforms using historical and current data, and projections of future conditions, the Puget Sound Nearshore Study has been able to infer the state of natural process degradation within Puget Sound. These findings serve as the condition that can be expected in Puget Sound if a project is not authorized and implemented. Figure 1-3 shows the major documents associated with plan formulation of the Nearshore Study.

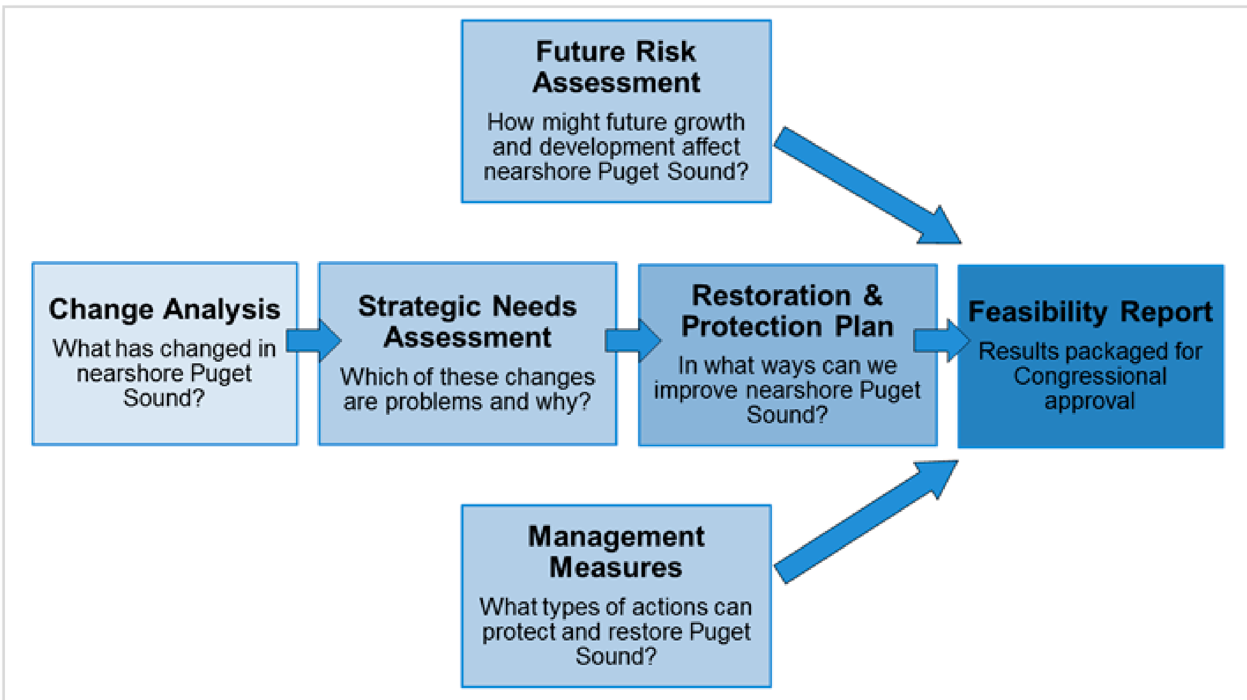


Figure 1-3. Supporting Documents in the Nearshore Study Planning Process

1.8.1 Process-based Restoration

Ecosystem processes are the interactions among physiochemical and biological elements of an ecosystem that change in character or state over time (Fresh et al. 2004). Processes operate at naturally occurring rates, frequencies, durations, and magnitudes that are controlled by human and natural factors (Goetz et al. 2004). Human attempts to control or "fix" dynamic coastal systems (such as beaches, bluffs, floodplains, and river deltas) using structural approaches (such as groins, bulkheads, dikes, and levees) disrupt the natural processes and degrade nearshore ecosystems. Restoration actions aimed at restoring damaged processes enable the ecosystem to be naturally productive, self-sustaining, and diverse (Goetz et al. 2004).

The Puget Sound Nearshore Study has identified guiding principles for nearshore ecosystem restoration that favor process-based restoration over species-based restoration (see sidebar). Key physical processes such as tidal hydrology and sediment supply are understood to be essential to biotic function. The study identifies three main reasons for favoring process-based restoration (Simenstad et al. 2006):

- Without restored processes, the long-term maintenance of the structure and its associated ecological functions is highly uncertain.
- The processes are inherently involved in the functions to be recovered.
- Incorporating or accepting natural ecosystem dynamics is less likely when considering only the services an ecosystem provides to a single species.

A detailed discussion of a process-based restoration approach, as applied by the Puget Sound Nearshore Study, is provided in "Introduction and Background" of the Management Measures Technical Report (Clancy et al. 2009).

Process-based restoration includes intentional changes made to an ecosystem to allow natural processes (such as erosion, accretion, accumulation of wood debris, etc.) to occur. This restoration typically involves actions supporting or restoring the dynamic processes that generate and sustain desirable nearshore ecosystem structure (e.g., eelgrass beds) and functions (e.g., salmon production, bivalve production, and clean water). Process-based restoration is distinguished from species-based restoration, which aims to improve the services an ecosystem provides to a single species or group of species as opposed to improving elements that support the entire ecosystem.

Alterations to natural processes alter nearshore ecosystem structures (e.g. river deltas, beaches, and coastal embayments) that provide ecosystem goods and services. Sound Science (2007) defines ecosystem services as the outputs and experiences of ecosystems that benefit humans, which are generated by the structure and function of natural systems, often in combination with human activities. The Puget Sound Nearshore Study refers to these benefits collectively as ecosystem functions, goods, and services (EFG&S).

1.8.2 Conceptual Model Used to Support Process-Based Restoration

The Puget Sound Nearshore Study approach to process-based restoration relies upon conceptual models explaining the linkages between nearshore ecosystem processes, structures/systems, habitats, and ecological functions. These linkages, depicted in Figure 1-4 for Puget Sound beaches, are based on the Puget Sound Nearshore Study's underlying scientific hypothesis that "alterations of natural hydrologic, geomorphologic (i.e., pertaining to geological structure), and ecological processes impair important nearshore ecosystem structure and functions" (Simenstad et al. 2006).

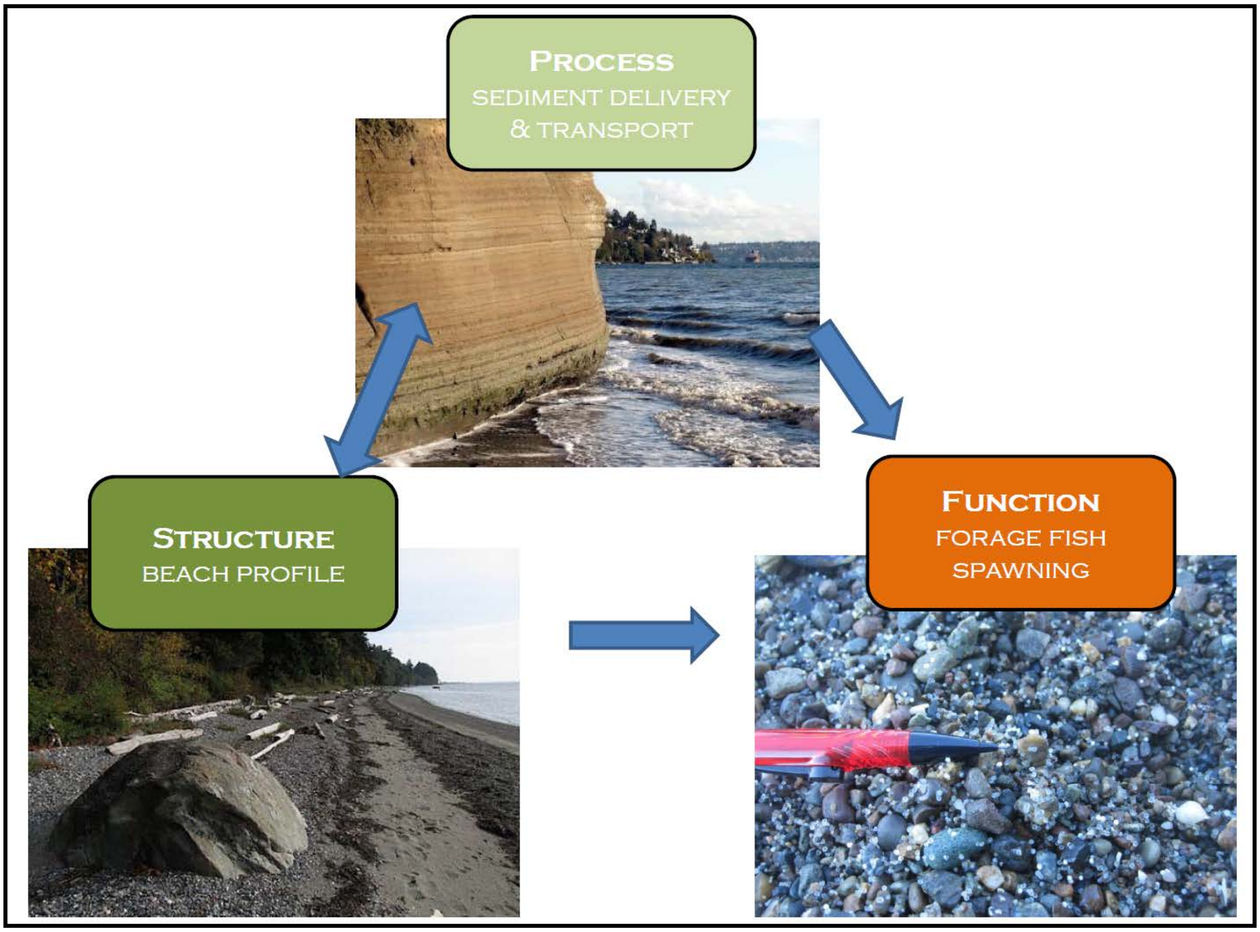


Figure 1-4. Beach Conceptual Model of Relationship of Process, Structure, and Function

1.8.3 Change Analysis

The change analysis of the Puget Sound nearshore zone (Change Analysis; Simenstad et al. 2011) serves as ". . . a comprehensive, spatially explicit assessment of the extent of change over Puget Sound's shorelines, estuaries and deltas." The change analysis report provides a detailed discussion of the Study team's approach and results in assessing change between historical and current conditions. The report provides detail on data structure and components for the Puget Sound-wide geodatabase assembled for this analysis (Simenstad et al. 2011).

The Change Analysis quantified structural and physical change between historical (ca. 1850s – 1890s) and current (ca. 2000 – 2006) conditions. This analysis correlates the location, occurrence, and amount of stressor impacts on nearshore ecosystems in the context of dominant ecosystem processes. Finally, the analysis interpreted the spatially explicit significance of the various changes and stressors in terms of impairment to EFG&S.

To provide a spatially explicit accounting of nearshore ecosystem process changes, the Puget Sound shoreline was delineated into geomorphically similar segments (landforms) based on the adopted geomorphic classification system (Shipman 2008). This classification provided the basis for independently classifying both historical and current landforms that reflect varying sedimentation processes (beaches) and freshwater inflow and tidal mixing (estuaries/deltas) as the dominant controlling factors.

Ecosystem functions, goods, and services (EFG&S) are the outputs and experiences of ecosystems that humans value, which are generated by the structure and function of natural systems, often in combination with human activities (Sound Science 2007). These services have been described to include: fish, shellfish, and wildlife; water filtration; water supply, wastewater treatment; floodwater absorption and attenuation; storm surge protection; recreation; and aesthetics. Ecosystem goods and services have been categorized as provisioning, regulating, cultural and supporting (Millennium Ecosystem Assessment 2005)

Because of the Nearshore Study's emphasis on addressing change in nearshore ecosystem processes, this analysis was organized around the spatial limits of two prominent nearshore ecosystem "process unit" types: 1) shoreline process units for beaches associated with littoral drift cells, where the primary ecosystem process is sediment delivery and transport along the beach; and 2) delta process units in large river deltas and drainages, where the ecosystem is organized by flooding duration and frequency and different salinity ranges. The resulting change analysis geodatabase documents changes over the (current) approximately 2,466 miles of Puget Sound shoreline and corresponding 13,930 square miles of drainage area. Change is characterized at each of the 828 process units: 812 shoreline process units and 16 delta process units.

Historical change was analyzed for each process unit in Puget Sound, as well as in each sub-basin, in the following four categories, which are also referred to as "tiers" because of the nested scales they represent:

- Landform Transition (Tier 1): changes in landform composition
- Shoreline Alterations (Tier 2): changes in historic attributes, such as wetlands, or human modifications (considered stressors) along the shoreline
- Adjacent Upland Change (Tier 3): human changes within 200 m of the adjoining uplands
- Watershed Area Change (Tier 4): human changes in the drainage area

Change data is tabulated and mapped in a variety of analytical outputs at the individual process unit level and summarized within Puget Sound sub-basins, among sub-basins, and Sound-wide. An example graph showing Landform Transition (Tier 1) from historic to current at the Puget Sound-wide scale is provided in Figure 1-5.

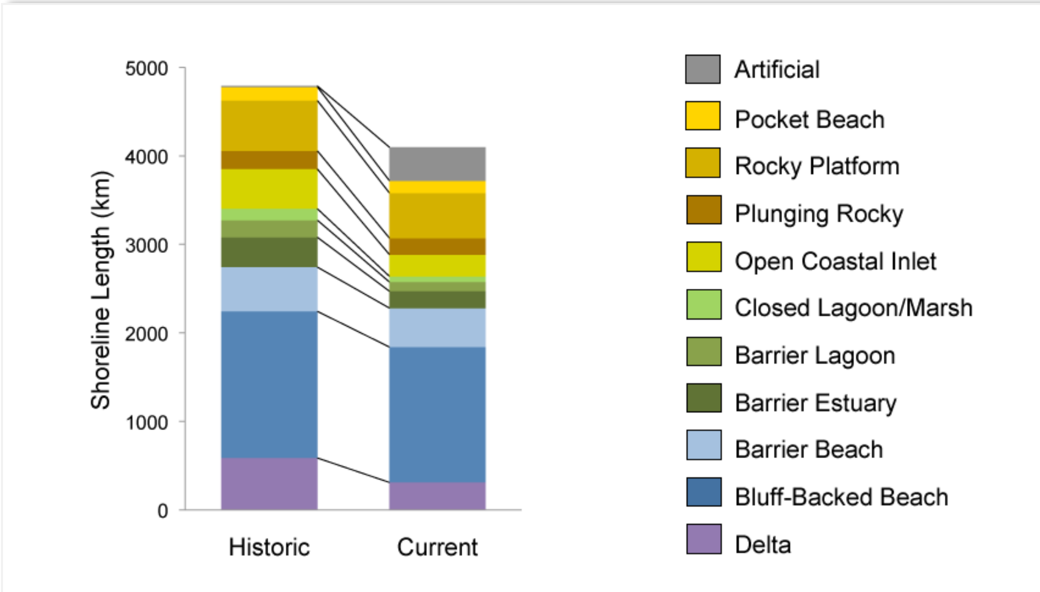


Figure 1-5. Puget Sound-wide Landform Transitions (from Simenstad et al. 2011)

1.8.4 Strategic Needs Assessment

The purposes of the strategic needs assessment (Schlenger et al. 2011a) were to characterize the impacts of shoreline and watershed alterations on nearshore ecosystem processes, identify the fundamental causes of the observed ecosystem degradation, and assess which of the causes most need to be addressed in this feasibility study through restoration and protection alternatives. Specifically, the assessment does the following:

- Explains the impacts of stressors (human alterations) along shorelines and in watersheds on the nearshore processes that create and sustain the ecosystems.
- Explains the resulting effects of the impacted nearshore processes on nearshore habitat structures and functions.
- Presents a spatial analysis that applies a set of rules to assess nearshore ecosystem process degradation resulting from human alterations to physical conditions along the shoreline and throughout the watershed.
- Uses spatial analysis outputs to identify and characterize locations and magnitudes of degradation of nearshore ecosystem processes Sound-wide and in each of the sub-basins.
- Presents a discussion of the major physical changes and problems affecting the overall function of the Puget Sound nearshore ecosystems.
- Identifies recommended priorities for locations and nearshore processes to be addressed through restoration and conservation.

While the change analysis results identify ecosystem impairment (as measured by EFG&S scores), Schlenger et al. (2011a) developed a complementary methodology to investigate the degree of degradation to nearshore ecosystem processes as part of the strategic needs assessment. To develop this tool, the Study team documented the current scientific understanding of the impacts that shoreline and upland stressors (human alterations) have on nearshore ecosystem processes, habitat structures, and functions. For each stressor, a separate section of the strategic needs assessment report was prepared, using available scientific literature to explain the linkages among stressors, processes, structures, and functions. In addition, each section described the impacts of the stressors on socially important biota and habitats, and the distribution of the stressor throughout Puget Sound and the sub-basins.

Although many datasets that were considered desirable for inclusion in the strategic needs assessment analysis were evaluated, several were rejected because they provided data for one or more sub-basins but would not support comparable analysis at the Sound-wide scale (Simenstad et al. 2011). The ability to support Sound-wide comparable analysis was one of the criteria for approving datasets. One example of a rejected dataset is the nearshore-dredging dataset. The 12 stressors considered in the Nearshore Study (Table 1-3) were limited to those physical stressors for which sufficient Sound-wide data were available. Some of these stressors lie directly along the nearshore zone, while some are features within the contributing watershed.

Table 1-3. Nearshore Stressors

Stressor	Description
Tidal barriers	Structures (e.g., dikes and levees) designed to impede tidal flow
Nearshore fill	Material placed below the ordinary high water mark (OHWM) to create upland area
Shoreline armoring	Shore-parallel erosion control structures, such as bulkheads and rock revetments
Nearshore railroads	Active and abandoned railroads within 25 meters of the shoreline
Nearshore roads	Roads along the shoreline and within 25 meters of the shoreline
Marinas	Temporary and permanent boat slips, and associated in-water facilities to accommodate vessel moorage and upland support facilities
Breakwaters and jetties	Structures designed to mitigate the impact of wave energy
Overwater structures	Large industrial/commercial docks, single-family residence docks, floating docks, fixed piers, bridges, floating breakwaters, moored vessels
Dams	Barriers that block the flow of water in a stream or river channel
Stream crossings	Places where transportation corridors (i.e., roads and railroads) cross rivers, streams, and estuaries
Impervious surfaces	Pavement, buildings, and other largely impermeable areas
Developed land cover	Type of human feature present on the surface of the earth

The strategic needs assessment presents a process evaluation framework used to assess the degree of degradation for each of the nearshore ecosystem processes. This framework assesses co-occurrence of stressors that degrade ecosystem processes along the portions of the nearshore zone that support these important processes. An overall characterization combining the observed degradation of all 12 processes was presented for shoreline and delta process units (Figure 1-6).

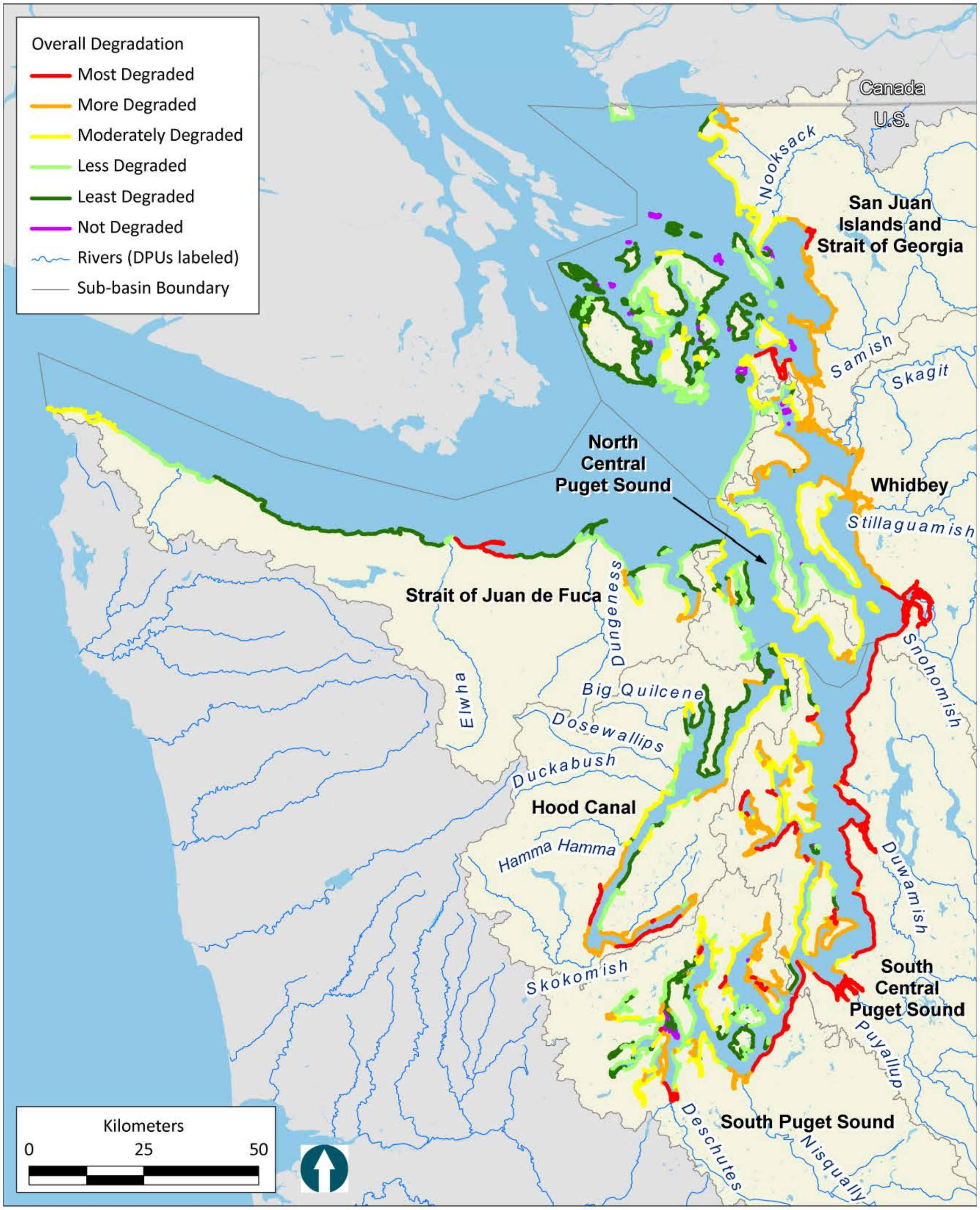


Figure 1-6. Puget Sound-wide Degree of Process Degradation (from Schlenger et al. 2011a)

1.8.5 Problem Statement

The Nearshore Science Team (NST; see section 8.1.3 for a description) identified six major changes to the physical characteristics of the nearshore ecosystems of Puget Sound, based on the team's evaluation of findings in the change analysis and the strategic needs assessment. These changes are described and summarized in a comprehensive document commonly referred to as "the problem statement" (Fresh et al. 2011). Changes have two broad categories: 1) direct changes to nearshore ecosystems; and 2) widespread and pervasive changes. These observations support a science-based problem, providing a focus for evaluating restoration alternatives and formulating a restoration plan.

Significant direct changes to nearshore ecosystems include the following:

1. Large river deltas have been widely impacted by multiple alterations that significantly limit the size of the estuaries and degrade the nearshore ecosystem processes that support them. For the 16 largest river deltas in Puget Sound combined, shoreline length has declined nearly 27% from historical conditions (Fresh et al. 2011).

2. Many coastal embayments, including open coastal inlets, barrier estuaries, barrier lagoons, and closed lagoons/marshes, have been eliminated or disconnected from Puget Sound by the placement of fill, tidal barriers, and other stressors. Puget Sound has experienced a loss of 305 embayment landforms (from 884 under historical conditions to 579 currently). The length of embayment landforms in Puget Sound declined nearly 46% (Fresh et al. 2011).

3. Stressors along beaches and bluffs have disconnected sediment inputs and altered sediment transport and accretion along long sections of the Puget Sound shoreline. Approximately 27% of the shoreline of Puget Sound is armored; 59% of divergent zones (a major source of sediment to Puget Sound beaches) have some armoring associated with them (Fresh et al. 2011).

4. Estuarine wetlands have been extensively lost throughout Puget Sound, including a loss of 56% in the 16 largest river deltas. In particular, oligohaline and freshwater tidal wetlands have been almost completely eliminated (loss of 93%) in Puget Sound (Fresh et al. 2011).

Widespread and pervasive changes include the following:

1. The shoreline of Puget Sound has become much shorter and simpler, as well as more artificial. Since Europeans began settling the region, Puget Sound's shoreline has had a net decline of 15% in length. Artificial landforms now represent 10% of the shoreline of Puget Sound (Fresh et al. 2011).

2. Large portions of Puget Sound have been altered by multiple types of changes that may cumulatively combine to severely degrade nearshore ecosystem processes. Approximately 40% of the shoreline of Puget Sound has been altered by a stressor (e.g., overwater structures, roads, marinas, etc.). Only 112 of 828 natural shoreline segments (encompassing all of Puget Sound's

shoreline with the exception of large deltas) have no stressor associated with them (Fresh et al. 2011).

The cumulative effects of these multiple human-induced stressors threaten to overwhelm the ability of naturally occurring ecosystem processes to maintain structures, biological resources, and ultimately, the goods and services provided by the ecosystem. Thus, the synergistic efforts of restoring the nearshore processes, structures, and functions must be thoroughly coordinated and pursued simultaneously with other restoration efforts, such as the protection of water quality, freshwater resources, good land use practices, and human health.

The effects of ecosystem degradation and potential restoration opportunities are illustrated in Figure 1-7 and Figure 1-8. These images show a typical Puget Sound nearshore site not included in this study, Seahurst Beach, as a reference condition for similar sites under consideration in the Nearshore Study. These figures illustrate the site in a formally degraded condition followed by restoration of approximately 2 miles of nearshore habitat through removal of shoreline armoring. These images depict the typical types of degraded processes in the nearshore zone as well as a reference condition for a site that has undergone process-based restoration.

Figure 1-7. Reference Condition: Seahurst Beach "Before" Process-Based Restoration

Figure 1-8. Reference Condition: Seahurst Beach "After" Process-Based Restoration

1.8.6 Restoration and Protection Strategies

To inform restoration and protection strategies so that actions are directed toward "sites where we can best protect and restore nearshore ecosystem services", Cereghino et al. (2012) have further evaluated the results of the change analysis and the strategic needs assessment. This evaluation seeks to answer the following questions about nearshore ecosystem restoration and protection:

1. Where should we try to recover the ecosystem services we have lost?
2. How should our approach respond to the variable conditions found in the landscape?
3. How should we consider an individual project as part of a cohesive landscape strategy?
4. What kinds of opportunities and risks should we keep in mind as we work in different settings?

By applying principles proposed by Goetz et al. (2004) and ecosystem restoration theory reviewed by Greiner (2010), river deltas, beaches, barrier embayments, and coastal inlets were categorized based on attributes of opportunity, degradation, and risk. Statistical treatment of these attributes suggests organizing sites into groups in which management strategies of protection, restoration, or enhancement are most likely to be successful (Figure 1-9). These recommendations are identified for each landform type (e.g., beaches or embayments), but not across types. The authors (Cereghino et al. 2012) explain, "Our strategies do not attempt to compare deltas to beaches or beaches to inlets. We need deltas, beaches, embayments, and inlets to restore historical ecosystem services in the nearshore zone. The physical structure of the landscape defines landform, and the potential for a landscape to provide these services."

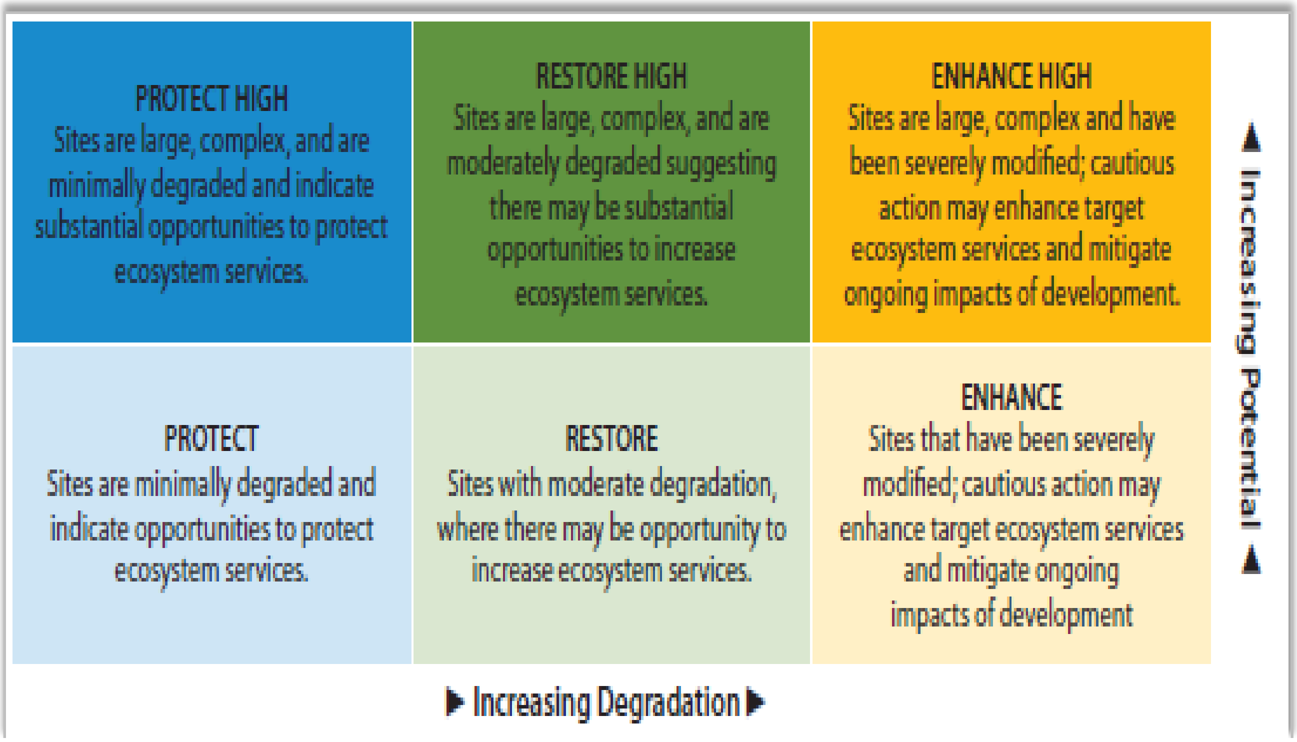


Figure 1-9. Types of Sites Where Protection, Restoration, or Enhancement is Likely to Succeed

In evaluating potential restoration actions, the Study team used preliminary results from the Restoration and Protection Strategies evaluation, hereafter called the "Strategies Report" (Cereghino et al. 2012), to determine whether each proposal could support restoration objectives with the "right action in the right place." (More detail on this concept is provided in Section 4.1)

1.9 REPORT ORGANIZATION: INTEGRATION OF NEPA COMPLIANCE & THE PLANNING PROCESS

This document is an integrated Draft Feasibility Report and Environmental Impact Statement (DFR/EIS). The purpose of the feasibility report is to identify the plan that reasonably maximizes ecosystem restoration benefits, is technically feasible, and preserves environmental and cultural values. The purpose of the EIS portion of the report is to identify and present information about any potentially significant environmental effects of the alternatives and to incorporate environmental concerns into the decision-making process.

1.9.1 The 6-Step Corps Planning Process and NEPA Requirements

The six steps of the Corps planning process each align with a NEPA requirement. The planning steps are listed below followed by the document chapter and NEPA element to which they relate:

Planning Step	Document Chapter and NEPA Element:
Step one **– specification of problems and opportunities**	Appears in Chapter 2, as described in the need for and objectives of the action.
Step two **– inventory, forecast, and analysis of resource conditions within the study area**	Appears in Chapter 3, which describes the existing conditions of the study area, and Chapter 5 with the comparison of the action alternatives to the no-action alternative, also known as the future without-project condition.
Step three **– formulation of alternative plans**	Appears in Chapter 4 in the description of the screening process and formulation of alternative plans.
Step four **– evaluation of the effects of the alternative plans**	Appears in Chapter 5 with the comparison of how each alternative affects the significant resources identified in Chapter 3.
Step five**– comparison of the alternative plans**	Begins near the end of Chapter 4 after the description of the alternatives and continues in Chapter 5 with the comparison of how each alternative would affect the significant resources.
Step six**– selection of the recommended plan**	Appears in Chapter 6 and includes details of the Tentatively Selected Plan

1.9.2 NEPA Scoping and Identification of Issues*

Scoping took several forms for this DFR/EIS. The various committees of the Nearshore Study consist of regional experts in natural resources and ecosystem restoration programs; these individuals and committees have been discussing the significance of issues related to the project throughout the life of the Study, and those concepts are captured within this document. Additionally, the primary project delivery team consulted natural resource agencies such as the NMFS and U.S. Fish and Wildlife Service, and held internal meetings to discuss the scope of issues included in this report. Furthermore, the Corps and WDFW hosted public meetings to solicit comments from the public about their concerns for this project. The comprehensive list of activities is detailed in Section 8.3. The significant resources identified for detailed analysis are described in Chapter 3 and the effects of the alternatives on these resources are compared in Chapter 5.

2 NEED FOR AND OBJECTIVES OF ACTION

This chapter lays out the objectives for this ecosystem restoration project and explains their importance. The chapter begins with a statement of the Federal objective that underlies Corps ecosystem restoration efforts. Next, this chapter addresses how the resources that comprise the ecosystem are recognized as significant institutionally, technically, and publicly. The Problems and Opportunities section explains how the ecosystem has been affected, and describes opportunities the Nearshore Study has identified to address those problems. Finally, this chapter identifies planning objectives and constraints that guide plan formulation described in Chapter 4.

2.1 THE FEDERAL OBJECTIVE

The Federal objective of the Nearshore Study is to contribute to the nation's ecosystems through ecosystem restoration, with contributions measured by changes in the amount and quality of marine habitat. Corps guidance on ecosystem restoration philosophy and policy (Engineer Pamphlet 1165-2-502 [USACE 1999a]) states, "ecosystem restoration is a primary mission of the [Corps] Civil Works program." This guidance continues, stating, "The purpose of Civil Works ecosystem restoration activities is to restore significant ecosystem function, structure, and dynamic processes that have been degraded … Restoration projects should be conceived in a systems context, considering aquatic, wetland, and terrestrial complexes to improve their long-term survival as self-sustaining, functioning systems. Fish and wildlife resources are dependent on, and functionally related to, other ecosystem components and therefore interactions among all relevant ecosystem components need to be described and assessed during an ecosystem restoration study." Ecosystem restoration consists of separable features undertaken to return a degraded condition to a less degraded condition. The goal of ecosystem restoration is to reverse the adverse impacts of human activity and restore ecological resources, including fish and wildlife habitat, to a productivity level that would have existed under natural conditions in the absence of human activity or disturbance.

2.2 SIGNIFICANCE OF RESOURCES: INSTITUTIONAL, PUBLIC, TECHNICAL

The criteria for determining the significance of resources are provided in the Federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (Water Resources Council 1983) and in Corps planning guidance Engineer Regulation (ER) 1105-2-100 (USACE 2000a). Protecting and restoring significant resources is in the national interest. The significance and the relative scarcity of the resources help to determine the Federal interest in the project.

Significant resources in the project area include natural and cultural resources that are recognized as significant by institutions, the scientific/technical community, and the public (see sections 2.2.1 through 2.2.3 below). For ecosystem restoration projects, the significance of resources is based on both monetary and non-monetary values. Monetary value is based on the contribution of the resources to the Nation's economy. Non-monetary value is based on technical, institutional, or public recognition of the ecological, cultural, and aesthetic attributes of resources in the study area. Often referred to as ecosystem goods and services, these attributes provide socially important functions that are not typically exchanged in markets (and thus do not have explicit monetary value). However, functions supported by ecosystem goods and services do have value to society as they provide benefits that support economic activity (e.g. flood storage) and human well-being (e.g. clean water). Significant nearshore ecosystem features in the project area include the following:

- Beaches and bluffs
- Coastal embayments
- River deltas
- Natural variation, complexities, and spatial arrangement of the shoreline
- Significant ecological and cultural resources in the project area include marine riparian vegetation, floodplain forest wetlands, and emergent marsh wetlands
- Salmonids and other commercially important fish species
- Forage fish (herring, sand lance, surf smelt)
- Native shellfish
- Nearshore birds that use Puget Sound shorelines including dunlin, surf scoter, black oystercatcher, and great blue heron
- Subtidal vegetation including kelps and eelgrass
- Killer whales (orcas)
- Places of religious or cultural significance to Native Americans in the nearshore zone
- Significant cultural resources/historic properties in the nearshore zone
- Scenic beauty of the Puget Sound

Significance of ecosystem outputs are evaluated by institutional, technical, and public criteria as provided in ER 1105-2-100 appendix E-37 (USACE 2000b). This guidance assists in addressing the challenge of dealing with non-monetized benefits associated with ecosystem restoration and provides context for the selection of the recommended plan.

2.2.1 Institutional Significance

Institutional recognition criteria recognize significance of an environmental resource as acknowledged by laws, adopted plans, and other policy statements of public agencies, tribes, or private groups. Following enactment of the Endangered Species Act (ESA) in 1973, the Federal government began to address the decline of individual species with the listing of endangered species and the subsequent development of recovery plans. As of 2014, 13 fish and marine mammal species in Puget Sound are listed under the ESA as threatened or endangered species. The responsible agencies have developed or are working on recovery plans for eight of the listed species. State efforts to address the decline of Puget Sound have been underway for many years, focusing on addressing water pollution. In 2007, the Puget Sound Partnership (PSP) replaced previous water quality agencies, and began integrating the work of State, local, and Federal government entities, as well as local watershed planning and salmon recovery efforts. The PSP created the Puget Sound Action Agenda in 2008 and revised it in 2012 (PSP 2008, 2012). The Puget Sound Action Agenda serves as a statement of common purpose across Puget Sound and forms the basis for cooperation and collaboration among implementing partners. The Puget Sound Nearshore Study is the nearshore component of PSP's set of actions identified to protect and restore Puget Sound.

The Nearshore Study is a critical aspect to the various mission areas and agency interests outlined below. The proposed actions in the Nearshore Study are integral to a comprehensive restoration effort of institutionally significant resources within Puget Sound. Specific examples of institutional recognition of the significance of the resources being addressed by this study include the following:

A. *Washington Department of Fish and Wildlife (WDFW)* - WDFW is the non-Federal sponsor for the study. The agency's mission is "to preserve, protect, and perpetuate fish, wildlife, and ecosystems while providing sustainable fish and wildlife recreational and commercial opportunities." Improvement to the ecosystem processes of Puget Sound will assist WDFW in meeting its goals and legislative mandate.
B. *Puget Sound Partnership (PSP)* - The State of Washington has invested in the health of Puget Sound by creating specific agencies including the former Puget Sound Action Team, since replaced by PSP. PSP has developed an Action Agenda that addresses restoration and protection of Puget Sound, and uses "indicators" and "recovery targets" to help measure success. These include habitat features such as estuaries, floodplains, and eelgrass, and species including birds, herring, killer whales, and salmon (PSP 2012).
C. *Washington Department of Ecology (WDOE)* - Washington State passed the Shoreline Management Act (SMA) in 1971 and became the first state to achieve an approved Coastal Zone Management Program under the Federal Coastal Zone Management Act of 1972. The SMA designated shorelines of statewide significance, which includes Puget Sound shorelines. The Act requires cities and counties to establish Shoreline Master Programs that designate preferred uses of shoreline areas and aim for protection of environmental resources as well as public access. Any shoreline development must be permitted through WDOE.
D. *Environmental Protection Agency (EPA)* - Puget Sound has been designated an estuary of National Significance under §320 of the Clean Water Act. The goal of the Puget Sound National Estuary Program is to restore and maintain the Puget Sound Estuary's estuarine environment so that it will support balanced indigenous populations of shellfish, fish, and wildlife, and support the extensive list of recognized uses of Puget Sound. In 2009, the EPA adopted the PSP Action Agenda as the Comprehensive Conservation and Management Plan of the Puget Sound National Estuary Program.

E. *Council on Environmental Quality (CEQ)* - President Obama established the Interagency Ocean Policy Task Force in 2009 to develop recommendations to enhance the nation's ability to maintain healthy, resilient, and sustainable oceans, coasts, and Great Lakes resources (CEQ 2010b). The task force established a new National Policy for the Stewardship of the Ocean, Our Coasts, and the Great Lakes that set nine national priority objectives. The Nearshore Study aligns well with these objectives, especially the recommendation to "establish and implement an integrated ecosystem protection and restoration strategy that is science-based and aligns conservation and restoration goals at the Federal, State, tribal, local, and regional levels." These recommendations target Puget Sound as one of the prioritized regions for restoration effort.
F. *National Oceanic and Atmospheric Administration (NOAA)* - NOAA adopted the Puget Sound Salmon Recovery Plan in 2007. The PSP is the local government organization that will implement the plan. Because the plan for each watershed is a local effort that engages citizens as well as technical leaders, this speaks to the public and technical significance of this resource.
G. *National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS)* - The Services recognize the significance of the ecological resources in the study area, particularly species listed as threatened or endangered under the ESA and the critical habitat. Within the Study area, there are three ESA-listed endangered species and 10 threatened species (see Section 3.2.7 for rare, threatened, and endangered species).
H. *The Nature Conservancy (TNC)* - TNC has provided technical and institutional recognition of the Puget Sound as a conservation priority area. Noting Puget Sound can be cleaned up by "protecting and restoring… rivers and shorelines and the clean water and habitat they provide…" (TNC 2012). Ecosystem outputs associated with TNC's restoration efforts will complement the recognition of the conservation priority area by improving the quality of resources and habitat suitability.
I. *Washington Natural Heritage Program* - The WDNR protects rare plant associations in Washington State by managing site-specific and species/ecosystem-specific information on priority species and plant communities. Their mandate is to identify priority species and ecosystems for conservation, maintain a database, and share the information with the public for conservation planning purposes.
J. *Washington State Federally-Recognized Tribes* - There are 20 federally-recognized tribes in the Puget Sound area. The Federal trust responsibility to Native American tribes is a protection and preservation of land and certain rights for them. Treaties with the tribes are the supreme law of the land, superior to State laws, and equal to Federal laws. There have been recent concerns raised by Western Washington Treaty Tribes about continued habitat losses and associated diminishment of fishery resources; restoration of the nearshore zone would have significant benefits to salmonid and shellfish resources, which are of economic and cultural value to the tribes within the project area.

2.2.2 Public Significance

Public recognition of the significance of a resource may involve memberships in a conservation organization, financial contributions to resource-related efforts, volunteer labor, and correspondence regarding the importance of the resource. Public concerns with the health of the Puget Sound ecosystem have been evident for decades. As early as the 1920s, shellfish growers pointed to pollution from pulp mills as an issue, and in 1945 the state formed the Pollution Control Commission (The Olympian 2007). More recently, several large non-profit organizations have indicated interest in improving the ecosystem quality and function of the Puget Sound (e.g., Ducks Unlimited, Seattle Audubon Society, and TNC). Reflecting the concerns of a range of people nearby, a large number of local groups have formed around improving conditions in the Puget Sound within the project area, including the following:

- Marine Resource Committees
- Regional Fisheries Enhancement Groups
- Orca Network
- Puget Sound Restoration Fund (Olympia Oysters)
- Pacific Coast Joint Venture
- Friends of the San Juans
- Puget Soundkeeper Alliance
- The Mountaineers
- Volunteers for Outdoor Washington
- Washington Council of Trout Unlimited
- Washington Water Trails Association
- Wild Fish Conservancy
- People for Puget Sound

Public significance is also highlighted by the state of Washington’s multi-million restoration budget, support from municipalities, NGOs, and other non-Federal partners in the cost-sharing of restoration efforts, as well as implementation of millions of dollars worth of restoration work in Puget Sound without Corps involvement. These investments are important aspects of public significance of the resources within Puget Sound.

2.2.3 Technical Significance

Along with institutional and public recognition of significant resources, technical recognition means that a resource qualifies as significant based on its merits that are based on scientific knowledge or judgment of critical resource characteristics. Some technical reasons that resources in the study area are considered significant include the following:

A. Nearshore Science Team (NST): This component of the Nearshore Study consists of experts representing various technical disciplines to support and inform the Study in aspects of Puget

Sound including biology, geology, and sociology. The NST has collaborated and/or authored several pivotal publications including these:

- Strategies for Nearshore Protection and Restoration in Puget Sound (Cereghino et al. 2012)
- Implications of Observed Anthropogenic Changes to the Nearshore Ecosystem in Puget Sound (Fresh et al. 2011)
- Historical Change and Impairment of Puget Sound Shoreline (Simenstad et al. 2011)
- A Geomorphic Classification of Puget Sound Shorelines (Shipman 2008)
- Conceptual Model for Assessing Restoration of Puget Sound Nearshore Ecosystems (Simenstad et al. 2006)

B. Washington State Priority Habitats and Species (PHS): WDFW operates this program to identify habitats and species determined to be priorities based on defensible criteria, and to map the known locations of priority habitats and species using Geographic Information Systems (GIS) technology. PHS uses best available science to provide information on the conditions required to maintain healthy populations of priority species and viable priority habitats.
C. SalmonScape: This interactive mapping application from WDFW is designed to display and report a wide range of data related to salmon distribution, status, and habitats. The data sources used by Salmonscape include stream-specific fish and habitat data, and information about the status of salmon stocks and evaluations of their recovery.
D. Nearshore Habitat Kelp and Eelgrass Monitoring: The WDNR, Aquatic Resources Division has been monitoring kelp and eelgrass abundance and distribution since 2000. Changes in abundance and distribution reflect changes in environmental conditions and affect resources that depend on these habitats.
E. Puget Sound Vital Signs: The PSP has adopted a series of indicators of Puget Sound health. These "vital signs" will be used to evaluate the effectiveness of management actions implemented to recover Puget Sound, as well as status and trends in the health of the Sound. The 21 indicators are organized into six categories:

- Healthy human population
- Human quality of life
- Healthy native species and food web
- Protection and restoration of habitat
- Water quantity for humans and the environment
- Water quality for human and ecosystem health

The Puget Sound Action Agenda includes performance measures, which are monitoring criteria for evaluating success, for the eelgrass, estuaries, and shoreline armoring indicators associated with "protection and restoration of habitat"; these relate to objectives of the Nearshore Study.

F. Marine Protected Areas: WDFW recognizes the value in setting aside certain areas of Puget Sound marine waters for the protection and preservation of species and/or habitat. These are known as Marine Protected Areas (MPAs), and include conservation areas, marine preserves, and harvest exclusion zones. Twenty-five MPAs around Puget Sound collectively protect approximately 2,100 acres of intertidal and subtidal area.
G. Shared Strategy for Puget Sound: The Shared Strategy is a groundbreaking collaborative effort to protect and restore salmon runs across Puget Sound. Shared Strategy engages local citizens, tribes, technical experts and policy makers to build a practical, cost-effective recovery plan endorsed by the people living and working in the watersheds of Puget Sound. This non-profit effort has the support of NMFS, USFWS, Puget Sound tribes, and state natural resources agencies, and local government and non-government organizations.

2.3 PROBLEMS AND OPPORTUNITIES

This section documents the identification of problems and opportunities in Puget Sound's nearshore area, which is the first step in the Corps' six-step planning process (ER 1105-2-100; USACE 2000a). From the planning perspective, a problem can be thought of as an undesirable condition, while an opportunity offers a chance for progress or improvement. The identification of problems and opportunities gives focus to the planning effort and aids in the development of planning objectives. The problems identified in the Puget Sound nearshore area are listed here and discussed below.

- Degradation of large river deltas
- Loss of coastal embayments
- Disconnection between beaches and bluffs
- Loss of estuarine wetlands
- Shortening and simplification of the shoreline
- Accumulation of multiple stressors

The Nearshore Study identified "valued ecosystem components" (VECs) that share the three characteristics described in "Valuing Puget Sound's Valued Ecosystem Components" (Leschine and Petersen 2007). First, each is judged likely to be enhanced by nearshore zone restoration. Second, each VEC has direct or indirect value to humans socially, culturally, or environmentally. Third, many people recognize each component as emblematic of a "healthy" Puget Sound. The Nearshore Study identified the following nine VECs:

- Coastal forests (marine riparian vegetation)
- Beaches and bluffs
- Eelgrass and kelp
- Forage fish
- Juvenile salmon (including three ESA-listed species)

- Killer (orca) whales (ESA-listed)
- Native shellfish (includes one state candidate species)
- Great blue herons
- Nearshore birds

The problems described below affect these VECs directly or indirectly as detailed in a series of white papers available at *www.pugetsoundnearshore.org*. For example, forage fish rely directly on suitable beach habitat for spawning, and juvenile salmon rely directly on suitable delta habitat for rearing and on embayments for migration, while orcas benefit indirectly through increased availability of salmon as prey and through the water quality improvements that healthy deltas with abundant wetlands provide.

2.3.1 Sound-wide Problems

In their 2009 State of the Sound Report, the PSP's Science Panel evaluated ecosystem status indicators including human health, human well-being, species and food webs, habitats, water quantity, and water quality. The report concludes that "compared to historical conditions, the Puget Sound ecosystem shows signs of stress and degradation from human activity." About half of the indicators in the report provide evidence of continuing decline in the Puget Sound ecosystem, while several other indicators show evidence of improving conditions. The remaining few indicators describe ecosystem aspects for which no clear trend was apparent. Declining indicators include three of the VECs that the Nearshore Study evaluated: killer whales, eelgrass, and forage fish (herring). Shellfish harvest shows signs of improvement, and Chinook salmon run size has slightly increased since their ESA listing in 1999; however, Chinook populations remain substantially below recovery targets (PSP 2009). In a subsequent report, the PSP adopted a set of 21 indicators for assessing Puget Sound health. Data on status and trends of these "vital signs" are under development. Many of these overlap with the VECs that the Nearshore Study identified, including Chinook salmon, killer whales, herring, birds, eelgrass, estuaries, and functioning beaches (without shoreline armoring) (PSP 2012).

2.3.2 Nearshore Ecosystem Problems

Impairment of nearshore processes and degradation of ecosystem functions are critical factors in the declining health of Puget Sound. Anthropogenic stressors causing this impairment and degradation include the direct effects of physical alterations to the landscape that have eliminated large expanses of habitat and have disrupted the major ecological processes that create and sustain habitats (see Section 1.8.4 for more information on stressors). The degradation and loss of nearshore ecosystems is of critical importance because the nearshore zone serves as the connection between terrestrial, freshwater, and marine ecosystems. This means that the nearshore zone vitality, resilience, and productivity influence the productivity of the entire Puget Sound Basin. The alterations to the physiographic processes of the nearshore zone directly affect the ecosystem functions, goods, and services upon which humans depend.

Along with the direct effects, indirect effects degrade nearshore ecosystems. Indirect effects can come from upland and marine environments—impaired water quality and invasive species from marine sources, and downstream or downhill effects, such as reduced water quantity and quality, altered sediment transport, and disrupted landscape linkages. The cumulative effects of these multiple human-induced stressors overwhelm the ability of naturally occurring ecosystem processes to maintain structures, biological resources, and ultimately the goods and services provided by the ecosystem.

Based on the results of the Change Analysis Report (Simenstad et al. 2011) and Strategic Needs Assessment Report (Schlenger et al. 2011a), the Nearshore Science Team identified six major changes to the physical characteristics of the Puget Sound nearshore ecosystems (Fresh et al. 2011). These changes are in two broad categories: 1) significant direct changes to the nearshore ecosystems, and 2) widespread and pervasive changes. These observations support a science-based problem statement, providing a focus for evaluating alternatives and formulating a restoration plan. Sections 2.3.2.1 through 2.3.2.6 below are excerpted from Fresh et al. (2011).

Watersheds comprising a mere 0.2% of the Puget Sound shoreline length and 0.003% of the Puget Sound watershed area have not encountered any degradation of nearshore ecosystem processes (Schlenger et al. 2011a). The problems of the other 99.8% of the shoreline and 99.997% of the watershed area are summarized in this section. The problems described below directly affect many plants and animals in Puget Sound and the ecosystem as a whole.

2.3.2.1 *Effects to Large River Deltas*

Barriers to tidal hydrology have affected large river deltas.

2.3.2.1.1 *Physical Changes*

All of the 16 largest deltas of Puget Sound have been extensively modified. Combining all 16 deltas, the total length of their shoreline has decreased by 109 miles or 26.6% from historical conditions. The two primary anthropogenic stressors in large deltas are tidal barriers, which account for nearly 200 miles of the current delta shoreline, and armoring, which accounts for 108 miles of the current delta shoreline. Changes to the wetlands of the large deltas have been especially dramatic. In aggregate, 55.5% of the historical wetlands (57,823 acres) in the 16 largest deltas of Puget Sound have been eliminated (Simenstad et al. 2011).

Watershed changes can affect deltas in ways that were not directly detected in the Change Analysis. For instance, water diversions can alter the equilibrium between sediment transport to deltas and sediment transport within them. Half of the watersheds associated with the large deltas of Puget Sound have at least one significant water diversion. In one case, Jay and Simenstad (1996) suggested that the effects of a 40% reduction in the average annual discharge of the Skokomish River due to a hydropower diversion could be responsible for a 15 to 19% loss of low intertidal area and a 17% loss of subtidal eelgrass on the outer delta.

Bolte and Vache (2010) project that by the year 2060, population growth will introduce development and stressors to five of the six large river deltas that do not yet have significant development at their mouths; the forecast for all 16 large river deltas represents an overall loss of 59% of historical tidal wetlands. In addition to wetlands protection under the Corps' regulatory program, Executive Order 11990 dictates no net loss of wetland functions and values; however, Corps enforcement of this policy when unauthorized fill occurs is discretionary. The wetland-fill permitting process may prevent a net loss of total wetland area, but mitigation measures may cause the type and location of wetlands to shift toward wetland banks and areas protected from development, and away from desirable nearshore zone development locations such as private waterfront properties. Furthermore, mitigation ratios are intended to account for potential loss of in-kind functions and temporal impacts, but there are risks and uncertainties that may hamper the success of mitigation projects, and monitoring is not always performed consistently enough or long enough to ensure full replacement of functions and values.

2.3.2.1.2 *Implications*

One significant implication of changes to deltas is that much less native habitat is available for plants and animals. In particular, diking and filling of deltas have eliminated most of the channels that historically cut through deltas and have thus restricted fish and wildlife to smaller areas. River deltas that have been simplified to a single channel, such as the Puyallup and Duwamish, concentrate fish into a smaller area, thereby limiting their ability to avoid predators or stressful environmental conditions, and significantly reducing the overall habitat carrying capacity. Loss of delta area has affected the quantity and quality of habitats available for birds for feeding, roosting, and reproduction. At least 30 species of shorebirds use estuarine tide flats associated with Puget Sound's deltas (Buchanan 2006).

The loss of tidal prism (volume of water exchanged by tides) can have ramifications to the local flooding regime by increasing freshwater flood peaks. In addition, tidal prism loss can cause the simplification and loss of volume of tidal channel networks outside the area enclosed by tidal barriers (Hood 2004). The loss of tidal prism in the delta and the addition of dams and diversions within the watershed can alter estuarine salinity structure, shifting the area and location of wetland types sensitive to certain salinity regimes.

2.3.2.2 *Disconnection or Loss of Coastal Embayments*

Small coastal embayments have been eliminated throughout Puget Sound or had their connections to the Sound severed.

2.3.2.2.1 *Physical Changes*

Puget Sound has experienced a significant loss in the numbers of small, coastal embayment landforms. Overall, 884 historical embayment landforms were mapped, and 579 were mapped in current conditions representing a loss of 305 embayments.

Embayments historically accounted for 689 miles of Puget Sound shoreline (23.2%) but now account for 375 miles of shoreline (15.0%); this represents a decline in length of 45.5%. Historically and currently, the embayment landform type that represents the greatest proportion of Puget Sound's shoreline is the open coastal inlet. Of the embayments that remain along Puget Sound, many have been extensively modified. Armoring is the main modification, with 18% of the shoreline length of embayments armored. Changes to embayments vary considerably among the seven sub-basins (see Section 1.2 for sub-basins).

Based on land cover projections from Bolte and Vache (2010), losses of tidal wetlands are expected to continue. They project these losses to occur in embayments and large river deltas. Modeling the effects of increased regional population and associated development leads to a projected loss of 17%, or 1,013 acres, of the current extent of tidal wetlands by 2060. This forecast represents an overall loss of 75% of historical tidal wetlands in embayments. Mitigation required through wetland-fill permitting could create new wetlands in other locations such as wetland banks to maintain no net loss; however, wetlands upstream from the nearshore zone have different benefits than the marine and estuarine types with their associated species assemblages.

2.3.2.2.2 *Implications*

The sheltered condition of embayments makes them important habitat for native shellfish, fish, and shorebirds. For example, embayments can provide a sheltered, food-rich environment for several species of juvenile fish during certain times of the year. Recent evidence from the Whidbey Sub-basin shows that large numbers of post-larval and juvenile surf smelt rear in some of the "pocket estuaries" found there (Beamer et al. 2006). In addition, during late winter and early spring, large numbers of juvenile Chinook and chum salmon rear in pocket estuaries of the Whidbey Sub-basin. The juvenile Chinook salmon are part of federally protected populations and are considered to be one of the life history types that support viability of the species (Beamer et al. 2005).

2.3.2.3 ***Disconnection or Loss of Beaches and Bluffs***

Changes to beaches and bluffs have resulted in the loss of sediment supply and the interruption of sediment transport processes.

2.3.2.3.1 *Physical Changes*

As with other Puget Sound landforms, the amount of beach shoreline has declined from historical conditions, but the magnitude of changes was less pronounced than for embayments and large deltas. Historically, 38.5% of Puget Sound's shoreline (950 miles) was composed of bluff-backed beach; it was (and remains) the dominant landform in Puget Sound. Barrier beaches (i.e. depositional features that form across bays or small estuaries) were the fourth dominant landform, accounting for 273 miles (11.1%) of the shoreline. From historical to current conditions, bluff-backed beach and barrier beach length declined by 80 miles and 37 miles, respectively. Changes to beaches varied greatly between sub-basins (Simenstad et al. 2011).

Puget Sound beaches have seen many modifications. Armoring (seawalls and revetments) is the most pervasive direct alteration. Armoring occurs along 33.4% of bluff-backed beaches and 27.2% of barrier beaches; 34.0% of all bluff-backed beaches are armored along more than half of their length. Only 25.0% of all bluff-backed beaches are completely unarmored. The distribution of armoring associated with beaches varies greatly among sub-basins. Other than armoring, roads and nearshore fill are the most significant stressors affecting beaches in Puget Sound. For example, roads and nearshore fill each affect about 10% of the length of bluff-backed beaches.

2.3.2.3.2 *Implications*

One of the most important physical processes occurring along beaches and bluffs is the erosion, transport, and distribution of sediment. Sediment processes are dynamic and driven by storms, wave action, and tides. They vary significantly alongshore and from one part of Puget Sound to another, due to variability in wave action, geology, and the shape of the inherited glacial landscape (Finlayson 2006). Sediment processes, in combination with other factors, such as disturbance regimes, directly affect characteristics of beaches fed by those sediments and the composition, abundance, and diversity of plant and animal communities associated with them (Turner et al. 1995; Farina 2000).

Disruption of sediment processes can result from anthropogenic stressors such as structures placed either along (parallel to) or across (perpendicular to) the shoreline, which can affect the amount and size (grain size) of sediment delivered to the beach, and how and where it is transported. One of the most apparent human-caused changes to a beach is placement of structures (e.g. nearshore fill or armoring) parallel to the shore that cuts off or isolates bluffs that are sediment sources (so-called feeder bluffs) (Shipman et al. 2010). This is because the primary source of sediment to the non-delta landforms of Puget Sound is the feeder bluffs associated with bluff-backed beaches. Downing (1983) estimated that erosion of coastal bluffs supplies 90% of the sediment to Puget Sound beaches, and shoreline armoring occurs along approximately 33% of those bluffs (Schlenger et al. 2011a). Disruptions in sediment processes can change the physical characteristics of a beach, including changes in sediment composition (e.g., coarsening of the material), beach slope, and beach width (Pilkey and Wright 1988; Shipman et al. 2010). Down-drift beaches in the vicinity can disappear, and beach width can decline (Griggs 2005).

Various biological effects can result from changes in sediment processes including changes in invertebrate communities, loss of forage fish spawning habitat, and loss of feeding and migration habitat for juvenile salmon and forage fish (Shipman et al. 2010). Armoring can affect benthic and epibenthic invertebrates due to a loss of beach area, changes in beach slope, and changes in substrate characteristics. Because the composition of intertidal invertebrate communities is strongly linked to substrate characteristics (Dethier and Schoch 2005), changes in local sediment characteristics due to armoring (e.g., caused by wave reflection or blocked sediment sources) can alter the abundance and composition of infaunal and epifaunal organisms, including shellfish.

Armoring can affect reproduction of forage fish in several ways. First, armoring low in the intertidal zone can displace the spawning habitat of several species (e.g. surf smelt and sand lance) that spawn on fine-grained substrates on the upper beach (Penttila 2007). Second, by blocking sediment input to the beach, armoring can cause spawning areas to convert from the fine-grained material that the fish need for spawning to coarser materials such as gravel and cobble that are unsuitable for spawning. Third, armoring can negatively affect forage fish populations by increasing sediment temperatures on the upper beach, where shading by natural shoreline vegetation has been removed; this reduces survival of incubating embryos (Rice 2006). In addition to effects on reproduction of forage fish, armoring can affect feeding behavior of juvenile forage fish (as well as juvenile Pacific salmon) that often feed in shallow water at high tide. When shoreline modifications extend lower on the shore, the truncation of intertidal shallow water habitat by armoring reduces foraging by juvenile fish on riparian insects (Toft et al. 2007).

Projected sea-level change and increased storm frequency and magnitude are expected to cause the base of the coastal bluffs along bluff-backed beaches to be more frequently inundated by waves. This increased wave action on the base of the bluffs is expected to cause additional bluff erosion and increase sediment inputs to the nearshore zone. It is expected, however, that shoreline property owners may respond by constructing additional armoring to reduce bluff-backed beach erosion. Expected increases in shoreline armoring related to sea-level change are unquantified and are not included in the Bolte and Vache (2010) projections.

2.3.2.4 *Loss of Estuarine Wetlands*

Extensive losses of tidal/estuarine wetlands have occurred throughout Puget Sound. There are four types of tidal/estuarine wetlands: euryhaline unvegetated, estuarine mixing, oligohaline transition, and tidal freshwater.

2.3.2.4.1 *Physical Changes*

Puget Sound has experienced a dramatic loss of tidal/estuarine wetlands. Most Puget Sound tidal/estuarine wetlands are associated with the 16 large deltas. These delta systems historically contained nearly 103,000 acres of tidal/estuarine wetlands (all four types combined), compared to the current 45,220 acres, a decline of 56%. For landforms other than large deltas (mostly embayments), the estimated 25,205 acres of historical wetlands has declined to 8,229 acres, a loss of 69% (because data on the amount of euryhaline unvegetated wetland is only reliable for the large deltas, the estimated 25,205 acres of historical wetlands does not include that wetland type).

Considering just the estuarine mixing, oligohaline transition, and tidal freshwater (i.e. vegetated) tidal/estuarine wetland types, 74.2% of wetlands that historically surrounded the shores of Puget

Sound have been lost. Tidal freshwater and oligohaline transitional wetlands have been nearly eliminated. Taken together and combining all landforms, 93.1% of these two wetland types have been lost throughout Puget Sound. Of the 15,815 acres of historical oligohaline transition marsh, only 371 acres remain. The loss of tidal wetlands has been especially dramatic in several sub-basins and in several large deltas in particular. In the Duwamish and Puyallup river deltas, almost no wetlands remain of any type. In the Whidbey Basin, the amount of oligohaline transition and tidal freshwater wetlands declined from 14,826 acres to 148 acres and from 21,745 acres to 2,224 acres, respectively. Most of this loss was in the three large deltas found in this sub-basin.

Based on land cover projections from Bolte and Vache (2010), losses of tidal wetlands are expected to continue. These losses are projected to occur in embayments and large river deltas. In addition to previously cited projected future losses of coastal embayment wetlands, (17%), large river deltas are projected to lose 3% (1,606 acres) of their current extent of tidal wetlands between now and the year 2060. While new wetlands can be created through the permitting process to prevent a net loss of total wetland area, the use of mitigation banking is rare in estuarine areas, so mitigation may cause a shift in wetland types from estuarine to other types.

The projected increases in armoring coupled with the projected sea-level change will likely result in further wetland losses beyond those projected by Bolte and Vache (2010). Some of the current tidal wetlands occur at elevations that will be inundated too deeply and/or too frequently as the sea-level changes. In a natural setting, many of these wetlands might shift to colonize higher elevations that would provide suitable conditions; however, the presence of barriers to tidal inundation (e.g., tidal barriers and armoring) will limit the ability of estuarine wetlands to migrate landward.

2.3.2.4.2 *Implications*

Wetlands are one of the most important ecosystem types, wherever they occur, because they provide a wide variety of functions, including primary production; nutrient cycling; biophysical mediation of contaminants; fish and wildlife habitat, particularly for reproduction and feeding; and support of coastal fisheries species (Boesch and Turner 1984; Mitsch and Gosselink 2007).

Throughout the Pacific Northwest, one of the most prominent functions of estuarine wetlands, especially those associated with large deltas, is that they support extended rearing of several species of juvenile salmon (Healey 1982; Levy and Northcote 1982; Simenstad et al. 1982; Bottom et al. 2005a, 2005b; Henning et al. 2006). Studies have demonstrated that particular “life history types” are those that use delta wetland habitats for extended periods and depend on this habitat for initial, early growth (Fresh 2006). The production of these life history types is important to maintaining population resilience and supporting efforts to rebuild salmon populations (Bottom et al. 2005a). Because there is a strong relationship between juvenile salmon size and their survival to the next life phase (Duffy 2009), high growth rates in juvenile salmon during their residency in estuarine areas are critical to the survival of these life history types and their contribution to population resilience.

2.3.2.5 *Shortening and Simplification of Shoreline*

The shoreline has become shorter, simpler, and more artificial.

2.3.2.5.1 *Physical Changes*

In addition to the types of structural changes (i.e., stressors) described previously (e.g., construction of bulkheads, roads, and overwater structures), the basic character of the shoreline has changed. In particular, the shoreline of Puget Sound has become shorter and simpler over the past 150 years. Over all of Puget Sound, the net loss of shoreline length has been 431 miles, meaning the current shoreline is about 15% shorter than the historical length of the shoreline, as shown in Figure 1-5. While more than 600 miles of natural shoreline was eliminated, 229 miles of artificial shoreline was added (herein, artificial means human-made landforms such as seawalls backed by fill). Although the length of shoreline classified as artificial was negligible historically, artificial shoreline now represents about 9.5% of the length of shoreline in Puget Sound. There was a strong association between fill placed in the nearshore zone and the artificial landform type, with fill occurring along 62% of the length of artificial landforms.

Although available land cover projections from Bolte and Vache (2010) do not provide estimates of shortening and simplification of the shoreline, it is anticipated that the projected addition of nearly 100 miles of shoreline armoring between now and 2060 will continue a long trend of shortening and simplifying the shoreline through development. In those areas where armoring is added, the shoreline loses its natural complexity and heterogeneity; in those areas, the shoreline will be converted from a mix of landforms and habitats to straightened and simplified reaches within which the connection between terrestrial and aquatic habitats and resources is interrupted.

2.3.2.5.2 *Implications*

Although some of the changes in shoreline length and in landform were clearly due to natural processes such as erosion, waves, and floods, many are due to anthropogenic influences. The simplification and shortening of Puget Sound’s shoreline has altered the fundamental way that nearshore ecosystems function. The way an ecosystem works depends in part upon characteristics of surrounding ecosystems and the spatial arrangement of their components, sizes, shape, and location (Forman and Godron 1986; Turner 1989; Fahrig and Merriam 1994; Bell et al. 1997; Wiens 2002; Bilkovic and Roggero 2008; Partyka and Peterson 2008). Simply by changing how Puget Sound’s parts are arranged, people have changed how water and sediment move around, where and how much sediment is deposited, and how detritus and nutrients are processed and cycled (Farina 2000; Lourie and Vincent 2004). Furthermore, people have modified the behavior and survival of species and altered the composition of plant and animal communities (Bell et al. 1997; Farina 2000; Wiens et al. 2002; Lourie and Vincent 2004).

Changes to shoreline complexity and the loss of shoreline length have affected the rate, magnitude, and effectiveness of many ecosystem processes that depend on the amount of space available. The loss of shoreline length has reduced the amount of space in Puget Sound for fish and wildlife to reproduce, feed, and grow (Dethier 2006; Coen et al. 2007). In particular, juvenile salmon, which are closely associated with nearshore ecosystems during their migration from Puget Sound to the ocean, now have less space to feed, grow, and evade predators; such impacts have reduced their survival (Beamer and Larsen 2004). The loss in shoreline length has likely affected other habitats as well, such as eelgrass beds, although historical data is insufficient to quantify this change.

2.3.2.6 *Cumulative Effects of Multiple Stressors*

Many nearshore places have experienced multiple types of stressors (cumulative effects).

2.3.2.6.1 *Physical Changes*

Many of the altered shoreline segments around Puget Sound have not just one, but multiple types of human-caused alterations. Of the 812 shoreline segments (not including deltas) in Puget Sound, only 112 (14%) have no shoreline stressor (e.g., a dock, a marina, armoring, or fill). Segments with only one stressor make up 5% of the count, and 60% of shoreline segments have two to four stressors. Although no shoreline segments contain all nine stressors, 81% of segments have more than one type of stressor, suggesting a high potential for cumulative effects. Of the nine shoreline stressors considered in the Nearshore Study, armoring is clearly the dominant stressor, occurring in 78% of all shoreline segments. When calculating length of changes rather than number of segments, armoring occurs along 27% of the shoreline of Puget Sound. Other stressors often co-occur with armoring. Of the 2,466 miles of shoreline in Puget Sound, 23% of the length has one stressor, 12% has two stressors, and 6% has three or more.

2.3.2.6.2 *Implications*

It is highly likely that cumulative effects are negatively affecting nearshore ecosystem functions. Cumulative effects refer to the combined, incremental effects of human activities on the environment (EPA 1999). Cumulative effects may be synergistic, in that the overall effect is more than the sum of the individual effects (Williams and Faber 2001; Peterson and Lowe 2009). While a small-scale alteration may be insignificant (and not even noticed) by itself, cumulative effects from one or more sources often accumulate over time and space (Jordan et al. 2008; Peterson and Lowe 2009). Such changes to ecosystems are usually small-scale and can occur through persistent additions or losses of the same resources and through the compounding effects of two or more stressors (Reeves et al. 1993; May 1996). In the nearshore ecosystems of Puget Sound, cumulative effects include not only the physical changes upon which the Nearshore Study has focused, but other effects as well, such as changes to water and sediment quality.

2.3.3 Opportunities

Opportunities exist to address problems in Puget Sound nearshore ecosystems and thereby contribute to the health of species that depend on that habitat, directly or indirectly, for survival.

2.3.3.1 *Restoration Opportunities*

Puget Sound deltas have opportunities to increase the quantity and quality of valuable habitat for a variety of fish, wildlife, and plants. For example, restoration of estuarine habitat would benefit salmonids that depend on such habitat as they transition from freshwater to saltwater and back. Restored estuarine wetlands would benefit over 30 species of shorebirds found in Puget Sound deltas. There are opportunities to improve the overall water quality of Puget Sound through restoring some of the deltas that have historically provided that function.

At degraded coastal embayments around Puget Sound, opportunities exist to improve conditions for native shellfish, fish, and shorebirds. In particular, there are opportunities to benefit juvenile Chinook salmon populations that depend on the protected nature of coastal embayments for rearing habitat, and there are opportunities to improve conditions for surf smelt, a forage fish species that is an important part of the diet of Chinook salmon. There are also opportunities to restore degraded wetlands associated with coastal embayments, re-establishing diminished habitat, and contributing to improved water quality in Puget Sound.

Through restoration of beaches and the bluffs that provide the sediment that beaches depend on, there are opportunities to improve conditions for the fish and wildlife that inhabit or use Puget Sound beaches; and to contribute to the sustainability of barrier embayments that are made up of accreted sediment from eroding bluffs, providing habitat for migrating salmonids, native shellfish, and shorebirds. Such restoration represents opportunities to improve conditions for creatures at many levels of the food chain, including invertebrates, forage fish, and salmonids.

An additional consideration for restoration is the potential for sea level change. Although it is often seen as a limiting condition, it can also be viewed as an opportunity to enact managed retreat from altered coastal conditions. In the situation where it is not feasible to preserve historic infrastructure while also restoring habitat under conditions of sea level change, artificial shorelines may be restored to natural function by removal of the threatened structures.

In summary, through addressing the problems observed in Puget Sound's deltas, embayments, beaches, and bluffs, there are opportunities to restore some of the historic structural complexity to the shoreline, increasing the area available for habitat as well as the diversity of ecological niches required to support Puget Sound's rich natural heritage.

2.3.3.2 *Protection Opportunities*

A critical part of a comprehensive approach to ecosystem recovery is to protect healthy, functioning portions of the nearshore zone. Considering that restoration often requires protecting lands, and full function of restored lands may be delayed while systems reestablish, protection is often a more cost-effective approach to ensuring delivery of ecosystem functions, goods, and services. The Strategies Report (Cereghino et al. 2012) identifies intact sites with high potential for protection; however, because protection is not a Corps mission, it is not included in the planning objectives for this study. Actions that are solely protection-focused will need to be addressed outside of the Corps' authority by local, State, or tribal organizations.

2.3.3.3 *Learning Opportunities*

Restoration efforts offer opportunities for further learning, research, and education. Specifically, learning opportunities include the following:

- Increased institutional capability and capacity will arise as ecosystem restoration provides a setting for learning.
- Improvement in the performance of projects will provide feedback that can help reduce the uncertainty in implementing new projects and in applying adaptive management measures to constructed projects.

2.4 PLANNING OBJECTIVES

The Study team developed four planning objectives with associated sub-objectives to guide the formulation of alternative plans aimed at addressing the problems and opportunities described in section 2.3. The planning objectives articulate the Study's goal to restore the physiographic processes that sustain the Puget Sound nearshore ecosystem and its broad array of nationally and regionally significant resources. Through process restoration, the project aims to sustainably address impairment to the nearshore zone's ability to deliver ecosystem functions, goods, and services, and to support valued ecosystem components. The planning objectives are shown in Table 3-1, along with associated problems, opportunities, and affected species.

This General Investigation is aimed at addressing Sound-wide problems in Puget Sound nearshore ecosystems. In so doing, this project will contribute to achieving a subset of the recovery targets identified in the Puget Sound Partnership's Action Agenda (described in section 2.2.1). No one set of recommended solutions will be able to fully address all problems in the study area, given logistical and funding constraints. However, this study has systematically assessed nearshore conditions in Puget Sound, delivering a comprehensive understanding of problems and opportunities. Our approach to plan formulation, described in the next chapter, insures that by implementing a broad range of actions at strategic locations throughout the study area, the Corps and WDFW will substantially contribute to regional efforts to restore the health of Puget Sound.

In the following sections, each planning objective is briefly described along with sub-objectives that more fully detail the planning objective's intent. Sub-objectives refer to removal of stressors that impact physiographic processes that sustain the nearshore ecosystem; in all cases the

Nearshore Study's intent is to remove all stressors within the footprint of a given restoration site, except where constraints limit that goal. The degree to which objectives are achieved by proposed solutions will be measured by the ecosystem output model developed for the Puget Sound Nearshore Study. The ecosystem output model score is based on the size of area impacted, amount of stressors removed, and changes to ecosystem process, structure, and function; the model is described in more detail in Section 4.2.

Table 2-1. Planning Objectives

Planning Objectives[1]	Sub-objectives	Problems	Representative Species Affected[2]
1. Restore connectivity and size of large river delta estuaries	Restore tidal flow and inundation area in river deltas Restore quality and quantity of tidal wetlands in river deltas with emphasis on oligohaline and tidal freshwater wetlands Improve connectivity between the nearshore zone and adjacent uplands/ watershed Increase the shoreline length of large river deltas	• Large River Delta Impacts • Estuarine Wetland Loss • Shortening and Simplification of Shoreline Multiple Stressors	• Puget Sound Chinook salmon and other salmonids Great blue herons Peregrine falcons • Shorebirds (>30 species) Killer whales
2. Restore the number and quality of coastal embayments	Restore embayment shoreline length that has been reduced through fill placement Restore embayments that have transitioned to an artificial landform or have been lost through conversion to uplands Restore degraded embayments Restore quality and quantity of tidal wetlands in coastal embayments	• Coastal Embayment Loss or Disconnection • Estuarine Wetland Loss • Shortening and Simplification of Shoreline Multiple Stressors	• Puget Sound Chinook salmon and other salmonids Shellfish Olympia oysters Forage fish Kelp and Eelgrass
3. Restore the size and quality of beaches	Restore sediment input processes at bluff-backed beaches in divergence zones and transport zones of sediment drift cells Improve sediment transport and accretion processes by removing subtidal and intertidal stressors contributing to shoreline degradation	• Beaches and Bluffs Disconnection Multiple Stressors • Shortening and Simplification of Shoreline	• Puget Sound Chinook salmon and other salmonids Forage fish Shellfish Olympia oysters
4. Increase understanding of natural process restoration in order to improve effectiveness of project actions	Gather and analyze data to inform adaptive management and ensure project success Gather and analyze data to inform future restoration efforts by the Corps and others	• Large River Delta Impacts • Estuarine Wetland Loss • Coastal Embayment Loss or Disconnection • Beaches and Bluffs Disconnection • Shortening and Simplification of Shoreline Multiple Stressors	• Puget Sound Chinook salmon and other salmonids Great blue herons Peregrine falcons • Shorebirds (>30 species) Killer whales Olympia oysters Shellfish Kelp and Eelgrass

Notes: 1. All objectives cover the 50-year period of analysis.

2.4.1 Objective 1 – Restore Connectivity and Size of Large River Deltas

The 16 large river deltas distributed throughout Puget Sound vitally contribute to the overall health of Puget Sound ecosystems. These delta areas support a broad set of nearshore ecosystem processes in different ways than shoreline areas, and their contributions extend far beyond their delineated boundaries. Opportunities to restore processes should be identified and developed in areas with consideration for restoring "stepping stones of healthy patches" to increase landscape connectivity, as described in Principles for Strategic Conservation and Restoration (Greiner 2010). This objective has the following four sub-objectives:

- Restore tidal flow in river deltas
- Restore wetland quality and quantity with emphasis on oligohaline and tidal freshwater
- Improve connectivity between the nearshore zone and adjacent uplands/watershed
- Increase the shoreline length of large river deltas

2.4.2 Objective 2 - Restore the Number and Quality of Coastal Embayments

Embayments are significant landscape features that contribute to the complexity and heterogeneity of the Puget Sound shoreline. Embayments between the large deltas and in areas where deltas are absent provide important habitats for a variety of valued species including several species of salmon, more than 30 species of shorebirds, and migratory waterfowl. Many of the remaining embayments have been reduced in size, complexity, and function through stressors such as fill, armoring, stream crossings, roads, and railroads. Restoration can recover the historical footprint (size and shape) and associated functions of the embayment. Embayments can also be restored at sites where, due to fill and other stressors, they no longer exist. This objective is broken into the following four sub-objectives:

- Restore shoreline length reduced through fill placement and other stressors
- Restore embayments that have transitioned to artificial or have been lost
- Restore degraded embayments
- Restore quality and quantity of tidal wetlands in coastal embayments

2.4.3 Objective 3 – Restore the Size and Quality of Beaches

The nearshore ecosystem processes of sediment input, transport, and accretion are vital to supporting many of the unique and important characteristics of Puget Sound, such as shallow beach slopes, woody debris and algae accumulation, migration corridors for wildlife, beach spits, and other habitat features critical to the survival of Puget Sound biota. Results of historical change analysis indicate that there is a widespread need for the restoration of these processes of sediment movement throughout Puget Sound. While restored sediment supply at the site of an historic bluff-backed beach will support the reestablishment of the intertidal habitat, the benefits of restoring processes extend far beyond the site of restoration. Reconnecting a sediment source to the intertidal area at the updrift end of an undegraded longshore sediment drift cell can contribute to maintenance of barrier beaches miles downdrift. The following two sub-objectives are included in this objective:

- Restore sediment input processes by reducing degradation of bluff-backed beaches in divergence zones and transport zones of sediment drift cells
- Improve sediment transport and accretion processes by removing subtidal and intertidal stressors contributing to shoreline degradation

2.4.4 Objective 4 – Increase Understanding of Natural Process Restoration to Improve Effectiveness of Project Actions

Continued evaluation of Puget Sound restoration projects and tracking of ecological response is essential to achieving improvements in the effectiveness of proposed and future actions. Though functional and structural responses to restoration can be hypothesized, uncertainty remains regarding the response to restoration actions at the process level. Clearly stated hypotheses that describe both anticipated outcomes and key uncertainties underlie effective monitoring and adaptive management. A mix of projects with known outcomes and uncertainties is necessary to improve delivery of actions for Puget Sound recovery. Managing uncertainties is the focus of this objective. Accomplishing this involves two key elements:

- Development of an adaptive management framework to guide the adoption of newly acquired data into the delivery of restoration projects as part of Puget Sound Nearshore Study
- Hypothesis testing and data collection associated with efficacy of management measures and response by physical processes.

2.5 PLANNING CONSTRAINTS AND OTHER CONSIDERATIONS

Unlike planning objectives, which represent desired positive changes, planning constraints represent restrictions. A planning constraint is any technical, legal, departmental, or operational restriction that limits the extent of the planning process or scope.

Regional or local land use plans are not strict planning constraints, but can inform project development. The Nearshore Study will try to synchronize with such plans; for example, if local land use rules concentrate development in certain areas to minimize environmental impact, it may be more efficient to concentrate restoration efforts in the areas not slated for development. Where changes in local plans developed under the State’s Growth Management Act, Shoreline Management Act, or Sensitive Areas Ordinances could help achieve study objectives, the Study team will work with project partners to advance these for consideration.

The majority of tidelands within Washington State are privately owned, with over 70% of the Puget Sound shoreline in private ownership (Davison 2006). While not necessarily a planning constraint, this private ownership must be considered during site-specific design development. The Nearshore Study will attempt to maintain public access to the shoreline where appropriate, given that it is already restricted by private ownership. Ability to implement solutions could depend on landowner willingness (noted in constraints below), and purchasing privately owned tidelands would add to implementation costs.

The planning constraints identified in this study are as follows:

- Land ownership is a constraint; management measures will be implemented on lands that are in public ownership or are provided by willing owners or willing sellers. The local sponsor has indicated that condemnation cannot be used to acquire private lands for this project.
- Presence of hazardous, toxic, and radioactive waste; no restoration action will be considered in locations with known HTRW issues; all HTRW sites will be avoided.
- Protection of public health, safety, and well-being; any restoration solution that would propose removing some form of protection against flooding, storm damage, or erosion must ensure the safety of people who were protected by said measures.
- International boundaries constrain project opportunities. Puget Sound is the U.S. portion of the larger Salish Sea that extends into Canada. The study area is limited to Puget Sound, and does not include Canadian portions of the Salish Sea.
- The recommended set of restoration actions should be sized so it would be reasonable to expect them to be funded and implemented within the next 10 to 20 years.

3 AFFECTED ENVIRONMENT*

This chapter describes the existing conditions and future without-project conditions used for analysis during the Nearshore Study. Existing conditions are the physical, chemical, biological, and sociological characteristics of the study area. Characterizing resource conditions is critical for understanding their probable future condition (i.e. the without-project condition) and for defining problems and opportunities. Scoping required under the National Environmental Policy Act (NEPA) was introduced in Section 1.9; all related activities appear in Section 8.3.6. During the scoping process, agencies and the public identified topics of interest for analysis. Those resources that would be affected by proposed actions are described here and project effects are analyzed in Chapter 5. The remaining resources did not receive a detailed analysis because the agencies determined the project would not have significant effects on these resources, and the public did not raise concerns. This chapter outlines the approach the Study team used to organize information to analyze existing and future conditions, in particular the analysis of ecosystem processes, structures, and functions. This chapter serves as a baseline of without-project conditions for analyzing the effects of different alternatives.

3.1 PHYSICAL ENVIRONMENT: NEARSHORE PROCESSES AND STRUCTURES

As discussed in Section 1.8, the linkages between nearshore ecosystem processes, structures, and functions provide the analytical framework of the Nearshore Study. This framework derives from the hypothesis that “alterations of natural hydrologic, geomorphologic, and ecological processes impair important nearshore ecosystem structures and functions” (Simenstad et al. 2006). These relationships are important because ecosystem structure, a fundamental component of habitat, sustains socially relevant functions, including support for fish, wildlife, and plants, which in turn provide ecosystem functions, goods, and services to humans. A series of white papers produced by the Nearshore Study describes relationships between nearshore ecosystem processes and a subset of fish, wildlife, and plants considered emblematic of Puget Sound, referred to collectively as “valued ecosystem components” (see section 3.2).

3.1.1 Nearshore Ecosystem Processes

Ecosystem processes are interactions among physical, chemical, and biological attributes of an ecosystem that cause change in character of the ecosystem and its components. The nearshore ecosystem processes that influence the marine and estuarine shorelines of Puget Sound occur and vary over diverse spatial and temporal scales. The processes are classified into three scales of influence on nearshore ecosystems: regional influences, broad physiographic processes, and local geochemical and ecological processes. *Regional influences* include factors such as climate, wave exposure, geology, inherited physiography, sea-level history, and tidal regime. The *broad physiographic processes* are considered landscape-forming processes, and are embedded within regional influences but vary considerably on scales of kilometers or smaller. Examples include sediment input to beaches and distributary channel formation. The *local geochemical and ecological processes* that occur within a given landscape structure, and vary within the local structure of nearshore ecosystems, are shaped by the combined effects of the regional influences and broad physiographic processes. They vary on the order of meters within the local structures and, thus, are spatially and temporally complex. Examples include geochemical reactions that lead to nutrient cycling, primary production of plants, and food web interactions.

Table 3-1. Nearshore Ecosystem Processes

Nearshore Ecosystem Process	Process Description
Sediment Input	Flux of sediments from bluff, stream, and marine sources Depending on landscape setting, scale can vary from acute, low frequency (hillslope mass wasting from bluffs) to chronic, high frequency (some streams and rivers)
Sediment Transport	Bedload and suspended sediment transport of sediments and other matter by water and wind along (longshore) and across (cross-shore) the shoreline
Erosion and Accretion of Sediments	Erosion (coastal retreat) of coastal bluffs and shorelines Deposition (dune formation, delta building, spits, and bars) of non-suspended (e.g., bedload) sediments and mineral particulate material by water, wind, and other forces Settling (accretion) of suspended sediments and organic matter on marsh and other intertidal surfaces
Tidal Flow	Localized tidal effects on water elevation and currents, differing significantly from regional tidal regime mostly in tidal freshwater and estuarine ecosystems
Distributary Channel	Change of distributary channel form and location caused by combined freshwater and

Nearshore Ecosystem Process	Process Description
Migration	tidal flow
Tidal Channel Formation and Maintenance	Geomorphic processes, primarily tidally driven, that form and maintain tidal channel geometry Natural levee formation
Freshwater Input	Freshwater inflow from surface (stream flow) and groundwater (seepage)
Detritus Import and Export	Import and deposition of particulate (dead) organic matter Soil formation Recruitment, disturbance, and export of large wood
Exchange of Aquatic Organisms	Organism transport and movement driven predominantly by water (tidal, fluvial) movement
Physical Disturbance	Change of shoreline shape or character caused by exposure to local wind and wave energy input Localized disturbance such as large wood movement, scour, and overwash
Solar Incidence	Exposure, absorption, and reflectance of solar radiation (e.g., radiant heat) and resulting effects

The Nearshore Study assessment of ecosystem conditions focuses on the broad physiographic processes because they are responsible for creation and maintenance of the different complexes of landforms that characterize Puget Sound's shorelines. Eleven broad physiographic processes have been identified as most essential to the creation, maintenance, and function of Puget Sound's shoreline ecosystems; they are listed in

Table 3-1. A more detailed description of this definition and a delineation of nearshore ecosystem processes are provided in appendix B of the Change Analysis report (Simenstad et al. 2011).

3.1.2 Geologic and Physiographic Setting

Puget Sound's striking terrain is a complex mixture of beaches, bluffs, deltas, mudflats, rocky archipelagos, and wetlands. Extensive glacial and tectonic activities are responsible for many of the geomorphological features that characterize Puget Sound's shoreline environment. Other geologic processes, including weathering, erosion, and sedimentation, have further defined landforms and physical characteristics of the Puget Sound basin. At the peak of the Pleistocene epoch, a one-mile thick sheet of glacial ice covered the region and reached as far south as the current extent of south Puget Sound. The repeated advance and retreat of glaciers over many ice ages carved and scoured Puget Sound into its present form and reworked the till deposits. The region's soils are characterized as immature, being less than 10,000 years old. As is typical of fjords, water depths in Puget Sound increase rapidly from shore, with an average depth of 200 feet and a maximum depth of more than 1,200 feet.

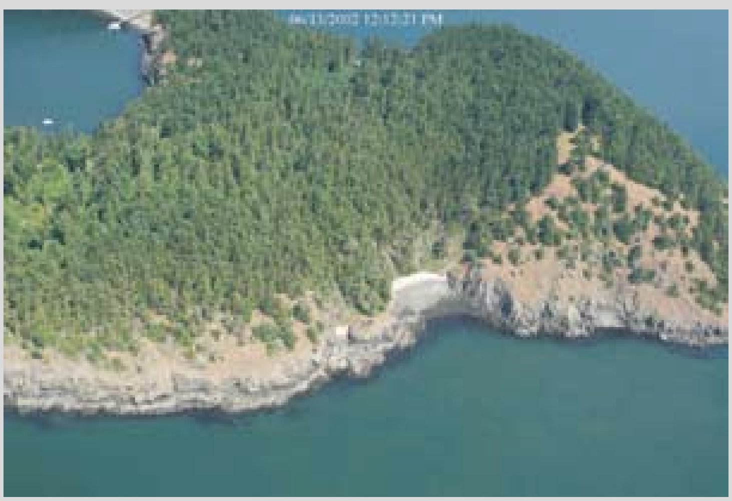
Erosion, weathering, and alluvial deposition processes since the retreat of the last glaciers have contributed to the mix of substrates that characterize Puget Sound's nearshore environment. Studies show tremendous variability in substrate grain size along the shoreline. Puget Sound beaches have mixed sand and gravel sediments derived primarily from glacial till and outwash material that eroded from coastal bluffs (Downing 1983, Finlayson 2006). Sandy and muddy sediments from fluvial sources characterize large river deltas. The complexity and variability in Puget Sound shoreline substrates is mirrored in the subsequent geomorphology, the diversity of the biota that characterizes nearshore ecosystems, and ecosystem functions, goods, and services provided. These relationships between process, structure, and function and the resulting biodiversity are the primary reasons that the Nearshore Study has chosen to focus on restoration and preservation of the natural processes that supply and transport natural sediment sources.

The structures and habitats of Puget Sound are a complex mosaic of beaches and bluffs, estuaries, lagoons, river deltas, and rocky coastlines. Shipman (2008) defines a classification of Puget Sound nearshore landforms that reflects the primary role of geomorphic processes in shaping the landscape. This classification system identifies four geomorphic systems (structures) that form the foundation of this shoreline classification. Three of these systems (beaches, embayments, and river deltas) reflect differences in the roles of waves, tides, and rivers in transporting sediment and shaping the coastline. The most common Puget Sound shoreline type consists of mixed sand and gravel beaches backed by high coastal bluffs. Other sediment-dominated shoreline environments include large river deltas, tidal flats, salt marshes, and estuaries. A fourth system, rocky coasts, is characterized primarily by the limited availability of mobile sediment and the lack of major depositional landforms. Rocky-bottom habitat is less common than soft-bottom habitat and is confined mostly to northern Puget Sound.

Within each of these geomorphic systems, there can be a variety of smaller landforms. These can be complex features, their configuration determined by the shoreline, availability of sediment, and local influence of waves, tides, and stream-related processes. Landforms extend across the nearshore zone and include subtidal, intertidal, and supratidal components. Figure 3-1 shows typical shapes and relationships of landform types. Table 3-2 summarizes the geomorphic systems and natural landforms described in detail by Shipman (2008). In addition to the natural landform types defined by this classification system, the Nearshore Study mapped "artificial" areas, which are areas that have been fundamentally altered by dredging and filling. Artificial landforms often support biotic communities not present in natural shorelines. Approximately 240 miles (10%) of the shoreline in the study area is classified as artificial (Simenstad et al. 2011).

Figure 3-1. Coastal landforms typical of Puget Sound

Table 3-2. Summary of Geomorphic Classification System (Shipman 2008)

System	Landform
River Deltas Long-term deposition of fluvial sediment at river mouths 	**River-dominated deltas** Extensive alluvial valleys with multiple distributaries and significant upstream tidal influence
	Wave-dominated deltas Deltas heavily influenced by wave action, typically with barrier beaches defining their shoreline
	Tide-dominated deltas At heads of bays where tidal influence is more significant than fluvial factors, typically with a wedge-shaped estuary
	Fan deltas Steep, often coarse-grained deltas with limited upstream tidal influence
Rocky Coast Resistant bedrock with limited upland erosion 	**Plunging** Rocky shores with minimal erosion/ deposition and no erosional bench or platform
	Platform Wave-eroded platform/ramp, but no beaches
	Pocket beaches Isolated beaches contained by rocky headlands

System	Landform
Beaches Shorelines consisting of loose sediment and under the influence of wave action 	**Coastal Bluffs** Formed by landward retreat of the shoreline **Barrier Beaches** Formed where sediment accumulates seaward of earlier shoreline
Embayments Protected from wave action by small size and sheltered figuration 	**Open coastal inlets** Small inlets protected from wave action by their small size or shape, but not significantly enclosed by barrier beaches **Barrier estuaries** Tidal inlets largely isolated by barrier beaches and with significant inputs of freshwater from streams or upland drainage **Barrier lagoons** Tidal inlets largely isolated by barrier beaches and with no significant input of freshwater **Closed lagoons and marshes** Back-barrier wetlands with no surface connection to Puget Sound

3.1.3 Oceanography

Puget Sound is the second largest estuary in the United States, composed of many smaller estuarine components with a total shoreline length of more than 2,466 miles. An estuary is a semi-enclosed body of water in which saltwater from a nearby ocean mixes with freshwater runoff from the surrounding watershed. In estuaries, denser saltwater sinks deeper and moves toward the land with tides, while freshwater moves seaward as a surface layer. Shallow sills (submerged ridges that separate basins of water) in Puget Sound’s sea floor disrupt tidal movements and promote mixing of the water layers. Exchange of water between estuarine Puget

Sound and saline Pacific Ocean primarily occurs through the Strait of Juan de Fuca, northwest of Puget Sound. Limited exchange occurs through a more obstructed pathway along the eastern side of Vancouver Island, through the Georgia and Johnstone Straits north of Puget Sound. Oceanography of Puget Sound is important to the Nearshore Study because it is a significant factor in the creation and maintenance of landforms (see section 3.1.2). It is a part of the natural processes that contribute to the functions, goods, and services that humans and wildlife value.

Tides

Tides of Puget Sound are mixed-semidiurnal with significant biweekly spring-neap modulation (Mofjeld and Larsen 1984). Thus, twice each day, the shorelines are alternately underwater and exposed to the air, rain, or sun. Beaches can be delineated into zones based on the length of time the substrate is underwater or exposed to air. The *intertidal* zone is between the limits of the tidal highs and lows and is inundated and exposed during each tidal cycle. The *subtidal* zone is under water except during extreme low tides. The *supratidal* zone, or splash zone, is not frequently inundated except for during extreme high tides. Each tidal zone hosts unique assemblages of species. The tidal range within the Puget Sound system varies depending on location, the geomorphological characteristics, and the distance from the Pacific Ocean. In the mid-sound, the mean tidal range is 7.66 feet and the maximum is 14.4 feet of difference between the lower low and higher high tide. Muted and restricted tidal flows are a problem throughout Puget Sound, particularly in estuaries where the mouth is restricted by causeways and/or much of the adjacent wetlands are cut-off due to levees. Armoring along beaches limits the tidal inundation of higher beach elevations, creating deeper water along the shoreline. Restricted tidal flow affects sediment transport and delivery, detritus import and export, and exchange of aquatic organisms. Shoreline modifications inhibit the habitat quantity, quality, and species diversity of these tidal zones.

Currents

A large volume of water, roughly 1.25 cubic miles, continually moves in and out of Puget Sound with each tidal cycle (Lincoln 2000). The twice-daily exchange of this water produces strong tidal currents through the narrow passages and over the seafloor sills that constrict flows. In addition to the saline water of the Pacific Ocean, freshwater discharge volumes within the Puget Sound watershed contribute to the volume. More than 10,000 rivers and streams drain into the Puget Sound system (WDFW 1975), providing highly seasonal freshwater discharges originating in the Olympic and Cascade Mountain watersheds. The total river discharges range seasonally from a minimum of about 141,000 cubic feet per second (cfs) to a maximum of 3.7 million cfs with a yearly mean of 410,000 cfs. The range in volume of water discharged from the rivers can influence local currents around the deltas. Figure 1-1 (page 3) shows the basins and rivers included within the Nearshore Study area. Levees, jetties, and groins interfere with current patterns that deliver sediment and detritus, and exchange of aquatic organisms within and adjacent to river deltas, as well as along drift cells that run parallel to beaches, which affects habitat quality and quantity.

Waves

Climatic conditions (e.g. storms, wind, etc.) contribute to the wave environment that influences shorelines. Broad regional differences occur in wind patterns and directions within the Puget Sound region, which affect wave energy and its influence on erosion and sediment transport rates within the study area. Exposure to wave action depends on the relative location of the individual shorelines around Puget Sound. The orientation of shorelines to open water is another significant factor. Shorelines that are exposed to considerable expanses of open water, particularly from a northwesterly direction, allow winds to blow unobstructed, creating wave climates having greater amplitudes and frequencies. Long-term exposure of shorelines to these energy conditions influences their physical features, substrate conditions, and susceptibility to erosion.

In Puget Sound, waves are primarily limited by fetch (the distance over water the wind blows), resulting in waves with small to moderate heights and short periods (Downing 1983). An exception is along the Strait of Juan de Fuca and the western side of Whidbey Island, where long-period swell waves can enter from the Pacific Ocean. The irregular shape of Puget Sound, combined with the relatively smaller sizes of its interconnecting basins, produces a fetch-limited environment with significant local variability in wave energy, orientation to winds, and exposure to waves. The direction of prevailing wind in Puget Sound is from the south or southwest during the winter and from the west or northwest during the summer; the strongest winds come from the south when winter storms move inland from the eastern Pacific (Mass 2008). The ability of waves to erode the shoreline, particularly feeder bluffs, is severely limited in Puget Sound as much of the shoreline is armored. Wave erosion of bluffs is essential as a source of sediment for Puget Sound beaches that serve as critical spawning habitat for forage fish and migration corridor for salmonids among other important habitat characteristics.

3.1.4 Sedimentation and Erosion

Puget Sound beaches are primarily defined by sediment movement driven by wave action, which includes erosion, transport, and deposition of material (Downing 1983, Woodroffe 2002). Sediment movement perpendicular to the shoreline, cross-shore transport, creates the characteristic beach profile. Movement parallel to the shoreline, or longshore transport, redistributes coastal sediment over many miles. Longshore transport is significant in shaping and forming other nearshore ecosystems, including barrier embayments and closed lagoons, which are maintained by spits or other depositional features. Puget Sound sedimentation and erosion is highly episodic. It relies heavily on the sources of sediments and the frequency of the strong storms that contribute sediments to the Sound and redistribute them in the coastal zone. The benefits sought by restoration actions will likely depend on the nature of episodic storm events as well as the quantity of available sediments.

Most beaches of Puget Sound lie within littoral cells (drift cells), which have a net transport of substrate from sediment sources to deposition areas. Beaches can generally be assigned to one of two fundamental geomorphic types: coastal bluffs or barrier beaches. Coastal bluffs occur where the coastline has eroded landward, into upland terrain. Barrier beaches are formed where beach sediment has accumulated seaward of the original coastline, forming a barrier beach (Shipman 2008). The spatial pattern of bluffs and barriers along Puget Sound's shoreline is complex, reflecting the irregular shape of the shoreline and accompanying local changes in wave energy and orientation, differences in the abundance and texture of sediment sources, and the redistribution of coastal sediment by longshore transport (Finlayson and Shipman 2003). As discussed in the previous section, erosion and sedimentation is severely limited along Puget Sound beaches due to the presence of shoreline armoring and jetties and groins. This armoring restricts the erosion of feeder bluffs that provide a source of sediment input, and groins and jetties interrupt sediment transport to beaches that are down drift.

While coastal embayments of different sizes derive from a variety of geologic origins associated with glaciations, stream channel formation, spatial orientation to wind and waves, and other forming processes, sediment delivery and transport play an important role in their current geomorphology and functioning. Embayments with the same geologic origins and initial morphology can have widely varying geomorphology and functioning due to the effects of more recent nearshore processes. The influx of fluvial sediment from contributing watersheds, influx of coastal sediments from adjacent shorelines, volume of sediment relative to embayment size and depth, and the extent of isolation from wave energy and associated sediment transport forces define the complex mosaic of embayment landforms in Puget Sound. Sediment delivery and transport are fundamental shaping processes used to distinguish embayment landforms identified by Shipman (2008), including open coastal inlets, barrier estuaries, barrier lagoons, and closed marsh lagoons. In short, these systems are distinguished by the extent to which sediment supply supports depositional features (spits, bars, beaches) that enclose embayments completely, partially, or insignificantly.

River delta systems are dominated by tidal and fluvial processes, and are typically not strongly influenced by littoral (beach) sediment transport and delivery. However, sediment erosion and accretion are still important in delta ecosystem functions. The shape and size of a delta is largely determined by amount and type of sediment available, as well as the configuration of the shoreline near the river mouth. Wave and tidal action redistribute deltaic sediments delivered from the watershed (Wright 1985, Bird 2000, Woodroffe 2002), defining each delta's dynamic shape and size. Upstream of a delta, estuarine wetlands develop where sediment accretion exceeds erosion and subsidence rates. Changes in this balance can lead to erosion of salt marsh and changes to tidal channel morphology (Grossman 2005). Over many decades, this can lead to great differences in geomorphic as well as ecological processes among large portions of a delta.

Sediment input and transport are limited in Puget embayments and estuaries due to the presence of causeways and levees that inhibit the erosive forces of tidal hydrology and freshwater input. Jetties and groins at the mouths of large rivers and streams limit the delivery of riverine sediment to adjacent beaches and marine submerged vegetation. Stressors that restrict erosion and sediment dynamics in river deltas and embayments also inhibit distributary and tidal channel formation and migration that aid in the delivery of detritus and exchange of aquatic organisms and provide important habitat for aquatic species.

3.1.5 Hazardous, Toxic, and Radioactive Waste (HTRW)

Hazardous, toxic, and radiological waste (HTRW) sites in the Puget Sound basin are regulated primarily by the Environmental Protection Agency and the Washington State Department of Ecology (Ecology) through the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, with amendments), and the Washington State Model Toxics Control Act (MTCA). HTRW is defined in ER 1165-2-132 as “any material listed as a "hazardous substance" under the Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. 9601 et seq. (CERCLA). (See 42 U.S.C. 9601(14). Hazardous substances regulated under CERCLA include "hazardous wastes" under Sec. 3001 of the Resource Conservation and Recovery Act, 42 U.S.C. 6921 et seq; "hazardous substances" identified under Section 311 of the Clean Air Act, 33 U.S.C. 1321, "toxic pollutants" designated under Section 307 of the Clean Water Act, 33 U.S.C. 1317, "hazardous air pollutants" designated under Section 112 of the Clean Air Act, 42 U.S.C. 7412; and "imminently hazardous chemical substances or mixtures" on which EPA has taken action under Section 7 of the Toxic Substance Control Act, 15 U.S.C. 2606; these do not include petroleum or natural gas unless already included in the above categories.” Contamination at a site that is the result of a spill or some other uncontrolled release, or is an abandoned hazardous waste site meets the definition of HTRW in ER 1165-2-132. If a substance is used for its intended purpose (application of pesticides IAW labeled directions) or released via a permitted structure (stormwater pipe), the substance would not meet the definition as HTRW.

A Phase 1 Environmental Site Assessment (ESA) was conducted by the project sponsor and did not identify any known or suspected hazardous material releases as defined by ER 1165-2-132 (USFWS 2011). However, it was concluded that Phase II assessments were recommended for some proposed project sites (Section 5.1.5) based on the potential for contaminants to exist in the environment from permitted or controlled uses. The Phase I report conclusions were based on literature that noted developed areas such as Puget Sound contain elevated concentrations of contaminants that may impact biota, even if they do not exceed the regulatory or risk criteria used to define HTRW. Therefore, the Phase I report methods and conclusions are not consistent with ER 1165-2-132 and further assessment of HTRW at these sites is not being considered. Although we do not anticipate HTRW concerns within the project footprint presented, one site will be further assessed in PED to assure that no HTRW-impacted areas are included in the project boundary in compliance with ER 1165-2-132.

3.1.6 Water Quality

Types and sources of pollution that affect water quality in Puget Sound can be categorized into industrial, urban, and agricultural sources. Pollutants enter the nearshore zone from point sources (directly from commercial or industrial sites) and non-point sources (surface runoff). The most common pathway of chemical contaminants in surface runoff is stormwater runoff, especially in urban areas. Industrial and urban pollution in water and sediment tends to be concentrated around large urban centers, such as the cities of Seattle and Everett; however, some of these pollutants, such as PCBs, bioaccumulate in tissues via the food chain and can end up in animals distant from contamination sources. For example, killer whales spend most of their time foraging in less contaminated areas, but they are some of the world's most contaminated marine mammals due to their position on the food chain as a top predator (Kriete 2007). Other problematic contaminants for water quality include fecal coliform and estrogen-mimicking chemicals from pharmaceutical sources (many of these are prescription drugs or veterinary treatments) that are excreted and are not removed by sewage treatment plants.

WDOE assesses marine water quality and marine and freshwater health. Marine water quality measurements include fecal coliform, nitrogen, ammonium, dissolved oxygen, and thermal stratification. Marine water quality monitoring data from 39 sites between 1967 and 2005 indicate that typically, there is some level of concern for at least one of the measured parameters at most sites. In 2005, eight of the sites were considered of "highest concern," exceeding the standards for several or all of the parameters. Ten additional sites were rated "high concern" because dissolved oxygen and fecal coliform in those areas exceeded standards.

Marine and freshwater health is measured as temperature, dissolved oxygen concentrations, pathogen types and amounts, and toxic substance types and amounts. Marine and freshwater health throughout the Puget Sound region is assessed by monitoring water, sediment, and tissue at sites that are then categorized based on compliance with standards. WDOE monitors physical parameters such as temperature, pH level, and dissolved oxygen concentrations because they serve as indicators of pollution. Waters that do not meet standards are considered "polluted waters" and placed on a 303(d) list that WDOE publishes regularly (in reference to Section 303(d) of the Clean Water Act). Waters that have signs of diminished health but not enough to fail the criteria and be deemed "polluted" are "waters of concern" on the 303(d) list. Polluted sites and waters of concern occur throughout the nearshore zone of Puget Sound. Below is a summary of where site listings occur in higher densities (WDOE 2009a):

- Pollutants in and around the Bremerton, Everett, Olympia, and Tacoma areas include industrial, urban, and agricultural pollutants. Industrial and urban pollutants originate primarily from the cities, and agricultural pollutants are transported mostly via the Snohomish, Deschutes, and Puyallup Rivers. The Bremerton Naval Shipyard has been a major contributor to poor water and sediment quality in Bremerton.

- Pollutants in and around Seattle are primarily industrial and urban. The Duwamish River, which is highly industrialized along its banks, is a major pathway of the chemical contamination in Elliott Bay. Another pathway of pollution in the Seattle area is stormwater runoff that enters Puget Sound untreated during combined sewer overflows.

- Sources of pollution in Skagit Bay are almost exclusively agricultural. The Skagit River drains 3,000 square miles, with the floodplain being almost entirely cropland or pasture.

- Pollution in Hood Canal mainly originates from agricultural sources, and from faulty septic systems. Several areas of Hood Canal are nearly devoid of oxygen partly because of its bathymetry and partly because of pollutants (Hood Canal Dissolved Oxygen Program 2009). This results in mass die-offs of fish and other marine life.

Although monitoring data and 303(d) listings indicate impairment based on one or more of the parameters monitored, there are no known publications discussing effects of Sound-wide or systems-scale water quality degradation that are expected to affect restoration success. Site-specific actions to restore physical processes must account for local conditions that may affect the desired outcome. These conditions include known water and sediment quality within and adjacent to the sites as well as overall water quality of the area. For example, site-specific sediment contamination would require remediation before intertidal beach restoration to minimize potential impacts on desired habitat function such as forage fish spawning. The feasibility study will identify potential risks to success at each site.

3.1.7 Greenhouse Gas Emissions

The Earth’s atmosphere is changing, the climate system is warming, and the changes are likely due in part to human activities that produce greenhouse gases (GHGs). This concept has been recognized by leading organizations in the scientific community including the Intergovernmental Panel on Climate Change (IPCC 2007), The National Academy of Sciences, The American Meteorological Society, the American Geophysical Union, and the American Association for the Advancement of Science (Oreskes 2004). GHGs include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and some hydrocarbons and chlorofluorocarbons. These compounds create a greenhouse effect when they accumulate in the Earth’s atmosphere. They act as a layer of insulation, retaining within Earth’s atmosphere some of the thermal radiation that originated from the sun.

GHGs can be produced both naturally and by non-natural human activities such as the combustion of fossil fuels and production of cement. Water vapor is the most abundant of the GHGs and carbon dioxide is the second most-abundant. Carbon dioxide is naturally absorbed during some physicochemical and biological processes, but human activities can also affect these processes. For example, deforestation reduces the amount of carbon dioxide absorbed by plants via photosynthesis. After carbon dioxide, the most abundant GHGs in the atmosphere are methane, nitrous oxide, and ozone. These compounds are also produced through both natural processes and human activities. Of the GHGs, water vapor and carbon dioxide have the most significant impact on the greenhouse effect, contributing 36 to 72% and 9 to 26%, respectively (Kiehl and Trenberth 1997).

As a primary contributor to the greenhouse effect and with production and absorption sources closely linked to human activity, CO_2 is typically the focus of GHG discussion. According to National Oceanic and Atmospheric Administration's (NOAA) Earth Systems Research Laboratory, the concentration of CO_2 in the atmosphere increased by 36% from 280 parts per million (ppm) in pre-industrial times to 382 ppm in 2006. The current annual increase in carbon dioxide concentration is 1.9 ppm/year. Projections for future emissions vary greatly based on the assumptions made about trends in human activities related to carbon dioxide production and absorption. Generally, however, the scientific community agrees that without significant changes to current policies and practices, carbon dioxide concentrations in the atmosphere will continue to increase.

3.1.8 Underwater Noise

Anthropogenic activities have increased the ambient sound levels throughout Puget Sound. To analyze the proposed action's potential effects of underwater noise on aquatic resources, some fundamental characteristics of sound and the existing conditions (i.e., the status of underwater noise in Puget Sound) are laid out here for a basic understanding for the analysis presented in Section 5.1.8. Underwater noise was raised as an issue of concern due to potential construction impacts, although there would not be any long-term effects or increase to ambient sound from the proposed actions.

Sources of Sound
Ambient noise is the combination of all sound sources, which creates a steady background noise. Underwater sound source categories are biological (caused by marine life), hydrodynamic (caused by wind, waves, and rain), marine vessel traffic, and seismically produced such as during earthquakes or seismic surveys for oil exploration. Ambient noise conditions underwater in Puget Sound have many contributors including shipping traffic to the Ports of Everett, Seattle, and Tacoma, U.S. Navy activities, the Washington State ferry routes across Puget Sound with up to 23 vessels operating at a time, cruise ships, commercial fishing vessels, and recreational boats. As one example location, permanent ambient underwater noise in Admiralty Inlet, a major route for shipping traffic near Port Townsend, is around 98 dB (1 µPa @ 1 m; Bassett 2010). Mean ambient levels in most marine waters is 80 to 100 dB (Richardson et al. 1995).

Sources of sound are intermittent as well as ambient. Some temporarily occurring noises include dredging, ships passing nearby, naval sonar testing, and pile driving or other construction-related activities. For example, in addition to the ambient noise in Admiralty Inlet, the Washington state ferry vessel in the Port Townsend-Coupeville route emits roughly 179 dB (1 µPa @ 1 m; Bassett 2010). Small ships around 100 to 150 feet long are common in Puget Sound and their engines emit broadband sound (20 Hz to 1 kHz) at 150 to 170 dB (1 µPa @ 1 m; Richardson et al. 1995). Larger commercial vessels emit lower frequency noise as loud as 170 to nearly 200 dB (1 µPa @ 1 m). Naval active sonar testing is likely the loudest sound produced emitting 230 dB (1 µPa @ 1 m) in the range of 2 to 5 kHz.

Animals in Puget Sound Potentially Affected by Underwater Noise
The major groups of animals in Puget Sound that can be affected by underwater noise are fish, diving birds, pinnipeds (seals, sea lions, and sea otters), and the two types of whales, mysticetes (baleen whales) and odontocetes (toothed whales). The species of focus for this analysis are identified as significant biological resources in Section 3.2 or are otherwise protected by the Marine Mammal Protection Act.

Fish can be harmed in different ways, particularly through their swim bladder because of the large difference in impedance between the gas-filled bladder and the surrounding water-filled body tissues (Nedwell et al. 2004). Intense sound pressure waves can cause physical harm and mortality. Fishes' sensitivity to hearing varies, but most exhibit a response to sounds in the range of 50 Hz to 2 kHz, with a minimum threshold around 70 dB (Hastings 1995). Herring, a forage fish with declining populations, have high sensitivity to sound due to their specialization of pressure-sensing mechanisms (Blaxter and Hoss 1981); this is in contrast to Cottids, which have no swim bladder and are therefore not sensitive to sound waves (Nedwell et al. 2004).

Diving birds, such as marbled murrelets, are vulnerable to excessive underwater noise because it affects their ability to catch prey while diving, and can cause disorientation and injury. Excessive noise can cause a range of problems including aborted feeding attempts, disorientation, and even injury if the sound pressure wave is strong enough.

Marine mammals use vocalizations to identify themselves, their location, territory, or reproductive status and communicate with each other about presence of prey, another animal, or danger. Loudness, frequency, duration, and types of sounds vary widely among the species, and can be compared to the audiogram for the species if one has been developed. Audiograms are the graphic display of hearing sensitivity, which plot frequency against hearing threshold. Available data show that whales' auditory thresholds can extend as low as 10Hz for the mysticetes and as high as 500kHz for some odontocetes (Gordon and Moscrop 1996). California sea lions are most sensitive to sounds between 1 kHz and 28 kHz with peak sensitivity around 16 kHz (Schusterman et al. 1972). Harbor seals have a slightly broader range with ability to hear up to about 50 kHz for sounds over 60 dB (1 µPa @ 1 m; Richardson et al. 1995). The Steller sea lion hearing range is 500 Hz to 32 kHz with less sensitivity at the low and high frequencies.

Killer whales rely on their highly developed acoustic sensory system for navigating, locating prey, and communicating with other individuals (Ford 1989). Noise pollution from marine vessel traffic is one of the main concerns with decline in the endangered Southern Resident killer whale population because of how it may affect their vocalizations and hearing. Excessive noise levels may mask echolocation and other signals the species use, as well as temporarily or permanently damage hearing sensitivity (NMFS 2005a). Vessel traffic negatively affects foraging behavior of the Southern Resident killer whales, which can have biologically significant consequences and is likely a factor in their low population level (Lusseau et al. 2009).

3.2 BIOLOGICAL ENVIRONMENT: NEARSHORE FUNCTIONS

Puget Sound is home to approximately 100 species of shorebirds, 200 species of fish (regular inhabitants), 15 species of marine mammals, hundreds of plant species, and thousands of invertebrate species (Sound Science 2007). Many of these species rely in some way on Puget Sound nearshore ecosystems utilizing productive and complex food webs that derive from interactions among terrestrial, nearshore, and deep water/pelagic ecosystems. The following sections of this chapter provide an overview of biota that occupies the nearshore ecosystem, with a focus on the biota of embayments, beaches, and river deltas. Rocky shorelines have unique species assemblages but are not specifically addressed by the Nearshore Study. The results of the change analysis (Simenstad et al. 2011) indicated that from a geomorphic perspective, rocky coast systems are largely unchanged from historic conditions and therefore have not been identified as a restoration priority in Puget Sound (Fresh et al. 2011). Appendix F has more information on the biota of the rocky shorelines. Table 3-3 lists common names for nearshore biota found in the four landforms.

Table 3-3. Nearshore Biota

	Rocky Coast	Beaches	Embayments	Large River Deltas
Vegetation	See Table 1 in Appendix F	Eelgrass and variety of marine macro-algae.	Eelgrass, marine macro-algae, and salt-water and estuarine wetland species.	Eelgrass, estuarine wetland species.
Macro-Invertebrates	See Table 2 in Appendix F	Beachhoppers, isopods, amphipods, cancer crabs, barnacles, polychaetes, sea cucumbers, sea stars, several shrimp species, sand dollars, Lewis's moon snail, mussels, cockles, and horse, macoma, and geoduck clams. Species diversity and abundance increase in eelgrass beds.	Amphipods, isopods, copepods, geoduck, horse, and macoma clams, cockles, Olympia and Japanese oysters, cancer crabs, shore crabs, polychaetes, sea slugs, burrowing anemones, and sea and brittle stars. Species diversity and abundance increase in eelgrass beds.	A variety of crab and shrimp, mussels, anemones, and sea cucumbers in higher salinity marine portions. Isopods, amphipods, oligochaete and polychaete worms, and fly larvae in brackish marshes.

	Rocky Coast	Beaches	Embayments	Large River Deltas
Fish	Rockfish, kelp greenlings, pricklebacks, wolf eels, perch, sculpin species such as cabezon, red Irish lord, buffalo sculpin, and sailfin sculpin.	Flatfish (sole and flounder), sculpin species, juvenile salmonids, forage fish, and perch.	Flatfish (sole and flounder), sculpin species, stickleback, juvenile salmonids, sturgeon. During high tides in eelgrass beds: bay pipefish, gunnels, shiner perch, and surf smelt.	Flatfish, shiner perch, surf smelt, bay pipefish, salmonids (juvenile and adult), sturgeon, lamprey, longfin smelt, and eulachon.
Marine Mammals	Harbor seals, sea lions, sea otters, killer whales, and occasionally northern elephant seals.	Harbor seals, occasionally sea lions (California and Steller), and killer whales.	Harbor seals, occasionally sea lions (California and Steller), and killer whales in larger embayments.	Harbor seals.
Birds	Oystercatchers, harlequin ducks, turnstones, surfbirds, pigeon guillemots, auklets, and belted kingfishers.	Surf scoters, buffleheads, a variety of gulls, mergansers, loons, brants, Canada geese, cormorants, and sandpipers.	Snow geese, brants, gadwalls, American wigeons, teals, plovers, dowitchers, and great blue heron.	Brants, plovers, gadwalls, sandpipers, dowitchers, and great blue herons on mudflats and in estuaries. Mallards, pintails, wigeons, green-winged teals, and snow geese in floodplains.

Note: This table is intended to be a *general* rather than comprehensive list of species representative of different Puget Sound landforms. In many cases, species are not endemic to a particular landform, and numerous species that occur in Puget Sound have not been included. (Sources: Kozloff 1973 and 1993, and Dethier 1990)

To relate the benefits of process-based restoration to ecological outcomes, the Nearshore Study team identified a subset of Puget Sound species, species guilds, and habitats, termed “valued ecosystem components” (VECs), that depend on nearshore ecosystems and have social significance to the region’s human inhabitants. The relationships between VECs and nearshore ecosystems, documented in peer-reviewed literature, appear in a series of white papers. Conceptual models, restoration objectives, and outreach materials often reference VECs and these documented relationships to nearshore ecosystem process and structures. While not intended to be inclusive of all socially important ecosystem services, the VEC list does represent a useful cross section of diverse ecological attributes supported by the nearshore, including the following:

- Kelp and eelgrass
- Marine riparian vegetation
- Native shellfish
- Forage fish
- Juvenile salmon
- Beaches and bluffs
- Orca whales
- Nearshore birds
- Great blue herons

Species and guilds identified by the Nearshore Study team as "valued ecosystem components" (VECs) that have been used to relate project benefits to ecological outcomes are denoted in this section with an asterisk (*).

3.2.1 Vegetation

Marine Submerged Vegetation
Two main types of submerged marine vegetation inhabit the nearshore zone of Puget Sound: marine algae (which includes kelp and a variety of other seaweeds) and eelgrass. Most marine macroalgae require solid substrate to attach to, but exposure to waves, currents, and sedimentation affect distribution. The highest diversity and abundance of seaweeds in greater Puget Sound occurs in the San Juan Islands and Strait of Juan de Fuca, largely due to the heterogeneity of habitat, exposure to waves and currents, and timing of the tides (Mumford and Dethier, pers. comm., 2010). Native eelgrass generally occurs in intertidal and shallow subtidal areas throughout Puget Sound (Mumford 2007).

The larger perennial species of kelp, bull kelp (*Nereocystis luetkeana*) and giant kelp (*Macrocystis integrifolia*), need consolidated substrate such as bedrock and boulders, and therefore tend to grow more continuously along the rocky shorelines, but kelp beds are not necessarily unique to rocky landforms. Almost all of the 625 marine algal species of Washington can occur on the unconsolidated (boulder/cobble) substrate that is more characteristic of beaches and, in some cases, embayments (Mumford, pers. comm., 2010). Once these kelp and algae detach from their substrate, they typically wash onto Puget Sound beaches providing important nutrients to the upper beach community.

Kelp* plays a critical role in nearshore ecology by providing three-dimensional structure and refuge for a variety of organisms. It has an important role in primary production, directly by serving as a food source for grazers such as urchins and abalone and by providing drift kelp to the shoreline for scavengers, and indirectly by providing a source of carbon for phytoplankton as the kelp decomposes. Floating kelp forests occur primarily along the Strait of Juan de Fuca and the rocky shores of the San Juan Islands, and Puget Sound proper has patchily distributed beds. Non-floating kelp occurs throughout Puget Sound (Mumford 2007). Recent studies have shown that the floating kelp canopy is increasing along the Puget Sound and Strait of Juan de Fuca shoreline (Berry et al. 2005); however, losses in certain areas such as Bainbridge and Marrowstone Islands and small beds in southern Puget Sound are of concern (Mumford 2007).

Eelgrass* (*Zostera marina*) is the most common native vegetation in intertidal and subtidal beach habitats of Puget Sound, as well as in embayments with minimal freshwater influence. Large eelgrass beds can grow on the fringes of large river deltas where the salinity is high enough and sediment supply is sufficient. Eelgrass meadow size varies throughout Puget Sound, ranging from a few to several hundred square meters. Biological diversity of eelgrass beds is much higher than that of surrounding areas because the three dimensional structure provides cover and foraging habitat. A variety of epiphytic algae can be associated with eelgrass. Lack of data hinders ability to judge trends in eelgrass populations in Washington (Mumford 2007), although evidence suggests major losses in several large embayments such as Bellingham Bay and the Snohomish River delta and a set of small embayments in the San Juan Islands. Hypotheses for the loss of eelgrass in the San Juan Islands include increases in sediment load, hypoxia, eutrophication, shading by overwater structures, overgrowth by macroalgae, and presence of toxic contaminants (Mumford 2007).

Wetland Vegetation

Wetlands are present in the shallows of many landforms in Puget Sound including barrier estuaries, barrier lagoons, closed marshes and lagoons, and large river deltas. Many of these wetlands have severely declined or been lost due to anthropogenic stressors (see Appendix F for information on wetland trends). Wetlands provide foraging and rearing habitat to a variety of organisms in Puget Sound. Some species use coastal wetlands year-round, and others use the habitat during their transition from freshwater to saltwater. Along the fringes of lagoons (which are typically high salinity marine water), pickleweed (*Salicornia virginica*) and jaumea (*Jaumea canosa*) typically dominate the vegetation communities. Where freshwater is present, as in barrier estuaries, closed marshes, and large river deltas, three types of vegetated wetland classes are present: estuarine mixing, oligohaline transition, and tidal freshwater. These classes transition from more saline to freshwater as one moves upstream. In the estuarine mixing and oligohaline transition wetlands, salt marsh vegetation such as saltgrasses (*Distichlis spicata*) and pickleweed dominate. As the marsh transitions from oligohaline transition to freshwater tidal, Lyngby's sedge (*Carex lyngbyei*), tufted hairgrass (*Deschampsia caespitosa*), bulrush (*Schoenoplectus* spp.), and hooker willow (*Salix hookerii*) become more prevalent. Other vegetation tolerant of the higher salinities in estuaries and lagoons includes arrowgrass (*Triglochin maritima*), saltwort (*Glaux maritima*), seaside plantain (*Plantago maritima*), sea-spurrey (*Spergularia* spp.), gumweed (*Grindelia integrifolia*), and saltbrush (*Atriplex patula*) (Dethier 1990, Cummins pers. comm. 2009). Another class of wetland in Puget Sound is euryhaline unvegetated, commonly called tidal flats. Little vegetation other than diatoms inhabits this wetland type.

Estuarine wetlands have a special regulatory status within Western Washington such that they receive high levels of protection regardless of their size or condition (Hruby 2004). Even so, much of the salt marsh and wetland habitat has been lost due to the diking and filling of small embayments and tidally influenced portions of the delta and floodplain for the development of pastures, cropland, industry, and urban centers. Some large river deltas have suffered more than others have. For example, the Skagit River delta has lost 74 percent of its historical wetlands (mostly at the upstream area of the estuary), whereas the Duwamish River, which no longer has a recognizable delta, has lost nearly 100 percent of its historical wetlands (Simenstad et al. 2011).

*Riparian Vegetation**

Riparian vegetation characteristic of Puget Sound lowlands includes coniferous trees such as western hemlock (*Tsuga heterophylla*), Douglas fir (*Pseudotsuga menziesii*), and western red cedar (*Thuja plicata*). Pacific madrone (*Arbutus menziesii*) occurs in drier areas. Native deciduous trees such as red alder (*Alnus rubra*), big leaf maple (*Acer macrophylla*), and vine maple (*Acer circinatum*) are present if there is disturbance, minimal soil development, and a local seed source to facilitate colonization. Shrubs and understory plants such as ocean spray (*Holodiscus discolor*), Oregon grape (*Mahonia spp.*), Indian plum (*Oemlaria cerasiformis*), and sword ferns (*Polystichum munitum*) are common in riparian areas (Brennan 2007). In addition to regionally common upland plant communities, the nearshore zone is the only location of the wetland communities described above, sand spit vegetation such as dune grass, and coastal bluff prairies (see “Rare Communities” in Appendix F).

Colonization of Puget Sound has resulted in large-scale changes to terrestrial vegetation patterns as a result of agriculture, timber harvest, and industrial and residential development. These disruptions and conversions interfere with natural forest processes, structure, and functions, setting the stage for invasions of non-native species (Brennan 2007). Invasive shrubby species such as Himalayan blackberry (*Rubus armenicus*), butterfly bush (*Buddleja davidii*), reed canary grass (*Phalaris arundinacea*), and Japanese knotweed (*Polygonum* spp.) commonly invade disturbed areas, often so aggressively that they inhibit establishment of native vegetation. In large river deltas, the majority of the forested wetlands and riparian zones are entirely devoid of trees or consist of sparse, narrow, and patchy strips of small- to medium-sized cottonwood (*Populus balsamifera*), willow (*Salix* spp.), and alder. River channelization and bank stabilization with levees have required vegetation removal, which results in the majority of the stabilized banks being covered with grasses and invasive species (e.g., blackberry, knotweed, and reed canary grass) of low value to the native fish and wildlife.

3.2.2 Shellfish and Other Macroinvertebrates

Invertebrates on beaches, embayments, and large river deltas assemble largely according to extent of tidal inundation. Invertebrates that inhabit landforms with softer substrate can be endobenthic (living within the substrate), epibenthic (living on top of the substrate), or pelagic. In river deltas, invertebrate communities may differ among rivers depending on factors such as the extent of freshwater influence and chemical contamination. Benthic macroinvertebrates in brackish and saline conditions include amphipods, isopods, oligochaete and polychaete worms, and copepods (Cordell et al. 1998). Insect larvae are more prevalent in freshwater. Other invertebrates found in more saline conditions include cancer crabs, polychaetes, sea cucumbers, sea stars, many shrimp species, and sand dollars (Dethier 1990). Native and introduced oysters can reside in the protected intertidal zones of embayments. Lewis’s moon snail and sunflower sea stars are common predators in intertidal and subtidal zones. Occasionally, giant Pacific and red octopi dwell in the lower intertidal and subtidal zones (Harbo 2006). Beach hoppers live underneath driftwood in the upper tidal elevations of beaches (Kozloff 1993). In eelgrass meadows and kelp beds, diversity and density of invertebrates increase tremendously with nudibranchs, jellyfish, decorator crabs, sea urchins, sea pens, and a variety of bivalves, shrimp, crabs, and echinoderms.

Shellfish*, mainly clams and oysters, are an important part of the Puget Sound ecosystem and regional economy, and have cultural significance for Native American tribes. Geoduck clams are the largest of the bivalve species in Puget Sound, ranging from the lowest intertidal elevations to depths of 100 meters (Harbo 2006). These large clams can reach over 80 years old. Native Americans and recreational users harvest wild geoduck. Geoduck aquaculture is increasing along beaches and embayments of south Puget Sound and Hood Canal, as demand for overseas export increases. Another shellfish, the native Olympia oyster (see Section 3.2.7) has declined dramatically over the past century mainly due to overharvest (Dethier 2006). The Pacific oyster, introduced from Japan, is artificially propagated throughout Puget Sound. Pacific oysters could not sustain themselves as a population without aquaculture efforts as they require higher temperature for reproduction; however, they occasionally reproduce successfully in the wild.

Artificial landforms often attract unique benthic communities. Given that many pilings and docks are treated with preservatives to prevent bio-fouling, a few hardier species typically move in first and then others follow. Invertebrates commonly found on floats, docks, and pilings in the Puget Sound include plumose anemones, ochre and sunflower sea stars, tubeworms, and breadcrumb sponges (*Halichondria* spp.) (Kozloff 1993). Other invertebrates may be present, such as sabellid worms, bryozoans, barnacles, mussels, several types of snails, crabs, and shrimp, and native and invasive ascidians.

3.2.3 Fishes

Widely varying fish communities utilize Puget Sound nearshore ecosystems where individuals spend all or just portions of their lives. Three general groupings are demersal/reef fish, forage fish, and anadromous fish, although some nearshore species may not fall neatly into a single category. Fish diversity tends to be higher in kelp beds and eelgrass meadows due to the refuge and feeding opportunities they provide. At high tide, the diversity of fish species in the nearshore zone increases significantly, especially in eelgrass meadows (Dethier 1990). Information on the three categories of fish follows.

Demersal/Benthic Fish

The demersal/benthic (associated with and located on the bottom) fish category includes fish that use a wide spectrum of habitats including rocky shores, submerged vegetation, and sandy bottoms. Fish found in the rocky/boulder habitat are referred to as reef-dwelling fish; however, they may use areas with softer substrate, particularly if there is structure to hover over, such as vegetation, sunken boats, riprap, or old pilings. The lingcod is the typical top predator in reef-like habitats. Juvenile rockfish often hide in understory kelp and rocky crevices (Hayden-Spear and Gunderson 2007), and certain species use areas as shallow as tide pools (Love et al. 2002). A few rockfish species forage in shallow areas as adults. A variety of sculpin use reef habitats to rest on the bottom and feed on the abundance of invertebrates indicative of rocky substrates. Kelp greenlings, pricklebacks, wolf eels, gunnels, and shiner perch forage in and around rocky substrates and their associated kelp forests. Demersal fish more typical of softer substrate include flatfish such as sole and flounder, certain sculpin species, and the occasional rockfish species. Occasionally, deepwater fish such as spiny dogfish, ratfish, eelpout, Pacific tomcod, and hake may enter the shallows of the nearshore zone to feed.

*Forage Fish**

The three species of small schooling fish that are most highly dependent on the nearshore zone are Pacific herring, Pacific sand lance, and surf smelt. Collectively referred to as "forage fish", their sheer abundance makes them a primary food source for a variety of marine fish and birds, particularly salmonids. These three species are highly dependent on nearshore habitats and substrate for spawning (Penttila 2007). Pacific sand lance and surf smelt spawn in the upper intertidal zone of sand/gravel beaches leaving their eggs to incubate in the substrate. Their spawning areas are common in Puget Sound, scattered throughout the region. Pacific herring spawn almost exclusively in the shallow subtidal and lower intertidal zones, mainly on eelgrass and kelp. Other forage fish species, such as longfin smelt and eulachon, use river deltas for spawning (see Appendix F).

Anadromous Fish

Fifteen native species of anadromous fish use marine and freshwater of the Puget Sound area. These include all five species of Pacific salmon (pink, coho, chum, Chinook, and sockeye), two species of native char (bull trout and Dolly Varden), steelhead and coastal cutthroat trout, longfin smelt, eulachon, white and green sturgeon, and two species of lamprey. Salmon are discussed in more detail because of their ecological, cultural, and economic importance in Puget Sound. For detailed information on other anadromous fish that occur in Puget Sound, see Appendix F.

<u>Salmonids:</u> The most well-known anadromous fish in Puget Sound are salmonids (salmon, trout, and char). Several agencies monitor salmonid populations due to the ecological and economic importance and declining numbers (warranting the listing of several species on the Federal Endangered Species List). Pacific salmon, in particular, have a critical role in Puget Sound's ecosystem dynamics. Known as a keystone species (Willson and Halupka 1995), Pacific salmon are a food source for many marine, freshwater, and land animals and provide marine nutrients to freshwater environments post-spawning (Cederholm et al. 1999). All salmonids spawn in freshwater gravel substrates where the eggs incubate and hatch.

Although most species and life history stages of salmonids can be observed in nearshore areas, juvenile salmonids* typically use these ecosystems extensively as a migration corridor and foraging habitat; however, not all species or runs within a species use the nearshore zone in the same way (Fresh 2006). For example, Chinook and chum use coastal embayments and non-natal estuaries from other rivers whereas steelheads do not. As the juveniles grow, they expand their range into deeper water before migrating to the North Pacific Ocean, with the exception of a few runs that are Puget Sound residents (Fresh 2006). As adults, large salmonids such as steelhead and Chinook typically only use the larger rivers for spawning, but pink, chum, and coho salmon adults can transit small embayments en route to their spawning grounds in smaller streams that flow into Puget Sound. Adult bull trout use the nearshore areas along beaches and at the entrances of embayments and large river deltas as foraging habitats.

Salmonid use of the nearshore zone depends on the species, the particular run of a species, and environmental conditions. Dendritic tidal channels in large river deltas are an important feature for juvenile rearing and smoltification (Beamer et al. 2005, Fresh 2006); however, much of this off-channel habitat has been lost in large river deltas due to diking of rivers for development of floodplains. See Appendix F for information on population trends of salmonids in Puget Sound.

3.2.4 Birds

Approximately 100 bird species utilize Puget Sound nearshore ecosystems. Shorebirds* forage along the beaches at the tide line in search of benthic invertebrates that are close to the surface; representative species include spotted sandpipers, surf scoters, dunlins, Western sandpipers, yellowlegs, and turnstones. Embayments and river deltas host a variety of birds that are attracted to abundant eelgrass beds, salt marshes, and mudflats. Birds associated with tide flats include snow geese, brants, gadwalls, American widgeons, mallards, pintails, teal, plovers, sandpipers, and dowitchers (Buchanan 2006). Great blue herons* forage on a variety of fish and invertebrates in shallow pools, mudflats, and eelgrass beds during low tides (Eissinger 2007). American bitterns, Virginia rails, marsh wrens, savannah wrens, song sparrows, and common yellow throats nest and forage in and around salt and freshwater marshes.

In fall and winter, the more agriculturally developed river deltas, such as Skagit and Snohomish, host large numbers of snow geese and trumpeter swans that feed on vegetation in shallows and agricultural fields. The trumpeter swan, once an endangered species, has increased in numbers in Skagit County from a 1963 population of 20 to several thousand today. Other shorebirds, such as dunlin and black bellied plover, use flooded agricultural fields and estuaries mainly during migration and in winter. Several species of raptors appear throughout Puget Sound including bald eagle, red-tailed hawk, rough-legged hawk (winter only), northern harrier, gyrfalcon (winter only), peregrine falcon, merlin, Cooper’s hawk, sharp-shinned hawk, and osprey. The Skagit Delta hosts one of the largest wintering populations of raptors in the contiguous United States. In heavily urbanized river deltas such as the Duwamish River estuary, abundance of birds is much lower due to lack of foraging and nesting habitat.

More widely distributed birds throughout Puget Sound include cormorants, grebes, loons, crows, geese, and a variety of gulls. Some of these, such as cormorants and gulls, take advantage of human-made shoreline structures for nesting and foraging. A variety of passerines, also known as song and/or perching birds, nest and forage in riparian areas of rivers and along the shoreline.

3.2.5 Mammals

Marine

Harbor seals are the most common marine mammal, found nearly ubiquitously throughout Puget Sound, often seen basking on rocky outcroppings, beaches, and occasionally human-made structures. They occasionally enter the mouths of rivers and travel several miles upstream. Steller sea lions visit the San Juan Islands every fall to rest and forage before they go to coastal rookeries to mate. California sea lions, northern elephant seals, and sea otters visit Puget Sound, though not in large numbers. Killer whales*, also known as orcas, are top predators in Puget Sound. These whales appear most frequently around the San Juan Islands; however, they occasionally explore other areas of Puget Sound. Of the four types of killer whales in the northeastern Pacific, only the Transients and Southern Residents are common in the San Juan Islands and greater Puget Sound region; the Offshores and Northern Residents rarely enter Puget Sound (Kriete 2007). Transient killer whales feed on marine mammals such as harbor seals, sea lions, and porpoises, and their presence is somewhat unpredictable. The Southern Residents regularly occur among the San Juan Islands and occasionally in Puget Sound; they feed almost exclusively on fish, primarily Chinook and chum salmon. The Southern Residents are ESA-listed as endangered (see section 3.2.7).

Freshwater and Terrestrial

If freshwater is present or a stream is nearby, river otters may forage and play in embayments and at the mouth of rivers. Beaver, muskrat, and mink inhabit upstream portions of the many streams and rivers that flow into Puget Sound. Terrestrial mammals such as black tail deer, raccoon, weasels, opossum, coyote, and a variety of small mammals inhabit riparian areas and occasionally browse the shoreline. Carlton and Hodder (2003) introduced the term “maritime mammal” and have documented many predation events by terrestrial mammals that forage specifically in marine intertidal areas; the majority of records involved raccoon, mink, and black bear on shores of the Eastern North Pacific Ocean. Habitat areas have significantly decreased due to urbanization and industrialization around Puget Sound.

3.2.6 Aquatic Invasive Species

Biological monitoring of Puget Sound in the last 20 years has identified many exotic species that have invaded the region. At least 52 non-indigenous marine species inhabit Puget Sound based on a comparison of listings by WDFW and researchers (Cohen 2004). Ray (2005) found 125 non-indigenous marine and estuarine animal species in the state of Washington by querying lists maintained by the Smithsonian Institution (*www.nisbase.org*). In this report sponsored by the Corps’ Engineer Research and Development Center, there are 12 invasive marine animal species deemed most threatening to Corps habitat restoration efforts in Washington. These include several species of clams and mussels as well as Atlantic salmon and green crab. In addition, the Washington State Aquatic Nuisance Species Management Plan (Meacham 2001) identifies nine marine plant species as present in Washington, including *Pseudo-nitzchia australis*, the algae linked to domoic acid and shellfish poisoning in humans. Shipping imports for aquaculture and fisheries provide the dominant pathways for marine invasion within this region (Wonham and Carlton 2005); however, human modification of shorelines, including marina development, can increase the likelihood of spread as exotic species fill voids following native habitat loss. See Appendix F for more specific information on aquatic invasive species.

3.2.7 Rare, Threatened, and Endangered Species

Puget Sound supports numerous rare, threatened, and endangered species. Many of these have specific ecological niches that are vulnerable to multiple anthropogenic pressures including habitat loss, overharvest, and pollution. Some have protection under the Federal Endangered Species Act (ESA); others are recognized at the state level, and some have no formal protection status but have been identified as rare by the conservation community. Plants discussed herein have been identified as rare on the Washington Department of Natural Resources (WDNR) Natural Heritage website. Many of these species also have special status listing in British Columbia under the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Species discussed below use nearshore ecosystems either **directly** as habitat (exclusively or intermittently), **indirectly** by foraging for species that have a strong dependence on the nearshore zone, or **intermittently** by occasionally using the nearshore habitats, including use as migratory corridors. Details on distribution, population status, and threats to each of these species appear in the following sections. Appendix F provides additional information on life history and population status on rare, threatened and endangered species.

Southern Resident Killer Whale (Orca)

Southern Resident killer whales (*Orcinus orca*) occur in Puget Sound from early spring to late fall when they move north and south along the coast for the winter. Due to the low numbers and potential threats, Southern Resident killer whales are ESA-listed as endangered (NMFS 2005a). Critical habitat is designated as marine water more than 20 feet deep in Puget Sound, San Juan Islands, and Strait of Juan de Fuca (NMFS 2006b). Southern Resident killer whales eat a variety of fish and squid, but have a strong feeding preference for chum and Chinook salmon, which rely heavily on the nearshore zone for juvenile rearing. Southern Resident killer whales are often spotted in Haro Strait, the west side of the San Juan Islands, the southern part of Georgia Strait, Boundary Passage, the southern Gulf Islands in Canada, and the eastern end of the Strait of Juan de Fuca, sometimes playing and foraging in shallow kelp beds adjacent to rocky shorelines (Kriete 2007). In the fall, the whales may expand their range in Puget Sound to the south in pursuit of local salmon runs before leaving for their winter habitat outside of Puget Sound (Kriete 2007).

Three matrilineal pods of Southern Resident killer whales frequent Puget Sound, named J, K, and L pods, numbered at 87 individuals for all three pods in 2010. Threats to this population include decline in prey abundance, presence of toxic substances, and whale-watching vessel traffic. Concentrations of contaminants in Southern Resident killer whale are some of the highest of any marine mammal in the world (Kriete 2007). In addition, the Southern Resident pods are relatively small, reproductively isolated, and face the risk of population decline through inbreeding effects. Currently, these pods have few reproductive males and females, and the loss of a key reproductive male or female could stunt population growth for years until another individual reaches maturity, which typically occurs at 10 to 15 years of age (Perrin and Reilly 1984). The social cohesion within pods concentrates individuals within a relatively close extent; this can lead to large population declines resulting from one catastrophic event.

Humpback Whale

Humpback whales (*Megaptera novaeangliae*) have at least three different populations in the North Pacific Ocean. The California/Oregon/Washington stock is relevant to this project. This population winters in coastal Central America and Mexico and migrates to areas ranging from the coast of California to southern British Columbia in summer/fall (NMFS 2013). Due to past commercial exploitation, humpback whales are ESA-listed as endangered. Although humpbacks were one of the more common cetacean species in Puget Sound in the early 1900s, they are now sighted only intermittently (Calambokidis and Steiger 1990). Humpbacks observed in Puget Sound do not remain for long periods and are generally considered stragglers. Recent increases in the population have resulted in more frequent sightings in Puget Sound and along the Strait of Juan de Fuca. Reports of humpback whale sightings have appeared on whale watching and local news websites as recently as June 2011 in Puget Sound (King 5 News 2011) and February 2012 in Hood Canal (Kitsap Sun 2012).

Humpbacks are increasing in abundance in much of their range. In the North Pacific, humpback abundance was fewer than 1,400 whales in 1966 after heavy commercial exploitation. The current abundance estimate for the North Pacific is about 20,000 whales. Threats to humpbacks include entanglement in fishing gear, boat strikes, whale watch harassment, and habitat degradation (NMFS 2013).

Sea Otter

Sea otters (*Enhydra lutris*) range from Southern California to the Aleutian Islands in Alaska, in non-contiguous patches. The Washington population of sea otters is listed as endangered by the State of Washington due to its small population size, restricted distribution, and vulnerability. The southern population, in California, and the northern population, in Alaska, are each listed as a federally threatened species; however, the Washington and British Columbia populations are separate (USFWS 1977; USFWS 2004). Sea otters almost never leave the water where they inhabit the shallow kelp forests of the nearshore zone and prey on a variety of invertebrates (Haley 1986).

Historically, sea otters inhabited the entire west coast of North America, but harvest for pelts that began in the 1700s extirpated them from many areas, including Washington. In 1969 and 1970, sea otters were reintroduced to the Washington coast from Alaska. Surveys indicate that the sea otter population is gradually increasing in Washington State and in British Columbia off Vancouver Island. Most of the Washington population is on the northern coast and the western Strait of Juan de Fuca; however, sightings have occurred as far south as Olympia and more frequently in the San Juan Islands (Lance et al. 2004). Threats to sea otters in Washington include oil spills, infectious disease, and entanglement in fishing nets (WDFW 2012b).

Hood Canal Summer Chum Salmon

Chum salmon (*Oncorhynchus keta*) range from Monterey, California to the Arctic coast and Beaufort Sea along the coast of North America. The Hood Canal Summer-Run chum salmon Evolutionarily Significant Unit (ESU) is ESA-listed as threatened (NMFS 2005b). Critical habitat exists throughout Hood Canal and its tributaries. Juvenile chum salmon use small coastal embayments and eelgrass beds as foraging grounds and refuge from predators before migrating to the North Pacific Ocean (Fresh 2006).

Six of the eight summer chum salmon stocks within the Hood Canal ESU have decreased in abundance with return stocks below viable replacement levels (Fresh 2006). The Hood Canal summer chum populations have been declining since 1978. The Strait of Juan de Fuca populations have been declining since 1988 and although they are not declining as rapidly as those in Hood Canal, these populations are at very low levels. Threats to Hood Canal summer-run chum include degradation of habitat, harvest, and low water flows in the Hood Canal watersheds (Johnson et al. 1997).

Puget Sound Chinook Salmon

Chinook salmon (*Oncorhynchus tshawytscha*) range from central California to Kotzebue Sound, Alaska along the coast of North America. The Puget Sound Chinook salmon ESU found east of the Elwha River is ESA-listed as threatened (NMFS 2005b). Critical habitat exists throughout Puget Sound and its tributaries. Puget Sound populations are largely summer/fall runs, which are typically considered ocean-type fish (migrating to marine water within their first year). Like chum, juvenile Chinook use small coastal embayments and nearshore areas while rearing along the shoreline before they migrate to the North Pacific Ocean (Fresh 2006). Few Chinook salmon (called residents) reside year-round in Puget Sound (Pressey 1953, Brannon and Setter 1989).

Abundance estimates indicate that most populations are at a small fraction of their historic levels; several populations within the Nooksack, Lake Washington, mid-Hood Canal, Puyallup, and Dungeness basins have returns of fewer than 200 adult fish, signifying extinction risk. Only the upper-Skagit stocks have returns of native (non-hatchery) fish in excess of 10,000 adults. A 1998 status review of these populations indicated a decline of 1.1 percent per year; more recent calculations indicate a slower decline (Shared Strategy 2007). Threats to Puget Sound Chinook salmon include diking, draining, and filling of freshwater and estuarine wetlands; sedimentation of upper tributaries due to timber harvest; and blockages and altered hydraulic regimes from dams (Good et al. 2005).

Puget Sound/Strait of Georgia Coho Salmon
Coho salmon (*Oncorhynchus kisutch*) range from the Bering Sea to central California along the coast of North America. NMFS identified Puget Sound/Strait of Georgia coho as a species of concern. While in Puget Sound, juvenile and sub-adult coho migrate and forage along the shoreline before migrating to the North Pacific Ocean. A few coastal and inland coho salmon stocks reside year-round (called residents) in Puget Sound (Weitkamp and Neely 2002).

The majority of coho in U.S. water originate from hatchery production. Stocks in Puget Sound range from healthy to critical (WDFW 2002). Three stocks in Puget Sound/Strait of Georgia are at high risk of extinction and one as possibly extinct (Nooksack River) (Nehlsen et al. 1991). None of the stocks identified as healthy are strictly of wild origin. Bledsoe et al. (1989) reported an 85 percent decline of coho salmon runs in South Puget Sound from 1896-1975. Hatchery production is a major threat to Puget Sound/Strait of Georgia coho by way of genetic outbreeding and genetic homogenization, as many hatchery strains are from out-of-basin sources. Other threats include loss of habitat and unfavorable ocean conditions (NMFS 2009c).

Coastal/Puget Sound Bull Trout
Bull trout (*Salvelinus confluentus*) are native char of Washington, Oregon, Idaho, Nevada, Montana, and western Canada. Puget Sound bull trout are ESA-listed as threatened (USFWS 1999). Critical habitat exists throughout much of Puget Sound and its tributaries. Unlike Pacific salmon, anadromous bull trout are year-round residents of the Puget Sound basin. In marine water, sub-adult and adult bull trout commonly forage in shallow nearshore habitat and natal and non-natal estuaries along the shoreline, but usually return to their natal estuary to migrate upstream to spawn.

Bull trout populations have declined throughout much of the species' range; some local populations are extinct, and many other stocks are isolated and may be at risk (Rieman and McIntyre 1993). Insufficient data exist to confidently estimate bull trout abundance for many core areas and for the entire management unit (Shared Strategy 2007). Combinations of factors including habitat degradation, expansion of exotic species, and exploitation have contributed to the decline and fragmentation of bull trout populations.

Puget Sound Steelhead
Steelhead (*Oncorhynchus mykiss*) range from Kamchatka in Asia, east to Alaska, and south along the Pacific Coast to about the U.S.-Mexico border (Busby et al. 1996). Puget Sound steelhead are ESA-listed as threatened (NMFS 2007b). Relative to the longer nearshore rearing periods of other juvenile salmonids, juvenile steelhead smolts generally outmigrate to offshore

areas quickly and the transit time through the estuary is brief (days to weeks). Few reference sources discuss estuarine use by steelhead adults.

In the last 10 years, Puget Sound steelhead populations have decreased at a steady pace with marked decreases seen within the Strait of Juan de Fuca, Bellingham Bay, Hood Canal, and South Puget Sound. The more intense population declines since 1990 in Puget Sound mimic declines of steelhead in British Columbia along the Strait of Georgia and eastern Vancouver Island. Speculated causes of these declines include climate change, hatchery production, harvesting, and increased UV radiation (Hard et al. 2007).

Green Sturgeon

Green sturgeon (*Acipenser medirostris*) are a broadly distributed fish ranging from Mexico to Alaska along the coast of North America. The Southern distinct population segment (DPS) of green sturgeon is ESA-listed as threatened (NMFS 2006a). In Washington, critical habitat was designated for green sturgeon along the coast, the Strait of Juan de Fuca, and the southern portions of the San Juan Islands, along with major rivers and bays. No critical habitat exists in Puget Sound proper (NMFS 2009a). Although no freshwater spawning habitat occurs in Puget Sound, green sturgeon use the nearshore zone as foraging habitat. Population declines of the southern DPS of green sturgeon are due to a reduction in spawning area to a limited number of rivers including the Sacramento, Rogue, and Klamath, and have little to do with Puget Sound. Other threats include insufficient freshwater flow rates, contaminants, bycatch, impassible barriers, and elevated water temperatures.

Rockfish (Bocaccio, Canary, Yelloweye)

Bocaccio (*Sebastes paucispinis*) range from northern British Columbia to central Baja California. Juveniles are the most abundant life stage occurring in the nearshore zone where they hover over rocky substrate with various understory kelps or sandy bottoms with eelgrass. Due to declining numbers and increased rarity, bocaccio are ESA-listed as endangered (NMFS 2009b). Threats to bocaccio include direct fishing and bycatch, which led to recruitment failure in the early 1990s (NMFS 2009b).

Canary rockfish (*Sebastes pinniger*) range from northern British Columbia to northern Baja California, potentially living to be 80+ years old. Juveniles are the most abundant life stage in the nearshore zone where they hover over rock-sand interfaces and sand flats. Due to declining numbers and increased rarity of canary rockfish in Puget Sound, they are ESA-listed as threatened (NMFS 2009b). Threats to canary rockfish are the same as those for bocaccio.

Yelloweye rockfish (*Sebastes ruberrimus*) range from the eastern Aleutian Islands to Northern California and can live up to 118 years. Due to declining numbers and increased rarity, they are ESA-listed as threatened (NMFS 2009b). Adults, sub-adults, and juveniles occupy the nearshore areas with rocky substrate. Threats to yelloweye rockfish are the same as those for bocaccio and canary rockfish.

Eulachon
Eulachon (*Thaleichthys pacificus*) are a small anadromous fish in the eastern Pacific Ocean that range from California to Vancouver Island, including northern Puget Sound. The southern Distinct Population Segment (DPS) of eulachon is ESA-listed as threatened (NMFS 2010). No spawning areas are documented in Puget Sound. The only documented eulachon spawning near the project area is the Elwha River in the Strait of Juan de Fuca (designated as critical habitat) and the Fraser River in southern British Columbia (NMFS 2011); however, migrants from the northern population likely forage in areas of the Puget Sound nearshore zone that extend beyond their spawning range (Goetz pers. comm. 2009).

Eulachon abundance exhibits considerable year-to-year variability; however, nearly all spawning runs from California to southeastern Alaska have declined in the past 20 years, especially since the mid-1990s. From 1938 to 1992, the median commercial catch of eulachon in the Columbia River was approximately 2 million pounds (900,000 kg), but from 1993 to 2006, the median catch declined to approximately 43,000 pounds (19,500 kg), representing a nearly 98 percent reduction in catch from the prior period (Gustafson et al. 2010). Threats to eulachon include habitat loss and degradation of spawning grounds via dams, siltation, and dredging, and potentially chemical pollution (Gustafson et al. 2010).

Marbled Murrelet
Marbled murrelets (*Brachyramphus marmoratus*) are small marine diving birds that range from southern California to Alaska. They are ESA-listed as threatened (USFWS 1992). Critical habitat includes upland forested stands used for nesting, but does not include marine water. Murrelets are common winter residents of Puget Sound, especially the northern portions. Forage habitat is deeper water in entrance channels of rocky shores, estuaries, and protected bays where the birds can dive in pursuit of forage fish, which are dependent on nearshore habitat (Angell and Balcomb 1982).

Few data are available to interpret trends in population; however, there was an estimated 51 percent decline in north Puget Sound between 1978 and 2003 (Huff et al. 2006). Recent trends indicate a continued steady decline of marbled murrelets, with a decrease in population of 7.9 percent from 2000 to 2009 in Puget Sound and the Strait of Juan de Fuca (USFWS 2009). The marbled murrelet population estimate for Puget Sound and Strait of Juan de Fuca in 2010 was around 4,400 birds (Pearson et al. 2011a). Threats include habitat loss from timber harvest and windthrow in their terrestrial environment, and harmful algal blooms, declining prey availability (forage fish), and catastrophic events such as oil spills in their marine environment.

Northern Abalone
Northern, or pinto, abalone (*Haliotis kamtschatkana*) range from Alaska to Mexico. National Marine Fisheries Service (NMFS) lists northern abalone as a Federal Species of Concern (NMFS 2007b), and Canada recently listed them as Endangered under COSEWIC (2009). In

Washington, they inhabit rocky shorelines with significant kelp cover around the San Juan Islands and the Strait of Juan de Fuca. Although there has never been a commercial fishery for northern abalone in Washington State, sport harvests continued into the mid-1990s. Declining numbers triggered WDFW to close the recreational harvest in 1994; however, populations continue to decline (Puget Sound Restoration Fund 2009). Reasons for the continued decline include the Allee effect (in which individuals are too far from each other for successful fertilization), water quality conditions, and poaching.

Olympia Oysters

Olympia oysters (*Ostrea lurida*) historically ranged from southeast Alaska to Baja California. Oyster reefs often occur between eelgrass beds and mudflats, where they filter-feed on plankton and other matter (Dethier 2006). Although they were once abundant in shallow subtidal zones of southern Puget Sound in wild and cultured forms, natural reproduction of Olympia oysters has nearly disappeared. Factors leading to the decline include overharvest, siltation, and domestic and industrial pollution of estuaries. Other stressors include predation from invasive drilling snails and flatworms, and displacement by culture of the hardier introduced Japanese oyster (*Crassostrea gigas*) (Dethier 2006).

California Buttercup

California buttercup (*Ranunculus californicus*) grows in open grassy areas, rocky slopes along the coast, and in rocky wooded areas from southern California to southern Vancouver Island. It is listed as a rare plant by the WDNR Natural Heritage Program (WDNR 2009). It tends to be associated with Sitka spruce, Douglas fir, and madrone, and dryer areas such as grasslands. Very few sites in Puget Sound still contain California buttercup and presently are only around the coastline of the San Juan Islands. Given the small range, any disturbance via grazing, development, or recreation can be a threat (WDNR 2009).

Sharpfruited Peppergrass

Sharpfruited peppergrass (*Lepidium oxycarpum*) grows in the salt spray zone from central California to Victoria, British Columbia. In Washington, WDNR lists it as a rare plant on the Natural Heritage website. This plant grows in moist cracks and vernal pools and in sand or saline soil in direct sunlight along the coastline. The only known occurrence of sharpfruited peppergrass in Washington is on the coastline of the San Juan Islands. Given the small range, any disturbance via grazing, development, or recreation can be a threat (WDNR 2009).

Golden Paintbrush

Golden paintbrush (*Castilleja levisecta*) historically occurred at many sites in Puget Sound, British Columbia, and as far south as the Willamette Valley in Oregon. Its extirpation from the majority of these sites, including all of Oregon, led to its ESA listing as threatened (USFWS 1997). It occurs in open grasslands at low elevations around the perimeter of Puget Sound. Most remaining populations are in the San Juan Islands and on Whidbey Island. Loss of golden paintbrush is associated with the conversion of grasslands to agriculture, and residential and commercial development (WDNR 2009).

3.3 CULTURAL RESOURCES

Cultural resources encompass a wide range of historic and cultural places and property types. Buildings, structures, and sites; groups of buildings, structures, or sites forming historic districts; landscapes; and individual objects may be eligible for listing in the National Register of Historic Places (National Register) if they meet three main standards: age, significance, and integrity. Resources generally must be 50 years old or older for National Register consideration, although properties more recent in age may be determined eligible if they possess exceptional significance. To be significant, a property must have a demonstrated association with events, activities, or developments that were important in the past; with the lives of people who were important in the past; and/or have potential to yield information through archaeological investigations. Integrity refers to the ability of a property to demonstrate significance through the retention of aspects of location, design, setting, materials, workmanship, feeling, and association. The term "historic properties" refers to cultural resources that are either eligible for or listed on the National Register.

Preliminary investigations to identify historic properties at the proposed restoration sites have been completed. Sponsored by USFWS and conducted under contract by a cultural resources consulting firm, these investigations included a records/literature review and reconnaissance-level survey work (see annotated bibliography). The records/literature search considered all proposed restoration sites and was designed to identify any known (previously recorded) potential cultural resources as well as the extent and location of previous cultural resource investigations. Materials reviewed included reports, field notes, and site forms at the Washington State Department of Archaeology and Historic Preservation and various historical, ethnographic, and environmental documents. The contractor summarized the findings of the records/ literature search in a confidential report, restricted in distribution due to the sensitive nature of cultural resource information. Conceptual design reports prepared for restoration sites identified several additional buildings and structures potentially historic in age. Reconnaissance-level surveys occurred at eighteen sites. Only areas where landowners granted access were considered for investigation. Pedestrian archaeological surveys were further limited to sample areas based on various environmental factors and extent of previous cultural resource investigation and site finds. Additionally, no "occupied" buildings were inventoried. The Corps considers the survey's findings and recommendations tentative and further investigation at each of the proposed sites is needed to determine the presence/absence of unidentified archaeological resources and to evaluate the previously recorded sites. In addition, further inventory of historic structures is necessary.

Common archaeological sites located within the Puget Sound nearshore environment include the following types:

- Occupation sites such as prehistoric hunting camps, prehistoric and ethnohistoric villages, as well as early Euro-American cabins, and farms
- Prehistoric and Ethnohistoric Shell Middens
- Prehistoric and Ethnohistoric Lithic Assemblages/Scatters
- Cemeteries (both prehistoric and historic)
- Railroad camps associated with the construction of railroads and other transportation methods (roads, bridges)
- Logging camps

Common historic buildings and structures found in the Puget Sound Nearshore include the following types:

- Levees and dike Systems
- Canneries
- Early pioneer houses and farming complexes (barns, sheds, fences, and orchards)
- Roads and bridges
- Railroads
- Sawmills

3.4 SOCIOECONOMIC RESOURCES AND HUMAN ENVIRONMENT

The Puget Sound ecosystem is a cornerstone of the region's prosperity and quality of life. People from around the world are drawn to the Puget Sound region because of the dynamic economic opportunities and abundant natural assets the region offers. Puget Sound is bordered by twelve Washington counties, and is home to 4.3 million people or over 70 percent of Washington's total population (U.S. Census Bureau 2010). The Seattle Metropolitan Statistical Area (MSA) is the population center and economic engine of the Puget Sound Region. The Seattle MSA encompasses three of these twelve counties; with a total 2010 population of over 3.5 million, it is the fifteenth largest metro area in the U.S. (U.S. Census Bureau 2010).

Puget Sound serves as the major North American gateway for trade with Pacific Rim countries. Together the ports of Seattle and Tacoma make the Sound the second largest U.S. harbor for container traffic. The Puget Sound ecosystem—among the most productive and ecologically diverse in the U.S.—supports one of the largest commercial shellfish fishing and aquaculture industries in the country. Visitors and local residents alike enjoy a thriving outdoor recreation industry including such water-related activities as sportfishing, whale watching, shellfishing, kayaking, and scuba diving. These commercial and recreational activities are dependent upon the ecosystem functions, goods, and services (described in Section 1.8.3) that come from the "natural capital" (i.e. ecosystem elements of geology, water and nutrient flow, native plants and animals, etc.) of the Puget Sound environment (Earth Economics 2008). The following sections describe the socioeconomic resources and human environment with a focus on how the natural capital of the Nearshore Study area benefits the socioeconomics of Washington State.

3.4.1 Shoreline Ownership and Land Use

Washington State has a unique patchwork of public and private tideland ownership along its shoreline. Unlike some coastal states, Washington's tidelands and beaches are not all in public ownership. Based on a recent public access study by WDOE, 62% of Washington's marine waterfront property is privately owned (or 1,898 of 3,065 miles) (WDOE 2009b). The state Legislature elected to sell tidelands and beaches in 1889 and continued the practice for many years. In 1971, the State of Washington ceased all sales of tidelands to private entities. The boundaries and ownership of tidelands are complex due to changes in the law.

Various entities hold adjacent upland ownership. Some areas are predominantly residential in private ownership, supporting vacation and retirement communities. Other areas are in state or local government ownership for public recreational use or for transportation features such as roads or infrastructure related to ports and harbors. Private industries, especially those that are water-dependent for production or distribution of goods, are another common owner of adjacent uplands. The size and density of adjacent upland parcels often reflect proximity to urban centers.

3.4.2 Public Access and Recreation

Many of the opportunities associated with the nearshore zone and enjoyed by the public are dependent on access. The Washington State Public Trust Doctrine states that the waters of the state are a public resource for use and owned by the public for purposes of navigation, fishing, and recreation. While the doctrine provides for public use of waters regardless of tideland ownership, it does not require property owners adjacent to tidelands to provide access to these areas. The Washington Shoreline Management Act of 1971 acknowledges the need for public access by including it, along with shoreline use and environmental protection, as overarching policies of the Act. Table 3-4 provides a summary of shoreline access in Washington State by general geographic area. This information is from a shoreline public access database project recently completed by WDOE (2009b).

Table 3-4. Shoreline public access summary Source: WDOE 2009b

Shoreline Location	Miles	Percent of total statewide shoreline miles	Number of public access sites
Puget Sound Shore	591	17%	821
Outer Coast of Pacific Ocean	363	11%	152
Strait of Juan de Fuca	102	3%	66
Hood Canal	39	1%	74
Total Shoreline Public Access	*1,095*	*32%*	*1,113*

Recreational opportunities associated with the Puget Sound Nearshore range from passive (e.g., viewing the nearshore zone and its associated wildlife or sunbathing on a beach) to active including fishing, swimming, scuba diving, and boating. According to economic information summarized by WDOE, the Puget Sound area attracts $9.5 billion in travel spending, including 88,000 tourism-related jobs and $3 billion in income (WDOE 2008). Based on a 2001 wildlife viewing survey completed for the USFWS, approximately 208,000 U.S. residents (over the age of 16) travels to Washington State annually to view killer whales and other marine mammals. This estimate for 2001 shows Washington's whale watching industry generated approximately $18.4 million in sales and 205 jobs in counties adjacent to the coastal habitat of killer whales (Industrial Economics, Inc. 2006). According to the 2006 Outdoor Recreation Survey (Clearwater Research, Inc. 2007), 34% of Washington's 6.5 million residents engaged in beach combing, 31% swam or waded at marine beaches, 7% fished from a bank, dock, or shoreline jetty, and 9% collected shellfish. All of these recreational opportunities bring many visitors to the area; nearly 80% of the state's revenue from tourism is generated in the Puget Sound area (Earth Economics 2008).

Sportfishing for salmon and other marine fish is a popular activity in Puget Sound; however, the decrease in the availability of some salmon species for sportfishing has been dramatic. Nonetheless, the activity remains popular; marine recreational anglers in Washington State spent an estimated $126 million in 2004 including fishing equipment expenditures, but this figure does not include trip-related expenditures, which can be hundreds of dollars per trip and employ many individuals as captains and crew (Southwick 2006). Of all the salmon caught in freshwaters of Washington, 57% were caught in rivers that drain into Puget Sound, and of all salmon caught in marine waters, 60% of these fish are from Puget Sound stocks (TCW Economics 2012).

Shellfishing around Puget Sound includes Dungeness crabs, clams, oysters, and spot shrimp. Non-tribal recreational crabbers have been taking an average of 1.4 million Dungeness crabs each year since 2000, and treaty-reserved tribal collections amount to roughly 4 million per year (WDFW 2012a); the Puget Sound contribution to these figures is 85% (TCW Economics 2008). Non-tribal clam harvesting within Puget Sound produced nearly 350,000 pounds of clams in 2006; recreational harvesters collected over 650,000 oysters as well (TCW Economics 2012). Most of the spot shrimp in Washington (78%) comes from South Puget Sound areas, caught by recreational harvesters.

Expenditures for these activities go toward equipment, boat launching, fuel, and bait among other goods and activities. Economic effects of recreational fishing and shellfishing have direct benefits to food and beverage suppliers and establishments, lodging, gas stations, sporting goods suppliers, equipment rental suppliers, and guide services. Recreational anglers spent an estimated $905 million in Washington State in 2006 on fishing equipment and trip-related expenditures; approximately half of the net economic value of this figure is associated with species that rely on the nearshore zone for some part of their life history (TCW Economics 2008).

3.4.3 Commercial Fisheries and Aquaculture

Commercial fishing and aquaculture are key industries in the Puget Sound economy. In 2007, approximately $3.9 billion, or 2.1 percent of Washington's overall revenue for the year, was generated from industries directly and indirectly associated with the commercial fisheries of Washington State. The industry includes businesses that harvest, distribute, and process finfish and shellfish products, as well as those that provide supplies and services to them. Puget Sound salmon, groundfish, Pacific herring, shellfish, and Dungeness crab are commercially harvested, processed, and distributed from multiple ports throughout the region. Commercial aquaculture includes the production of farmed clams, oysters, mussels, and geoducks.

Commercial fisheries for finfish in Washington State harvest a wide variety of species; key examples are salmon, rockfish, lingcod, sablefish, and halibut. Landings of commercially harvested fish statewide were valued at $272 million in 2010 (NMFS 2012); Puget Sound ports account for about 52% percent of Washington commercial fishery landings (TRG 2008). Fourteen of the 19 commercial fishing ports in Washington State are located in Puget Sound. The highest grossing ports are located in Bellingham Bay, Seattle, Anacortes, and Blaine. Other commercial fishing ports adding substantial economic value to their local economies are located in Neah Bay, La Conner, Everett, Tacoma, Olympia, and Shelton. Over the past three decades, the combined total harvest of tribal and non-tribal commercial fisheries has decreased by 60%, ranging from approximately 70 down to 30 million pounds harvested annually (Plummer pers. comm. 2009). Figure 3-2 illustrates the historical trends for commercial finfish and shellfish harvest in Puget Sound from 1981 through 2008. The rate of decline has lessened since the mid-1990s, although annual variation exists.

Shellfish such as oysters, clams, and mussels have been commercially grown and harvested in Puget Sound for over a hundred years, leading to a robust aquaculture industry that is one of the largest shellfish producing regions in the U.S. Shellfish aquaculture in Puget Sound has shown significant growth in harvest since the early 1980s, including an increase in geoduck production, a shellfish species that was virtually unknown outside the Pacific Northwest 40 years ago. Today, Puget Sound commercial harvesters sell 1.7 million pounds of this species each year, primarily in overseas markets bringing in $20 million in yearly state revenues (PCSGA 2012). Puget Sound's commercial aquaculture industry as a whole has been relatively stable over the past several years. The most recent data available are for 2009, when the total weight of all oysters, clams, mussels, and geoducks was nearly 75 million pounds, with a sales value of $107 million (PCSGA 2012).

Harvested fisheries and seafood products are destined for domestic as well as foreign markets, creating a commerce system with many beneficiaries. The industry contributes to seafood and fisheries processing and other sectors of the state economy such as marine technology and vessel maintenance and repair. Fishing vessels, processors, and related support businesses provide many jobs and substantial economic benefits to the regional economy. As reported earlier in this section, in 2007 approximately $3.9 billion, or 2.1 percent of Washington's overall earnings for the year, was generated from industries directly and indirectly associated with commercial fisheries in Washington State (BEA 2010, as cited in Radtke 2011).

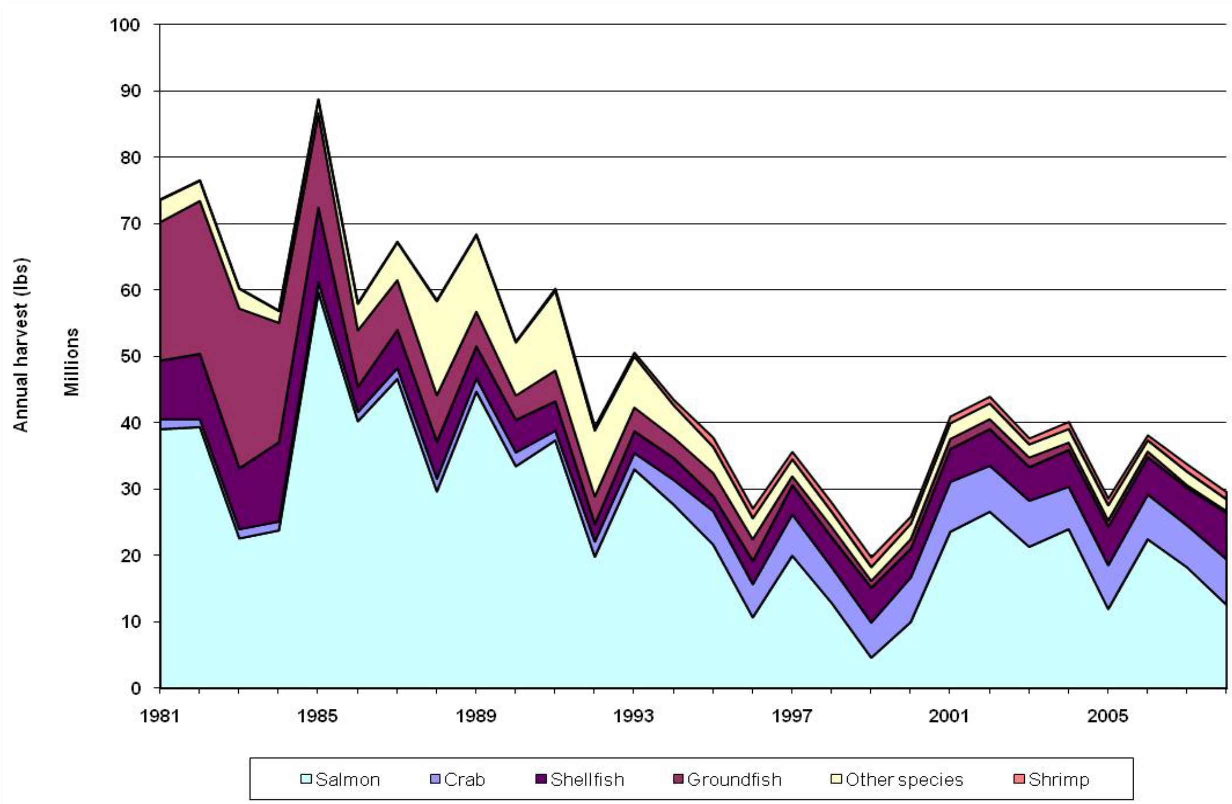


Figure 3-2. Puget Sound Commercial Fishery Harvest, 1981-2008 Source: Plummer (2009)

3.4.4 Transportation

The Puget Sound transportation system is a network of infrastructure moving people and goods within the region. In addition to the typical network of roads, highways, and railways, the system includes a fleet of vehicle and passenger ferries operated by the Washington State Department of Transportation. Puget Sound is home to the second largest U.S. harbor for container traffic, shipping over 62 million metric tons annually in recent years (WDOE 2008). The lucrative commerce industry located in Puget Sound has led to an expansive port and rail system.

Roadways within Puget Sound are commonly located along the shoreline to take advantage of the relatively flat and unobstructed terrain, avoiding the design challenges associated with hilly terrain. Roads along the shoreline are scenic and provide access to shoreline properties and public beach access points.

By necessity, ferry terminals and international shipping port infrastructure are located in the nearshore zone. Terminals that allow for access to ferries and their associated vehicle holding areas (paved impervious surface) are located on wharves over the subtidal and intertidal zones and extend into the adjacent upland area. The ports of Seattle, Tacoma, and Everett were built in historical river deltas to take advantage of flat real estate for upland storage and the easy access to deep water that allows large vessels to reach the wharves, cranes, storage yards, and rail lines for nationwide distribution of goods and commodities. Each port includes the terminus of a rail line, and much like the region's roads, rail corridors follow along the shoreline for efficient use of a flat right-of-way. Long stretches of rail lines extend along the eastern Puget Sound shoreline from Everett to Seattle and Tacoma to Nisqually. Shoreline roads and rail lines have contributed a significant amount of the degradation of the shoreline through fill, armoring, and stabilization of the Puget Sound nearshore zone.

3.4.5 Public Safety

NEPA requires the consideration of public safety in any Federal proposal. Public safety is a primary concern for any Federal water resources project. The following features may be included in the proposed action and may have relevance for public safety: levees, tide gates and culverts for flood risk management, shoreline armoring for erosion protection, roads for access of emergency and police vehicles, vehicle and railroad bridges, and public utility infrastructure. The proposed action also contains ecosystem restoration features that must be designed to maintain public safety, for example proposed projects would at a minimum maintain the existing level of flood risk management.

Restoration of nearshore habitat requires balancing improved estuarine flow conditions with the need to maintain road and railway access in and across the project, especially during emergencies and high water conditions. Public utilities such as phone lines, sewer, fiber optic cabling, electrical transmission lines, and pipelines frequently follow the linear corridors already occupied by roads, highways, and railroads. These corridors often cross streams, rivers, and estuaries to deliver services to cities, towns, and developments of all sizes. Ecosystem restoration features that enhance the flow of water must consider and design for continued railway and vehicle access as well as delivery of all public utility services.

Airports near wetlands need to minimize risks from birds and wildlife. The Federal Aviation Administration provides an advisory circular regarding land uses that attract "hazardous wildlife" on or near public-use airports (FAA 2007); it references a 2003 Memorandum of Agreement on this topic signed by the Corps and other Federal agencies. This circular covers considerations for airports near wetlands and other wildlife habitat. In addition, the Navy has their Bird/Animal Aircraft Strike Hazard (BASH) (U.S. Navy 2010) program, which describes a variety of measures that help minimize risk to aircraft from bird and animal strikes.

3.5 NEPA SCOPING RESULTS

As stated in the introduction to Chapter 2, certain resources were not raised as significant issues during the NEPA scoping process and therefore were not analyzed in detail as they related to potential impacts of the proposed action. Resources not carried forward for detailed analysis are sediment quality, air quality, aesthetic resources, environmental justice, public utilities, and airborne noise. The following sections provide a summary of the existing conditions of these topics and brief rationale for exclusion from detailed analysis.

3.5.1 Sediment Quality

Glacial retreat left a mix of substrate types around the Puget Sound nearshore zone, which include mixed sand, gravel, and cobbles on the beaches, and sandy and muddy sediments around the large, fertile river deltas. Relatively recent human activities in the adjacent watersheds have contributed some of the finer sediments to the substrates. The primary characteristic of sediments is the vast variability in grain size distribution.

No sediments in Puget Sound are free from contamination typical of urbanized and industrialized waterfronts in the United States. Under the No-Action Alternative, these sediments in Nearshore Study-identified sites would likely remain in place and may release contaminants for an extended period, whereas under the proposed action alternatives, any contaminated sediments at Nearshore Study-identified sites would be addressed in accordance with applicable laws and regulations. The result of construction would not reduce the quality of any sediment. Project features shall be designed to minimize post-project erosion of any identified areas of contaminated sediment. Some sediment of agricultural value may be lost to the aquatic environment as natural ecosystem processes are restored to the nearshore zone, which include sedimentation and erosion processes. Other aspects of sediment quality such as presence of toxic substances and invasive species seed sources are analyzed in their respective chapters in this document. The proposed ecosystem restoration activities would be expected to improve sediment quality at the site locations and would have no effect toward degradation of sediment quality; therefore, the proposed action would have no significant impact to sediment quality.

3.5.2 Air Quality

Under the provisions of the Clean Air Act (CAA), the U.S. Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS). The standards specify maximum concentrations for carbon monoxide, particulate matter smaller than 10 micrometers, particulate matter smaller than 2.5 micrometers, ozone, sulfur dioxide, lead, and nitrogen dioxide. The EPA has published a list of all geographic areas with their NAAQS compliance status; for each NAAQS pollutant, each area is considered an “attainment” or “non-attainment” area. In a non-attainment area, the air pollutant concentration exceeds the NAAQS for one or more of these pollutants.

The proposed action may have temporary minor adverse impacts on highly localized air quality at the construction sites; construction may take months to years depending on the site. For all sites, best management practices would keep fugitive dust under control during land clearing activities. Heavy equipment would produce hydrocarbons in exhaust emissions although the incremental contribution would be extremely small compared to all sources of exhaust emissions in the region. Construction contractors would be required to keep all equipment in good working order to minimize emissions. Exhaust emissions would not be at a level that puts human health at risk, and the restoration sites would not have any permanent source of air pollutant emissions. A long-term effect of this ecosystem restoration project is that the increased area of vegetated wetlands could aid in removal of carbon dioxide and some other gaseous air pollutants. For these reasons, this project would have no significant impact to air quality in the Puget Sound area.

3.5.3 Aesthetic Resources

The visual character of the Puget Sound nearshore zone ranges from nearly pristine wilderness shorelines, to quaint waterfront towns such as Port Gamble and Port Townsend, to modern cityscapes like Tacoma and Seattle. While aesthetic value of a landscape can be highly subjective and vary widely depending on the viewer, the standard used for analysis for this project relies on values stated in the Washington State Shoreline Management Act (RCW 90.58.020). This Act protects the public interests of the natural character of the shoreline, resources and ecology of the shoreline, and public access and recreational opportunities.

The proposed project sites would have a temporary reduction of aesthetic quality for the duration of construction, which may take months to years per site. The long-term change, however, would be a return of the shoreline to a more natural configuration resembling the pre-settlement wilderness conditions. None of the stated values of the Shoreline Management Act would be precluded or degraded. The result of the proposed action would not degrade natural viewsheds, conflict with local guidelines or goals related to visual quality, reduce sunlight availability in residential areas, or obstruct views of valued resources. Therefore, the proposed action would have no significant impact on the visual quality and aesthetic resources in the Puget Sound area.

3.5.4 Environmental Justice

The purpose of Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations” is to protect minority and low-income populations from disproportionately high and adverse human health or environmental effects from government programs, policies, and activities. Only one of the proposed sites is located in proximity to a qualifying stakeholder community, the Lummi Nation. The Lummi Nation has been a strong proponent of the Nearshore Study since the beginning of the General Investigation and has no opposition to an ecosystem restoration site proposed in proximity to their tribal lands and interests. The nature of the proposed action is such that it would have no adverse human health or environmental effects and would in fact benefit the stakeholder community identified. Therefore, the proposed action would have no significant impact on environmental justice or any identified minority or low-income population.

3.5.5 Public Utilities

Public utilities have rights-of-way in the Puget Sound nearshore zone that include natural gas pipelines, water supply pipelines, sanitary sewer collection lines, and phone, cable, and electric lines. In general, public utility services at the proposed restoration sites would be avoided, modified, relocated, upgraded, or abandoned in accordance with applicable regulations. Specific impacts to utility lines located within the project sites would be evaluated during the design phase and mitigated during construction. In most cases, the public utility infrastructure would benefit from upgrades and replacement, or relocation that reduces risk of inundation in predicted sea level change scenarios. There would be no or very minimal disruptions to services during construction and no long-term change to availability of the utilities; therefore, this project would have no significant impact on public utilities in the Puget Sound nearshore zone.

3.5.6 Airborne Noise

Urbanization and industrial development have affected the soundscape of many areas around Puget Sound. Anthropogenic noise reflected off hard surfaces such as buildings and pavement can affect the behavior of certain species that use sound for communication (Dowling et al. 2011). Typical noise sources around the Puget Sound nearshore zone consist of motorized traffic on shoreline roads; train traffic on the rail lines along the eastern shoreline of Puget Sound; aircraft noise from military, commercial, and private airplanes; and heavy industry at the major ports and developed waterfronts.

Airborne sound sources that would occur during restoration construction activities would mainly be from large vehicle traffic on local roads, and construction machinery operating at the sites. Machinery noise at the project sites as well as haul truck traffic during construction would cause unusually high noise levels at residences and businesses near the site and near roads that access the site. This engine noise, however, would only occur during regular working hours, and would only endure for the construction period. Most of the proposed sites are located away from residential areas, and the effects would certainly not be Sound-wide. Therefore, the proposed action would have no significant impact on airborne noise in the Puget Sound nearshore zone.

3.6 FUTURE WITHOUT-PROJECT CONDITIONS

This section describes the Study team’s approach to assessing the most likely future conditions in Puget Sound, and summarizes the findings. Characterizing expected future conditions informs strategic water resources planning by providing a baseline against which to evaluate the effects of proposed alternatives. While the Study team has collected and analyzed information that suggests Sound-wide trends of increased degradation, it is not possible to accurately predict the degree of future degradation of nearshore ecosystem processes and functions at the scale of a particular restoration action. For this reason, when applying the model used to estimate ecosystem benefits to evaluate the relative cost-effectiveness of proposed actions (described in Chapter 4), the Study team conservatively assumes that without a project, degradation will continue throughout the period of analysis. With-project conditions benefits may therefore be underestimated.

The Corps defines the period of analysis as spanning 50 years beyond when benefits would commence once an authorized project is implemented. The Nearshore Study period of analysis is from 2015 to 2065. As part of a strategic approach to restoration planning, the team has also considered implications of expected population growth and associated development, climate change, and sea-level change. While the "future" for this project has been defined at 2065, future conditions are reported in the years for which resource documents report their data.

3.6.1 Nearshore Ecosystem Processes

Ecosystem process degradation was measured using the process evaluation framework summarized in Section 1.8 and described in detail in the Strategic Needs Assessment report (Schlenger et al. 2011a). The framework provides a method for quantifying the degradation of nearshore ecosystem processes associated with nearshore stressors. These results were used to characterize existing conditions and as an input into the ecosystem benefit model used for the cost-effectiveness analyses described in Chapter 4. To help depict future without-project conditions and to inform the Study team's understanding of where Nearshore Study objectives could best be achieved, authors completed an addendum to the Strategic Needs Assessment using development patterns forecasted as part of a future risk assessment conducted by Oregon State University researchers (Bolte and Vache 2010). This report describes the application of scenario-forecasting computer model called ENVISION. It is titled "Envisioning Puget Sound Alternative Futures" and is incorporated by reference and is available online at *www.pugetsoundnearshore.org*.

3.6.1.1 *Future Risk Assessment*

The Study team recognizes that projected population growth and associated development within the Puget Sound region pose a potential risk to the success of recommended restoration actions. To investigate this risk, the Study team forecasted regional development patterns associated with expected population growth. Future population estimates were computed based on a medium-growth projection from the Washington State Office of Financial Management (OFM) through 2030. By extrapolation of the OFM annual growth estimates, the Puget Sound region's population is expected to grow to 9.1 million residents by 2065.

To forecast land development patterns in Puget Sound, the Study team applied a scenario-forecasting computer model (ENVISION). This peer-reviewed model has also been used by the U.S. Environmental Protection Agency (EPA) to study potential future conditions in the Willamette Basin of Oregon. The model-based forecast was completed for three land development scenarios. Land development scenarios account for potential changes in land use policy and associated development patterns. Bolte and Vache (2010) provided a detailed description of methods and results for the Future Risk Assessment report. See Appendix F for further information on the use of ENVISION.

3.6.1.2 *Projected Future Nearshore Ecosystem Process Degradation*

3.6.1.2.1 *Forecasting Approach*

To forecast degradation of nearshore processes in the study area, the Bolte and Vache (2010) Status Quo scenario projections were used for the analyses in this section. These projections were applied to the same process evaluation framework as was used to evaluate existing conditions. Due to the limitations of the input data and the technology in supporting the modeling of spatially explicit projections for all of the stressors, Bolte and Vache (2010) provided projections on the distribution of a subset of the stressors. As a result, the assessment of forecasted process degradation used projections of future distributions of three stressors, and relied on present distribution data for the other nine stressors used for nearshore ecosystem process degradation calculations. The assumptions used in the forecast of process degradation and an explanation of the justification for accepting each assumption are detailed in Appendix F.

3.6.1.2.2 *Forecasting Results*

As reported in an addendum to the strategic needs assessment report (Schlenger et al. 2011b), many portions of the Sound are expected to encounter further degradation of nearshore ecosystem processes (Figure 3-3) well beyond current conditions (Figure 1-6). The evaluation suggests that the most concentrated increase of areas entering the more-degraded or most-degraded categories will be along the western shoreline of the South Central Puget Sound sub-basin, in an area that includes Bainbridge Island. As a result, much of the central portion of Puget Sound, which forms the only connection between South Puget Sound and the ocean, will be among the most degraded areas in the Sound. In fact, the forecast shows 55% of the South Central Puget Sound shoreline length will fall into the most-degraded category.

The most widespread increases in degradation among the currently less-degraded or least-degraded areas in Puget Sound are forecasted to occur in three sub-basins: the South Puget Sound, San Juan Islands, and Georgia Strait sub-basins. In addition, as suggested by the land use/land cover projections presented the in the Future Risk Assessment (Bolte and Vache 2010), process degradation will begin to appear in more remote portions of Puget Sound.

Another important factor to consider is that without restoration, the present stressors will still be in place in the year 2065. As such, the natural ecosystem setting and the processes that create and maintain it will have been impaired and will continue degrading for another 50 years. For example, for nearshore ecosystem processes related to sediment supply, transport, and accretion, the prolonged degraded condition can lead to significant lowering of the beach profile and coarsening of the shoreline substrate (i.e., much less sand and much more cobble). In addition, since these processes are vital to creating and maintaining barrier beach features such as spits, locations throughout Puget Sound could see some loss of these landforms and the embayments they protect. The reduced availability of fine-grained sediment to maintain features and functions would affect a large portion of the remainder of these landforms.

Figure 3-3 shows the projected future degradation of nearshore ecosystem processes throughout Puget Sound and this can be compared to Figure 1-6.

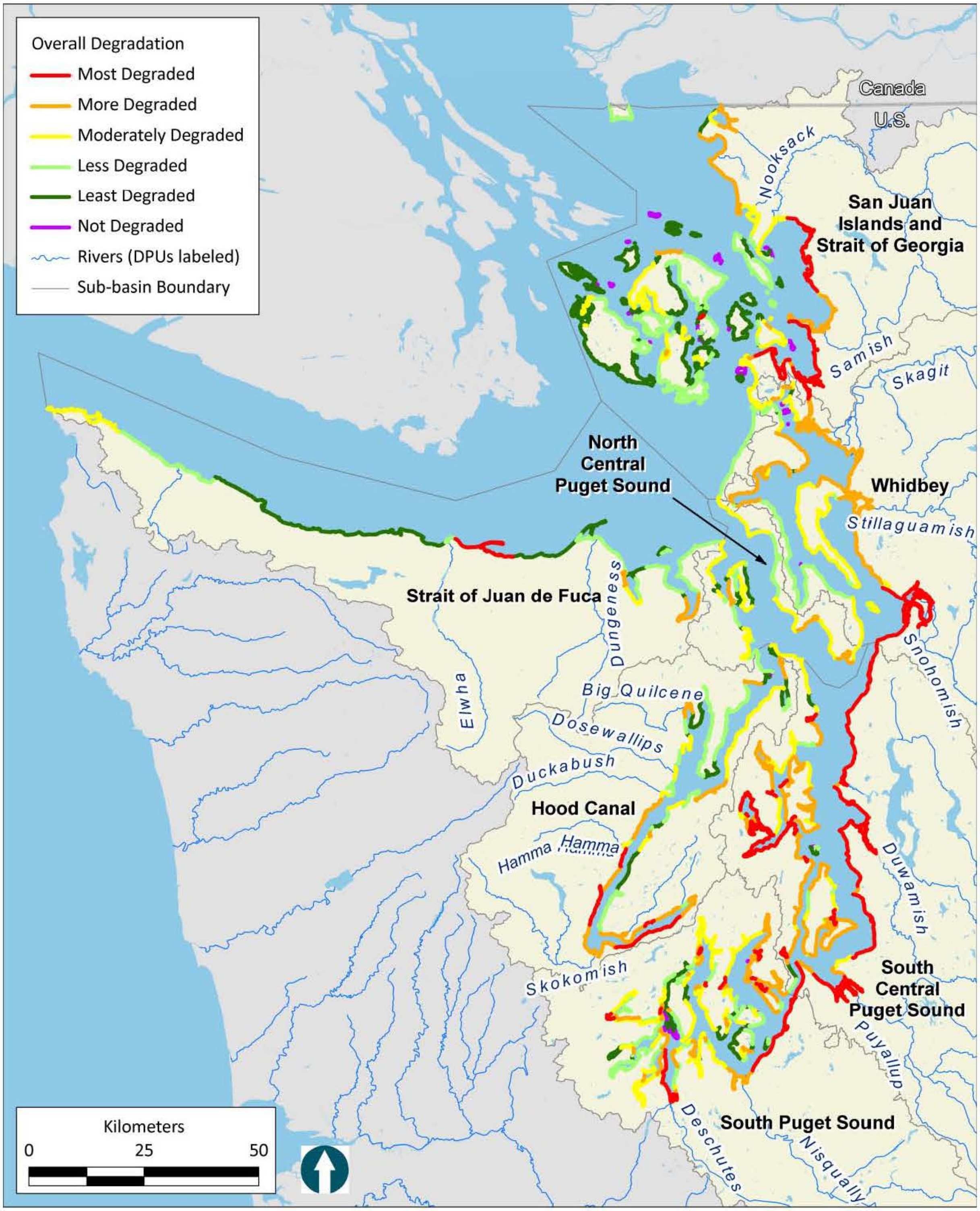


Figure 3-3. Projected Overall Process Degradation by Process Unit in the Year 2060

3.6.2 Biological Environment: Nearshore Zone Functions

Shoreline and watershed development are forecasted to continue to expand into new areas and contribute to degradation of the nearshore ecosystem processes that create and maintain Puget Sound ecosystems. The expanded footprint of degraded areas, combined with climate change and sea-level change, will further imperil the ecosystems that support diverse biological communities that inhabit or otherwise depend on Puget Sound. While evidence of the implications of this ecosystem degradation is apparent in the declines of many biological communities to date, forecasts show increases in degradation will greatly worsen the species declines. As summarized below, the declining conditions of Puget Sound ecosystems are expected to influence declines across all levels of the food web, from lower trophic levels like invertebrates to top predators such as killer whales. Forecasts show that without significant ecosystem restoration, species populations that are low now will move closer to extinction and additional species may become threatened.

3.6.2.1 *Vegetation*

Marine Submerged

Stressors that affect submerged aquatic vegetation (SAV) include those that affect the amount of light available to the plant, the direct and indirect effect of high or low nutrient levels, toxic substances, and physical disturbances (Mumford 2007). Decreased light levels often occur from an increase in suspended sediments (i.e., turbidity) or because of overwater structures such as piers, docks, and moored boats. Sedimentation from upland runoff or re-suspension can prevent kelp spores or zygotes from attaching and cause injury from smothering and light blockage (Schiel et al. 2006, Mumford 2007). Degraded water quality can cause kelp losses as well. The ENVISION status quo trajectory results show shoreline development, deforestation, and impervious surfaces are anticipated to increase by 2060. Each of these increases could decrease water quality and increase turbidity to the degree that kelp populations will decline. The predicted construction of additional marinas and other over water structures will likely contribute to the (potential) decline of kelp by 2065. It is possible that increased ocean temperatures associated with climate change could decrease kelp abundance, particularly in embayments already experiencing near-lethal temperatures.

A wide variety of factors adversely influence eelgrass meadows including dredging, marinas, increased storm intensity attributable to climate change, and a variety of human activities that reduce water quality and decrease light reaching plants. Water quality often deteriorates due to coastal development, land-based practices, dredging, and eutrophication. The decline in water quality from projected population growth and its associated land use practices paired with additional shading from docks and marinas may lead to declines in eelgrass bed size and abundance throughout Puget Sound.

Ulvoids (a type of green algae) tend to dominate nearshore algal blooms, which may result from nutrient loading and non-point source pollution. These blooms have the ability to deplete oxygen concentration in a process referred to as eutrophication, alter the structure and diversity of marine communities, and reduce eelgrass shoot density and fragment eelgrass meadows. Additions of shoreline development and impervious surfaces will likely contribute to an increase in the abundance of ulvoids due to nutrient loading, which could exacerbate hypoxia events as the ulvoids decay and consume oxygen. Water temperatures higher than 64 °F promote harmful algal blooms and since water temperatures in Puget Sound are expected to increase by 10 °F by 2100 (Climate Impacts Group 2009), there will likely be earlier and longer lasting blooms (Pearson et al. 2011b).

Climate change and sea-level change are likely to impact eelgrass meadows, but the exact effects are uncertain. Climate change stressors are related to water quality and light availability (sea level and temperature rise, suspended sediment, nutrient-driven harmful algal blooms, contaminants, disease, and freshwater input) and physical changes from shoreline armoring. The resulting increased depth and light attenuation from sea level change may contribute to vulnerability of eelgrass and/or result in eelgrass decline at the lower edges of beds. Warmer water directly affects the productivity and respiration rates of eelgrass with extended periods of high temperatures reducing eelgrass growth and survival, which can affect large areas of the Sound. In places where the water warms substantially in the summer (e.g., poorly flushed shallow bays), small increases in temperature would cause loss of plants. In the case of climate change driven sea temperature increases, the reversibility would be low (Thom et al. 2011).

Increased frequency of El Niño conditions are an anticipated implication of climate change, and are known to affect growth patterns of SAV. El Niño conditions are associated with increased storminess that can stress eelgrass. Increased precipitation resulting from climate change will likely compound with the forecasted increase in deforestation, development, and impervious surfaces to further degrade water quality (e.g., increased suspended sediment and harmful algal blooms) with ensuing decline in eelgrass meadows. As sea level changes and beach profiles migrate landward, eelgrass meadows will also recede inland. Armored shorelines constrain the shallow water edge of the eelgrass beds, which will not be able to move landward. Additional impacts to species distribution of all SAV types are likely to result from climate change, which may alter the competition between eelgrass species and algal populations (Short 1999).

Wetlands

Estimates of wetland loss over the past 150 years in Washington State range from 20 to 39%, while other estimates are as high as 50% statewide and 70 to 100% in highly urbanized areas (Lane and Taylor 1997). Current nearshore wetland loss and degradation in Puget Sound are most commonly the result of urban expansion, forestry, and agricultural practices (Canning and Stevens 1989; WDOE 1992a, b). Estimates of continuing wetland loss range from 700 to 2,000 acres per year with additional and significant degradation to remaining wetlands (WDOE 1992a, b); however, these estimates are statewide and not specific to the Puget Sound nearshore zone. Given previous trends of wetland loss in the nation, one could deduce that those trends would continue for Puget Sound. A few causes of continued loss, despite a national policy of no net loss, are that some wetlands are exempt from regulation based on small size or isolation, and required buffer widths are too small to provide protection. Even if there is not a loss of acreage, functions are often lost due to tradeoffs between water quality versus habitat value. Ultimately, projections of wetland abundance in the nearshore zone depend on a variety of factors including land development and zoning, regulatory permitting and enforcement, mitigation requirements, sea-level change, and climate change.

Estuarine salt marshes and other wetlands potentially affected by sea-level change face new risks related to climate change. Modest sea-level change during the 20th century does not appear to have adversely affected the majority of the region's salt marshes. These systems were able to keep pace through accretion (accumulation of sediments), generally captured by vegetation structure (Thom 1992). Increasing rates of sea-level change may lead to substantial loss of salt marsh habitat, especially in areas that are subsiding and/or where sediment supply is reduced or where upland migration of marshes is prevented by shoreline armoring, coastal development, or natural bluffs. Projected changes in water temperature, water salinity, and soil salinity could change the mix of plant species in salt marshes and the viability of invertebrates that play a key role in the health of salt marsh systems (Snover et al. 2005). Furthermore, many freshwater marshes and swamps adjacent to marine waters are likely to convert to salt marshes or to transitional marshes that experience frequent saltwater inundation (NWF 2007).

Riparian Areas

Results of ENVISION modeling of the Status Quo scenario show a loss of an additional 1,350 square miles (3,500 km^2) of forest due to new development in Puget Sound by 2060. Less than one percent of the forest loss is expected to occur within 200 feet of the shoreline. Shrub/Scrub will likely incur the greatest loss as a percentage of total natural area. The relative abundance of all other terrestrial vegetation types is shown in Table 3-5 (note these figures are for the Puget Sound watershed, not just the shoreline).

The influences of climate change and sea-level change will result in additional changes to the structure and composition of terrestrial vegetation throughout the region. Potential forest impacts are tied to changes in summer and winter temperature and precipitation, snow pack duration, and regional hydrology (Littell and Binder 2007). Sea-level change will result in the inland migration of the shoreline and halophytic vegetation assemblages will shift landward. Salt marshes are anticipated to expand at the expense of freshwater wetlands as saltwater inundates them. Exacerbated bluff and bank erosion associated with sea-level change and precipitation, stream flows, and flooding will reduce bluff and bank vegetation. Deciduous forest may increase in abundance along these disturbed areas, which might previously have been predominantly coniferous forest. The increase in disturbance combined with changes in climate zones could result in rapid shifts in species ranges (or in genetic variability within species). Increased risk of wildfires, vulnerability to insects, and a decrease in growth and regeneration are anticipated in drier, lower elevations according to the University of Washington's Climate Impacts Group (Littell and Binder 2007).

Table 3-5. Projected Land Cover Distributions in 2060 (Source: Bolte and Vache 2010)

Natural land Cover Type	2010 (%)	2010 (km^2)	2060* (%)	2060 (km^2)	Change (km^2)
Barren land	3%	1,011.2	1%	920.1	-91.1
Deciduous forest	3%	945.7	2%	756.1	-189.6
Emergent Herb Wetlands	1%	329.5	1%	321.3	-8.3
Evergreen forest	62%	20,061.5	31%	17,512.8	-2,548.7
Herbaceous	3%	1,136.3	2%	921.7	-214.5
Mixed forest	9%	3,011.3	5%	2,491.8	-519.5
Open Water	2%	498.1	1%	472.7	-25.4
Snow/Ice	1%	380.2	1%	380.2	0.0
Shrub/Scrub	14%	4,499.7	4%	3,897.2	-602.4
Woody Wetlands	2%	637.0	1%	606.9	-30.1

*By 2060, 51% of the natural land cover types that occur in 2010 will have changed to some type of developed, non-natural land cover.

Forest Aggregation Index

According to the Regional Geographic Initiative (RGI), conducted by Urban Ecology Research Laboratory at the University of Washington between 1991 and 2001, the majority of sub-watersheds of the Puget Sound saw a significant decline in their forest aggregation index (an indicator of the level of forest fragmentation). According to the Cascade Land Conservancy, the business-as-usual trends for this region will result in increased forest fragmentation. According to the Rural Forest Initiative, western Washington has been losing forestland at increasing rates in the last two decades.

3.6.2.2 *Invertebrate Assemblages*

Several invertebrate species are in decline due to loss or degradation of habitat. At least two species, Olympia oyster and Northern abalone, have undergone long-term declines with little evidence of potential for recovery. All native invertebrate populations are still affected by habitat loss or pollution due to human development (Dethier 2006). Continued declines are anticipated with further habitat encroachment and the effects of development such as pollution. Changes in water quality conditions from increased temperature, ocean acidification, and more frequent episodes of low dissolved oxygen will exacerbate existing stressors on most invertebrate assemblages (Newton et al. 2008). Select species that have adapted to anthropogenic changes to the shoreline may flourish, potentially to the detriment of more sensitive species. The further transition of nearshore invertebrate communities to more tolerant species is anticipated given a status quo future scenario.

3.6.2.3 *Fish Communities*

Demersal/Benthic Fish

Some groups of demersal/benthic fish, such as rockfish, are in depressed or critical condition, while others like English sole and Pacific halibut have seen increases (PSP 2009). While the overall trend of demersal/benthic fish population could remain stable, further declines are expected for long-lived and late maturing fishes, such as certain species of rockfish. Such species have been assessed as vulnerable to extinction warranting protection under the ESA.

Forage Fish

Pacific herring are the only forage fish species that have been monitored comprehensively in Puget Sound in the last 20 years. For the 2007-08 period, fewer than half (47%) of Puget Sound herring stocks are classified as healthy or moderately healthy. This is the lowest percentage of individual stocks meeting these criteria since development of the stock status summary in 1994 (Stick and Lindquist 2009). Moreover, additional impacts could result from sea-level change potentially inundating intertidal spawning grounds on shoreline beaches, and projected development trends that could cause further habitat loss within the region. Sea-level change is likely to cause substantial loss of surf smelt spawning habitat on beaches with armored shorelines because armoring prevents beach migration inland (Griggs et al. 1994), thereby reducing the area of beach with elevations preferred for spawning. Estimates of sea-level change suggest that on beaches with armored shoreline, substantial surf smelt spawning habitat might be lost in the next few decades and most spawning habitat might be lost by 2100 (Krueger et al. 2010).

Anadromous Fish

Many anadromous fish species are in decline due to loss or degradation of habitat. The Salmon and Steelhead Stock Inventory is used to compare the trends in salmon stocks within Puget Sound. Between the 1992 and 2002 inventories, the number of salmon stocks that were listed as depressed or critical increased by one-third (WDFW 1993 and 2002). Given a status quo future scenario it is likely that populations of anadromous fish, particularly salmonids, will continue to decline due to sub-optimal habitat for rearing and spawning that has been altered by armoring, filling, and diking of the shoreline, as well as development in the upper watersheds. The impacts of climate change will likely exacerbate degraded habitat conditions in nearshore areas and may affect populations of anadromous salmonids. For example, an 18- to 32-inch sea-level change in the Skagit Delta may reduce the rearing capacity in marshes for juvenile Chinook salmon by an estimated 211,000 and 530,000 fish respectively (Hood 2005). The projected changes are also likely to affect coho and pink salmon, cutthroat trout, and bull trout, which depend on marshes and other nearshore habitats for parts of their life cycle (Williams and Thom 2001). If recovery efforts in the region are successful, they may eventually diminish these losses, but many other variables could influence population trends of salmonids including harvest, environmental contaminants, oceanic conditions, and other aspects of climate change such as increased water temperature and changes in stream flows. Population trends for certain anadromous species, such as green and white sturgeon, will depend more heavily on conditions outside of Puget Sound.

3.6.2.4 *Birds*

Species with statistically significant declines in abundance included red-throated loon, numerous grebe species, canvasback, scaup, black scoter, common goldeneye, ruddy duck, Bonaparte's gull, glaucous-winged gull, common murre, and two murrelet species. Trends between 1992 and 1999 indicate a reduction of 58% for all three Puget Sound scoter populations. Great blue heron populations show an overall trend that indicates a slight to moderate increase; however, significant changes in colony dynamics were apparent as birds shifted from engagement with numerous small colonies to a consolidation of herons into fewer larger colonies. This trend is disturbing in that it increases the risk of large population loss through a single catastrophic event. Other species such as the common loon, double-crested and pelagic cormorants, bald eagle, and most notably the Canada goose showed significant increases (Bower 2009). Due to the likely continued loss of habitat and prey species, such as forage fish and juvenile salmonids, through a status quo scenario, continued decline of many Puget Sound bird species is likely. Species like cormorants, crows, and gulls that have successfully adapted to development within the region may increase and may out-compete species that are more sensitive.

3.6.2.5 *Mammals*

Populations of terrestrial mammals that use the Puget Sound nearshore zone, such as raccoons and deer, will likely remain stable given the status quo future condition largely because they have adapted to the human environment. Likewise, harbor seal and California sea lion populations may remain stable or increase due to their similar adaptability. However, declines of the more sensitive marine mammal species such as killer whales are likely as they continue to be limited by prey abundance and environmental contaminants.

3.6.2.6 *Invasive and Introduced Species*

Human modification of shorelines, including marina and shoreline development, can increase the likelihood of spread of invasive species either by way of additional boat traffic or the opportunity for colonization by invasive species, which are often more tolerant of disturbance than native species. Increases in the densities and diversity of exotic species populations are anticipated, given existing conditions and trends.

3.6.2.7 *Rare, Threatened, and Endangered Species*

The future conditions of rare, threatened, and endangered species in Puget Sound depend on a variety of factors including habitat loss, climate change, environmental contaminants, and harvest and poaching, as well as whether or not there is a recovery plan and how well it is implemented. Species with population declines that are tied to habitat loss, such as salmonids, may recover to some extent due to habitat restoration efforts throughout Puget Sound. Marine mammal species that are adversely affected by environmental contaminants, such as Southern Resident killer whales, have more uncertainty associated with forecasts. Species that are vulnerable to fishing pressure may recover if fishing and poaching are halted (as is the case with some of the listed rockfish species). Acidification of Puget Sound marine waters will affect the persistence of shellfish and other calcifer species. Other species' populations are dependent on conditions outside of Puget Sound. Below are expected trends for Puget Sound populations of ESA-listed species. As stated above, a variety of factors will influence these trends, not just the physical condition of the Puget Sound shoreline. See Section 5.2.7 (No-Action Alternative) for an analysis of how ESA-listed species would be affected if this study's proposed restoration were not implemented.

Southern Resident Killer Whale (Orca)
The 2002 and 2004 NOAA Status Reviews of the Southern Resident killer whales presented population viability analyses. The most optimistic model (based on data from the last 30 years) predicted a relatively low extinction risk of less than 0.1 to 3% in 100 years and 2 to 42% in 300 years respectively. However, the most pessimistic model (based on data from the last 10 years) predicted an extinction risk of 6 to 19% in 100 years and 68 to 94% in 300 years respectively. When modeled to a quasi-extinction rate (fewer than 10 males or females) instead of actual extinction (less than one male or female), the model predicted a risk of extinction of 40 to 67% in 100 years and 76 to 98% in 300 years. The Southern Resident killer whale's dependence on salmon and the persistence of bioaccumulating environmental contaminants make significant population declines likely.

Sea Otter
A survey from 2008 indicates that sea otter populations have increased moderately along the Washington Coast with a count of approximately 1,073 otters. Populations reintroduced on the western side of Vancouver Island are also increasing and expanding their range within British Columbia. If kelp beds along the San Juan Islands and Strait of Juan de Fuca remain unaltered, this sea otter population may continue to increase. However, the predicted loss of kelp habitat and declining shellfish populations may keep the Puget Sound sea otter population low.

Hood Canal Summer Chum
The Biological Review Team concluded that the Hood Canal summer-run chum Evolutionarily Significant Unit (ESU) is in danger of extinction due to degradation of habitat, harvests, and low water flows in the Strait of Juan de Fuca and Hood Canal watershed (Johnson et al. 1997). Of the original 18 spawning aggregations, only 10 are extant. The overall abundance trend over the past 40 years is positive for natural origin spawners in the Strait of Fuca populations, but negative in the Hood Canal populations (Ford et al. 2010). Declines are possible given the latest population trends and continued loss of habitat in Hood Canal. Certain smaller stocks in decline may lead to

regional extinction of non-hatchery populations. Populations in Strait of Juan de Fuca may continue to increase given dam removal and restoration efforts.

Puget Sound Chinook Salmon

Nine of 31 populations of Chinook salmon within the Puget Sound ESU are classified as extinct and eight of those were early run populations. Most of the remaining 22 Chinook populations in Puget Sound are summer or fall runs , with larger populations often supplemented through hatchery fish (Shared Strategy 2007). The 2005-2009 geometric mean of natural spawners ranges from 81 (Mid-Hood canal population) to 10,345 (upper Skagit population); most populations that contain natural spawners number in the high hundreds. Many populations have either declined or maintained spawning numbers of wild fish over the past 30 to 40 years. The overall trend during this period for natural origin spawners in Puget Sound has declined, where 2009 showed the lowest returns since 1997 (Ford et al. 2010). This indicates a significant loss of genetic diversity. A continued decline in non-hatchery Chinook is anticipated given habitat loss trends; these declines will likely lead to extinction in basins that produce runs with fewer than 200 adults unless substantial habitat restoration occurs in the near future.

Puget Sound/Strait of Georgia Coho

Puget Sound/Strait of Georgia coho salmon populations are stable; however, it is difficult to tell native stocks from hatchery stocks (Weitkamp et al. 1995). It is likely that native origin coho will continue to decline in the Puget Sound basin due to decreases in genetic diversity via inter-breeding with hatchery origin fish, as well as factors like habitat loss and pollution that affect all salmonids in the region.

Puget Sound Bull Trout

Of all the bull trout sub-population areas in Puget Sound, only the Skokomish area, which is thought to be the most depressed core area within the Olympic Peninsula management unit, has abundance data and trends based on monitoring. The species status in this core area is depressed with fewer than 60 adults documented in the South Fork Skokomish and approximately 100 adults documented in the North Fork Skokomish (Shared Strategy 2007). Given current trends of habitat loss and fragmentation, fisheries managers expect significant declines within the Puget Sound region and even extinction within the most depressed basins such as the Skokomish. Increasing water temperatures and changes in hydrology associated with climate change will impact bull trout disproportionately as it is the most temperature-sensitive species in Washington. Increased marine water temperatures will restrict the distribution of bull trout in nearshore areas while decreased snowpack and higher temperatures in freshwater will limit spawning and rearing areas in all watersheds.

Puget Sound Steelhead

Population trends reported in 2007 indicated significantly declining abundance in natural escapement for the Puget Sound ESU (NMFS 2007). All but a few demographically independent populations of steelhead in Puget Sound are declining. Redd counts are declining 3 to 10% annually. From 2005-2009 the geometric mean of winter-run steelhead has been fewer than 250 fish annually for eight of the 15 populations evaluated. The extinction risk for most populations in the next 100 years is estimated to be moderate to high (Ford et al. 2010). The Biological Review Team concluded that substantially declining abundance and low productivity as well as a moderate loss of diversity and spatial structure indicate that steelhead are "likely to become at risk of extinction" in the foreseeable future (Hard et al. 2007). Thus, continued declines of steelhead are anticipated given habitat conditions and population trends.

Green Sturgeon
The Biological Review Team concluded that small population sizes, water temperature changes, harvest losses, loss of spawning habitat in areas outside of Puget Sound, predation by exotic species, and pollution are having a deleterious effect on the Southern DPS of green sturgeon. The researchers concluded that these populations are "likely to become extinct" in the foreseeable future (NMFS 2006).

Rockfish
The Biological Review Team for NMFS (Biological Review Team, hereafter) estimated a 3% per year declining trend in the overall abundance of rockfish. Bocaccio is believed to be at high risk of extinction, and yelloweye and canary rockfish are rated at moderate risk of extinction (NMFS 2009b). Given continued trends, further declines in these species are expected due to their late-maturing nature and low reproductive success in any given year.

Eulachon
The Biological Review Team found that even with little monitoring of eulachon, almost all data available for the species indicate an abrupt decline. Their assessment returned a moderate risk of extinction within the southern Distinct Population Segment (DPS) of eulachon. The continued loss of habitat, largely outside of Puget Sound, and likely overuse of the species as sturgeon bait will likely cause further declines.

Marbled Murrelet
Modeling in the Pacific Northwest indicates annual declines of 4 to 7% (Beissinger and Nur 1997 from Huff et al. 2006) with a 16% probability of extinction in 100 years within California and Oregon and only 45 birds remaining in Washington (Huff et al. 2006). Estimates based on four years (2000 to 2003) of at-sea monitoring indicate no declines and even moderate increases in densities within Puget Sound. However, for the entire Northwest Forest Plan study area (including Washington, Oregon, and California), the authors anticipate being able to estimate a 5% annual decline with 80% power after seven years of data collection and modeling (Huff et al. 2006). Declines in marbled murrelets can be expected due to declining prey abundance (forage fish) and development in the upper watersheds where they nest. If a catastrophic event occurred, steeper declines and possible extinction within the region is conceivable.

Northern Abalone

Abalone in the San Juan archipelago declined by 77% between 1992 and 2006, and resulting densities were well below the threshold required for successful reproduction (Rothaus et al. 2008). Growth trajectory models in Canada suggest continued abalone declines in northern British Columbia (Zhang et al. 2007); given the documented Allee effect for Washington populations, this trend is likely transferable to Puget Sound populations (Babcock and Keesing 1999). Continued declines after fishery closures indicate a lack of recovery from past overharvesting. The fact that this continued decline is in some cases reaching levels below a successful reproduction threshold indicates the likely extinction of abalone populations within the Puget Sound basin in the near future. Climate change effects from increased acidification will decrease calcification rates and could compromise the survival of abalone and other organisms.

Olympia Oysters

Given the status quo scenario leading to continued degraded water quality, and lack of oyster reef habitat for larval settlement, Olympia oyster populations are not expected to increase. Restoration efforts may result in temporary holds in population numbers, but without significant changes to water quality, they will likely not last. Ocean acidification has been implicated as a possible cause of recent large die-offs of cultured larval oysters, and will be an additional constraint to recovery efforts.

California Buttercup, Sharpfruited Peppergrass, and Golden Paintbrush

If the predicted status quo rate of development and disturbance of the shoreline continues in areas where these species occur or could occur, then the likelihood of extirpation will increase.

3.6.3 Cultural Resources

Cultural resources within the Puget Sound nearshore zone would continue to be subject to both natural and man-made processes. Natural processes could negatively affect cultural resources through erosion, rising tides, landslides, or severe storms. Conversely, less severe natural processes could have little to no effect on cultural resources in the study area. Man-made processes such as shoreline development could negatively affect cultural resources by destroying both known and unknown cultural resources. Adverse effects by man-made processes would likely be mitigated if the process is subject to Section 106 of the NRHP. However, actions with adverse effects on historic properties that are not subject to Section 106 review would likely not be mitigated.

3.6.4 Socio-Economic Characteristics

Population growth and associated land development are key drivers shaping the future of Puget Sound. While development is also influenced by the economy, people will continue to build homes along the shore, conduct maritime activities, build roads and infrastructure, recreate, and consume food from the nearshore zone. Land and water use, release of pollutants, shoreline modifications, and other effects of population increase will be major drivers of ecosystem change, particularly without significant ecosystem restoration activities.

The human population in the Puget Sound Basin has increased rapidly over the last two decades. In 2005, there were approximately 4.4 million people in the Puget Sound Basin, a 25% increase from 1991, with an average annual growth rate of 1.28%. The Washington State Office of Financial Management forecasts population growth by looking at economic trends, migration, and natural growth (fertility and mortality). The Puget Sound population is expected to grow to 9.1 million residents by 2065, which is expected to lead to an expansion of developed areas in the Nearshore Study Area. The ways in which this development occurs to accommodate the forecasted growth will be a key driver affecting the future condition of Puget Sound.

3.6.4.1 *Shoreline Ownership*

Washington State shorelines and adjacent tidelands consist of a patchwork of public and private ownership. Today, an estimated 60 to 70% of Washington's tidelands are in private hands. Shoreline and tideland ownership patterns are not expected to change significantly from existing conditions. There are no forthcoming laws that are anticipated to affect shoreline and tideland ownership. Therefore, it is expected that the current mix of private and state owned tidelands will persist, and land development will occur according to the status quo scenario predictions from the ENVISION analysis.

3.6.4.2 *Public Access and Recreation*

Given the largely private ownership of shoreline, public access is expected to remain similar to current conditions. Public access is recognized as an important component of shoreline activities as directed by the Shoreline Management Act, which strives to balance responsible shoreline development with environmental protection and public access (WDOE 2009c). The Interagency Committee for Outdoor Recreation (IAC) notes that projecting recreation participation into the future is at best a problematic exercise because participation in various outdoor activities is affected by a wide array of factors, including changes in population, available sites and infrastructure, lifestyles, economics, technology, and the politics of land use (IAC 2003). Nevertheless, the Committee used the best data available to forecast participation in outdoor recreation activities in Washington State over periods of 10 and 20 years. Figure 3-4 shows the forecast participation in water-related activities as the percent change in the number of people participating in the future compared to current (2003) levels.

Participation in some activities is predicted to be substantially higher—canoeing and kayaking, swimming, and beach visitation are all predicted to increase by around one-third over the next 20 years. However, other activities are anticipated to show slow growth or even a declining trend. The IAC states that new boat launch sites are rarely developed with proponents facing significant challenges in populated areas such as Puget Sound, where developable low bank waterfront property is at a premium. Slow expansion of the inventory of boating facilities will likely result in slow growth in motor boating.

The IAC notes that participation in motor boating appears to be linked closely to participation in recreational fishing, which is predicted to show negative growth. The expected decline in fishing is based in part on the diminishing interest in this activity among younger generations due to competing leisure interests, from field sports to video games and the Internet. According to the IAC, however, the main reason for the expected decline in fishing is the perception of or actual decrease in the availability of fish for recreational harvest. They note that timber harvest, farming, urban development, hydroelectric development, and other land uses have had an appreciable adverse impact on salmon and other fish. While studies (e.g., Dawson and Wilkins 1980) show that the quality of a recreational fishing experience is not solely dependent on catching fish, the prospect of catching at least some fish is an important factor motivating people to go fishing, and repeated poor catch during fishing trips undoubtedly diminishes angler satisfaction and discourages further participation. They conclude that unless there is considerable improvement in the numbers of fish available for recreational harvest, declines in fishing activity are expected.

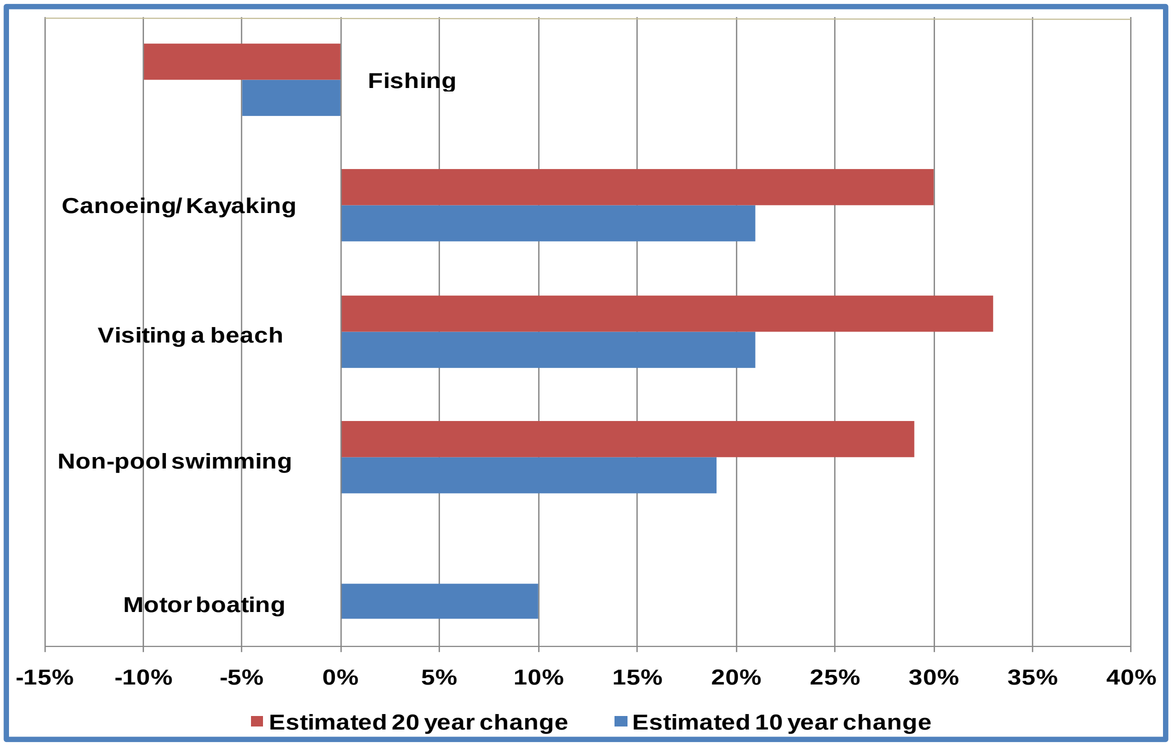


Figure 3-4. Predicted Change in Participation in Water-Related Recreational Activities in Washington State Source: IAC (2003)

Furthermore, the IAC suggests that the expected increases in the levels of other water-related activities may have to be adjusted downward if resource quality deteriorates. They observe that swimming, wading, surfing, SCUBA diving, and other water-contact activities are directly affected by water quality, including pollution and the presence of noxious weeds. Similarly, they note that photographing and observing wildlife depend on natural settings including habitat for species of interest. It is clear that the future of Puget Sound's whale-watching industry is contingent on robust populations of whales, which, in turn, is dependent on clean water and a healthy food source. The IAC draws the conclusion that, "For resource recreation to be sustained over time, resource protection must come first."

3.6.4.3 *Commercial Fisheries and Aquaculture*

Commercial fish and shellfish production has long been an important natural resource-based industry in the Puget Sound region, one that provides jobs, wages, profits, taxes, and a local food source. In addition, the commercial harvest of fish and shellfish is a significant part of the culture and heritage of the residents of the Puget Sound region.

The future viability of commercial finfish and shellfish harvesting is inexorably tied to specific species' populations and related policies developed for species protection including actions to restore the degraded ecosystems that finfish and shellfish depend upon. Section 3.4.3 describes past trends in finfish and shellfish fisheries, which may be instructional for predicting future commercial harvests. As discussed in the existing conditions section, over the past three decades, the combined tribal and non-tribal commercial fisheries harvest has decreased by 60%, from approximately 70 million down to 30 million pounds harvested annually. However, the rate of decline has lessened since the mid-1990s, although with significant annual variation. The state of Dungeness crab in Puget Sound appears to be healthy with an increasing trend in commercial harvest. In addition, shellfish aquaculture operations show steady growth in harvest levels, probably caused by increased acreage under production and improved culturing techniques.

Moreover, recent changes in management approaches suggest that some depressed commercial fisheries could improve. Although fish hatcheries did not prove to enhance fisheries as once predicted, and actually harmed wild salmon populations, improved hatchery practices represent an opportunity to help recover salmon. Puget Sound populations of rockfish, one type of groundfish, have potential for recovery. Of the 17 marine fish stocks in Puget Sound that have been petitioned for listing as threatened or endangered under the ESA, about half are rockfish. In 2009, WDFW prepared a draft plan that includes a range of policies, strategies, and actions that could rebuild rockfish stocks (WDFW 2009). It is uncertain whether the proposed conservation efforts are sufficient to protect rockfish and allow rebuilding given their late maturation and low reproductive success.

The ecological requirements of Dungeness crab and commercially important bivalve shellfish make them vulnerable to stressors associated with human population increases. In the absence of remedial actions, estuarine habitat degradation in Puget Sound from increased shoreline development, contaminants, and poor water quality will eventually offset the potential growth in the harvest of these species, leading to the loss of a traditional employment opportunity and source of revenue.

Washington State is now the top producer of farmed clams, oysters, and mussels in the United States; however, threats to continued shellfish production in the Puget Sound region include land development, which is likely a major contributor of reduced water quality. Shellfish, including clams, oysters, and other bivalves filter marine waters accumulating bacteria, viruses, and harmful pathogens. While these pathogens do not affect shellfish, humans consuming contaminated shellfish can suffer severe illness. Shellfish harvesting and growing areas are therefore monitored continually to assure public safety. Concentrations of contaminants in Puget Sound shellfish and the geographic scope of shellfish closures have increased over the past four to five decades. Since the 1980s, the frequency of detection of Paralytic Shellfish Poisoning toxins has increased in the southern basins of Puget Sound, an area containing the region's most productive shellfish beaches (Snover et al. 2006). In 2005, nearly one-third of Puget Sound's shellfish growing areas had high enough levels of fecal coliform bacteria pollution to restrict harvest (PSAT 2007b). While aquaculture production will likely increase in the next 50 years, trends in human development patterns, increased impervious surfaces, and hardening of shorelines continue in the Puget Sound region. The resulting increases in toxins, nutrients, and degradation of habitat may offset this potential growth in the industry, leading to the loss of a traditional employment opportunity, revenue, and Northwesterners' strong sense of place.

3.6.4.4 *Transportation*

Puget Sound residents benefit from high connectivity at the local and regional level. Transportation infrastructure, such as roadway expansion, has served as a catalyst for development intrusion into natural lands. Over the last 30 years, the number of roads within the region has doubled (PSRC 2010). Major public investments will be required over the next 50 years to maintain and upgrade the transportation system in light of projected population increases. The Transportation 2040 Plan (PSRC 2010) anticipates a need to invest $189 billion to $225 billion over the next 30 years to accommodate projected increases in population, employment, and commerce. In general, regional transportation plans involve expansion of public transit options, state highways and other major roads, non-motorized transportation (bike and walk improvements), and ferry systems.

3.6.5 Predicted Effects of Climate Change and Sea-Level Change

There is consensus among international and regional scientists that global climate change and associated sea-level change will result in widespread and far-reaching changes to Puget Sound nearshore ecosystems. According to the Climate Impacts Group (2009) at the University of Washington, climate change is already disrupting Washington's natural environment, economy, and communities. Projections of the specific implications of climate change show that impacts will occur to climate, water resources, forests, and coastal areas with forthcoming impacts to salmon, economics, and human health. Climate change will affect several general types of processes in Puget Sound that in turn affect its structure and function including changes in sea-level via ocean thermal expansion and melting of land ice, weather and temperature, large- and local-scale atmospheric forcing, the water cycle, and ocean acidification (Pearson et al. 2011b). Climate change and sea-level change (SLC) will cause changes to physical processes and structures including an increased frequency of damaging storms and floods, a gradual inundation of low lying areas, increased erosion rates, loss or major shifts in nearshore habitats, escalating costs of maintaining and repairing infrastructure, effects on shellfish harvesting and agriculture, and seawater intrusion into coastal aquifers (Snover et al. 2005, Climate Impacts Group 2009).

Effects of SLC and weather patterns will vary by coastal area and landscape types. Along marine shorelines, increased erosion rates will increase frequency of landslides, larger erosional events may occur more often, and patterns of sediment transport on beaches will change, leading to complex, perhaps rapid shoreline changes. SLC will cause progressive loss of upper beach where the shoreline cannot retreat landward while other nearshore and estuary habitats may disappear if they cannot migrate landward (Section 3.6.2 discusses impacts to vegetation types forming key habitats). SLC in river deltas will cause loss of nearshore habitats seaward of dikes, with increased intrusion of saltwater into the estuary, increased flooding, soil saturation, and drainage problems, and potential changes in agricultural land use. Costs to maintain infrastructure including seawalls, levees, marinas, septic systems, and port facilities will increase.

The ecological changes associated with climate change and human responses to these changes are likely to affect ecosystem processes. In particular, physical processes will be affected by the forecasted SLC, increased storm surge, changes in weather patterns including changing hydrology with increased winter flooding and lower summer flows, increased water temperature, and ocean acidification. All of these appear likely to significantly impact many of the ecosystem processes directly as well as indirectly through the actions people take to counteract the impacts of climate change. For example, SLC coupled with increased storm surge and flooding can directly affect nearly all of the nearshore ecosystem processes; in addition, climate change may lead to increased storm frequency. People may respond to such events by adding shoreline armoring or other stressors to limit shoreline inundation and erosion.

Over the last century, the temperature increase in the Puget Sound basin slightly exceeded the global average increase of 1.26 ° F (0.7 °C), with an overall increase of 1.44 ° F (0.8 °C) (IPCC 2007, Mote et al. 2003). The rate of temperature change is predicted to increase, with an average temperature rise in the Pacific Northwest of 1.98 ° F (1.1 °C) by the 2040s and 5.22 ° F (2.9 °C) by the 2080s compared to 1970 to 1999 temperatures. Warming is expected to occur throughout all seasons with the largest increase found in the summer months. Sea surface air temperature is found to be the primary cause of variability in the temperature of the Puget Sound, with effects of regional climate variability from El Niño/Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) being secondary (Moore et al. 2008). The coastal sea surface temperature of the Pacific Northwest helps determine the biological and physical conditions of the marine environment and estuaries. Temperature is a dominant controlling factor of growth rates of most cold-blooded marine organisms. By the year 2100, surface water temperature in Puget Sound is predicted to increase by roughly 10.8 ° F (6 °C) (Climate Impacts Group 2009). Higher average water temperatures and changes in water and soil salinity could change the mix of plant species in coastal marshes and the viability of invertebrates that play a key role in the health of the marsh systems. Plankton are highly sensitive to changes in temperature, and temperature driven shifts in plankton species and abundance could affect the food web, changing the composition of invertebrates, fish, and mammal communities. Increased algal productivity in surface waters and changes in circulation and upwelling due to warmer marine temperatures could exacerbate low-oxygen events (Snover et al. 2005, Glick et al. 2007, Newton et al. 2008).

Decreased snowpack and earlier snowmelt are expected to contribute to lower summer stream flows, higher winter stream flows, and a change in the timing and extent of freshwater inputs into marine waters. The combined effects of warming stream temperatures and altered stream flows will very likely reduce the reproductive success for many salmon populations (Mantua et al. 2010). Changes in temperature and stream flow can influence the spring bloom timing of algae and zooplankton with attendant impacts to other trophic levels timed to historical blooms (reduced growth and survival). Changes in timing of freshwater input may affect the circulation, stratification, and mixing of the Sound, but the subject is largely unstudied. The higher freshwater inputs during certain climatic periods cause the inflow of salty water to be at shallower depths (nearer the surface) than during drier conditions when the inflow is nearer the bottom (Snover et al. 2005). In winter months, projected increases in stream flow would increase stratification in Puget Sound. The degree of stratification can affect upwelling of nutrient supplies to surface waters, phytoplankton growth, the availability of dissolved oxygen to waters at depth, and pollutant flushing (Newton et al. 2003).

The increasing rate and amount of human-caused carbon dioxide (CO_2) emissions is progressively affecting the ocean system and linked estuaries such as Puget Sound, causing the acidity of seawater to increase. When CO_2 reacts with seawater it creates carbonic acid, lowering the pH level of the of the ocean water (acidifying). At the same time, the reduction in pH reduces the availability of carbonate ions, which play an important role in shell formation in a number of marine organisms. This acidification of ocean water is harming marine organisms that build calcium carbonate shells (calcifers) such as zooplankton, oysters, and mussels and can, in turn, affect higher trophic levels. In Puget Sound 30% of all species are calcifers. In the subsurface waters of Hood Canal, pH values as low as 7.4 have been observed; these values are more than 200% more acidic than open ocean surface waters (Feely et al. 2010). Recent declines and mass die-off of commercial oyster larvae are thought to have possible links to ocean acidification.

3.6.5.1 *Calculating Sea Level Change Predictions*

The Intergovernmental Panel on Climate Change (IPCC, 2007) indicates the present rate of global mean sea level (GMSL) change has been 1.7 ± 0.5 mm/year, or between five and nine inches during the 20th century. Vertical land movement (VLM) strongly influences sea-level change (SLC) in Puget Sound and affects local SLC differently in the various sub-basins. As shown in Figure 3-5, VLM varies from uplift (+) on the Olympic Peninsula creating a net sea-level decline, to subsidence (-) in the southern sub-basins resulting in net sea-level rise.

NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) maintains seven tidal stations (for oceanographic data collection) within the Puget Sound Basin. Of these seven, the three longest operating stations are located at Seattle on the east shore of the South Central sub-basin, at Friday Harbor in the San Juan Islands/ Strait of Georgia sub-basin, and at Neah Bay in the Strait of Juan de Fuca sub-basin. Additionally, the Canadian Hydrographic Service (CHS) maintains an active station in Victoria, B.C. within the Strait of Juan de Fuca sub-basin. Table 3-6 lists the measured mean SLC trends published by NOAA, along with the 95% confidence intervals, the mean 100-year SLC equivalent, and the period of record used to compute the SLC trend.

Table 3-6. Measured sea level change at longest tidal station in the Puget Sound Basin

Station	CO-OPS* tidal station ID	SLC* (mm/yr)	SLC (mean 100-yr equivalent, inches)	Period of Record
Neah Bay	9443090	-1.43 ± 0.33	-5.6	1934-2011
Victoria, B.C.	822-101	0.59 ± 0.21	2.3	1909-2010
Friday Harbor	9449880	1.04 ± 0.30	4.1	1934-2011
Seattle	9447130	1.99 ± 0.16	7.8	1898-2011

* CO-OPS – Center for Operational Oceanographic Products and Services, National Oceanic and Atmospheric Administration; SLC – sea level change

3.6.5.2 *Scenario Rules and Forecasts for Sea-Level Change Associated with Climate Change*

The concept of planning for the "most likely" future was formalized in the 1983 Executive Order based on the Water Resource Council's Principles and Guidelines, which the Corps uses for water resource planning decisions. Studies report on the single trend developed for the "most likely" expected future to compare with- and without-project conditions. To use the technique, Corps planners assign probabilities to different future trends to determine the most likely trend. Yet, scenario planners select key drivers of the future scenarios to be those that are the most important and most uncertain (Alberti 2009). For SLC scenario planning, researchers acknowledge that assigning probabilities is not scientifically defensible. The Nearshore Study is required to consider the effects that SLC could have on the management, planning, design, construction, operation, and maintenance of projects (Corps Engineering Regulation [ER] 1100-2-8162 [USACE 2013] hereinafter referred to as the Sea-Level Change Engineering Regulation, or SLC Regulation).

The SLC Regulation requires feasibility studies to examine three scenarios to consider the sensitivity and adaptability of projects to sea level change. These scenarios include “low,” “intermediate,” and “high” forecasts of SLC. These scenarios correspond to the historical SLC trend computed from local, long-term, tidal stations and two National Research Council GMSL change acceleration curves (National Research Council 1987) modified by new data from the IPCC. The analysis requires combining local VLM with values from the three SLC scenarios to determine total SLC for each scenario forecast for the period of analysis, which extends 50 years beyond the year when the first project benefits can be expected.

Corps guidance acknowledges that VLM is dependent on local conditions and requires coastal studies to report on global and local effects that may influence Federal decisions. Research by the University of Washington Climate Impacts Group has evaluated VLM rates across the Puget Sound Basin through the Pacific Northwest Geodetic Array (PANGA) network (*www.panga.cwu.edu*). Puget Sound VLM depends on two factors, tectonic movement of two colliding plates and rebound from glacial ice. Due to relatively recent (in geologic time scales) glaciations of this tectonically active area, VLM rates vary substantially throughout the Nearshore Study area. Figure 3-5 depicts VLM rates within various parts of the Puget Sound Basin, shown in millimeters per year. While the data is too coarse for site-specific evaluations, it clearly shows widely different rates across the study area.

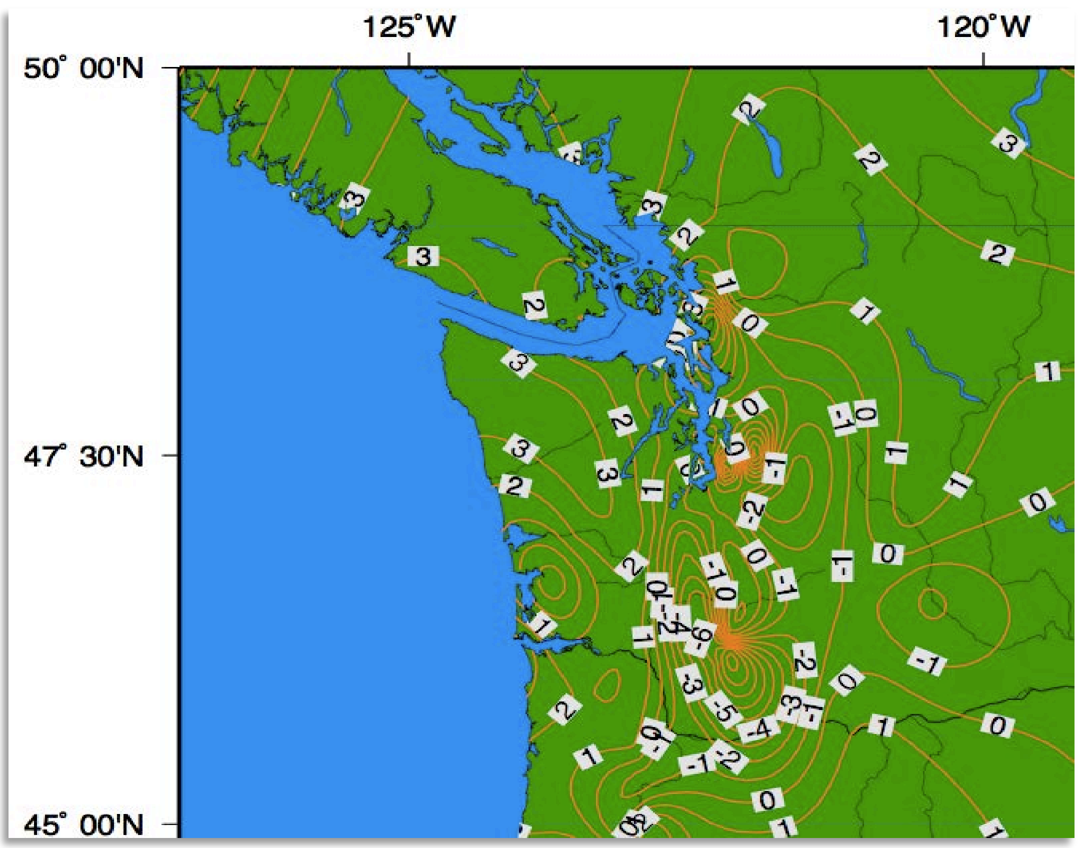


Figure 3-5. Vertical Land Movement Rates in the Puget Sound Region (Source: Mote et al. 2008) (rates in mm/yr with positive values indicating vertical uplift and negative indicating subsidence)

Table 3-7 shows the results of combining Puget Sound vertical land movement data with the three scenarios required by the SLC Circular at 2065, the end of the 50-year period of analysis.

Table 3-7. Puget Sound Nearshore Zone Sea Level Change Estimates for 2065

Puget Sound Sub-basin	Tidal Station	VLM (mm/yr)	SLC "Low" Scenario (feet)	SLC "Intermediate" Scenario (feet)	SLC "High" Scenario (feet)
Strait of Juan de Fuca (western)	**Neah Bay**	3.34	-0.39	0.08	1.58
Strait of Juan de Fuca (eastern)	**Victoria, B.C.**	1.11	0.14	0.62	2.12
Hood Canal	**Seattle**	-0.54	0.54	1.01	2.51
South Puget Sound	**Seattle**	-0.54	0.54	1.01	2.51
South Central	**Seattle**	-0.54	0.54	1.01	2.51
North Central	**Seattle**	-0.54	0.54	1.01	2.51
Whidbey	**Seattle**	-0.54	0.54	1.01	2.51
San Juan–Strait of Georgia	**Friday Harbor**	0.58	0.27	0.74	2.24

Note: Sea-Level Change Estimates in Feet using Corps ER 1100-2-8162 (USACE 2013; positive VLM values indicating uplift and negative values indicating subsidence). VLM = vertical land movement; computed from NOAA regional estimates; the NOAA methodology estimates the regional oceanographic component by detrending each series and averaging the oceanographic residuals over an entire region, and adds 1.7 mm/yr to the regionally averaged residual, and finally subtracts that final adjusted time series out of each observed time series from each station to get the final local component, which is due mainly to local vertical land movement (*www.corpsclimate.us/ccaceslcurves.cfm*)

3.6.5.3 *Conclusions of Sea-Level Change Analysis*

The Nearshore Study recognizes that given the current state of knowledge, SLC computations are coarse scale approximations of actual values. For much of Puget Sound, using the Corps SLC Regulation method, VLM counterpoises global SLC, resulting in a nearly imperceptible net effect in the "low" and "intermediate" scenarios. In the "high" scenario, global SLC greatly exceeds local VLM effects, and all sub-basins of the Puget Sound would experience net sea-level rise during the period of analysis. High regional variability across the study area of VLM contributes uncertainty to local Puget Sound SLC projections. The Nearshore Study reports SLC forecasts at the sub-basin scale for characterizing the Nearshore Study's future without-project conditions. In a later project planning phase, when specific sites are evaluated for their restoration potential, SLC effects will be evaluated with localized VLM projections to forecast benefits from site restoration measures. At this time, three additional NOAA tidal stations (e.g. Port Angeles, Port Townsend, and Cherry Point) have the required 40-year period of record required by the SLC Circular and data from those stations may be used to supplement local VLM data. Still, local SLC estimates in the Hood Canal, South Puget Sound, and Whidbey sub-basins present the most uncertainty as no active tidal stations exist in these regions. Therefore, SLC estimates in these sub-basins are reliant on accuracy of the VLM correlation to data from the Seattle tidal station.

This analysis of available scenarios and projections provides ranges of local SLC rates that the Nearshore Study can use to incorporate SLC considerations into the analysis and evaluation of alternatives. The Study team will continue to evaluate sea-level change models, and further resolve VLM rates for site-specific project planning during the preconstruction engineering and design phase.

4 PLAN FORMULATION

This chapter explains the process used to formulate, evaluate, and compare alternative plans. To develop restoration plans, the Study team used the process illustrated in Figure 4-1. These steps are described in more detail throughout this chapter.

Figure 4-1. Summary of Plan Formulation Process

4.1 MANAGEMENT MEASURES AND STRATEGIES

This section presents the Study team's steps to identify potential restoration sites that could address the Nearshore Study's planning objectives. The planning objectives are presented in Section 2.4 and summarized here:

- Restore the connectivity and size of large river delta estuaries.
- Restore the number and quality of coastal embayments.
- Restore the size and quality of beaches and bluffs.
- Increase understanding of natural process restoration in order to improve effectiveness of project actions.

The first three objectives were addressed directly in the formulation of alternative plans. The fourth objective will be addressed through monitoring and adaptive management during implementation of the first three objectives. The Monitoring and Adaptive Management Plan is presented in Appendix E.

4.1.1 Management Measures – "Right Action"

Management measures are features or activities that can be implemented at a specific geographic site to address one or more planning objectives. To determine the "right action" for potential restoration activities in the Puget Sound nearshore zone, the Study team identified 21 management measures. Management measures identified for this study are fully outlined in the Management Measures for Protecting and Restoring Puget Sound Nearshore (Management Measures Technical Report, Clancy et al. 2009). A summary of the 21 management measures and their relationships to nearshore ecosystem processes are shown in Table 4-1. It should be noted that some of the management measures are not within the Corps' ecosystem restoration authority. They are included in the table to capture a complete list of possible measures but were not carried forward for future consideration (these measures are shaded in gray Table 4-1). The process used to evaluate and screen measures is summarized in the following paragraphs.

Table 4-1. Potential of Management Measures to Influence Nearshore Processes

No.	Management Measure[1]	Relationship to Puget Sound Nearshore Ecosystem Processes ● = strong effect; ◗ = weak effect; blank = no relationship									
		Sediment Supply and Transport	Beach Erosion and Accretion	Distributary Channel Migration	Tidal Channel Formation and Maintenance	Freshwater Input	Tidal Hydrology	Detritus Recruitment and Retention	Exchange of Aquatic Organisms	Solar Radiation (Sunshine)	Wind and Waves
1	Armor (a) Removal	●	●			◗		●			●
	(b) Modification		◗			◗					
2	Beach Nourishment	●	●								

No.	Management Measure[1]	Relationship to Puget Sound Nearshore Ecosystem Processes ● = strong effect; ◗ = weak effect; blank = no relationship									
		Sediment Supply and Transport	Beach Erosion and Accretion	Distributary Channel Migration	Tidal Channel Formation and Maintenance	Freshwater Input	Tidal Hydrology	Detritus Recruitment and Retention	Exchange of Aquatic Organisms	Solar Radiation (Sunshine)	Wind and Waves
3	Berm or Dike (a) Removal	●		●	●	●	●	●	●		◗
	(b) Modification	◗			◗	◗	◗	◗	◗		
4	Channel (a) Rehabilitation	●		◗	◗	●	●	●	●		
	(b) Creation	◗			◗	●	◗	◗	◗		
5	Contaminant (a) Removal								◗		
	(b) Remediation								◗		
6	Debris Removal	◗	◗		◗						
7	Groin (a) Removal	●	●	◗	◗	●	◗	◗	●		●
	(b) Modification	◗	◗	◗	◗	◗	◗	◗	◗		◗
8	Habitat Protection Policy or Regulations[2]	◗	◗	◗	◗	◗		◗	◗		◗
9	Hydraulic Modification	◗				◗	◗	◗	◗		◗
10	Invasive Species Control	◗	◗		◗	◗	◗	◗	◗	◗	◗
11	Large Wood Placement	◗	◗	◗	◗			◗	◗		◗
12	Overwater Structure (a) Removal	◗	◗							●	◗
	(b) Modification									◗	◗
13	Physical Exclusion								◗		
14	Pollution Control								◗		
15	Property Acquisition and Conservation[3]	●	●	●	●	●	●	●	●	●	●
16	Public Education and Involvement[4]	◗	◗	◗	◗	◗	◗	◗	◗	◗	◗
17	Revegetation	◗	◗	◗		◗		◗		◗	◗
18	Species Habitat Enhancement								◗		
19	Reintroduction of Native Animals								●		
20	Substrate Modification	◗	◗		◗	◗			●		◗
21	Topography (a) Restoration	●	●	●	●	●	●	●	●		●
	(b) Creation	◗	◗			◗	◗	◗	◗		◗

Notes:

1 Some management measures are separated into rows labeled (a) and (b) to distinguish variation in the degree of process restoration between full removal of a stressor and partial removal/modification of the stressor.

2 The Habitat Protection Policy or Regulations management measure influences process via specific regulations such as the Shoreline Management Act and the Growth Management Act (critical areas ordinances), which limit shoreline armoring, overwater structures, and removal of riparian vegetation; stormwater regulations, which require management of runoff and infiltration; and other regulations that protect ecosystem processes.

3 The Property Acquisition and Conservation management measure has potential to influence all processes to some degree and is an essential measure for long-term protection of ecosystem processes.

4 Public Education and Involvement potentially influences most ecosystem processes, through indirect mechanisms with varying durability.

The 21 management measures can be classified into groups as follows:

- **Restorative Measures –** These measures exert long-lasting effects on ecosystem processes and will often provide the best opportunity of achieving complete restoration of processes. They primarily involve removal of human-made stressors that physically impede processes.
- **Enhancement Measures –** Includes structural measures that provide immediate benefits in terms of habitat structure. Sustainability of these measures requires intact ecosystem processes.
- **Prerequisite Measures –** Includes measures that are often required prior to or in conjunction with other measures.
- **Protective Measures –** Measures such as Public Education and Involvement, Habitat Protection Policy and Regulation, and Property Acquisition and Conservation are a critical part of an overall recovery strategy. While important, these types of measures would not be implemented by the Corps as they are typically not within the Corps' ecosystem restoration mission area and authorities. Protective measures and are not considered further in this study.

Restorative management measures are considered keystone elements of sustainable restoration because they directly address degradation of the processes that create and sustain nearshore ecosystems. Of the 21 management measures originally identified, seven management measures were classified as restorative and were carried forward in the formulation of alternative plans. These seven restorative management measures and their relationships to the planning objectives are shown in Table 4-2.

Table 4-2. Relationship between Objectives and Restorative Management Measures

Restorative Management Measures[1]	**Objectives (●= relationship; blank = no relationship)**		
	Restore Deltas	**Restore Beaches**	**Restore Embayments**
Armor Removal or Modification		●	
Berm or Dike Removal or Modification	●		●
Channel Rehabilitation or Creation	●		●
Groin Removal or Modification		●	
Hydraulic Modification	●		●
Overwater Structure Removal/ Modification		●	
Topography Restoration	●	●	●

Notes: [1] Based on Management Measures Technical Report (Clancy et al. 2009)

4.1.2 Identification of Restoration Strategies – "Right Place"

To determine the "right places" for restoration in the Puget Sound nearshore zone, the Study team conducted an analysis to determine where process-based restoration would have the greatest likelihood of successfully achieving planning objectives. This analysis is documented in the Strategies Report (Cereghino et al. 2012). The analysis uses preexisting, Sound-wide, spatially explicit information on nearshore landforms, stressors, and land use.

As described in Section 1.8.3, the Change Analysis quantified structural and physical change between historic (1850s-1890s) and current (2000-2006) conditions. This analysis correlates the location, occurrence, and amount of stressor impact on nearshore ecosystems in the context of dominant ecosystem processes. Based on the historic and current conditions, the report presents four restoration strategies aligned with the Nearshore Study planning objectives: (1) a river delta strategy, (2) a barrier embayment strategy, (3) a coastal inlet strategy, and (4) a beach strategy. The resulting strategic recommendations are presented (in part) as maps indicating where the Study team recommends focusing efforts to implement one or more process-based ecosystem restoration or protection measures for the four strategies. As an example, the map illustrating the recommended approach for the River Deltas strategy is displayed in Figure 4-2.

These four strategies are the foundation of site identification, where the Study team identified potential locations where one or more measures can be implemented to restore river deltas, barrier embayments, coastal inlets, and beaches.

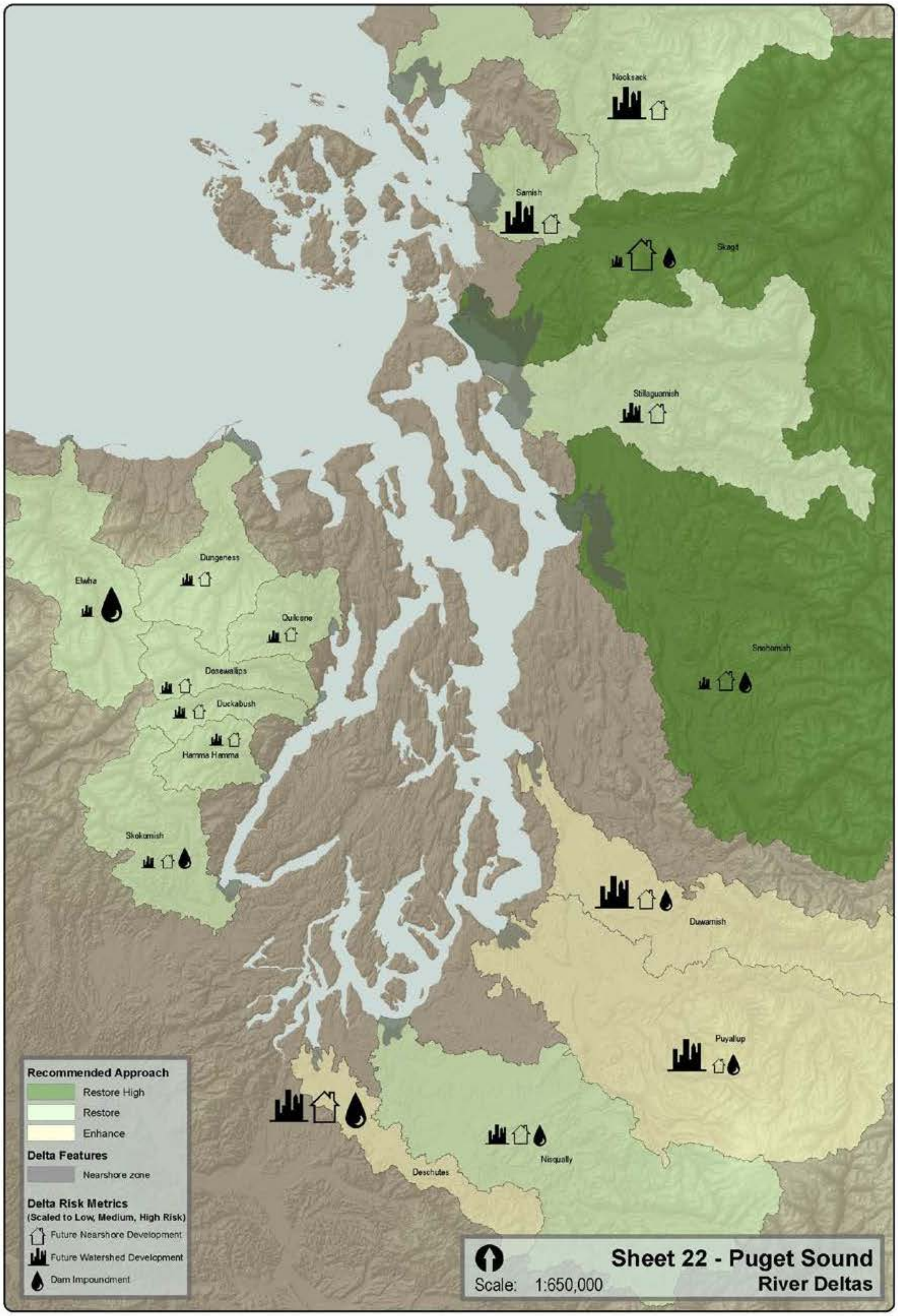


Figure 4-2. Map of Strategies Analysis for Deltas

4.2 SITE IDENTIFICATION AND ASSESSMENT

To foster collaboration and maximize efficiency in creating an initial list of potential restoration sites where one or more measures could be implemented, the Nearshore Study used the knowledge base of local restoration practitioners and organizations and the extensive backlog of restoration ideas generated by these groups. Information they provided was used to populate the Nearshore Database, which became a comprehensive list of restoration ideas throughout Puget Sound. The Nearshore Database was created in 2006 by the Nearshore Study and has been maintained by the Study team since then. In addition to serving as the pool of potential solutions to be used by the Nearshore Study, the Nearshore Database also serves as a tool for documenting the scope of Sound-wide restoration needs and opportunities. The restoration community was provided several opportunities between 2006 and 2010 to add and update entries in the database. The Nearshore Study improved overall data quality and consistency by assigning spatial coordinates and translating the restoration descriptions into management measures using the *Management Measures Technical Report* (Clancy et al. 2009). A final call to the restoration community for submittals of new entries into the database was made in May 2010, resulting in a total of 543 entries (site records) in the database.

4.2.1 Initial Screening

Site assessment began with a review of the 543 site records contained in the Nearshore Database. Sites that occurred in a location identified by one of the four strategies (including deltas, barrier embayments, coastal inlets, and beaches) were retained for further consideration. The team determined whether the remaining site records proposed the “right action” in the “right place;” in other words, if it centered on at least one of the seven restorative management measure that targets the spatially-explicit strategic needs of the site. For example, if a proposed restoration action included management measures that restore ecosystem processes that support deltas (right action), and if it was located in a delta where restoration was likely to succeed (right place), then it would be eligible for further consideration.

To complete initial screening of the 543 site records, Study team planners, biologists, project managers and members of the Nearshore Science Team met to systematically review the sites considering the following elements:

- the landforms present at a given site,
- the management measures proposed,
- the level and type of degradation present at a given site, and
- the position of the site in the landscape.

Sites that included one or more measures considered to have a strong effect on a strategy (i.e., those most able to restore the associated process or processes) were retained for further consideration. When these sites included one or more measures considered to have a weak effect on the strategy (for example, a measure that would accelerate benefit accrual without addressing underlying processes), the sites were retained for further consideration but the weakness was noted. Sites that contained no restorative management measures were excluded from further evaluation. This initial screening step narrowed the list of sites from 543 to 198 to be carried forward for additional evaluation.

4.2.2 Proponent Review

Study team members then met with representatives of the local restoration community to resolve any outstanding concerns, confirm project details, and verify proponent interest and site access for the remaining 198 sites. Sites were removed from the list of 198 for an array of reasons including significant concerns about landowner willingness, lack of public support, or the likelihood that the restoration may be completed by others. In some cases, two site records dealt with adjacent lands and were combined into one. Duplicate entries for the same or similar action with different project names were identified and merged in consultation with the project proponent(s). The result was a list of 46 site records suitable for development of conceptual designs, cost estimates, and additional evaluation.

4.3 SITE CONCEPTUAL DESIGNS

An interdisciplinary Conceptual Design Team (CDT) comprised of Study team members and expert consultants conducted field visits to each of the 46 candidate restoration sites. The CDT assessed site conditions, gathered data to characterize the site, obtained photographs, and evaluated "on-the-ground" opportunities and constraints. The CDT evaluated each site using a set of screening criteria to determine whether the proposed action is likely to achieve the Nearshore Study's restoration objectives. Screening criteria were meant to identify any “fatal flaws” of the sites and included determining the following: (1) whether the site was sufficiently described and spatially defined to allow the Study team to develop conceptual designs and develop quantity estimates, (2) whether the site was consistent with one or more of the Nearshore Study's restoration strategies, and (3) whether local proponents had precluded the Study team from including the site when developing conceptual designs. The results of this work are documented in characterization reports that describe the potential restoration opportunities in terms of ecological effectiveness and engineering feasibility (Strategic Restoration Conceptual Engineering — Final Design Report (aka “Conceptual Design Report”, ESA et al. 2011b). As a result of this evaluation and screening, six sites were removed from further consideration as they did not meet the “fatal flaw” evaluation using the screening criteria described above. Additionally, the four Big Quilcene River sites were combined into one site, and the two Telegraph Slough sites were combined, leaving 36 sites ready for design work.

Two site designs, one “full” and one “partial,” were developed for each of the remaining 36 sites. The CDT used the proponent's description of each candidate site as captured in the Nearshore Database (and/or any design plans that existed) as a guide in developing the site designs;

however, the CDT's designs may differ from what the proponent initially proposed with deviations made to meet the Nearshore Study's process-based restoration objectives.

A "full" design includes management measure(s) to fully remove site-specific stressors, maximize the area of influence, and maximize improvements in ecosystem benefits. Land ownership was not considered as a potential constraint in developing the full restoration alternative; however, the continued existence of major durable infrastructure (e.g., transmission lines, highways, utilities, railroads) was generally assumed. The full design can be understood as a way to maximize site potential for process based restoration by removal of stressors to the fullest extent possible, often expanding upon the original proposal for the site.

A second "partial" design was developed that addressed known constraints and concerns (from landowners, user groups, and the community) while still achieving process-based restoration. The partial design could differ from the full design in the number or type of management measures implemented, the area over which a management measure was applied, and/or the size or type of tidal openings. The partial restoration design was often similar to the description initially submitted to the Nearshore Database by the project proponent.

This step resulted in 72 designs at 36 sites, shown in Figure 4-3. Narrative descriptions of the sites, designs, assumptions, and future needs, along with the conceptual design plans, are documented in the Conceptual Design Report (ESA et al. 2011b) and are summarized in Section 4.6.

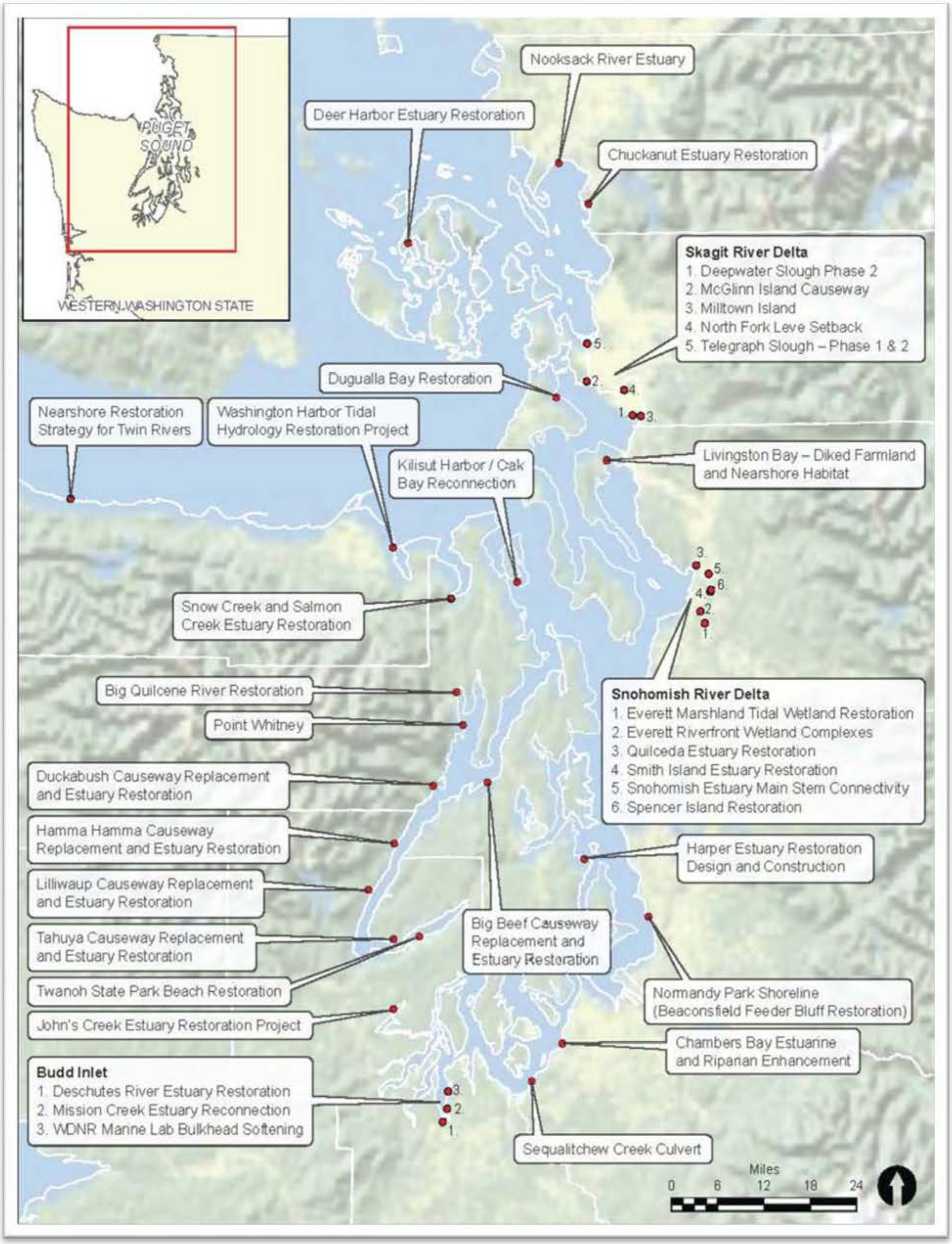


Figure 4-3. Location of 36 Sites for Conceptual Design Work

4.3.1 Site Design Review

The Corps hosted a workshop in March 2011 (Informed by the greater detail provided in the Conceptual Design Report) for the Nearshore Study team to re-evaluate the proposed restoration designs for consistency with Nearshore Study guiding principles and strategies. The Study team assessed each design for its potential to substantially restore ecosystem processes. Screening criteria included the following:

- Principles of process-based restoration, as assessed by the Nearshore Science Team
- Assessment for consistency with the recommendations from the Strategies Report
- Likelihood that the work may be completed by other project proponents (e.g., a local municipality or tribe) outside of the Nearshore Study effort
- General readiness such as technical feasibility, landowner willingness, social acceptability, and site-specific constraints based on up-to-date information

After designs were evaluated based on these screening criteria, 11 sites were characterized as offering some opportunity to improve nearshore conditions but better suited for implementation by other programs. As a result of this step, the team reduced the number of sites for further consideration from 36 to 25.

Based on the screening criteria outlined above, the Study team also identified one of the two designs (full or partial) to carry forward for each site. This determination was made by qualitatively evaluating each site based on the screening criteria outlined in the bullets above; ranking criteria of “high,” “medium,” and “low” were assigned to each of the four criteria listed above. In addition, each site was also assigned to prioritized categories (e.g., Category “A” included sites that meet the screening criteria outlined above and also represent a significant opportunity to advance nearshore process-based restoration) to further screen sites to be carried forward at this step. For 18 of the 25 sites, a single design was advanced for further consideration. For the remaining seven sites, the criteria used did not identify a clearly preferred design and both designs were carried forward for further consideration. Thus, 32 (18 + 14) site designs at 25 sites remained for further consideration. Subsequently, the local proponents of one site, Smith Island, identified alternative means to implement the project, reducing the count to 31 designs at 24 sites.

Upon completion of the site evaluation and screening steps described above, including identification of management measures and potential restoration sites, development of site designs, and additional qualitative screening, 31 restoration designs at 24 sites were identified as candidates for the final array of alternatives to be evaluated and considered for inclusion in the tentatively selected plan (TSP). Section 4.6 describes the restoration features proposed at each site as well as discussion of whether the full or partial design was carried forward for each site.

4.4 SITE BENEFITS AND COSTS

To effectively evaluate the 24 sites carried forward, the Nearshore Study team completed additional analysis including development of parametric cost estimates and evaluation of environmental outputs. Based on these parameters, a Cost Effectiveness/Incremental Cost Analysis (CE/ICA) was completed to help evaluate and quantify significant contributions or effects of individual plans. The following sections outline the assumptions and outcomes of this work in addition to the results of the CE/ICA.

4.4.1 Evaluation of Site Benefits

An interdisciplinary team including Corps staff, members of the Nearshore Science Team (NST), and contractor support staff developed an ecosystem output (EO) model to quantify the benefits that each site would provide. The framework of this model is consistent with the Nearshore Study's approach of restoring the ecosystem process, structure, and function that provide habitat and other ecosystem services. The model output is a product of quantity and quality. The quantity component of the model equation is defined as the area of restored process (in acres), and the quality component is comprised of multiple components that capture process, structure, and function. These three quality components are derived from calculations based on spatially explicit data in the Nearshore Geodatabase[1]:

- The process component is represented by one index: process degradation.
- The structure component is represented by five landscape indices: scarcity of landforms, heterogeneity of landforms, long-shore connectivity, cross-shore connectivity, and sinuosity.
- The function component is represented by one index: a site's ability to provide ecosystem functions, goods, and services (EFG&S).

The model equation combines these components as follows:

Quantity (A) — Quality ([(P² + S + F)/maximum possible score])

$$\mathbf{EO} = \underbrace{\mathbf{A}}_{\text{Quantity}} * \underbrace{\mathbf{[(P^2 + S + F)/maximum\ possible\ score]}}_{\text{Quality}}$$

Where:

EO − ecosystem output (project benefits)

A − area of restored process, in acres (Quantity score)

P − process degradation index score, scale 0 − 10 (process component of Quality score)

S − 2 (Sc + H + Lc + Cc + Sn), scale 0 − 10 (structure component of Quality score)

Sc- scarcity, scale 0-1

H- heterogeneity, scale 0-1

[1] The Nearshore Geodatabase was initially compiled as part of the Change Analysis (Simenstad et al. 2011)

Lc- long-shore connectivity, scale 0-1
Cc- cross-shore connectivity, scale 0-1
Sn- sinuosity, scale 0-1

F − EFG&S Tier 2 score, scale 0 − 10 (function component of Quality score)
Maximum possible score for quality: 120

A documentation report titled "Puget Sound Nearshore Ecosystem Output Model Documentation Report" describes the theory, framework, and detailed methodology of this model and the associated indices listed above (see Appendix G). The Nearshore Study's Strategic Science Peer Review Panel (SSPRP, described in further detail in Section 8.4) reviewed the documentation report. The Corps has reviewed and approved this model for one-time use.

4.4.2 Evaluation of Site Costs

Costs were estimated for the 31 site designs at 24 sites and input into IWR Plan for generation of alternatives and for CE/ICA. Costs used in the formulation and evaluation of alternatives are the economic costs of each site design; they include project first costs and net operations and maintenance (O&M) costs. Project first costs include pre-construction, engineering, and design (PED) costs; construction and construction management costs; and real estate costs.

Costs for PED and for construction and construction management were developed by Corps cost engineers in Micro-Computer Aided Cost Estimating System (MCACES)[2] using the quantities provided with the conceptual designs, standard features and rates, and input from the PDT. When necessary, quantities were developed by the cost engineer if not provided in the Engineering Appendix. Items such as the fuel rates, rock pricing, haul distances, and markups were discussed within the team and held consistent throughout all site designs. Certain features, such as some bridges and levees, were assumed to have similar designs but were sized according to the needs of each alternative site design. It was assumed that fill for each site design would be imported unless specifically noted otherwise in the design report. In addition, each site design was evaluated to determine whether barge access was necessary. Input was gathered from the PDT on each of the site designs to reflect the scope most accurately. The PDT was consulted for an abbreviated risk analysis. These discussions informed development of site design-specific construction cost contingency rates using the risk analysis template developed by the Corps' Cost Engineering Directory of Expertise. Cost contingencies were included for PED, construction, and construction management.

Initial real estate costs were developed using the site design footprint maps. Parcel numbers were identified by comparing the footprint boundaries to the respective county assessor's property records. Using the parcel data, costs were developed based on the county assessed value for the land and any improvements (buildings) listed for the affected parcels. All real estate costs

[2] MCASES is cost estimating software used by Corps cost engineers.

assumed fee title with a contingency rates ranging from 15% to 30% depending on the complexity of the respective project lands (reference Appendix C for individual Land Cost Estimates associated with each site).

Typically, Operations and Maintenance (O&M) costs reflect required ongoing maintenance to ensure functionality of a project. However, no ongoing O&M costs are directly associated with the restoration activities planned for the sites. Instead there will be a change in O&M costs associated with other site features, such as changes to transportation infrastructure (removing a road, lengthening a bridge, etc.). Net O&M costs may be either positive or negative. These changes to O&M are captured in the average annual O&M estimate.

4.4.3 Summary of Site Benefits and Costs

Table 4-3 provides an overview of the benefits and costs for the 31 site designs located at 24 sites. The site designs are grouped by strategy, which is shown in the left-most column.

Table 4-3. Benefits and Costs for 31 Site Designs, by Strategy (October 2011 price level)

		Costs ($1,000s)			Benefits	
Strategy	Site Design Name	First Costs[1]	Change in Average Annual O&M Cost	Total Average Annual Costs	Area	Average Annual Net Ecosystem Output
Delta	Big Quilcene Partial	$35,073	-$4	$1,628	25.5	0.6
	Deepwater Slough Partial	$6,652	-$66	$244	269.6	90.2
	Duckabush Full	$71,085	$0	$3,309	39.4	12.9
	Duckabush Partial	$58,403	-$1	$2,718	38.1	12.3
	Everett Marshland Full	$357,549	$38	$16,682	829.1	349.3
	Everett Marshland Partial	$154,286	$0	$7,182	427.4	167.8
	Milltown Island Partial	$4,246	-$2	$196	214.2	64.0
	Nooksack River Delta Partial	$331,473	$127	$14,259	1,807	650.5
	North Fork Skagit Delta Full	$64,393	-$25	$2,973	256.1	53.7
	Spencer Island Partial	$16,916	-$25	$762	313.2	136.0
	Telegraph Slough Full	$188,613	$11	$8,790	832.2	253.9
	Telegraph Slough Partial	$93,922	$52	$4,424	146.9	16.3
Beach	Beaconsfield Feeder Bluff Full	$7,929	$0	$369	6.9	2.2
	Beaconsfield Feeder Bluff Partial	$3,027	$0	$141	5.5	1.3
	Twin Rivers Partial	$5,546	$0	$258	4.3	0.2
	WDNR Budd Inlet Beach Full	$9,569	-$1	$445	2	1.1
Barrier Embayment	Big Beef Creek Estuary Full	$32,629	$0	$1,519	29.6	7.9
	Dugualla Bay Partial	$72,289	-$2	$3,363	572	162.6
	Livingston Bay Full	$12,863	-$19	$580	244.6	41.6
	Livingston Bay Partial	$12,062	-$14	$547	238.7	40.5
	Point Whitney Lagoon Full	$9,522	-$1	$442	6.1	2.0

		Costs ($1,000s)			Benefits	
Strategy	Site Design Name	First Costs[1]	Change in Average Annual O&M Cost	Total Average Annual Costs	Area	Average Annual Net Ecosystem Output
Coastal Inlet	Chambers Bay Full	$288,020	-$1	$13,407	83.5	8.5
	Chambers Bay Partial	$96,699	-$1	$4,501	47	3.4
	Deer Harbor Estuary Full	$6,679	$0	$311	16.1	4.8
	Harper Estuary Full	$12,240	$0	$569	6.2	1.7
	Harper Estuary Partial	$16,025	$5	$751	5.7	1.1
	Lilliwaup Partial	$30,619	$0	$1,425	19.6	1.1
	Sequalitchew Full	$166,320	$7	$7,750	4.5	0.9
	Snow/Salmon Creek Estuary Partial	$37,798	$4	$1,764	52.2	6.8
	Tahuya River Estuary Full	$28,917	$0	$1,346	36.1	7.6
	Washington Harbor Partial	$17,666	$5	$827	14	0.6

Note: 1. First costs include real estate, design, construction, and construction management.

4.5 FORMULATION OF ALTERNATIVE PLANS

As discussed in Section 4.1, four restoration strategies were developed to address the planning objectives, with one strategy to address Objective 1 (deltas), two to address Objective 2 (embayments - one strategy for barrier embayments and one for coastal inlets), and one to address Objective 3 (beaches). It is critical to formulate alternative plans that address each strategy because of the broad variety of and differences between ecological benefits that accrue from restoration of the different landforms. Restoration of the different landforms can have not only cumulative benefits, but potentially synergistic benefits as well. For example, restoring a large river delta site would benefit rearing salmonids, while restoring a beach would restore spawning habitat for forage fish, a primary prey resource for salmonids and many other species. The complexity of interactions among biota dependent on the nearshore zone means restoration benefits are needed across each strategy.

Water resource projects are generally directed to use a watershed approach. In that vein, the Nearshore Study uses a holistic view of the entire Puget Sound shoreline to address the variety of needs across all landforms and strategies of the nearshore zone.

Because outputs from sites of one strategy are not directly comparable to outputs from sites of the other three strategies, and to ensure that the final set of alternative plans includes sites from each strategy, alternative plans were generated through a multi-step process:

- First, sites were organized into four subgroups, one for each strategy (described in Section 4.1.2).

- Second, IWR Planning Suite (certified version 2.0.6.0) was used to generate an initial array of alternative plans comprised of all possible combinations of sites within each strategy. Based on this evaluation, one or more cost effective sites within each strategy were carried forward (described in Section 4.5.2).
- Third, IWR Plan was used to generate a focused array of alternative plans comprised of all possible combinations of the sites across all strategies carried forward from the previous step. Based on this evaluation, a focused array of 23 best buy plans was identified (described in Section 4.5.3).
- Finally, a final array of three alternatives was carried forward. Each alternative is comprised of multiple sites and addresses all four of the study's strategies (described in Section 4.4).

A more detailed explanation of this process and the alternative plans selected as a result is presented in the upcoming sections.

4.5.1 By-Strategy Subgroups

After estimating costs and benefits, the 31 site designs at 24 sites were grouped by the strategy they most prominently addressed. This step ensured that sites addressing each of the four strategies (and by extension all planning objectives) would ultimately be included in the TSP. The 31 site designs were grouped by strategy as shown in Table 4-3 and summarized below.

River Delta Strategy (9 sites; 12 site designs)

- Big Quilcene Partial
- Deepwater Slough Partial
- Duckabush Full
- Duckabush Partial
- Everett Marshland Full
- Everett Marshland Partial
- Milltown Island Partial
- Nooksack River Delta Partial
- North Fork Skagit Delta Full
- Spencer Island Partial
- Telegraph Slough Full
- Telegraph Slough Partial

Beach Strategy (3 sites; 4 site designs)

- Beaconsfield Feeder Bluff Full
- Beaconsfield Feeder Bluff Partial
- Twin Rivers Partial
- WDNR Budd Inlet Beach Full

Barrier Embayment Strategy (4 sites; 5 site designs)

- Big Beef Creek Estuary Full
- Dugualla Bay Partial
- Livingston Bay Full
- Livingston Bay Partial
- Point Whitney Lagoon Full

Coastal Inlet Strategy (8 sites; 10 site designs)

- Chambers Bay Full
- Chambers Bay Partial
- Deer Harbor Estuary Full
- Harper Estuary Full
- Harper Estuary Partial
- Lilliwaup Partial
- Sequalitchew Full
- Snow/Salmon Creek Estuary Partial
- Tahuya River Estuary Full
- Washington Harbor Partial

4.5.2 Initial Array of Alternatives

IWR Planning Suite was used to generate an initial array of alternative plans comprised of all possible combinations of sites within each of the four strategies described above. This approach was taken due to the software limitations of IWR Plan; because a large number of potential combinations of alternative plans could be identified if all 31 sites were analyzed together, the PDT ran the IWR Plan software application four times, once for each strategy.

Each run of IWR Planning Suite identified an initial array of cost effective and best buy alternatives comprised of one or more sites within each strategy. For these runs of IWR Planning Suite, all sites within each strategy were identified as combinable with the exception of the sites that had multiple scales (full and partial). This approach ensured that the initial array of alternatives only included a single scale (full or partial) at each site. No sites were dependent on any other sites.

Through comparison of incremental costs and benefits of the best buy plans for each strategy, the PDT identified the sites within each strategy that made sense for inclusion in the next step of alternative formulation and evaluation using the process outlined in ER 1105-2-100 for identification of a NER plan. For each of the four IWR Plan software runs (one for each strategy), the Study team evaluated costs per output for each plan to determine whether it was "worth it" in terms of costs and outputs to carry forward the next cost effective increment. Based on this analysis, one or more plans were identified to be carried forward to the next step of the alternatives formulation process, while some plans were not carried forward due to exceptionally high incremental costs per unit.

An example outcome of this step is provided in Table 4-4Figure 4-4 where alternative plans for the coastal inlet strategy are graphed according to their incremental costs and outputs.

For the coastal inlet strategy, the eighth plan was selected for inclusion in the next step of formulation and evaluation. This plan was selected in part due to the substantial incremental cost increase that occurs between coastal inlet plans 8 and 9. Coastal inlet plan 8 includes 7 coastal inlet sites that were carried forward.

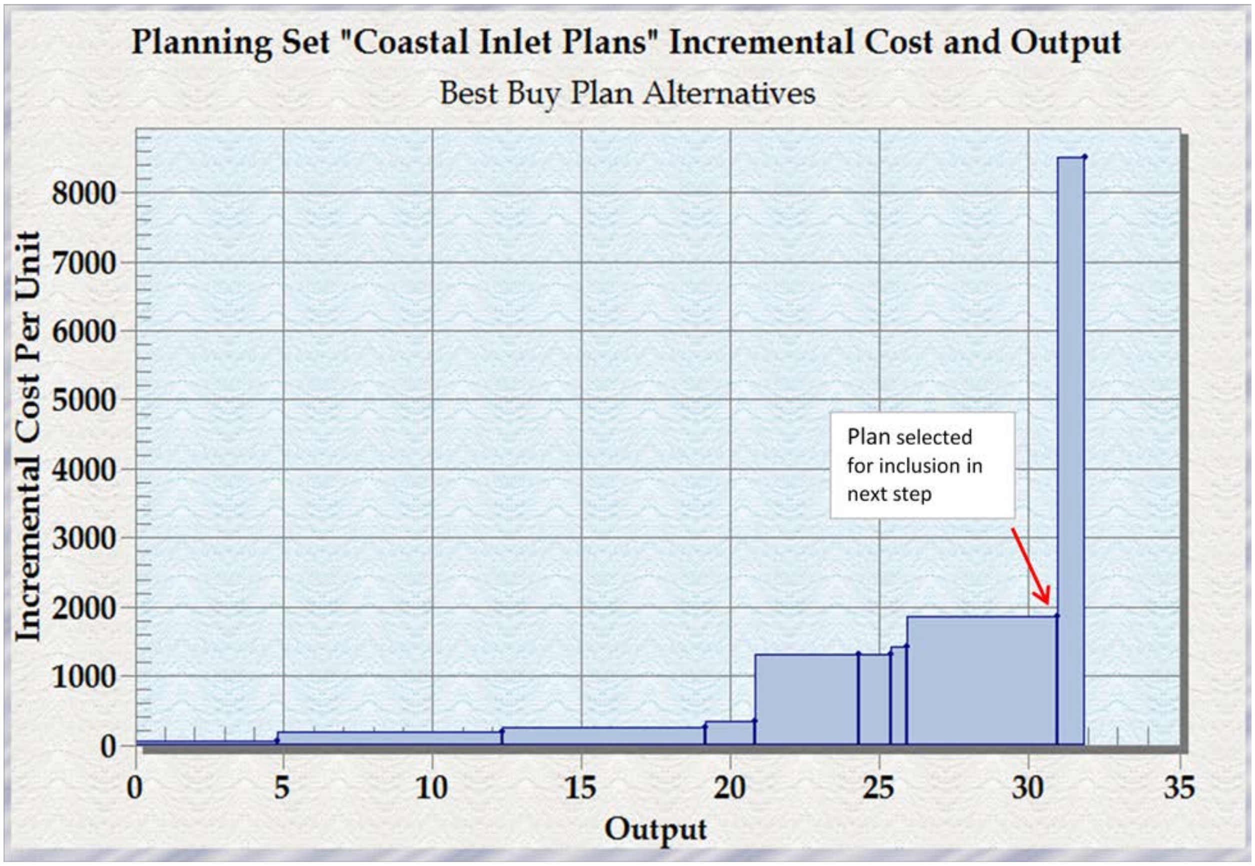


Figure 4-4. Incremental Cost and Output for Coastal Inlet Plans

A similar process was done for the other three strategies, leading to the inclusion of four barrier embayment sites, eight river delta sites, and three beach sites (in addition to the four coastal inlet sites) for a total of 22 sites. These sites were carried forward individually (versus part of a single, inseparable plan for each strategy) for the next step in the alternatives evaluation process.

4.5.3 Focused Array of Alternatives

IWR Planning Suite was then used to generate a focused array of alternative plans comprised of all possible combinations of the 22 sites carried forward from the previous step. This analysis identified 23 best buy alternative plans that contain one or more sites and address one or more strategies. The 23 best buy plans are shown in Table 4-4 along with the associated average annual cost per output and incremental cost per output for each best buy plan. Each plan builds on the previous plan. Beginning with plan number 2, Deepwater Slough Partial is the only site included in this alternative. Plan number 3 includes Deepwater Slough Partial plus Milltown Island Partial, and plan number 4 includes those two plus Spencer Island Partial. This pattern continues until Chambers Bay Full is added to create the most expensive, highest output plan, plan number 23, which includes 22 sites. The last site added is the site with the highest incremental costs per output. Plans highlighted in green in Table 4-4 were carried forward to the final array of alternatives (described in Section 4.6).

Table 4-4. Incremental Cost Analysis of Best Buy Plans (Oct 2011 price level)

Plan No.	Plan Name	Average Annual Output (HU)	Average Annual Cost ($1000)	Average Cost / Output ($1000/HU)	Incremental Output (HU)	Incremental Cost ($1,000)	Incr. Cost Per Output ($1,000)
1	No Action	0.0	$0	$0	0.0	$0	$0
2	Deepwater Slough	90.2	$244	$2.7	90.2	$244	$2.7
3	plus Milltown Island Partial	154.2	$440	$3.1	64.0	$196	$3.1
4	plus Spencer Island Partial	290.2	$1,202	$5.6	136.0	$762	$5.6
5	plus Livingston Bay	330.7	$1,749	$13.5	40.5	$547	$13.5
6	plus Dugualla Bay	493.3	$5,112	$20.7	162.6	$3,363	$20.7
7	plus Nooksack Delta Partial	1,143.8	$19,371	$21.9	650.5	$14,259	$21.9
8	plus Telegraph Slough Full	1,397.7	$28,161	$34.6	253.9	$8,790	$34.6
9	plus Everett Marshland Full	1,747.0	$44,843	$47.8	349.3	$16,682	$47.8
10	plus N. Fork Skagit River Delta	1,800.7	$47,816	$55.4	53.7	$2,973	$55.4
11	plus Deer Harbor Estuary	1,805.5	$48,127	$64.8	4.8	$311	$64.8
12	plus Beaconsfield Bluff Partial	1,806.8	$48,268	$108.5	1.3	$141	$108.5
13	plus Tahuya River Estuary	1,814.4	$49,614	$177.1	7.6	$1,346	$177.1
14	plus Big Beef Creek Estuary	1,822.3	$51,133	$192.3	7.9	$1,519	$192.3
15	plus Duckabush Delta Partial	1,834.6	$53,851	$221.0	12.3	$2,718	$221.0
16	plus Point Whitney Lagoon Full	1,836.6	$54,293	$221.0	2.0	$442	$221.0
17	plus Snow/Salmon Creek Partial	1,843.4	$56,057	$259.4	6.8	$1,764	$259.4
18	plus Harper Estuary Full	1,845.1	$56,626	$334.7	1.7	$569	$334.7
19	plus WDNR Budd Inlet Beach	1,846.2	$57,071	$404.5	1.1	$445	$404.5
20	plus Twin Rivers Partial	1,846.4	$57,329	$1,290.0	0.2	$258	$1,290.0
21	plus Lilliwaup Partial	1,847.5	$58,754	$1,295.5	1.1	$1,425	$1,295.5
22	plus Washington Harbor Partial	1,848.1	$59,581	$1,378.3	0.6	$827	$1,378.3
23	plus Chambers Bay Full	1,856.6	$72,988	$1,577.3	8.5	$13,407	$1,577.3

Note: Plans highlighted in green in were carried forward to the final array of alternatives (described in Section 4.6).

Figure 4-5 shows the incremental cost analysis results graphically. As shown in Table 4-4 and Figure 4-5, the incremental average annual cost per output ranges from a low of $0/ per output to

$1,577 per output. The first 11 plans range in incremental average annual cost per output from $0 per output to $109 per output, while the next 7 plans range in incremental average annual cost per output of $177 per output to $405 per output. A significant increase in cost per output occurs between plans 19 and 20 where the incremental cost per output increases from $405 per output to $1,290 per output. Figure 4-5 shows the incremental cost analysis graphically and indicates the two action alternatives that have been selected for final evaluation and consideration for the TSP, which are listed in Table 4-4 as plan number 12 and plan number 19.

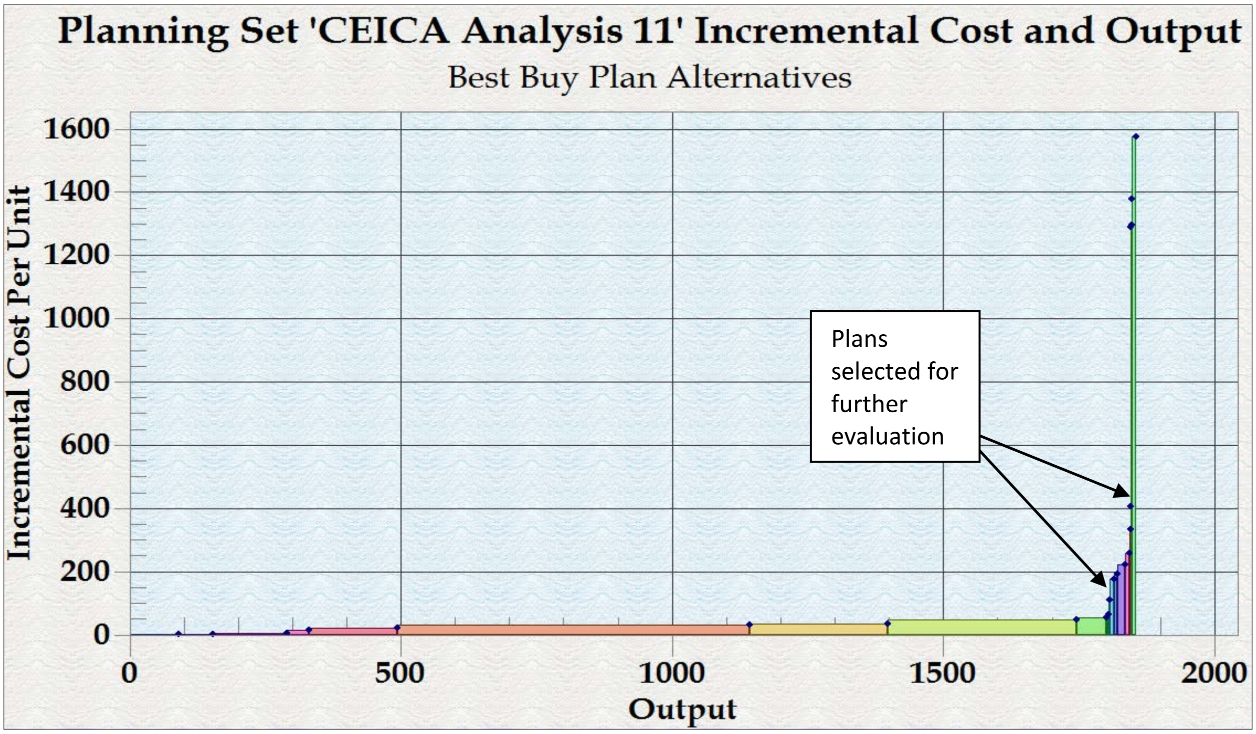


Figure 4-5. Incremental Cost Analysis

4.6 FINAL ARRAY OF ALTERNATIVES

After reviewing the analyses described above, the PDT identified a final array of three best buy alternatives to be carried forward for final evaluation, comparison, and selection of the TSP. The plans selected for inclusion in the next step of the process are Plan 1, the No Action Plan; Plan 12, which includes 11 sites; and Plan 19, which includes 18 sites.

Plans 2 through 10 were not carried forward because they do not address all four restoration strategies (river deltas, beaches, barrier embayments, and coastal inlets). Because the Nearshore Study aims to recommend a comprehensive restoration plan that addresses ecosystem degradation across different habitat types and sub basins, these alternatives are not considered complete and were not carried forward for further analysis or evaluation.

Plan 12 was carried forward in the final array because it is the first alternative that addresses all four restoration strategies, including beaches. Inclusion of at least one beach site (Beaconsfield) in the final array of alternatives is critical to making progress towards comprehensive restoration across different ecosystem types in Puget Sound. As described in Section 4.5, it is critical to formulate alternative plans that address each of the four restoration strategies because of the broad variety of and differences between ecological benefits that accrue from restoration of the different landforms. Restoration of the different landforms can have not only cumulative benefits, but potentially synergistic benefits as well. Bluff-backed beaches are a key component of the sediment transport process in the nearshore zone, which is why the Beaconsfield site was carried forward. Reference Section 4.6.4 for additional discussion of ecosystem benefits associated with restoration of beaches.

Plans 13 through 18 were not carried forward in the final array of alternatives; the next plan carried forward for additional analysis was Plan 19. Plan 19 was selected due to the significant increase in incremental cost/output that occurs between Plan 19 and 20 (from $405/output to $1,290/output), as well as the PDT's desire to evaluate a plan that, to the fullest extent possible, takes advantage of identified opportunities to implement cost-effective, high-quality restoration. Compared to Plan 12, Plan 19 contains three additional coastal inlet sites, two additional barrier embayment sites, one additional beach site, and one additional river delta site. The value of each of these seven sites is discussed below:

Four sites in Plan 19 – Big Beef Creek Estuary, Duckabush River Estuary, Point Whitney Lagoon, and Tahuya River Estuary – are located in the Hood Canal reach of Puget Sound, a 60-mile long fjord with over 200 miles of shoreline and estuaries fed by large river systems. Additionally, Big Beef Creek Estuary hosts three species of salmon and is an intensively monitored watershed due to large property ownership by the University of Washington; it serves as a reference creek for the entire Hood Canal area for coho salmon. The rest of this watershed is largely undeveloped, so restoring the estuary with its eelgrass and shellfish habitats could produce the rare condition of a minimally artificial watershed. The Tahuya watershed is similarly minimally developed and is at the southernmost reach of Hood Canal where restoration would connect other reaches of less impaired shoreline process units. Similarly, the Duckabush Estuary hosts a wide variety of fish and wildlife populations including a great blue heron rookery, eelgrass beds with herring spawning areas, shellfish beds, seal haulouts and pupping areas, trumpeter swan feeding areas, and waterfowl concentrations, and serves as part of the winter range for Roosevelt elk. The Duckabush also hosts six salmonid populations including three ESA-listed species.

The Point Whitney site is a tidal lagoon with nearby osprey and bald eagle nests. Just outside the inlet of this lagoon, there is clam and oyster habitat as well as spawning habitat for three species of forage fish, which are critical prey items for many Puget Sound aquatic species. WDNR Budd Inlet Beach, along the southernmost inlet of Puget Sound, is another area of forage fish spawning where restoration could expand the habitat available for this critical ecosystem component.

Harper Estuary is the only proposed site on the west side of Puget Sound's main basin. Inclusion of this site would mean a more comprehensive geographical distribution of restoration actions in the overall plan. There is a forage fish pre-spawning holding area just offshore from this estuary. Adjacent shorelines have been altered, so restoration at this area is important to provide refuge for aquatic species in the disturbed shoreline reach.

The Snow Creek and Salmon Creek Estuary is the only proposed site along the Strait of Juan de Fuca. The area provides diverse and abundant wildlife habitat including spawning habitat for three forage fish species, a great blue heron rookery, waterfowl and shorebird concentrations, and shellfish habitat. These two streams and their estuary are known to host multiple ESA-listed fish, bird, and mammal species.

Constructing these seven additional sites in Plan 12 would have far-reaching benefits well beyond the project sites. These sites would provide supporting habitat for many highly migratory species, provide connectivity between less disturbed shoreline reaches, or provide refuge between highly modified shoreline reaches. The relatively small length of 22 miles of stressors removed from these sites would add significant regional environmental benefits for the relatively small investment of doing so.

While Plans 20 through 23 have noteworthy environmental benefits, the incremental cost/output increases significantly for each of these plans. Although these plans would more completely address the broad restoration needs in the study area, it was determined that the proposed Federal investment of these plans is not justifiable and viable from a cost perspective.

A summary of the final array of three alternatives is included below. Formal evaluation and comparison of these alternatives is presented in Sections 4.5 and 4.6.

No Action Alternative

The No-Action Alternative is synonymous with the "Future Without-Project Condition." The assumption for this Alternative is that no project would be implemented by the Corps to achieve the planning objectives.

Alternative 2 (referenced as Plan 12 above)

Eleven sites were selected for Alternative 2. These sites address all four of the Nearshore Study strategies and are geographically representative of the entire study area (Figure 4-6). Sites included in Alternative 2 are the following:

- Beaconsfield Feeder Bluff
- Deepwater Slough
- Deer Harbor Estuary
- Dugualla Bay
- Everett Marshland
- Livingston Bay

- Milltown Island
- Nooksack River Delta
- North Fork Skagit River Delta
- Spencer Island
- Telegraph Slough

Alternative 3 (referenced as Plan 19 above)

A total of 18 sites were selected for Alternative 3. Similar to Alternative 2, the sites included in Alternative 3 address all four of the Nearshore Study strategies and are geographically representative of the entire study area (Figure 4-6). Sites included in Alternative 3 are the following:

- Beaconsfield Feeder Bluff
- Big Beef Creek Estuary
- Deepwater Slough
- Deer Harbor Estuary
- Duckabush River Estuary
- Dugualla Bay
- Everett Marshland
- Harper Estuary
- Livingston Bay
- Milltown Island
- Nooksack River Delta
- North Fork Skagit River Delta
- Point Whitney Lagoon
- Snow Creek and Salmon Creek Estuary
- Spencer Island
- Tahuya River Estuary
- Telegraph Slough
- WDNR Budd Inlet Beach

Figure 4-6 shows the geographic locations of the sites included in the final array of alternatives. The following sections provide an overview of each site included in Alternatives 2 and 3, including a short description and overview of restoration features. For more detailed information on the site designs, see Appendix A (Restoration Site Fact Sheets) and Appendix B (Engineering Appendix).

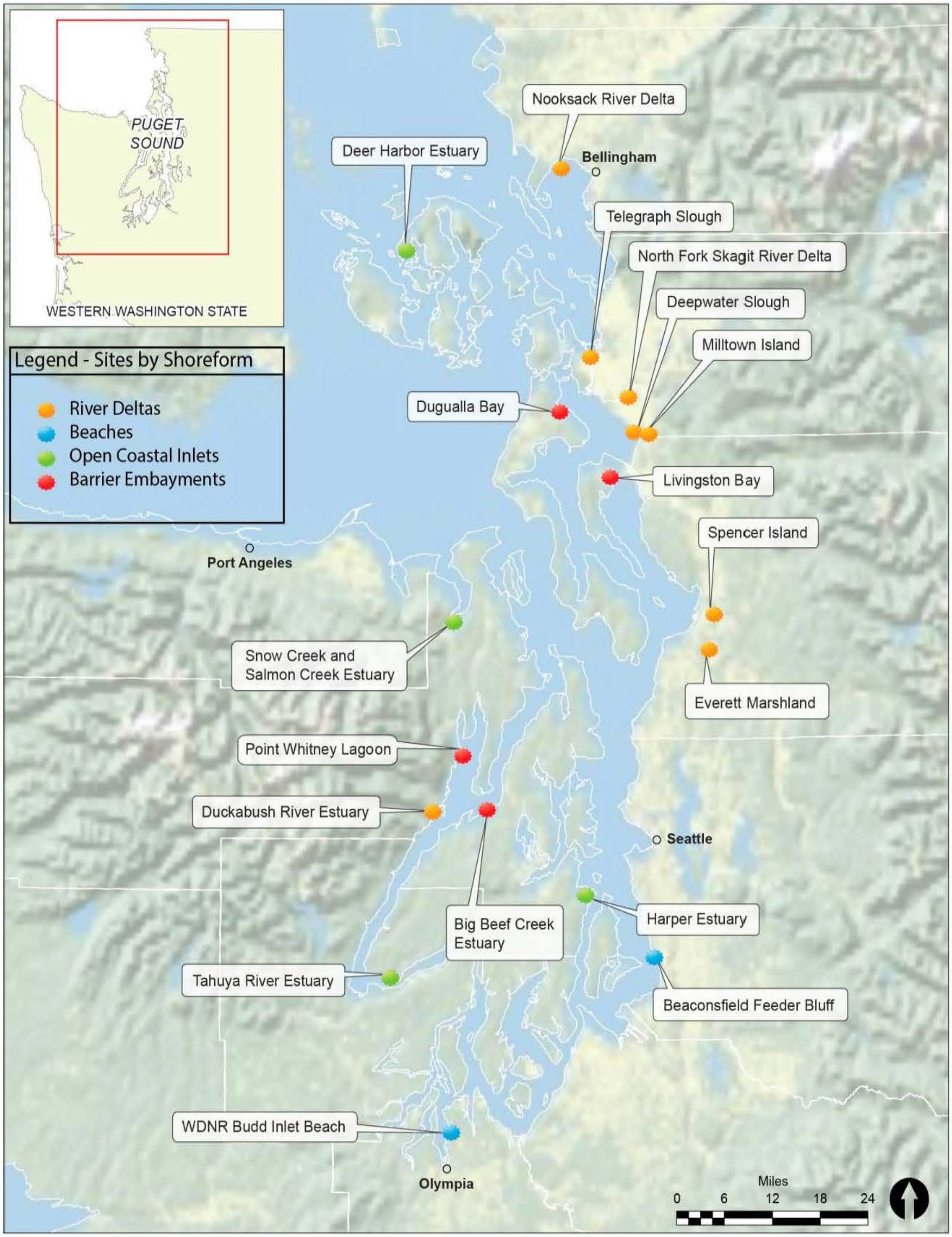


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Figure 4-6. Geographic Locations of the Sites included in the Final Array of Alternatives

4.6.1 Sites included in River Delta Strategy

There are eight best-buy sites included in the final array of alternatives that address the river delta strategy. The restoration objective associated with this strategy is to increase the size and quantity of large river delta estuaries by restoring tidal processes and freshwater input where major river floodplains meet marine waters. Target ecosystem processes for river delta restoration include the following:

- Tidal flow
- Freshwater input (including alluvial sediment delivery)
- Erosion and accretion of sediments
- Distributary channel migration
- Tidal channel formation and maintenance
- Detritus recruitment and retention
- Exchange of aquatic organisms

4.6.1.1 *Deepwater Slough*

Site Description, Geographic Location and Context

Deepwater Slough is located on the South Fork of the Skagit River (Figure 4-6 and Figure 6-3). Deepwater Slough is downstream of the town of Conway, where the South Fork bifurcates into Freshwater and Steamboat Sloughs. Deepwater Slough is a smaller channel between Freshwater and Steamboat Sloughs. The project area is comprised of two islands on either side of Deepwater Slough. Diking, ditching, and filling for agriculture greatly diminished the extent of freshwater and estuarine wetlands and tidal channels in the Skagit River delta. WDFW manages the site as a wildlife area, with some areas actively farmed for both crop production and wildlife enhancement.

Restoration Features

Restoration of this site involves dike removal to restore tidal hydrology to diked areas and reconnection of the historic tidal channel system on both sides of Deepwater Slough. These actions will restore 270 acres of scarce tidal freshwater wetlands in the Skagit River delta. Riparian plantings would occur on the low natural levee to expand the riparian corridor. Key design elements for this site include the following:

- Lower existing dikes to grade
- Excavate breaches to reconnect tidal channels
- Remove a temporary bridge between the islands

The “partial” design alternative was carried forward for this site. Compared to the “full” design, the partial design does not include the excavation of distributary channels or tidal channel networks in the interior of the islands. Formation of a channel network is expected to occur naturally once dikes are lowered or breached, so significant excavation of tidal channels was not carried forward as a design element.

4.6.1.2 *Duckabush River Estuary*

Site Description, Geographic Location and Context

The Duckabush River is one of several major river systems that drain the east slope of the Olympic Mountains to Hood Canal (Figure 4-6). The broad river delta fans out into Hood Canal on the south side of Black Point Peninsula. The Highway 101 causeway crosses the delta, spanning the main channel and a historic distributary channel via bridges with box culverts. Levees along the main channel upstream of the causeway prevent river flows into historic distributary channels. This causeway limits tidal exchange resulting in the aggradation of tidal channel networks and inhibition of channel migration. These hydrologic constrictions, along with fill within the estuary have led to decline in mudflats and salt marsh.

Restoration Features

The proposed restoration would restore tidal and riverine hydrology to 38 acres of the Duckabush River delta. This action would allow for natural habitat forming processes including sediment and detritus exchange, freshwater input, and tidal flushing within the delta. Key restoration elements of this site include the following:

- Replace the Highway 101 causeway with a widespan bridge to allow full tidal flushing at delta
- Remove fill from Shorewood Road and adjacent areas
- Reestablish tidally influenced distributary channels
- Excavate channels within the marsh areas

The “partial” design alternative was carried forward for this site. Compared to the “full” design, the partial design includes replacement of the Highway 101 causeway with a shorter bridge. The partial design has a greater length of road on fill, but the same amount of distributary and tidal channel habitat would be excavated compared to the full design.

4.6.1.3 *Everett Marshland*

Site Description, Geographic Location and Context

The Everett Marshland site is located along the west bank of the Snohomish River near the divergence of Ebey Slough and the mainstem river (Figure 4-6 and Figure 6-6). Most of the site is within the Everett city limits. Although it is within the 100-year floodplain of the Snohomish River, the action area is completely cut off from tidal hydrology by dikes and drainage structures installed to support agricultural land uses. In addition to roads and dikes, the action area is bisected by the Burlington Northern Santa Fe (BNSF) railroad running generally northwest/southeast, and utility corridors running east/west.

Restoration Features
This action would restore tidal hydrology and channel-forming processes to 829 acres of tidal freshwater wetlands, reconnecting the site to the Snohomish River. This would be accomplished through relocating dikes and roadways, altering and filling drainage canals, restoring tidal channels, and reconnecting streams to the tidal area. Key restoration elements of this site include the following:

- Remove dikes along the Snohomish River; construct new dikes to maintain existing level of flood risk management
- Fill agricultural ditches and reconstruct tidal channels
- Reconnect surrounding streams to restored area
- Upgrade railway bridges to allow for tidal exchange

The "full" design alternative was carried forward for this site. Compared to the "partial" design, the full design includes removal of 1.5 miles of dike along the Snohomish River, rather than removal of two small segments of dike. Complete dike removal allows for reconnection of a larger area to natural tidal hydrology, maximizes the connectivity and diversity of habitat, and more quickly restores the river's edge habitat complexity, which improves salmon productivity. The full design removes 30 times the length of tidal barriers and 10 times the amount of fill compared to the partial design. This will allow a more rapid establishment of tidal marsh and a longer channel of Wood Creek.

4.6.1.4 *Milltown Island*

Site Description, Geographic Location and Context
Milltown Island, located on the South Fork Skagit River Delta (Figure 4-6 and Figure 6-8), is part of WDFW's 17,000-acre Skagit Wildlife Area. This island was historically used for agriculture after construction of perimeter dikes, a central cross dike, and drainage channels. This diking has hydrologically disconnected the site from the Skagit River, resulting in a loss of tidal marsh and channels. The southern portion of Milltown Island, consisting of approximately 100 acres of tidal marsh, has not been diked.

Restoration Features
The proposed restoration action would breach (remove) sections of Milltown Island perimeter dikes to restore tidal and freshwater hydrology to the 214 acres of the island's interior marsh. The restored tidal and riverine processes will form, scour, and expand the dike breaches and marsh channels within the island's former agricultural areas. Key restoration elements of this site include the following:

- Breach west perimeter dikes in three locations
- Create pilot channels associated with breach locations

The “partial” design alternative was carried forward for this site. Compared to the “full” design, the partial design proposes a smaller extent of dike breaches. Channels would be excavated in the interior of the island, but to a lesser extent than under the full design and focused on the west side of the site near the new dike breaches. Marsh channels would still develop through natural processes and native vegetation will become established both through plantings and natural recruitment. Habitat communities will evolve consistent with the site’s landscape position within the larger Skagit River system processes, and the difference for the partial design alternative is that the end result will occur more slowly.

4.6.1.5 *Nooksack River Delta*

Site Description, Geographic Location, and Context

The Nooksack River estuary is centered on the Lummi Nation lands north of Bellingham (Figure 4-6 and Figure 6-9). It encompasses nearly all of the Nooksack and Lummi River estuaries below Ferndale, Washington. The flow path of the Nooksack River has been modified since the mid 19th century beginning with active removal of large wood, draining, diking, and levee construction, which forced almost all flow to the east side of the delta. The diversion of flow from Lummi Bay to Bellingham Bay occurred around 1860, when a log jam near what is now the City of Ferndale blocked the Nooksack River and diverted it to a small stream that flowed into Bellingham Bay.

Since around 1860, the Nooksack River has flowed to Bellingham Bay because of the construction of a more permanent structural diversion across the head of the Lummi River. This shift of the lower Nooksack River virtually eliminated migration of stream channels over the Lummi delta. Early General Land Office mapping (circa 1887-1888) shows that significant meandering channels and intertidal habitats existed on both sides of the Lummi Peninsula. Today, substantial surface water diversions, groundwater withdrawals, and drainage activities within the Nooksack River watershed impact the magnitude, timing, and duration of surface water flows in the Nooksack River Delta.

Restoration Features

The proposed restoration would modify levees, roads, and other hydrological barriers to restore riverine and tidal flow and sediment transport and delivery processes to the Nooksack River delta, restoring 1,807 acres of scarce tidal freshwater wetlands. Flood risk management for active businesses, residences, farms and transportation infrastructure would be preserved for much of the delta. The restoration is intended to complement, but not depend on, the implementation of the proposed Lummi Nation Wetland and Habitat Bank (Lummi Nation 2008). Mitigation bank features are not included in the proposed Federal project footprint. Additional analysis and coordination will occur to confirm the boundaries and requirements of the mitigation bank and to ensure no ecosystem restoration features that are cost-shared in the recommended plan are located on mitigation bank lands. Key restoration elements of this site include the following:

- Breach and/or remove dikes along both sides of the Nooksack and Lummi Rivers; construct new levees to maintain existing level of flood risk management
- Install log jams in Nooksack River
- Partial restoration of river flow to Lummi River through installation of water control structure at confluence of Lummi and Nooksack Rivers; structure intended to facilitate transfer of freshwater and sediment to the Lummi River
- Channel creation and rehabilitation on the Lummi River
- Remove several filled causeways and replace with widespan bridges to allow for tidal exchange

The "partial" design alternative was carried forward for this site. Compared to the "full" design, the partial design proposes a partial levee removal along both sides of the mainstem Nooksack River, rather than complete removal of the levee. The partial design, while roughly 40% smaller in total project scope, will still have huge benefits for rehabilitating channel and floodplain sediment deposition processes and greatly improving channel complexity that has been lost. The salt marsh at Lummi delta will recolonize with native plants and a native riparian forest will develop where levees are removed. The additional flows to the Lummi River will improve water quality, which would be expected to improve shellfish habitat in the estuary.

4.6.1.6 *North Fork Skagit River Delta*

Site Description, geographic location and context

The North Fork of the Skagit River empties into Skagit Bay just south (downstream) of the town of La Conner (Figure 4-6 and Figure 6-10). The proposed action is located between the former inlet of Dry Slough and the western terminus of the dike system near Rawlins Road. Extensive diking of the North Fork Skagit River has caused substantial loss of tidally influenced wetlands and their associated tidal channels. River levees have reduced floodplain area and constrained the river channel.

Restoration Features

The proposed restoration would set back flood risk management dikes on both sides of the river, restore natural levees, and restore 256 acres of scarce tidal freshwater marsh. Key restoration elements of this action include the following:

- Lower and breach dikes; construct new dikes to maintain existing level of flood risk management
- Excavate tidal channel network
- Remove shore armor and other hardened surfaces and infrastructure

The "full" design alternative was carried forward for this site. Compared to the "partial" design, the full design includes lowering, breaching, and setting back a larger extent of dikes, allowing creation of a more extensive tidal channel network on both the north and south sides of the North Fork Skagit River. The project will also restore natural riverbank levees and expand the significant areas of emergent marsh and riverine wetlands. Continuing this band of habitat would significantly improve the ecosystem connectivity within the floodplains, tidal channels, and estuarine wetlands. This would add to the quantity and quality of migratory conditions for salmon and restore large-scale ecological processes at Fir Island.

4.6.1.7 *Spencer Island*

Site Description, geographic location and context

Spencer Island is located in the Snohomish River estuary between Union and Steamboat Sloughs near Everett, Washington (Figure 4-6 and Figure 6-11). Diking and drainage of the island for grazing has lead to the loss of tidally influenced wetlands and distributary channels as well as subsidence of the site. The limited size of previous dike breaches and the persistence of a field drainage system have prevented restoration of full tidal hydrology and have precluded the development of tidal channel networks. Snohomish County and WDFW manage the site as a popular passive recreation park and wildlife management area.

Restoration Features

The proposed action will restore full estuarine processes and seasonal riverine flooding by dike lowering and breaching. Restoration actions will reestablish conditions necessary to recreate 213 acres of rare tidal freshwater marsh. Key restoration elements of this site include the following:

- Lower dikes adjacent to Steamboat and Union Sloughs
- Expand existing breaches on the eastern and northern dikes and add a breach on the western dike
- Retain public access by constructing a replacement pedestrian bridge over new breach site

The “partial” design alternative was carried forward for this site. Compared to the “full” design, the partial design does not include the excavation of distributary channels or tidal channel networks in the interior of the islands. Formation of a channel network is expected to occur naturally once dikes are lowered or breached, so significant excavation of tidal channels was not carried forward as a design element.

4.6.1.8 *Telegraph Slough*

Site Description, geographic location and context

Telegraph Slough is located in a diked area between the Swinomish Channel and Padilla Bay (Figure 4-6 and Figure 6-12). Major regional transportation (highway and railroad) and utility infrastructure bisects the site in an east/west direction. Tidal influence is blocked by State Route 20 and adjacent BNSF railroad, and is now limited to a small remnant portion of the historical slough north of the highway. South of this highway, Telegraph Slough and three other distributary channels are cutoff from Swinomish Channel and Padilla Bay. A series of tide gates drains the south portion of Telegraph Slough to the Swinomish Channel. Most of the land outside public road rights-of-way is privately owned and in agricultural use or largely abandoned. These dikes have led to the conversion of the area to freshwater marsh, dominated by invasive species in the southern portion, and limited areas of salt marsh and mudflats north of State Route 20.

Restoration Features

This action aims to restore tidal hydrology and channel-forming processes to historic distributary slough channels connecting Swinomish Channel to Padilla Bay, restore tidal hydrology to diked farmland that was historically estuarine marsh, and increase freshwater inputs to Padilla Bay by constructing bridges at causeway crossings, removing dikes, and creating and reconnecting channels. Key restoration elements of this action include the following:

- Construct a bridge at State Route 20 and BNSF railroad over Telegraph Slough, raise these causeways west of Swinomish Slough to allow for tidal exchange
- Excavate channel to connect distributary channels to Padilla Bay
- Remove tidal dikes and Swinomish Channel Dike; construct new dike to maintain existing level of flood risk management
- Remove culverts and tidegates
- Install culverts and tide gates

The “full” design alternative was carried forward for this site. Compared to the “partial” design, the full design proposes removing a larger extent of dikes along Telegraph Slough, Padilla Bay, and the east side of the Swinomish Channel (most of these dikes would stay in place under the partial design). Tidal connection would be restored to a significantly larger area under the full design. The full design alternative includes restoration of three distributary channels, more than six times the acreage of tidal influence, and more than three times the total length of tidal channels compared to the partial design. The length of tidal barrier removed is nearly 20 times that of the partial design. Overall, the full design would cause rapid improvements to tidal hydrology and productivity of native vegetation at this large site, which is connected to Padilla Bay, an estuary of national significance and part of the National Estuary Program.

4.6.2 Ecosystem Benefits of Restoration Sites in River Deltas

Qualitative benefits of these eight river delta sites would derive from restoring tidal inundation and hydrology to over 4,000 acres of highly productive estuarine mixing and tidal freshwater marshes. As these tidal marshes evolve, channel networks would form, water quality would improve, native vegetation would reestablish and, if a source is present, large woody debris would accumulate. The marshes would be used by steelhead[3], bull trout[3], and all five species of Pacific salmon, including Chinook[3]. Restoration in the Duckabush River would provide valuable rearing habitat for Hood Canal summer chum[3]. Three of the river deltas represented by these sites, the Nooksack, Skagit, and Snohomish, support some of the largest runs of salmon in the

[3] Federal ESA-listed species

Puget Sound. Increased habitat for salmon, particularly Chinook and chum, would benefit marine mammals, including ESA-listed southern resident killer whales (who feed on these species preferentially for much of the year). Puget Sound is an important stop on the Pacific flyway for migratory birds. Restored tidal marshes would also function as foraging and resting habitat for birds and waterfowl with an abundance of vegetation, invertebrates, and amphibians. Benefits of restoring wetlands in large river deltas will extend to the eelgrass beds located along their fringes by way of improved water quality, sediment delivery, and nutrient supply.

4.6.3 Sites included in Beach Strategy

There are two best-buy sites included in the final array of alternatives that address the beach strategy. Restoration objectives associated with this strategy are to restore the size and quality of beaches by removing or modifying barriers to sediment supply and transport processes to littoral drift cells. Target ecosystem processes for beach restoration include the following:

- Sediment supply
- Sediment transport
- Erosion and accretion of sediments
- Detritus recruitment and retention
- Freshwater input
- Solar incidence

4.6.3.1 *Beaconsfield Feeder Bluff*

Site Description, Geographic Location and Context

The Beaconsfield feeder bluff is located just north of Marine View Park in City of Normandy Park (Figure 4-6 and Figure 6-2). The bluff restoration site is composed of several narrow residential parcels along 1,000 feet of shoreline, 80% of which contains armoring composed of intermittent concrete vertical bulkheads and rock revetments. This armoring blocks sources of sand and gravel necessary to sustain beach structure and function.

Restoration Features

This action aims to restore the connection between the feeder bluff and the beach, providing a source of sediment to this degraded drift cell. Key restoration elements at this site include the following:

- Remove approximately 800 feet of shoreline armoring
- Minor regrading to recreate a gently sloping upper intertidal beach

The “partial” design alternative was carried forward for this site, primarily due to landowner willingness. Compared to the “full” design, the partial design would involve acquisition of some parcels abutting the shoreline and removal of a smaller extent of shoreline armoring. However, this alternative would not include acquisition of the residential property at the top of the bluff, requiring some shore armor to be retained to protect the house.

4.6.3.2 *WDNR Budd Inlet Beach*

Site Description, Geographic Location and Context

The WDNR Budd Inlet beach site is located along the east shore of Budd Inlet in southern Puget Sound (Figure 4-6), within a shoreline process unit that extends northward from Ellis Cove to Gull Harbor. The site includes a marine lab operated by the Washington Department of Natural Resources (WDNR), now largely obsolete and used primarily for storage. Structures associated with the former marine lab were built on a large fill area that encompasses the central portion of the site. The fill area infringes on the upper intertidal areas and appears to have a groin-like effect on littoral transport along much of the high tide beach. However, the fill does not appear to interfere with transport in the lower intertidal zone, and sediment is still able to reach beaches down-drift of the structure, which includes the large barrier beach/estuary of Gull Harbor. The armored, low-elevation shore north of the WDNR property contains fill and a bulkhead, which extends both waterward and landward into a narrow ravine. At least one culvert controls the hydrology of the wetland/historic lagoon on this property. A concrete bulkhead stands south of the WDNR property. The site also includes a privately owned low-elevation shoreline area to the north of the WDNR property. This area serves an adjacent residential community providing a recreational area and beach access.

Restoration Features

This proposed action entails restoration of sections of barrier and bluff-backed beach, which will alleviate degradation of sediment supply and transport, tidal flow, and other nearshore processes. Proposed restoration actions involve the removal of many nearshore stressors. Key design elements include the following:

- Remove bulkheads and fill
- Remove buildings, timber piles, and debris
- Dredge to recreate tidal lagoon
- Restore barrier beach and natural beach profile
- Excavate tidal channel to connect tidal lagoon with nearshore zone

The “full” design alternative was carried forward for this site. Compared to the “partial” design, the full design proposes restoration of the area north of the WDNR property, including removal of twice the length of bulkheads and quantity of fill as well as restoration of the beach profile. The full design would have three times as many large wood groupings and nearly three times the acreage of reestablishment of native riparian vegetation. Additionally, the full restoration would include restoring and connecting the historical barrier lagoon. Forage fish spawning occurs along the adjacent reaches of shoreline; restoration of this site would likely support these beach-spawning fish.

4.6.4 Ecosystem Benefits of Restoration Sites on Beaches

Qualitative benefits of these two beach restoration sites would derive from restoring erosion of the feeder bluffs (currently located behind armoring), as well as sediment transport and deposition. This erosion provides sediment to down-drift areas creating gently sloping beach profiles with shallow water habitat for migration of juvenile salmonids and natural barriers for small coastal embayments. In addition, a variety of substrate sizes provided by the bluff erosion will support colonization of a variety of biota. Populations of epi- and endo-benthic invertebrates like clams, worms and amphipods, as well as forage fish spawning and rearing would likely increase. Backshore vegetation will establish and large woody debris will accumulative on the beach, functioning as thermal refuge and structure for upper intertidal fauna. Benefits to these lower trophic levels would provide a forage base for marine predators like salmon and nearshore birds. Increased sediment delivery and nutrient input (via detritus) would lead to healthier eelgrass beds along the shoreline. Removal of shoreline armoring and fill from intertidal areas increases upper beach area and connectivity between terrestrial and marine components of nearshore ecosystems.

4.6.5 Sites included in Open Coastal Inlet Strategy

There are four best-buy sites included in the final array of alternatives that address the open coastal inlet strategy. Restoration objectives associated with this strategy are to remove barriers to tidal flow and freshwater input, restoring the quantity and quality of open coastal inlets. Target ecosystem processes for open coastal inlet restoration include the following:

- Tidal flow
- Freshwater input (including alluvial sediment delivery)
- Tidal channel formation and maintenance
- Detritus recruitment and retention

4.6.5.1 *Deer Harbor Estuary*

Site Description, geographic location and context

Deer Harbor encompasses the largest estuary on Orcas Island (Figure 4-6 and Figure 6-4). The Cayou Valley Lagoon, also known as the Deer Harbor Lagoon or Slough, is an open coastal inlet located north of the Channel Road Bridge. Tidal flushing from the larger bay into the northern inlet is limited by fill and shore armor associated with Channel Road bridge, constraining the width of the inlet mouth to less than half of its historical width. This constriction has altered the tidal prism and freshwater flows leading to sedimentation upstream of the bridge and the subsequent loss of intertidal marsh, mudflats, and tidal channels.

Restoration Features

The proposed restoration at Deer Harbor Estuary entails widening the mouth of the inlet to allow full tidal flushing and freshwater flows, restoring 16 acres of tidally influenced marsh and mudflats. Fish passage will also improve in the estuary. Key restoration elements of the site include the following:

- Remove Channel Road bridge; remove associated embankment armor and fill
- Construct a new bridge to allow full tidal flushing at the mouth of the inlet
- Remove sediments at inlet
- Remove nearshore debris (riprap and rock slope protection)

The “full” design alternative was carried forward for this site. Compared to the “partial” design, the full design proposes construction of a larger bridge across the opening of the estuary, allowing complete tidal exchange, sediment supply and transport, and natural tidal formation.

4.6.5.2 *Harper Estuary*

Site Description, geographic location and context

Harper Estuary is located on the east shoreline of the Kitsap Peninsula, approximately six miles east of Port Orchard (Figure 4-6). The estuary is bounded to the west by SE Southworth Drive (State Route 160), constructed through the historical estuary, and SE Olympiad Drive, which transverses the mouth of the of inlet. The east side of the estuary contains an abandoned roadway embankment. These causeways and associated fill restrict the tidal prism within the estuary leading to a loss of tidal marsh, and, in some areas, the conversion to freshwater wetlands that are dominated by invasive cattails.

Restoration Features

The proposed restoration would restore full tidal hydrology to six acres of marsh and mudflats. Fish passage, sediment transport, and detritus exchange will improve. Key restoration features at this site include the following:

- Remove a portion of SE Olympiad Drive
- Remove roadway embankment and armoring on the eastern side of the estuary
- Remove fill and other debris from the estuary
- Excavate a more sinuous stream channel and starter channels

The “full” design alternative was carried forward for this site. Compared to the “partial” design, the full design proposes to completely remove SE Olympiad Drive and associated fill to allow unrestricted tidal exchange throughout the entire estuary.

4.6.5.3 *Snow Creek and Salmon Creek Estuary*

Site Description, geographic location and context

Snow Creek and Salmon Creek discharge to Discovery Bay, a coastal embayment located along the Strait of Juan de Fuca (Figure 4-6). The mouths of Salmon and Snow Creeks form a low-gradient riparian area transitioning to marsh and mud flats in Discovery Bay. Agriculture and limited development have impacted the riparian area and channelized and separated creek channels. Highway 101 crosses the mouth of the estuary with a bridge at each creek. Farther downstream (north), an abandoned railroad grade crosses the wetland delta, further channelizing the creeks and impacting hydraulics, sediment, and morphology. The railroad continues northward at low elevations within the historical footprint of Discovery Bay, resulting in a range of modified shore habitat including a lagoon that supports Olympia oyster beds. The Olympic Discovery Trail, a 130 mile long regional pedestrian/bicycle trail, traverses the area, connecting nearby Port Townsend with the Pacific Ocean beachside town of La Push, Washington.

Restoration Features

The proposed restoration will restore tidal hydrology and channel forming processes to 52 acres within the Snow and Salmon Creek estuary, as well as freshwater input and sediment delivery to nearshore zone of Discovery Bay. Fish passage would also improve within the estuary. Key restoration features associated with this site include the following:

- Replace Highway 101 with a widespan bridge at Salmon Creek to allow full tidal exchange to the Snow/Salmon Creek estuary
- Remove fill associated with abandoned railway embankment
- Remove armoring on western shore of Discovery Bay

The “partial” design alternative was carried forward for this site. Compared to the “full” design, the partial design proposes smaller changes to the highways in the project footprint. While tidal channels would be restored in the estuary, Snow Creek would not be reconnected to Salmon Creek, so restoration of distributary and tidal channels would be more limited in this area.

4.6.5.4 *Tahuya River Estuary*

Site Description, geographic location and context

The Tahuya River Estuary is a coastal inlet near the great bend of southern Hood Canal (Figure 4-6). NE North Shore Road is built on an embankment across the mouth of the Tahuya River Estuary, with a short bridge crossing where the two Tahuya River channels converge into one. This roadway embankment and bridge fill part of the estuary and reduces the complexity of braided channels in the inlet. Large estuarine marshes still remain between the two main channels, and they are largely unconstrained except at the bridge.

Restoration Features

Restoration at this site would improve the tidal prism of this estuary, allowing for channel formation and migration and uninhibited fish passage. Key restoration features include the following:

- Remove the NE North Shore causeway and associated fill
- Construct a new widespan bridge that will span the width of the historical estuary, allowing full tidal exchange
- Remove debris, including derelict pilings and fill, throughout the estuary

The “full” design alternative was carried forward for this site. Compared to the “partial” design, the full design proposes removal of the entire roadway and embankment fill from the estuary, rather than a more limited roadway removal. The new bridge will span the width of the historical estuary, allowing for a greater extent of natural channel formation and uninhibited fish passage.

4.6.6 Ecosystem Benefits of Restoration Sites in Open Coastal Inlets

Qualitative benefits of these four open coastal inlet sites would derive from restoring and/or improving: 1) tidal flow to 110 acres of estuarine wetlands, and 2) freshwater and sediment input to adjacent nearshore areas. Restoration of these landforms adds complexity and length to the Puget Sound shoreline. Estuarine wetlands and associated vegetation, tidal channels and woody debris provide valuable nursery habitat for juvenile salmonids, including ESA-listed Chinook and Hood Canal Summer Chum. Although small in acreage compared with the large river deltas, coastal inlets are essential foraging and rearing “pit stops” for juvenile salmonids during shoreline migration. The improved water quality and exchange of sediment would support the expansion of shellfish populations and highly productive eelgrass beds. Benefits to these lower trophic levels would increase the forage base for birds, mammals, and predatory fish, such as surf scoters, Southern Resident killer whales[4], and bull trout[4].

4.6.7 Sites included in Barrier Embayment Strategy

There are four best-buy sites included in the final array of alternatives that address the barrier embayment strategy: Big Beef Creek Estuary, Dugualla Bay, Livingston Bay, and Point Whitney Lagoon. Barrier embayment restoration objectives are to restore the sediment input and transport processes that sustain the barrier beaches that form these sheltered bays. Objectives also include the restoration of the tidal flow processes within these partially closed systems, often cut off by fill or other constrictions from a tidal connection to Puget Sound. Target ecosystem processes for barrier embayments vary based on extent of freshwater input and nature of the barrier, but in general they include the following:

[4] Federal ESA-listed species

- Tidal hydrology
- Sediment supply and transport
- Erosion and accretion of sediment
- Tidal channel formation and maintenance
- Detritus recruitment and retention

4.6.7.1 *Big Beef Creek Estuary*

Site Description, geographic location and context

Big Beef Creek Estuary is located on the north end of Hood Canal on the Kitsap Peninsula across from Toandos Peninsula (Figure 4-6). Seabeck Highway runs along the shoreline over the barrier (a naturally dynamic spit) and the mouth of the estuary. This causeway constrains the mouth of the estuary and essentially “locks” the spit in place with armoring and fill. This restricts tidal flow and subsequent sediment transport, erosion, and accretion, tidal channel formation, and detritus exchange. These degraded processes reduce the quantity and quality of tidal wetlands in the estuary.

Restoration Features

Restoration of this estuary would recreate the historical opening to Hood Canal, allowing for unrestricted tidal flow to nearly 30 acres of tidal marsh and alluvial sediment delivery to the nearshore zone. The spit at the mouth would form and migrate freely with nearshore processes. Key design features include the following:

- Remove fill and armor associated with Seabeck Highway causeway
- Replace current bridge with a widespan bridge across the embayment inlet and spit to allow full tidal exchange at Big Beef Creek Estuary
- Restore tidal channel landward of the new bridge and around the spit

The “full” design alternative was carried forward for this site. Compared to the “partial” design, the full design proposes removal of the entire extent of the roadway pavement and current bridge section along with associated fill, armoring, and accumulated beach sediment. The new bridge would be longer compared to the partial design, allowing the processes of tidal exchange, sediment supply and transport, and tidal channel formation to be significantly greater.

4.6.7.2 *Dugualla Bay*

Site Description, geographic location and context

Dugualla Bay is located on the northeast side of Whidbey Island within the western portion of Skagit Bay (Figure 4-6 and Figure 6-5). The action area includes part of the Whidbey Island Naval Air Station, Dugualla Lake and the lower Dugualla Creek drainage, a former estuary and salt marsh, now separated from the marine waters of Dugualla Bay by a causeway that functions as a dike. To create agricultural land, Dike Road and an associated dike and tide gate/pump station system were constructed at the inlet of a historic barrier embayment. This eliminated tidal inundation, converting the estuary into freshwater Dugualla Lake and restricting fish access from Puget Sound.

Restoration Features
The proposed restoration would remove barriers to tidal hydrology in Dugualla Bay. This action will allow for tidal exchange between the bay and Dugualla Lake, create 572 acres of salt marsh and mudflats, and improve connection with the surrounding floodplain and fish access to the system. Key restoration features include the following:

- Remove roadway berm/dike and associated fill; and replace with a widespan bridge to allow full tidal exchange
- Excavate new tidal channel opening at Dike Road
- Install culverts
- Remove dikes and armoring
- Fill linear drainage ditches throughout site
- Remove structures on acquired properties within area of proposed tidal flooding
- Restore shoreline on east side of Dike Road

The "partial" design alternative was carried forward for this site. Compared to the "full" design, the partial design will return historical tidal inundation to Dugualla Bay, but would restore less of the historical footprint as only a portion of Dike Road would be removed. The partial design requires less property and agricultural lands; landowners are more supportive of the partial design.

4.6.7.3 *Livingston Bay*

Site Description, geographic location and context
Livingston Bay is a closed barrier embayment adjacent to Port Susan Bay near the Stillaguamish River delta on the southeast side of Camano Island (Figure 4-6 and Figure 6-7). Extensive diking and drainage of Livingston Bay has occurred for agricultural proposes, blocking exchange of tidal waters, sediment, and detritus between Livingston and Port Susan Bay.

Restoration Features
Restoration at this site involves opening up Livingston Bay to tidal flow to create 239 acres of tidal marsh. The action will allow for exchange of sediment and detritus, the evolution of tidal channels, and fish access. Key restoration features include the following:

- Lower dikes to existing grade; construct new dike to maintain existing level of flood risk management
- Excavate new tidal inlet through breach; excavate tidal channels and starter channels
- Remove fill to reestablish tidal inlet at its historic location

- Remove small pump station and associated utilities
- Nourish beach with excavated tidal inlet material

The “partial” design alternative was carried forward for this site. Compared to the “full” design, the partial design proposes a limited extent of channel excavation. Only starter channels would be excavated for the main channels, which would result in a slower evolution of the tidal channel system. However, formation of a channel network is expected to occur naturally over time once existing dikes are lowered or breached, so significant excavation of tidal channels was not carried forward as a design element.

4.6.7.4 *Point Whitney Lagoon*

Site Description, geographic location and context

Point Whitney Lagoon is located in northern Hood Canal near Dabob Bay (Figure 4-6). The action area consists of a lagoon and spit that extends along the shoreline of the bay. The lagoon was partially filled to create ponds used for shellfish rearing and for construction of buildings. The surface of the spit has been hardened by placement of concrete, asphalt, and gravel. Shore armoring, riprap, and concrete are present at the northeast corner of the spit. All of these stressors inhibit tidal flow within the lagoon and impact the historic beach spit.

Restoration Features

The proposed action would restore tidal influence to six acres of wetlands at Point Whitney Lagoon. The removal of fill within the historic lagoon footprint would restore embayment hydraulics and morphology, increasing tidal prism, helping to maintain the entrance channel, and improving tidal exchange. The removal of fill and armoring on the gravel spit (shore and crest) would restore natural sediment transport in the cross-shore direction and provide additional habitat area. Key restoration features include the following:

- Remove all pond dikes and associated culverts, tide gates, and other infrastructure
- Remove rock revetments, fill, and pavement on the spit
- Placement of beach gravel on the lower elevations of the eastern portion of the spit
- Remove all buildings and other structures in nearshore areas

The “full” design alternative was carried forward for this site. Compared to the “partial” design, the full design proposes a complete dike removal (versus a phased dike removal) at the site as well as removal of additional armoring and buildings to allow faster and more complete restoration of tidal flows to the lagoon. Removal of the additional armoring would allow natural evolution of the spit, increase the tidal prism, allow improved flushing, and allow natural sediment transport in the cross-shore direction for broader habitat area. The surrounding shorelines of this site host forage fish spawning, eelgrass beds, shellfish habitat, and osprey and bald eagle nests. Restoration will likely expand areas available to these resources.

4.6.8 Ecosystem Benefits of Barrier Embayment Sites

Qualitative benefits of these four barrier embayment sites would derive from restoring or improving tidal influence to 846 acres of marsh, mudflats and tidal channels. Barrier beaches associated with these partially enclosed embayments would also be restored or enhanced. Ecological benefits are similar to those described for open coastal inlets, although there are added benefits of barrier beaches. The presence of this type of beach provides more protection to the embayment as well as structure on the beach itself for invertebrate colonization and forage fish spawning. Restoring barrier embayments also adds to the complexity and length of Puget Sound's shoreline. These ecosystems have high ecological value, providing essential foraging and rearing habitat for migratory species of birds and juvenile salmonids.

4.7 EVALUATION OF FINAL ARRAY OF ALTERNATIVE PLANS

As initially presented in Section 4.4, the Nearshore Study team selected a final array of three alternatives. In addition to the No-Action Alternative, Alternative 2 includes 11 sites while Alternative 3 includes 18 sites. The alternatives are described below in more detail.

4.7.1 Alternative 1 – No-Action Alternative

This alternative is included for comparison purposes and represents future conditions without implementation of a large-scale Federal restoration project. Degradation trajectories would continue as influenced by development and existing restoration and protection authorities. Small-scale restoration requiring extensive local and state funding not supported by large scale Federal investment would continue based largely on an opportunistic approach. Funding of restoration and protection would continue at funding levels and spatial scales already determined feasible by local entities.

4.7.2 Alternative 2 – Restore 11 Sites

4.7.2.1 *Geographic Locations*

Alternative 2 includes 11 sites. The majority of these 11 sites are focused around the Skagit and Snohomish River Deltas, with one site on the stretch of shoreline between Tacoma and Seattle (Beaconsfield) and one to the north in the San Juan Islands (Deer Harbor). These 11 sites represent the minimum restoration action required to make progress toward the four restoration strategies defined by the Nearshore Study. Sites are distributed in four of the seven Puget Sound sub-basins defined by the Nearshore Study (Figure 1-1), with eight of the 11 sites located in one sub-basin (Whidbey). The western portion of Puget Sound (including Hood Canal and the Strait of Juan de Fuca) as well as the South Puget Sound are not represented in this alternative.

4.7.2.2 *Restoration Sites Included*

Alternative 2 includes 11 of the 18 sites described in Section 4.5. Sites included in this alternative range in size from six to 1,807 acres and include the following (refer to Section 4.5 for details on their restoration features):

The seven large river delta sites selected for this alternative, ranging in size from 214 to 1,807 acres, include the following:

- Deepwater Slough
- Everett Marshland
- Milltown Island
- Nooksack River Delta
- North Fork Skagit River Delta
- Spencer Island
- Telegraph Slough

Only one site has been selected to address the open coastal inlet strategy and the associated focus on restoring tidal hydrology and freshwater input processes. This site is 16 acres:

- Deer Harbor Estuary

The barrier embayment strategy would be addressed at two sites, where the restoration of tidal hydrology is required, as well as reestablishment of a stable barrier beach to provide necessary low-energy conditions. The sites range from 239 to 572 acres and include the following:

- Dugualla Bay
- Livingston Bay

Only one cost-effective site has been identified to address beach strategy target processes of restoring sediment supply and transport. While the team evaluated several potential sites, most did not appear to meet the identified restoration requirement to restore sediment delivery processes, typically by the removal of shoreline armoring. This site is relatively small at six acres of area of restored process, but it remains ecologically significant:

- Beaconsfield Feeder Bluff

4.7.2.3 *Construction, Real Estate and O&M Costs*

The 11 sites that comprise Alternative 2 have a total first cost of approximately $1,063,899,000 (October 2011 price level). The average net, or change in O&M costs from existing conditions is -$86,000 annually (after completion of construction, the non-Federal sponsor will assume O&M responsibility for the project). The average annual cost for Alternative 2 over the 50 year period of analysis is approximately $48,268,000.

4.7.2.4 *Ecosystem Benefits*

Benefits of this alternative would derive from removing nearly 75,162 linear feet of shoreline stressors, thereby restoring processes that would create 5,348 acres of tidally influenced wetlands in river deltas and shallow embayments; as well as sustain two beaches. Benefits to salmonids and forage fish would primarily focus on populations in the Snohomish and Skagit basins. Eight of the 11 sites are currently used for spawning and/or rearing and restoration will allow access at an additional three sites. Six of the 11 sites have documented or potential forage fish spawning within close proximity. Additionally, predators throughout the Puget Sound would benefit as these prey species disperse during the ocean portion of their lifecycle.

ESA-listed species in Puget Sound that have suffered from a loss or degradation of habitat would benefit from the removal of shoreline stressors at these 11 sites, either directly by using the restored habitat (as is the case for listed salmonids) or indirectly via reliance of their prey on the habitat (as is the case for killer whales and murrelets). Benefits to ESA-listed species would also be similar to those discussed for Alternative 3 (refer to Section 4.7.3.4), but to a lesser extent due to fewer stressors removed and associated habitat restored, and the limited geographic range of the proposed sites. Hood Canal salmon, eulachon, and green sturgeon would see little benefit since there are no sites in Hood Canal and only one in northern Puget Sound (where eulachon and Green sturgeon occur). ESA-listed species that would benefit from this alternative include Chinook salmon, bull trout, steelhead, and juvenile rockfish, and the predators that rely on them or other nearshore zone dependent species (killer whales and marbled murrelet).

Restored sediment transport and delivery to beaches and embayments will support ecologically valuable kelp and eelgrass beds (six of the eleven sites have eelgrass and/or kelp beds within close proximity). These beaches, shallow embayments, and kelp and eelgrass beds will provide refuge habitat for juvenile salmonids during shoreline migration, spawning substrate for forage fish (five of the 11 sites have documented or potential forage fish spawning within close proximity), and three-dimensional habitat for a variety of fish and invertebrates including juvenile rockfish, clams, and crabs. The restored wetlands in large river deltas and coastal embayments, and their associated tidal channels, would be colonized by native plants and invertebrates, resulting in critical rearing and foraging habitat for juvenile salmonids.

The additions and improvements of nearshore habitat would increase Puget Sound’s shoreline complexity, diversity, and connectivity providing a variety of habitat types and ecological niches for many nearshore species that play key roles in the Puget Sound food web, as well as provide ecosystem functions, goods, and services like nutrient cycling and water purification. These benefits would ascend trophic levels yielding prey for many bird species such as great blue herons, dunlins, and bald eagles that use nearshore wetlands and beaches to forage, as well as marine mammals.

4.7.3 Alternative 3 – Restore 18 Sites

4.7.3.1 *Geographic Locations*

The 18 sites included in this alternative are geographically diverse, representing excellent process-based restoration opportunities across the entire Puget Sound nearshore zone. These sites range from the Nooksack River estuary in northern Puget Sound to the WDNR Budd Inlet beach in the South Sound, as well as three sites in Hood Canal, one in Discovery Bay on the Strait of Juan de Fuca, and several sites in between. Sites are distributed in six of the seven Puget Sound sub-basins defined by the Nearshore Study. The exception is the North Central Puget Sound sub-basin, which is small in size with limited restoration opportunities compared to other sub-basins (Figure 1-1).

4.7.3.2 *Restoration Sites Included*

All 18 sites described in Section 4.5 are included in this alternative. This alternative includes eight sites addressing delta strategy target processes such as tidal and freshwater flow. The sites range in size from two to 1,807 acres.

The eight large river delta sites selected for this alternative, ranging in size from 38 to 1,807 acres, include the following:

- Deepwater Slough
- Duckabush River Estuary
- Everett Marshland
- Milltown Island
- Nooksack River Delta
- North Fork Skagit River Delta
- Spencer Island
- Telegraph Slough

Four sites have been selected to address the open coastal inlet strategy and the focus on restoring tidal hydrology and freshwater input processes. These sites range from six to 52 acres:

- Deer Harbor Estuary
- Harper Estuary
- Snow Creek and Salmon Creek Estuary
- Tahuya River Estuary

The barrier embayment strategy would be addressed at four sites, where the restoration of tidal hydrology is required, as well as reestablishment of a stable barrier beach to provide necessary low-energy conditions. The sites range from six to 572 acres and include the following:

- Big Beef Creek Estuary
- Dugualla Bay
- Livingston Bay
- Point Whitney Lagoon

Only two cost-effective sites have been identified to address beach strategy target processes of restoring sediment supply and transport. While the team evaluated several potential sites, most did not appear to meet the identified restoration requirement to restore sediment delivery processes, typically by the removal of shoreline armoring. These two sites are relatively small, with two and six acres of area of restored process, but remain ecologically significant:

- Beaconsfield Feeder Bluff
- WDNR Budd Inlet Beach

4.7.3.3 *Construction, Real Estate, and O&M Costs*

The 18 sites that comprise Alternative 3 have a total first cost of approximately $1,243,408,000 (October 2011 price level). The average net, or change in O&M costs from existing conditions, is $44,100 annually (after completion of construction, the non-Federal sponsor will assume O&M responsibility for the project). The average annual cost over the 50-year period of analysis for Alternative 3 is approximately $57,071,000.

4.7.3.4 *Ecosystem Benefits*

Benefits from this alternative would derive from removing approximately 113,094 linear feet of shoreline stressors (most of which are tidal barriers, nearshore fill, and shoreline armoring), thereby restoring processes that would create or restore 5,517 acres of tidally influenced wetlands in river deltas and shallow embayments, as well as sustain a bluff-backed beach and a barrier beach system. These benefits would be distributed among all but one of the sub-basins in Puget Sound (North Central), as described in Section 4.6.3.1.

Ecosystem benefits are similar to Alternative 2 but on a larger, more diverse geographic scale. Restored sediment transport and delivery to beaches and embayments will support the ecologically valuable kelp and eelgrass beds (12 of the 18 sites have eelgrass and/or kelp beds within close proximity). Refuge habitat for juvenile salmonids will be provided (13 of the 18 sites have documented or potential forage fish spawning nearby), along with critical rearing and foraging habitat for juvenile salmonids (14 of the 18 sites are used by anadromous fish for spawning and/or rearing; restoration will allow for access at the remaining four sites).

Benefits to ESA-listed species would be similar to those discussed for Alternative 2 (refer to Section 4.6.2.4), but to a larger extent due to more stressors removed and associated habitat restored, and the expanded geographic range of the proposed sites in this larger alternative. The majority of the sites in Alternative 3 would benefit Chinook salmon, steelhead, and bull trout, and three sites would benefit Hood Canal summer chum salmon by providing rearing habitat for juveniles and restoring shoreline processes that sustain beaches and kelp and eelgrass beds for forage fish spawning (a preferred prey item). Benefits to Chinook and chum will indirectly benefit Southern Resident killer whales since they preferentially feed on these species during much of the year. Eulachon would benefit from sites restored in the northern portions of Puget

Sound, including the 1,807 acres of restored river delta in the Nooksack Estuary. Species that have not necessarily seen declines in number due to habitat loss in Puget Sound would still benefit from added foraging areas (green sturgeon and Steller sea lions) and rearing habitat (kelp and eelgrass beds for juvenile rockfish).

4.8 COMPARISON OF FINAL ARRAY OF ALTERNATIVE PLANS

In this section, the final array of three alternative plans are compared to each other, with emphasis on the outputs and effects that will have the most influence in the decision-making process. Beneficial and adverse effects of each plan are compared including monetary and non-monetary benefits and costs. From this comparison, the tradeoffs between the plans are transparent. This comparison of alternatives is partially a reiteration of the evaluation presented in the previous sections with the exception that the two action alternatives are compared to each other, and not just against the without-project condition (aka the No-Action Alternative). The comparison of the alternatives is presented in terms of planning criteria and evaluation accounts, as well as the effects on significant resources described in detail in Chapter 5.

4.8.1 Planning Criteria

Performance of the alternative plans with respect to the planning objectives appears in Table 4-5 along with additional key evaluation criteria (e.g., cost, acres restored, etc.).

Table 4-5. Planning Criteria Comparison

PLANNING CRITERIA	Alternative 1 No Action	Alternative 2 11 Sites	Alternative 3 18 Sites
Strategy 1/Objective 1 - Deltas	0 Sites 0 Acres Net EO[1] = 0	7 Sites 4,521 acres Net EO = 1,598	8 sites 4,559 acres Net EO = 1,609
Strategy 2/Objective 2 - Beaches	0 Sites 0 Acres Net EO = 0	1 Site 6 acres Net EO = 1.3	2 Sites 8 acres Net EO = 2.5
Strategy 3/Objective 3 - Embayments (Barrier Embayments)	0 Sites 0 Acres Net EO = 0	2 Sites 811 acres Net EO = 203.1	4 Sites 847 acres Net EO = 212.9
Strategy 4/Objective 3 - Embayments (Coastal Inlets)	0 Sites 0 Acres Net EO = 0	1 Site 16 acres Net EO = 4.8	4 Sites 110 acres Net EO = 20.8
Objective 4 – Increase Understanding	N/A	11 Sites	18 Sites
Acres of Restored Habitat	0 acres	5,354 acres	5,523 acres
Net EO (Average Annual Benefits in Habitat Units)	0 EO	1,807 EO	1,846 EO

PLANNING CRITERIA	Alternative 1 No Action	Alternative 2 11 Sites	Alternative 3 18 Sites
Cost (Average annual at October 2011 price level)	$0	$48,268,000	$57,071,000
Total Estimated Costs	$0	$1,063,899,000	$1,243,408,000
Cost per Acre (Total Estimated Cost / Acres of Restored Habitat)	$0	$198,726 / acre	$225,112 / acre

Notes: [1] Net EO, Environmental Outputs, is represented by Average Annual Benefits measured in Average Annual Habitat Units (AAHU or HU)

4.8.2 Principles and Guidelines Accounts

Planning by Federal agencies for water resource development and management is guided by the requirements of the U.S. Water Resources Council's Principles and Guidelines. The Principles and Guidelines establish four accounts to facilitate the evaluation, display, and comparison of the effects of alternative plans. These accounts are National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE). These four accounts encompass all significant effects of plan implementation, including economic, socioeconomic, and environmental effects that must be considered in water resources planning.

Effects of the alternative plans in the four evaluation accounts are displayed in Table 4-5 above, Table 4-6 below, and the Summary of Environmental Consequences (Table 5-10) in Chapter 5.

Table 4-6. Evaluation Listed in the "Principles and Guidelines" (2012 $ values)

Evaluation Accounts	WITH- AND WITHOUT-PROJECT CONDITIONS		
	Alternative 1 No Action	**Alternative 2 11 of 18 Sites**	**Alternative 3 18 of 18 Sites**
National Economic Development Account			
Flood Risk Management/Storm Damage Reduction	No Impact	Improved resiliency of the shoreline to respond to changes in the environment such as rising sea levels and increasing frequency of storm events.	
Commercial Navigation	No impact.	No significant difference expected between with- and without-project conditions. For the site at Telegraph Slough (near Swinomish Channel) and to a lesser extent for the site at Everett Marshlands (upstream of Snohomish River Navigation Channel), the project plans will be evaluated for possible increased O&M costs in the navigation channels. If any cost increases are anticipated, the site features will be modified to prevent increased O&M. For the case of Telegraph Slough, this may mean omitting the connection between the slough and the navigation channel.	

Recreation	No impact	• Alternatives 2 & 3 directly contribute to restoring and sustaining the Puget Sound ecosystem, which is a critical component of recreational and tourism activities in the region. • The Puget Sound area provides $9.5 billion in travel spending, including 88,000 tourism-related jobs and $3.2 billion in income[1]. • Outdoor recreation contributes $8.9 billion annual in retail sales and services in WA State, including $687 million in annual sales tax[2]. • Waterfowl hunting opportunities may be displaced or substituted by new or different recreation opportunities e.g., bird watching.
Commercial/Recreational Fishing	No impact	• Significant positive economic impacts are expected to result from ecosystem improvements in Puget Sound. • The average annual commercial fishing value of fish caught in Puget Sound is valued at $4.4 million and $47 million for shellfish[1]. • Over $3.9 billion or 2.1 percent of Washington's GDP is generated from industries directly and indirectly associated with commercial fisheries in WA State[1]. • The average annual value of recreational fishing is $61 million and $45 million for shellfish[1]. • Resident and nonresident recreational anglers spend over $1.0 billion annually on trip-related expenditures[3].
Regional Economic Development Account	No significant difference expected between with- and without-project conditions.	
Environmental Quality Account	Refer to Table 4-7 and Table 5-10 for a display of ecological, cultural, and aesthetics attributes.	
Other Social Effects Account	Alternatives 2 and 3 would likely positively affect fish species of concern for many Native American tribes located in Washington State.	

Washington State Department of Ecology (WDOE 2008)

Trust for Public Land 2010

TCW Economics 2008

4.8.3 Trade-Off Analysis

Trade-off analysis is the procedure the Corps uses to identify the potential gains and losses associated with producing a larger or lesser amount of given outputs. The results of trade-off analysis are used in the formulation, evaluation, comparison, and selection of the recommended plan. The following paragraphs summarize the key trade-offs between Alternative 2 and Alternative 3.

Acreage and Geographic Spread

Alternative 3 more broadly addresses the identified problems at the scale of Puget Sound. Alternative 3 includes sites in six out of the seven Puget Sound sub-basins, including the highly productive shellfish regions of south Puget Sound and Hood Canal, and the Strait of Juan de Fuca, which is a transition zone between the Pacific Ocean and Puget Sound proper for many migratory species; Alternative 2 includes sites in three of the seven sub-basins with the majority occurring in just one sub-basin (Whidbey). Alternative 3 includes sites in four of the 16 major river deltas; Alternative 2 includes sites in three. Alternative 3 would restore 5,523 acres, an 8% increase over Alternative 2, which would restore 5,354 acres. Alternative 3 would remove 113,094 feet of stressors, a 50% increase over Alternative 2.

Complexity and Habitat

Alternative 3 includes eight sites in coastal embayments and eight sites in four major river deltas, whereas Alternative 2 includes three sites in coastal embayments and seven sites in three major deltas. Frequent and well distributed coastal embayments provide important rearing and refuge habitat for migrating Puget Sound salmonids and other species. Migratory birds that use the Pacific Flyway, a major north-south route of travel for migratory birds in America that includes Puget Sound, would benefit more from the more widely dispersed habitat improvements and the additional acreage of wetlands included in Alternative 3.

ESA-Listed Species

All 18 sites that comprise Alternative 3 (and 11 in Alternative 2) include critical habitat for ESA-listed species. While both Alternatives 2 and 3 would benefit ESA-listed species, Alternative 3 would benefit more species and would have a greater breadth of benefits. For example, Alternative 3 would benefit all Hood Canal salmon including the ESA-listed summer chum, whereas Alternative 2, with no sites in Hood Canal, would not. Similarly, Alternative 3 is more likely to benefit green sturgeon and eulachon, which are only known to forage in the Strait of Juan de Fuca and northern Puget Sound (three sites are located in this area versus only one for Alternative 2). Southern Resident killer whales would receive benefit from both Alternative 2 and 3 due to the inclusion of the Nooksack River Delta site, in addition to restoration in the Skagit and Snohomish River Deltas, which would improve a substantial amount of habitat for salmon, a major component of the diet of the ESA-listed Southern Resident killer whales in Puget Sound.

Principles and Guidelines Evaluation Criteria

Completeness – All sites included in Alternatives 2 and 3 account for all necessary investments or other actions needed to ensure the realization of the planned restoration outputs at the scale of each site. However, Alternative 3 is more complete than Alternative 2, in that it contributes more to the overall goals for Puget Sound recovery as laid out by the Puget Sound Partnership.

Effectiveness - All sites included in Alternatives 2 and 3 effectively restore the processes that create and sustain Puget Sound nearshore ecosystems at the scale of each site. Alternative 3 is more effective overall than Alternative 2 in that it addresses the observed problems at more locations around the sound, restoring 8% more acreage than Alternative 2.

Efficiency – Alternative 2 and Alternative 3 were identified through analysis as cost-effective and best-buy plans using the IWR Plan software. Both are considered to be efficient alternative plans.

Acceptability – Both Alternative 2 and Alternative 3 are acceptable to state and Federal resource agencies, local governments, and the tribes. Both alternatives do not violate laws or regulations.

4.9 TENTATIVELY SELECTED PLAN

The Corps objective in ecosystem restoration planning is to contribute to national ecosystem restoration (NER). Selecting the NER Plan requires careful consideration of planning goals, objectives, and constraints. The NER Plan is a plan that reasonably maximizes ecosystem restoration benefits considering cost effectiveness and incremental cost analysis, significance of outputs, completeness, effectiveness, efficiency, and acceptability. The selected plan must be shown to be cost effective and justified to achieve the desired level of output.

The information developed by the CE/ICA and evaluation, comparison, and trade-off analyses presented throughout this chapter have informed the decision-making process by helping to answer whether the proposed Federal investment of each alternative in the final array is justifiable and viable from a cost perspective; that is, whether the environmental benefit of the additional output in the next level of investment is worth its additional cost. Per the general decision-making guidelines outlined in Appendix E of ER 1105-2-100, the following factors assist in determining a justifiable and viable alternative:

- Output Target & Threshold: Although a formal habitat unit target has not been identified for the study, the Study Team has indicated that restoration of all four strategies (river deltas, barrier embayments, coastal inlets, and beaches) adds significant value to the proposed alternatives. Restoration of all four strategies is the minimum output threshold for this study. Additional investments to restore these four critical habitat types are worth the cost of doing so. Alternative 2 is the first cost effective and best buy alternative that includes all four restoration strategies. While Alternative 3 restores additional sites within each of the four strategies, Alternative 2 includes the minimum number of sites to meet the basic objectives of this study.

- Cost Affordability: Federal and Non-Federal implementation funds are a constraint. Although there are significant ecosystem restoration benefits associated with Alternative 3 this alternative is significantly more costly compared to Alternative 2. Alternative 3 is not likely affordable; funding limitations are a realistic constraint that must be factored into the decision-making process of determining the best investment for the funds available.

In consideration of the steps taken to formulate scientifically sound, sustainable solutions to solve the stated problems of Puget Sound nearshore ecosystem degradation, and upon review of the results of the evaluation and comparison of alternatives presented throughout this Chapter, Alternative 2 has been identified as the NER Plan and is selected as the Preferred Alternative.

Alternative 2 is a best buy plan that completely and effectively addresses nearshore ecosystem degradation around Puget Sound. Alternative 2 is an acceptable plan from the perspective of Federal and state agencies, tribes, and study stakeholders. Alternative 2 offers a complex and geographically extensive set of solutions to the stated problems, benefiting a large area and a significant number of ESA-listed and other species that either inhabit Puget Sound's nearshore zone or depend on such species as part of their food chain. Alternative 2 is the Preferred Alternative and TSP.

5 COMPARISON OF ENVIRONMENTAL EFFECTS OF THE ALTERNATIVES*

This chapter provides information on issues relevant to the decision process for selecting the preferred alternative. The analysis investigates the potential for activities associated with the considered alternatives to affect (either adversely or beneficially) the various issues of concern and provides a comparative assessment of each alternative's expected effect on the environment. The assessment of environmental effects is based on a comparison of conditions with and without implementation of the proposed plan and related alternatives; in this case, two alternatives were formulated through the screening process and are compared to the No-Action Alternative. Effects can be short-term or long-term, and beneficial or adverse. For the alternatives analysis in this chapter, the spatial scale of analysis focuses on the locations of the 18 proposed sites to provide a comparison between the No-Action Alternative and the two action alternatives. The time scale for analysis is a 50-year period beginning in 2015 extending to 2065. Finally, certain topics were screened out of detailed analysis during the NEPA scoping process as described in Section 3.5, and are therefore not covered in this section.

5.1 PHYSICAL ENVIRONMENT: NEARSHORE PROCESSES AND STRUCTURES

This section provides an analysis of how each alternative would affect a variety of significant physical resources associated with nearshore processes and structures. Effects of the No-Action Alternative would avoid impacts from construction, but would forego the opportunity for important ecosystem restoration benefits. Almost all of the negative effects of the two action alternatives would be short-term construction impacts lasting an estimated six months to two years, yet these proposals would have long-term benefits to the physical attributes of the nearshore zone, which support ecosystem functions, goods, and services. For the two sites in Alternatives 2 and 3 (Telegraph and Everett Marshland) that are near navigation channels, site features would be engineered so as to cause no significant impacts to operations and maintenance costs for navigation.

5.1.1 Nearshore Ecosystem Processes

As described in section 3.1, nearshore ecosystem processes influence marine and estuarine shorelines over diverse spatial and temporal scales and are responsible for the different complexes of landforms supporting a wide variety of flora and fauna described in section 3.2.

5.1.1.1 *Alternative 1 – No-Action Alternative*

Under the No-Action Alternative, ecosystem processes at the proposed sites would likely remain degraded and impaired. Given the level of impairment to nearshore processes at these locations, the associated habitats and biological resources would continue to decline or fail to recover and rebuild their populations.

5.1.1.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

Alternative 2 includes at least one site from each of the formulated strategies (see Section 4.1.1.2). This alternative would restore 5,348 acres of tidal wetlands and would remove 75,162 feet of stressors from the nearshore zone. Restoration measures at these 11 sites would include removal of at least 10 tidal barriers for more natural inundation and estuarine mixing, remove shoreline armoring in at least two sites for better sediment erosion and transport, excavate tidal channels in at least four sites to initiate natural channel development, and add plantings to riparian zones to initiate vegetation succession and shading to keep water temperatures cool. These stressor removal measures would restore the natural processes that support VECs. Nearshore ecosystem process that would be restored include natural formation of tidal channels in estuaries, unrestricted flow of freshwater rivers and streams into estuaries, unrestricted movement and migration of fish and wildlife, movement of sand and gravel along a shoreline, natural erosion and accretion of a beach, and natural exposure of a bluff to wind and wave action.

5.1.1.3 *Alternative 3 – 18 Sites*

Alternative 3 includes 18 sites that together address all four of the formulated strategies for process-based restoration. This alternative would restore 5,517 acres of tidal wetlands and would remove stressors from 113,094 feet of the nearshore zone. Restoration measures at these 18 sites would include removal of at least 15 tidal barriers, remove shoreline armoring in at least 4 sites, excavate or improve tidal channels in at least 7 sites, and would involve a much greater area of additional riparian plantings than would occur in Alternative 2. These measures would restore a larger area of the ecosystem processes described for Alternative 2, and this alternative adds a second beach restoration site, which is a rare restoration opportunity around the Puget Sound nearshore zone due to the length of shoreline in private ownership.

5.1.2 Geologic and Physiographic Setting

The significant resources analyzed here are based on Shipman's (2008) classification system of geomorphological features that characterize the natural shoreline of Puget Sound. These landforms reflect the primary role of geomorphic processes in shaping the landscape. Approximately 10% of all Puget Sound shoreline is classified as "artificial" (Simenstad et al. 2011). Human-made structures and armoring inhibit the natural processes and are targeted for removal under the two action alternatives.

5.1.2.1 *Alternative 1 – No-Action Alternative*

The No-Action Alternative would have no effect on the geologic and physiographic setting. The existing conditions would remain in place with artificial landforms that fail to support important habitats for Puget Sound species. One of the problems this study identified is the decreased length and complexity of the Puget Sound nearshore zone. The combined shoreline length at all 18 proposed sites is 394,087 feet, or 75 miles. Under the No-Action Alternative, this shoreline length would remain the same without improvement. Environmental protections and regulatory requirements may limit repair and/or replacement of artificial landforms, which may deteriorate over decades of exposure to natural elements (e.g. wind, waves). Natural landforms may re-emerge, but it would take a long time for transition and there is high likelihood that human-made debris would be left behind to influence the natural landforms.

5.1.2.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

Alternative 2 would remove artificial shoreline features and return sites to a more natural physiography that can support natural processes, by removing 75,162 linear feet of stressors from the nearshore zone among the 11 sites. The landforms of this alternative that would change from artificial back to their historical form include one bluff-backed beach, six deltas in tidal freshwater zones, one delta in an estuarine mixing zone, one open coastal inlet, one barrier estuary, and one barrier lagoon with estuarine mixing. The beneficial effects would extend beyond merely the length of stressor removal, but would not be as substantial as the extent of Alternative 3.

5.1.2.3 *Alternative 3 – 18 Sites*

Alternative 3 would remove 113,094 linear feet of stressors from the nearshore zone, as well as lengthen the shoreline by 47% among the 18 sites. The landforms of this alternative that would change from artificial back to their historical form include one bluff-backed beach and a barrier beach, six deltas in tidal freshwater zones, two deltas in estuarine mixing zones, four open coastal inlets, three barrier estuaries, and one barrier lagoon with estuarine mixing. The direct and indirect beneficial effects would extend well beyond the length of shoreline where stressors have been removed.

5.1.3 Oceanography

Just as the geologic and physiographic setting describes the landforms around the shoreline, tides, currents, and waves are the characteristics of the vast volume of water contained within Puget Sound. The dynamic interactions between the water and land are forces of nature beyond the control of humans on a large scale; however, removing the artificial landforms from the nearshore zone can restore natural processes at a local scale.

5.1.3.1 *Alternative 1 – No-Action Alternative*

The No-Action Alternative would leave in place all dikes, berms, and other stressors commonly associated with river deltas and waterfront development. This would continue to impede freshwater input and estuarine mixing with negative effects on species that use the mixing zones for foraging, refuge, and reproduction, especially salmonids that use estuaries as critical transition zones between freshwater and saltwater life stages. At many of the proposed sites, freshwater input is channelized and confined to specific outlet locations, which creates localized areas of freshwater input and prevents natural mixing. Habitat degradation would continue a downward trend through the period of analysis without restoration actions. The No-Action Alternative would have no effect on tides, currents, or wave action and would not meet the need to restore thousands of acres of tidal wetlands and beach sedimentation.

5.1.3.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

At eight of the 11 sites, degraded conditions would be rectified for freshwater input and distributary channel migration. This alternative would have no significant adverse effect on tides, currents, or interaction with the Pacific Ocean; in fact it would restore 5,354 acres of tidal wetlands and beach area. This alternative would restore natural interaction between tidal and wave action with a bluff-backed beach (Beaconsfield Beach) and would allow natural sediment transport in the shoreline current at this location. This alternative includes one open coastal inlet (Deer Harbor Estuary) where the tidal barrier would be removed allowing tides, currents, and waves to interact with this landform. One barrier estuary (Dugualla Bay) and a barrier lagoon (Livingston Bay) would have their tidal barriers removed. These four sites amount to 833 acres of restored natural processes involving tides, currents, and waves. Other sites in this alternative are more related to freshwater reaches of the deltas, which would experience benefits from increased tidal influence in their freshwater wetlands.

5.1.3.3 *Alternative 3 – 18 Sites*

At 15 of the 18 sites, degraded conditions would be rectified for freshwater input and distributary channel migration, which includes the largest river delta restoration opportunity in Puget Sound, along with several other large-scale sites. This alternative would have no significant adverse effect on tides, currents, or interaction with the Pacific Ocean; in fact it would restore 5,523 acres of tidal wetlands and beach area. This alternative would restore natural interaction between tidal and wave action with a bluff-backed beach (Beaconsfield Beach) and a barrier beach (WDNR Budd Inlet Beach) and would allow natural sediment transport in the shoreline currents at these locations. There are four open coastal inlets where tidal barriers would be removed allowing tides, currents, and waves to interact with the landform at these locations. Three barrier estuaries and a barrier lagoon (Livingston Bay) would have their tidal barriers removed. These 10 sites amount to 965 acres of restored natural processes involving tides, currents, and waves. Other sites in this alternative are more related to freshwater reaches of the deltas, which would experience benefits from increased tidal influence in their freshwater wetlands.

5.1.4 Sedimentation and Erosion

Sediments move in longshore and cross-shore directions under the influence of wave and tidal forces. Artificial landforms in the nearshore zone hinder these natural processes that deliver substrates from areas of erosion to areas of deposition. Removal of stressors from the nearshore zone restores the natural processes that shape and influence the wetland and aquatic habitats critical for supporting VECs and ecosystem functions, goods, and services. Because substrate type determines species assemblages, nearly every type of flora and fauna of the nearshore zone would benefit from restoration of the natural sedimentation and erosion processes. Furthermore, restoration of these sediment transport processes would build resiliency into the ecosystem.

5.1.4.1 *Alternative 1 – No-Action Alternative*

The No-Action Alternative would have no effect on sedimentation and erosion processes, which would remain impaired at the proposed sites. Shoreline armoring would continue to prevent erosion of bluffs and transport of sediment to natural depositional features of beaches, bars, and spits. Other nearshore stressors would continue to disrupt longshore and cross-shore movement and sorting of substrates that support VECs such as forage fish.

5.1.4.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

Alternative 2 would remove stressors from 75,162 feet of shoreline. Alternative 2 would restore sediment transport at 11 shoreline process units or deltas. Erosion of bluffs and restoration of tidal hydrology would allow for sediment transport and delivery that would provide appropriate substrate for wetlands, beaches, and submerged aquatic vegetation. Tidal and distributary channels would form at the mouth of these estuaries from the restored interactions between tidal hydrology and freshwater input. This alternative would meet the project purpose of nearshore process restoration but to a lesser degree than Alternative 3.

5.1.4.3 *Alternative 3 – 18 Sites*

Alternative 3 would remove stressors from 113,094 feet of shoreline. This would restore sediment transport, delivery, and erosion in each of these 18 shoreline or delta process units. Benefits would be similar to those described for Alternative 2, but more so due to a greater amount of stressors removed. This would assist with rebuilding broad areas of wetlands by restoring appropriate substrate for their development.

5.1.5 Hazardous, Toxic, and Radiological Waste (HTRW)

An HTRW site is defined as a site where a known or suspected uncontrolled release of a chemical contaminant occurred, as defined in CERCLA (see Section 3.1.5). Literature suggests that historically developed areas such as Puget Sound contain higher background concentrations of some chemicals that may impact biota, but these elevated background concentrations do not constitute HTRW as per ER 1165-2-132.

5.1.5.1 *Alternative 1 – No-Action Alternative*

The No-Action Alternative would result in the landforms continuing to persist in their present condition of impaired processes. The No Action alternative would have no impact on nearshore processes as they relate to HTRW sites.

5.1.5.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

Based on the information contained in the ESA Phase I report, there is no known or suspected HTRW at any of the 11 sites in the preferred alternative based on the footprint that is presented. Proposed restoration actions include demolition or relocation activities that may identify currently unknown HTRW sources which would be addressed as a component of construction. While we do not anticipate HTRW concerns within the project footprint presented, one site will be further assessed in PED to assure that the site boundary is defined such that it excludes any HTRW-contaminated areas in compliance with ER 1165-2-132.

Short-term impacts could occur if undocumented chemical contaminants are discovered during construction. Four of the 11 sites had industrial or commercial usage. Due to these uses, additional document research is recommended to determine whether an uncontrolled release of chemical contaminants occurred and may be uncovered during construction.

The Washington Department of Ecology (WDOE) has several databases that describe facilities of interest. The most general search is on their Facility/Site web page, which lists numerous facilities and sites of environmental interest (all 11 sites are represented in this search). A second database is their Confirmed and Suspected Contaminants Site List, which lists sites that are undergoing cleanup or awaiting further investigation (Everett Marshland, Dugualla Bay, and Nooksack site have facilities on this list which are adjacent to, but not included within, the proposed footprint). Lastly is the Hazardous Site List, which lists sites that have been assessed (Everett Marshland and Dugualla Bay have facilities on this list which are adjacent to, but not included within, the proposed footprint).

5.1.5.3 *Alternative 3 – 18 Sites*

Based on available information including current footprint, no HTRW sites exist in 16 of the 18 sites of Alternative 3. Among the three databases that WDOE maintains regarding facilities of interest, the following two sites are included. At the Point Whitney Lagoon site, a septic tank has been removed and the site is under voluntary cleanup. Based on the information contained in the ESA Level I report, one uncontrolled release from a leaking underground storage tank was documented at the Budd Inlet Beach site. This tank has been removed and the site is under voluntary cleanup.

Proposed restoration actions include demolition or relocation activities that may identify currently unknown HTRW sources which will be addressed as a component of construction. Short-term impacts could occur if undocumented chemical contaminants are discovered during construction. Ten of the 18 sites had industrial or commercial usage. Due to these uses, additional document research is recommended if this alternative is carried forward to determine whether an uncontrolled release of chemical contaminants occurred and may be uncovered during construction.

Compared to Alternative 2, this alternative has more sites with risk of encountering chemical contaminants due to having an overall greater number of sites. Two of the 18 sites included in this alternative appear to contain HTRW; however, this alternative is not being carried forward.

5.1.6 Water Quality

The primary contributor to diminished water quality at the proposed sites is polluted stormwater runoff and excess nutrients from agriculture from the adjacent watersheds. The focus of the proposed work is stressor removal, which would not eliminate pollution sources to stormwater; however, the proposed actions would increase the area of wetlands, which serve as natural filtration of pollutants in the environment.

5.1.6.1 *Alternative 1 – No-Action Alternative*

The No-Action Alternative would have no effect on the status of the water quality parameters of the nearshore zone at the proposed sites. This alternative would fail to provide the important water filtration afforded by increased wetlands, which is critical to maintaining uncontaminated shellfish beds.

5.1.6.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

Alternative 2 would restore 5,348 acres of tidal freshwater or estuarine mixing wetlands. Restoration would involve revegetation of riparian areas, which would increase shading and reduce water temperatures. Cooler water allows for higher concentration of dissolved oxygen, which benefits aquatic species. The increased area of wetlands would support a variety of functions that improve water quality, including sequestration of nitrogen and phosphates as well as pesticides and other chemicals that can harm the aquatic ecosystem. This alternative would include removal of chemical contaminants by the non-Federal sponsor from each site as part of the restoration design. Temporary construction impacts may cause pulses of turbidity, but the duration of effect would only be a matter of hours; the overall benefits of Alternative 2 for water quality far outweigh minor construction effects. Improved water quality is critical to restoration of Puget Sound.

5.1.6.3 *Alternative 3 – 18 Sites*

Alternative 3 would restore 5,517 acres of tidal freshwater or estuarine mixing wetlands. At 15 of the 18 sites, restoration would involve revegetation of riparian areas, providing cooler water temperatures. The increased area of wetlands would support a variety of functions that improve water quality, including sequestration of nitrogen and phosphates as well as pesticides and other chemicals that can harm the aquatic ecosystem. This alternative would include removal of chemical contaminants by the non-Federal sponsor from each site as part of the restoration design. Construction effects would be similar to those for Alternative 2, but would occur at more locations due to the larger number of sites. Likewise, the benefits of Alternative 3 would be similar to Alternative 2 but would cover a greater extent.

5.1.7 Greenhouse Gas Emissions

Estimating the total quantity of GHGs that would be produced or absorbed by each of the proposed sites would require extensive analysis and numerous assumptions about each site's final design and construction. An estimation of GHGs should not only consider causes of GHG production, but also causes of GHG absorption, which offset and reduce the overall impact of GHGs. Artificial and natural reservoirs, or "sinks," absorb GHGs from the atmosphere. Large-scale natural carbon sinks include oceans, wetlands, grasslands, and forests. Vegetated land of any size, however, removes carbon from the atmosphere when the plants absorb CO_2 for photosynthesis. Most of the proposed actions involve active revegetation through landscaping and hydro-seeding or passive revegetation through removal of human-made structures (such as roads), which allows natural plant recruitment. All of these changes would increase absorption of CO_2, but the rate at which it is absorbed will depend on many factors, such as the type of plants, vegetation density, and climate. Therefore, it would be quite challenging to estimate GHG absorption for each site. Bearing the "rule of reason" in mind for structuring the GHG evaluation for an EIS, although an extensive quantified analysis cannot be done, a qualitative comparison can be drawn from simplified analysis of the primary causes of GHG production and absorption. The major sources of GHG emissions would be construction activities and construction materials, while the primary cause of carbon absorption would be increased vegetation. This section discusses these factors and how they can be used to estimate relative GHG emissions among the three alternatives and among the actions included in each alternative.

5.1.7.1 *Alternative 1 – No-Action Alternative*

The No-Action Alternative would have no effect on greenhouse gas emissions. Alternative 1 does not involve construction activities and materials, and it would not change the amount of vegetation in the project area, so it would neither produce nor absorb GHG emissions.

5.1.7.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

Simplified analysis of the construction activities and materials associated with the proposed actions for Alternative 2 indicates that this alternative would produce GHG emissions. At the same time, it would result in GHG absorption by increasing the vegetated land area. This analysis does not reveal whether the net effect would be an increase or decrease in global GHG quantities, although it does provide insight into the design and construction factors that affect GHG production and, more importantly, those factors that represent opportunities to mitigate the production of GHG, as introduced at the end of this section and detailed in section 5.7.3.

During construction activities, energy would be required to, for example, excavate soil, pave roadways, and haul materials to and from the site. The energy required for these activities would come from a hydrocarbon fuel (typically diesel) used by dump trucks, graders, pavers, and other construction equipment. The primary GHG produced during diesel combustion is CO_2. Therefore, the quantity of GHG emissions related to construction activities for the alternative can be estimated based on the quantity of diesel to be used during the construction at each site, as shown in Table 5-1 for Alternative 2 and Table 5-3 for Alternative 3.

Table 5-1. Estimated GHG Emissions Related to Construction Activities for Alternative 2

Site	Estimated Diesel Usage (gal)[1]	Estimated CO_2 Emissions (ton)[2]
Beaconsfield Feeder Bluff	5,200	58
Deepwater Slough	32,900	365
Deer Harbor Estuary	16,100	179
Dugualla Bay	336,100	3,731
Everett Marshland	2,249,200	24,966
Livingston Bay	61,200	679
Milltown Island	2,800	31
Nooksack River Delta	2,307,900	25,618
North Fork Skagit River Delta	539,800	5,992
Spencer Island	127,800	1,419
Telegraph Slough	992,300	11,015
Alternative 2 Total	6,671,300	74,053

[1] Quantity estimates were developed during preliminary cost analysis for the proposed sites.
[2] CO_2 emissions from diesel = 22.2 pounds/gallon (EPA 2005)

In addition to construction activities, construction materials represent a significant source of GHG emissions for these actions. All materials have associated embodied emissions, or the emissions created throughout their lifecycles. For each product, the total embodied emissions depend on how the base materials are extracted, processed, transported, and constructed to create the final product, as well as how the product is disposed at the end of its usable life. Quantifying the total embodied emissions for all of the materials used on the proposed actions would require extensive analysis; however, it is reasonable to assume that the quantity of concrete and asphalt pavement used on these sites will provide a basis for comparison of the total embodied emissions for the proposed actions. These quantities can be estimated based on the area (in square feet [SF]) of new roadway and new bridges to be constructed, as shown in Table 5-2 and Table 5-4.

Moreover, analysis of the actions that produce relatively high levels of CO_2 can provide insight into which construction activities would have the greatest impact on GHG emissions. The total GHG emissions for these actions would depend heavily on the quantity of materials that must be hauled and the distance they must travel. The estimates in Table 5-3 were based on approximate material quantities and assumed locations for material sources and dump sites, but these factors may provide substantial opportunities for reducing GHG emissions as the actions approach final design and construction.

Table 5-2. Estimated Major Construction Areas for Alternative 2

Site	**Estimated New Roadway Area (SF)[1]**	**Estimated New Bridge Deck Area (SF)[2]**
Beaconsfield Feeder Bluff	0	0
Deepwater Slough	0	0

Deer Harbor Estuary	6,100	3,500
Dugualla Bay	206,400	27,000
Everett Marshland	391,700	48,100
Livingston Bay	0	0
Milltown Island	0	0
Nooksack River Delta	902,300	118,800
North Fork Skagit River Delta	0	0
Spencer Island	0	0
Telegraph Slough	486,500	40,800
Alternative 2 Total	1,993,000	238,200

[1]New roadways may be constructed with asphalt pavement or concrete.
[2]Bridge deck area is used to convey relative quantities of concrete used to construct bridges; it does not account for all bridge elements, such as foundations and approach slabs.

5.1.7.3 *Alternative 3 – 18 Sites*

Similar to Alternative 2, simplified analysis of Alternative 3 indicates that this alternative would result in both GHG production and GHG absorption. Table 5-3 shows the total estimated diesel usage and the associated CO_2 emissions.

Table 5-3 Estimated GHG Emissions Related to Construction Activities for Alternative 3

Site	Estimated Diesel Usage (gal)[1]	Estimated CO_2 Emissions (ton)[2]
Beaconsfield Feeder Bluff	5,200	58
Big Beef Creek Estuary	144,900	1,608
Deepwater Slough	32,900	365
Deer Harbor Estuary	16,100	179
Duckabush River Estuary	159,400	1,769
Dugualla Bay	336,100	3,731
Everett Marshland	2,249,200	24,966
Harper Estuary	57,200	635
Livingston Bay	61,200	679
Milltown Island	2,800	31
Nooksack River Delta	2,307,900	25,618
North Fork Skagit River Delta	539,800	5,992
Point Whitney Lagoon	54,200	602
Snow Creek and Salmon Creek Estuary	189,800	2,107
Spencer Island	127,800	1,419
Tahuya River Estuary	111,100	1,233
Telegraph Slough	992,300	11,015
WDNR Budd Inlet Beach	24,200	269
Alternative 3 Total	7,412,100	82,276

[1] Quantity estimates were developed during preliminary cost analysis for the proposed sites.
[2] CO_2 emissions from diesel = 22.2 pounds/gallon (EPA 2005)

These estimates do provide a reasonable basis of comparison among the actions even though they do not account for all construction activities. The estimates in Table 5-3 were based on approximate material quantities and assumed locations for material sources and dump sites, but these factors may provide substantial opportunities for reducing GHG emissions as the actions approach final design and construction.

Table 5-4. Estimated Major Construction Areas for Alternative 3

Site	Estimated New Roadway Area (SF)[1]	Estimated New Bridge Deck Area (SF)[2]
Beaconsfield Feeder Bluff	0	0
Big Beef Creek Estuary	26,800	30,000
Deepwater Slough	0	0
Deer Harbor Estuary	6,100	3,500
Duckabush River Estuary	63,600	35,200
Dugualla Bay	206,400	27,000
Everett Marshland	391,700	48,100
Harper Estuary	0	0
Livingston Bay	0	0
Milltown Island	0	0
Nooksack River Delta	902,300	118,800
North Fork Skagit River Delta	0	0
Point Whitney Lagoon	0	0
Snow Creek and Salmon Creek Estuary	90,000	28,500
Spencer Island	0	0
Tahuya River Estuary	27,800	21,000
Telegraph Slough	486,500	40,800
WDNR Budd Inlet Beach	0	0
Alternative 3 Total	2,201,200	352,900

[1]New roadways may be constructed with asphalt pavement or concrete.

[2]Bridge deck area is used to convey relative quantities of concrete used to construct bridges; it does not account for all bridge elements, such as foundations and approach slabs.

Because the proposed sites for Alternative 2 are a subset of those included in Alternative 3, the construction activities and materials associated with Alternative 2 would produce less GHG emissions than Alternative 3. This is confirmed by the estimated CO_2 emissions related to construction activities listed in Table 5-1 and estimated roadway and bridge deck areas listed in Table 5-2. It can be qualitatively concluded that Alternative 3 would increase GHG absorption because it would increase the area of vegetated land; as a result, a decrease in GHGs would be anticipated and an indirect beneficial effect to climate change from the absorbed GHGs. This analysis does not reveal whether the net effect would increase or decrease global GHG quantities but it provides some insight into GHG mitigation opportunities for the proposed actions.

Effects of GHG Emissions and Mitigation Measures

The potential effects of GHG emissions are by nature global and cumulative because they mix throughout the Earth's atmosphere from a variety of sources. The primary sources come from a few different sectors; various industries, energy sources such as coal and natural gas, personal consumption of fossil fuels, and natural causes are responsible for their release. The CO_2 emissions associated with the three alternatives have a minuscule difference when compared to the gigatonnes emitted globally every year; however, when GHG emissions from construction of Alternative 2 or 3 are combined with the GHG emissions from all sources and sinks, there would be a contribution to the global GHG emissions that are affecting climate change. Based on the enormity of GHG contributions from other sources, it is reasonable to assume that none of the alternatives for this project is large enough to have a significant effect on the climate because it would represent an extremely small fraction of the total GHG emissions produced globally.

Although Alternatives 2 and 3 would not cause substantial cumulative impacts associated with global climate change and there are no formally adopted NEPA thresholds of significance for GHG emissions, there are a number of mitigation measures that could be taken to reduce GHG emissions associated with Alternatives 2 and 3. These measures would largely encompass best management practices (BMPs) related to conservation of construction materials and fuel used for construction activities and transportation of materials, as well as sequestration of CO_2 in restored wetlands and eelgrass beds. Details are provided in Section 5.7.3.

5.1.8 Underwater Noise

The characteristics of sound pressure waves and animal sensitivity are described in Section 3.1.8 of this document. Intrusive noise levels can have behavioral and physiological effects on animals. Behavioral consequences are actions such as abandoning hunting, diving or increasing swimming speed to flee the area, interrupted communication between individuals or pods, attempts to shield the young, and even panic and stranding (Richardson et al. 1995). Physiological consequences range from minor to lethal and can include temporary and permanent hearing loss, weight loss if prey cannot be captured, stress-induced health decline, and the lethal effect of hemorrhaging of the brain or other organs. Consequences from masked sounds can include other effects such as inability to avoid predators, being separated from the pod, or missed opportunities for group hunting. Chronic noise pollution can affect not only individuals, but also whole populations.

For a determination on whether construction related noise would affect marine mammals, fish, and birds, one must consider the frequency, location, intensity, and duration of the sound source as well as the audiogram of the recipient species. If an audiogram is available for a species, then using that audiogram helps to analyze the effects of noise on important biological resources; otherwise, the hearing frequency range may be the best available information. Effects analysis requires calculating the sound exposure level (SEL) that the animal receives (described in

Section 3.1.8). Table 5-5 displays data collected on hearing capabilities of potentially affected species in the Nearshore Study area.

Table 5-5. Hearing capabilities of aquatic species and sound threshold for continuous and pulsed noise that can cause behavioral disruption and injury

Species	Audible Frequencies	Harassment and injury thresholds Sound Exposure Level in dB_{RMS}[1]		
		Level B harassment (continuous)	**Level B harassment (pulsed)**	**Level A injury**
Fish (general)[2]	50Hz – 2kHz	150 dB_{RMS}	187 dB_{RMS}	206 dB_{RMS}
Herring[2]	70Hz – 200Hz	150 dB_{RMS}	187 dB_{RMS}	206 dB_{RMS}
Salmonids[2,7]	10Hz – 600Hz	150 dB_{RMS}	187 dB_{RMS}	206 dB_{RMS}
Rockfish[8]	50Hz – 2kHz	150 dB_{RMS}	187 dB_{RMS}	206 dB_{RMS}
Pinnipeds[5]	500Hz – 50kHz	120 dB_{RMS}	160 dB_{RMS}	190 dB_{RMS}
California sea lions	1kHz – 28kHz	120 dB_{RMS}	160 dB_{RMS}	190 dB_{RMS}
Harbor seals	1kHz – 50kHz	120 dB_{RMS}	160 dB_{RMS}	190 dB_{RMS}
Steller sea lions	500Hz – 32kHz	120 dB_{RMS}	160 dB_{RMS}	190 dB_{RMS}
Mysticete whales[4]	10Hz – 8kHz	120 dB_{RMS}	160 dB_{RMS}	180 dB_{RMS}
Minke whale[4]	10Hz – 500Hz	120 dB_{RMS}	160 dB_{RMS}	180 dB_{RMS}
Odontocete whales[4]	100Hz – 500kHz	120 dB_{RMS}	160 dB_{RMS}	180 dB_{RMS}
Killer Whale (orca)[3]	500Hz – 105kHz	120 dB_{RMS}	160 dB_{RMS}	180 dB_{RMS}
Diving birds[9] (developed for marbled murrelet)	Not available, presumed at 1kHz – 5kHz	150 dB_{RMS} (guideline)	183 dB_{RMS} (onset of injury)	202 dB_{RMS}

[1] square root of the mean of the squares of the values recorded over a given time interval [2]Blaxter and Hoss 1981; [3] Hall and Johnson 1971, Bain et al. 1993, Szymanski et al. 1999; [4] Gordon and Moscrop 1996; [5] Schusterman et al. 1972; [6] Bailey et al. 2010; [7] Knudsen et al. 1992; [8] Skalski et al. 1992; [9] SAIC 2011

5.1.8.1 *Alternative 1 – No-Action Alternative*

The No-Action Alternative would not have any effect on the underwater noise conditions in Puget Sound since it would avoid additional construction noise in the marine environment.

5.1.8.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

This ecosystem restoration project would not constitute any long-term change to underwater noise in Puget Sound; however, construction of the proposed sites would have short-term underwater noise outputs that must be analyzed for effects on significant biological resources. As sites are only at the conceptual design level, duration of noise-inducing activities cannot be estimated accurately at this time. During design phase, the potential effects would be thoroughly analyzed and all appropriate mitigation measures would be incorporated into construction methods. The activities that have been identified as part of the necessary construction work for this ecosystem restoration project are briefly described below:

- Pile driving may involve an impact pile hammer to drive steel piles into the substrate for solid support of the structures. For analysis in this document, the loudest sound level was used to assess effects; however, as an alternative to driving piles, construction could use vibration or hydraulic insertion methods. Another alternative to pile driving is drilled or augured holes for cast-in-place piles. These methods would provide a significant sound reduction from traditional pile driving methods and would be used wherever feasible without sacrificing necessary structural integrity.
- A cofferdam or other water-isolation device most likely would involve use of a vibratory hammer for driving sheet-piles into sediment to encapsulate an area in the water to contain turbidity or to exclude aquatic animals. The frequency range is similar to round pole pile driving, but the decibel level is slightly quieter.
- Dredging may involve either a clamshell dredge or a pipeline dredge. Clamshell dredges produce discrete pulsed sounds and the decibel level depends largely on the substrate type with hard rock being louder than sand and mud. Pipeline dredges produce a constant sound profile at relatively low frequencies.
- Bridge construction often involves various construction methods including use of tugboats, drilling, rock placement, and pile driving. Some of these activities may be concurrent, but the nature of sound is such that sound pressure levels are not additive; for example, two boats idling at 85dB each would produce an audible sound at 88dB rather than 170dB. The SEL, however, would be calculated to estimate whether the duration of noise below the peak pulse threshold is creating enough energy to constitute harm or harassment to animals.

Implementing Alternative 2 would have no long-term effects on the ambient underwater noise conditions in Puget Sound. Construction would cause significant short-term noise disturbances at each of the 11 sites that have some noise-generating activity as described above. Sound levels would temporarily increase during construction with different characteristics and durations depending on the activity.

Table 5-6 provides the noise-making construction activities and their likely dB level, along with how many sites in each alternative would have each type of activity. Potential noise-generating events associated with construction of each site were identified, and sound levels are estimated based on various data sources. Additionally, the sound pressure levels for the construction activities have been compared to the data available on aquatic species’ hearing and the regulated sound threshold under the Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA) as presented in Table 5-5. Restoration work would involve noise levels that would cause behavioral responses or cause injury to aquatic animals if the noise were not mitigated. However, construction methods would make every effort to use sound attenuation devices to reduce the noise below the regulatory thresholds.

Table 5-6. Noise-making construction features and associated decibel levels for each alternative compared to the reaction or regulatory threshold under the ESA or MMPA

Construction Feature	Dominant Frequency and peak dB_{RMS}[1]	Alternative 2	Alternative 3	Exceeds regulatory threshold for 1 or more species
Bridge construction (in-water work)[4] Rock placement Tugboats/barges Drilling	 No data available, but likely similar to clamshell dredging 100-500Hz, 170 dB_{RMS} 100-500Hz, 160 dB_{RMS}	5 sites	9 sites	Yes; mitigation available
Pile driving[3]	30Hz - 8kHz, 192 dB_{RMS}	5 sites	10 sites	Yes; mitigation available
Installation of cofferdam – likely vibratory sheet-pile driving[5]	25Hz - 4kHz, 182 dB_{RMS}	5 sites	10 sites	Yes; mitigation available
Dredging[2]	Pipeline (continuous noise): 70Hz - 1000Hz, 110 dB_{RMS} Clamshell (continuous noise): 5Hz - 10kHz, 124 dB_{RMS}	1 site	2 sites	No

[1] square root of the mean of the squares of the values recorded over a given time interval [2]Dickerson et al. 2001; Clarke et al. 2002; [3] Betke et al. 2004; [4] Richardson et al. 1995; [5] Illingworth & Rodkin, Inc. 2007

Each method of construction that produces underwater noise can be mitigated through physical means such as bubble curtains and sound dampening mats, or through conservation measures such as having a certified monitor watching for wildlife. While noise may be significant at the construction sites, as the sound wave travels away from the noise-producing activity, the sound should attenuate below levels that cause harm to aquatic species.

5.1.8.3 *Alternative 3 – 18 Sites*

Implementing Alternative 3 would have no long-term effects on the ambient underwater noise conditions in Puget Sound. Ten sites in Alternative 3 have activities that would produce significant short-term underwater noise as described above. The temporary effects of noise that would occur during the construction necessary for Alternative 3 may include behavioral responses of animals that would flee the area, or could reach the level of physical harm. However, construction methods and timing would make every effort to use sound attenuation devices to reduce the noise below the regulatory thresholds. Alternative 3 has twice as many sites as Alternative 2 with noise-generating activities.

5.2 BIOLOGICAL ENVIRONMENT: NEARSHORE FUNCTIONS

This section provides an analysis of how each alternative would affect important nearshore biological resources. Effects of the different alternatives on the biological environment could be negative or positive. Three timeframes were considered when analyzing the effects of the action alternatives (2 and 3): construction, transition, and long-term trajectory. Construction effects are largely negative, but would be temporary, lasting six months to two years. Transition of the sites is expected to last a few months to a decade, depending on the conditions and targets of a particular restoration site. Long-term benefits are expected to last 50 years or more.

5.2.1 Vegetation

5.2.1.1 *Alternative 1 – No-Action Alternative*

This alternative would not meet the project purpose and need to restore ecosystem functions and structures that support vegetation. Kelp and eelgrass beds would continue to receive insufficient sediment delivery and transport that provides essential nutrients and riparian vegetation would continue to be sparse and/or dominated by non-native species due to presence of stressors that interrupt sediment dynamics and tidal hydrology. .

Marine Submerged Vegetation

Under the No-Action Alternative, marine submerged vegetation at the sites would continue to be limited by diminished sediment delivery (leading to lack of suitable substrate), and lack of solar incidence caused by overwater structures and increased turbidity due to impervious surface and lack of native vegetation. In addition, a lost opportunity of eelgrass and kelp bed colonization would continue in intertidal and subtidal areas at the proposed sites that have been filled.

Wetlands

The wetlands at the proposed sites would continue to be suppressed by tidal barriers and fill. Any freshwater wetlands that are present, either naturally or due to tidal barriers, would continue to be vulnerable to the spread of reed canary grass (an aggressive non-native species). Although more shoreline development in the Puget Sound region is inevitable, any additional loss of these wetlands would largely depend on the regulatory environment and enforcement of laws that protect such wetlands, like Sections 401 and 404 of the Clean Water Act. Wetland restoration efforts at the sites could occur, but would likely be a “piecemeal” approach rather than the large-scale process-based approach proposed in Alternatives 2 and 3.

Riparian Vegetation

Riparian vegetation at the sites would continue to be displaced by the presence of shoreline stressors including shoreline armoring, railroads, dikes, and berms. Riparian areas likely would remain undisturbed, but continue to be dominated by invasive species of lesser ecological value.

5.2.1.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

This alternative would remove 75,162 feet of shoreline stressors and restore 5,348 acres of tidal wetlands, which would promote the ecosystem structures and functions provided by wetlands, kelp and eelgrass beds, and riparian vegetation.

Marine Submerged Vegetation
Eelgrass occurs in patchy distributions at or near six of the 11 sites, and kelp beds occur in a patchy distribution at one site in this Alternative. Temporary construction impacts to eelgrass and kelp would include turbidity caused by excavation and pulses of sediment released from newly tidally inundated areas, leading to potential for decreased light for the duration of construction and perhaps for a year as the storm season moves sediment away followed by recovery during the growing season. Long-term benefits would occur as sediment and nutrient transport increase when stressors are removed along approximately 113,094 feet of shoreline including armoring and tidal barriers, allowing for more suitable substrate and increases in light and nutrients nourishing growth and expansion of the beds within or along the fringes of the sites. Benefits may take a couple of years to appear, but would endure for decades and longer.

Wetlands
Under this alternative, the removal of tidal barriers and fill would restore 5,517 acres of tidal wetlands (both tidal freshwater and estuarine mixing). Additional areas of freshwater wetlands (not tidally influenced) are located at nine of the 11 sites; at most of these, the design proposes to remove tidal barriers to restore the estuarine mixing zone. This would convert these freshwater marshes into brackish marsh, a rarer ecotype. Due to the past disturbances created by diking and the proximity to agricultural lands, reed canary grass has likely pervaded these non-tidal freshwater wetlands. The other areas that would be tidally inundated are mostly agricultural lands that are no longer in use. As water of higher salinity inundates the restoration sites, the freshwater marsh vegetation would die off, leading to temporary decreases in vegetative cover until salt tolerant species colonize the area. Based on information from other estuarine restoration projects in the Puget Sound area, such as the Nisqually River estuary, it is likely that high marsh vegetation would establish within the first five years and lower marsh vegetation would take decades before establishment. Restoring these tidally influenced marshes would create a distribution of wetland zones that more closely matches pre-disturbance conditions, providing rearing and foraging areas for a variety of estuarine-dependent species.

Riparian Vegetation
Most riparian vegetation that would be impacted by construction activities, either by direct or indirect removal (removal of stressors with vegetation growing on them) consists of non-native species. Native vegetation would be protected to the extent possible. Invasive species would be replaced with native plants. As these riparian species become established, they would form an overhanging canopy that provides thermal refuge and a source of organic input for aquatic systems, as well as habitat for birds and small mammals. It is anticipated that there would be a net increase in riparian vegetation associated with this alternative.

5.2.1.3 *Alternative 3 – 18 Sites*

This alternative meets the project purpose and need by restoring 5,517 acres of tidal wetlands and removing 113,094 feet of shoreline stressors. In general, total long-term benefits are greater than those described for Alternative 2; however, there are greater short-term construction impacts associated with Alternative 3.

Marine Submerged Vegetation

Eelgrass beds occur at or near 12 of the 18 sites in patchy and continuous distributions, and kelp occurs at or near four of the 18 sites in patchy distributions. Construction impacts would be similar to those described for Alternative 2, but to a greater extent due to the greater number of beds and the larger scale of construction. Benefits would be of similar types to those described for Alternative 2, with greater total benefit achieved since longer stressor length would be removed, providing proportionately more sediment delivery and nutrient transport.

Wetlands

Construction impacts on wetlands would be similar to those described for Alternative 2, but to a greater extent due to more freshwater wetlands being inundated with saltwater. Benefits would be similar to those described for Alternative 2, but would occur across a greater area since there would be more of the tidal wetlands restored than under Alternative 2.

Riparian Vegetation

Ten of the 18 sites include removal of invasive species and/or revegetation of riparian areas with natives. Construction impacts to riparian vegetation would be similar to those described for Alternative 2, but to a greater extent because of the larger number of sites. Benefits to riparian vegetation would be similar to those described in Alternative 2 with a larger area of riparian plantings and greater number and extent of stressors removed at Alternative 3 sites.

5.2.2 Shellfish and other Macroinvertebrates

5.2.2.1 *Alternative 1 – No-Action Alternative*

Under Alternative 1, invertebrate communities on the human-made structures at the proposed sites would continue to be dominated by opportunistic, tolerant species, such as tube worms, barnacles, mussels, snails, and ascidians. Native clams, oysters, and other bivalves would be limited by lack of habitat due to the diking and filling of embayments, sub-optimal substrate due to interruption of sediment flow by shoreline armoring, and siltation caused by urban and agricultural run-off.

5.2.2.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

Construction impacts on invertebrate communities would come from increases in turbidity and physical disturbance during beach regrading at one of the sites, dredging at one of the sites, and the removal of stressors in intertidal areas at all 11 sites. Removal of bridge pilings, abutments, and shoreline armoring, and the installation of water-isolation devices would be necessary at nearly all of the sites. These actions would disrupt or destroy benthic and epibenthic invertebrates. Once the stressors are gone, invertebrate colonization would follow a pattern of succession, with near complete recovery in one to three years (Hueckel and Buckley 1987, and

Martin 2012 pers. comm.) The 5,523 acres of restored habitat (which includes aforementioned tidal wetlands as well as beaches that would be restored) would transition to communities that include amphipods, isopods, and oligochaete and sabellid worms, as well as insect larvae in more freshwater areas. Invertebrate density and diversity would likely increase as the restored sites transition to native estuarine marsh vegetation. A variety of invertebrates in the higher salinity areas of embayments and beaches, including native clams, oysters, snails, and cancer crabs would benefit from increased sediment delivery (leading to more suitable substrate) and additional habitat provided by the removal of shoreline armor and tidal barriers. Upper inter-tidal and back-beach invertebrates, such as beach hoppers, would benefit from removal of shoreline armoring and planting of riparian vegetation. Restored areas adjacent to eelgrass beds may serve to increase the size and quality of these beds, thus increasing habitat for nudibranchs, shrimp, crabs, jellyfish, and anemones.

5.2.2.3 *Alternative 3 – 18 Sites*

Construction impacts on invertebrate communities of Alternative 3 would be similar to those described for Alternative 2, but to a greater extent due to the larger number and scale of sites and therefore more bottom disturbance. Likewise, benefits would be similar to those under Alternative 2, but more so with Alternative 3 because it restores more acreage of intertidal habitat for invertebrates to colonize.

5.2.3 Fish

5.2.3.1 *Alternative 1 – No-Action Alternative*

Fish would continue to use beach habitat that is degraded due to shoreline armoring effects on sediment dynamics, which in turn affect beach profiles and marine vegetation that provide valuable nursery and foraging habitat, as well as estuaries that provide rearing, foraging, and refuge habitat where dikes and causeways severely limit tidal hydrology.

Demersal/Benthic Fish

Many demersal/benthic fish species would not be affected by the persistence of stressors along the shoreline at the project sites. Much of the rocky habitat occupied by reef dwelling fish, such as rockfish and lingcod, has not undergone significant change and is not present at any of the sites. The exceptions are fishes that use estuaries and softer substrate, such as flounder and certain sculpin species, and rockfish species that use kelp and eelgrass beds as nurseries for juveniles. These species would continue to be displaced by shoreline stressors such as tidal barriers, fill, and shoreline armoring.

Forage Fish

Forage fish would continue to be negatively affected by suboptimal habitat at the project sites, particularly since their spawning habitats on beaches and submerged vegetation are altered by shoreline stressors that hamper processes such as sediment delivery and nutrient transport.

Although other restoration actions that benefit forage fish are likely to occur, these would not likely be the large-scale process-based efforts that would occur under Alternatives 2 and 3.

Anadromous Fish

Under the No-Action Alternative, anadromous fish, including salmonids and anadromous forage fish, would continue to be limited by a lack of suitable habitat caused by the loss or modification of the shoreline. Bulkheads and over-water structures would continue to decrease shallow water habitat for migration, and diking and filling of estuarine habitat would limit rearing and spawning. Although many programs in Puget Sound and its associated river basins benefit salmonids, these would not be the large scale program that restores ecological processes under Alternatives 2 and 3 and there would be no opportunity for synergistic benefits provided by multiple restoration programs in the region. The No-Action Alternative would maintain the status quo of stagnant or declining acreage of salmon habitat and would fail to assist with the recovery of these populations.

5.2.3.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

Under Alternative 2, fish communities would see negative and positive effects. Negative effects would come from construction activities causing 1) increases in turbidity from excavation of fill and dikes and dredging, and 2) noise and vibration associated with pile and/or sheet-pile driving, dredging, and large equipment operation for excavation and demolition. See Section 5.1.8 for a more detailed analysis of how noise might affect fish species. Elevated levels of turbidity and noise could cause a behavioral response to flee or delay migration, and/or physiological damage. Working within designated periods when fish are less likely to be present and during low tides would minimize effects of noise and turbidity on fish. The positive effects of Alternative 2 would vary among fish categories and among sites; details are discussed below.

Demersal/Benthic Fish

Most reef-dwelling fish, such as rockfish and greenlings, would not be affected by the proposed actions since none of the actions occur where there is substantial reef habitat. Predatory fish like lingcod that are typical of reef habitats that feed heavily on forage fish (Beaudreau 2009) would benefit from increases in habitat for those forage fish species (discussed in the following section). Juvenile rockfish species that use kelp and eelgrass beds as nurseries would benefit from improvement to these habitat types.

Several of the sites are located in river deltas, embayments, and beaches where there is finer substrate. Fish that occupy this habitat, such as flounder and certain species of sculpin, would benefit from the removal of tidal barriers and armoring, thus expanding brackish areas (5,517 acres) for foraging.

Forage Fish

Forage fish species that use beaches and submerged aquatic vegetation for spawning, such as sand lance and herring, would benefit from restored sites where 115,718 feet of armoring, tidal barriers, and other nearshore structures that inhibit sediment delivery and nutrient transport would be removed. Forage fish that use river deltas, such as longfin smelt and eulachon, would benefit from restored sites where tidal barriers would be removed, leading to an increase in spawning and foraging habitat. These benefits to forage fish would also benefit species in higher trophic levels since the forage fish are a preferred prey item for a variety of nearshore species.

Anadromous Fish

Anadromous fish, particularly salmonids, would benefit from restored sites where armoring, tidal barriers, and fill in river deltas, embayments, and beaches would be removed. Removal of shoreline armoring would result in 1) more shallow water habitat used for juvenile migration (particularly Chinook and chum), 2) a potential increase in eelgrass beds that are used by juvenile salmonids (mostly Chinook and chum) as nurseries for holding and rearing, and 3) more suitable spawning beaches and kelp and eelgrass beds for forage fish that are preferred prey of salmon. Removal of tidal barriers would result in 5,517 acres of restored tidal wetlands for juvenile rearing and foraging. Other anadromous species, such as sturgeon and anadromous forage fish, would also benefit from this estuarine habitat.

5.2.3.3 *Alternative 3 – 18 Sites*

Negative effects from construction would be more disruptive to fish communities than under Alternative 2 due the greater number and scale of the sites under this alternative, which requires removal of more roads and levees, construction of more levees, more raising of roads, and more bridge building. A greater number of sites in Alternative 3 would require dredging, excavation of fill, and pile and/or sheet-pile driving, causing greater increases in turbidity, noise, and vibration than Alternative 2.

Beneficial effects to fish communities would be similar to those discussed for Alternative 2, although to a greater extent. This is due to 1) more tidal wetlands restored for rearing and foraging, 2) more spawning and foraging habitat for forage fish species (a preferred prey item of salmon) because of more shoreline stressor length removed, and 3) more benefit to kelp and eelgrass beds that provide juvenile rearing habitat.

5.2.4 Birds

5.2.4.1 *Alternative 1 – No-Action Alternative*

Birds at the project sites would continue to be limited by lack of suitable estuarine tidal flats and eelgrass beds that provide foraging habitat. Loss of habitat for bird prey, including forage fish, juvenile salmonids, a variety of invertebrates, and marine vegetation would affect species such as great blue herons, dunlins, sandpipers, and brandts. Opportunistic species like gulls, Canada geese, and crows would continue to flourish at the sites due to their adaptation to the human environment. Migratory species that use the agricultural fields in the winter are likely to continue to be populous, assuming there is no future urbanization in those areas.

5.2.4.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

Construction activity including pile driving, demolishing roads and bridges, and hauling off large amounts of material would cause temporary disturbances to bird communities due to noise (both airborne and underwater) and the presence of heavy equipment. See Section 5.1.8 for more details on how underwater noise may affect diving birds. These disturbances would likely cause a behavioral response to flee the area. Best management practices, such as working outside of the nesting season, would minimize these impacts. At several sites, agricultural areas would be flooded due to removal of tidal barriers. These areas are often used heavily by migratory species; allowing tidal flow to enter would likely lead to a transition from communities dominated by snow geese and trumpeter swans (which are not habitat limited in the Puget Sound region) to a wider variety of species like goldeneye, sandpipers, wigeons, scaups, and brandts that are associated with salt water habitats. Freshwater marshes that would be flooded with brackish water would transition from species like mallards and pintails to the saltwater species mentioned previously. A variety of birds that depend on forage fish and juvenile and adult salmon would greatly benefit from restored sites where these fishes' habitats (including marshes, eelgrass beds, and spawning beaches) are increased.

5.2.4.3 *Alternative 3 – 18 Sites*

Construction effects on bird communities would be similar to those described for Alternative 2, but to a greater extent due to the larger number and scale of the sites. Transitions to bird communities that are more indicative of saltwater in agricultural areas and freshwater areas are expected under this alternative as well; however, the benefits to shorebirds and waterfowl would be greater than Alternative 2 since there would be more acreage of tidal wetland creation or improvement for their use and to support their prey.

5.2.5 Marine Mammals

5.2.5.1 *Alternative 1 – No-Action Alternative*

Marine mammals dependent on prey that use the nearshore zone would continue to be limited by the lack of suitable habitat for those prey at the project sites. This would particularly affect the Southern Resident killer whales, which feed preferentially on Chinook and chum salmon. Fill, dikes, and shoreline armoring at the project sites limit the area and quality of haul-out locations for harbor seals. Many of the marine mammals in Puget Sound are affected by factors that are not related to the physical condition of the shoreline, such as persistence of chemical contaminants or commercial harvest of their prey.

5.2.5.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

The primary impacts to marine mammals would result from noise disturbances caused by pile and/or sheet-pile driving, which could cause behavioral response such as fleeing, interfere with ability to locate prey, or result in physiological damage. See Section 5.1.8 for a more detailed analysis of how noise may affect marine mammals. All of the sites requiring pile driving are located in shallow embayments and river deltas, and this activity would predominantly occur during low tides to minimize underwater noise. Harbor seals are the most likely marine mammal to be affected by these elevated noise levels due to their ubiquitous distribution in Puget Sound and their tendency to swim into river deltas and embayments, where most of the sites are located. With the exception of Deer Harbor, Southern Resident killer whales are not likely to occur in the project areas during pile driving since it would occur during designated work periods when the killer whales are concentrated around the San Juan Islands and southern Vancouver (Hauser 2007, Kriete 2007). Transient killer whales are only intermittent visitors of Puget Sound so the likelihood is low that this pile driving would harm them. Other cetaceans, including baleen whales and porpoises require deeper water than what occurs at the project sites, so they have a moderate to low likelihood of encountering pile driving, especially if it occurs during low tides. Elevated turbidity could cause temporary displacement of marine mammals as well, likely those that occur in shallower water, such as harbor seals.

Long-term benefits to marine mammals would be closely tied to the benefits provided to their prey, including increased habitat for forage fish and salmonids (discussed in previous sections). Southern Resident killer whales would likely gain the most benefits from restoring processes that increase habitat for Chinook and chum salmon. Other marine mammals like porpoises, sea lions, and seals would benefit as well, but to a lesser extent since their diet consists of a wider variety of fish, some of which are not nearshore dependent. For example, harbor seals feed preferentially on herring from December through March, but generally select hake for the remainder of the year (Olesiuk 1993), which is not a nearshore-dependent species. Other benefits include better beach habitat for harbor seal haul-out due to the removal of shoreline armoring, and increased foraging habitat due to the removal of tidal barriers.

5.2.5.3 *Alternative 3 – 18 Sites*

Negative effects to marine mammals would be similar to those discussed for Alternative 2, but to a greater extent because of the larger number and scale of sites that require pile driving, and the closer proximity to summertime Southern Resident killer whale distribution. Benefits to marine mammals that feed on nearshore-dependent species would be more than Alternative 2, as Alternative 3 restores substantially more tidal wetlands that support their prey and removes a great deal more shoreline stressors. This would also mean more foraging area for pinnipeds, particularly harbor seals, under Alternative 3.

5.2.6 Invasive Species

5.2.6.1 *Alternative 1 – No-Action Alternative*

Under the No-Action Alternative, invasive species would continue to exploit human-made structures at the project sites and out-compete native species.

5.2.6.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

No survey for invasive species has been done at the proposed sites. If invasive species are present, removal of human-made structures paired with revegetation efforts would lead to repopulation with native species that are more likely to colonize the estuarine and beach habitat.

5.2.6.3 *Alternative 3 – 18 Sites*

Effects of this alternative would be similar to those described for Alternative 2, but to a greater extent due to removal of substantially longer linear footage of human-made structures.

5.2.7 Rare, Threatened, and Endangered Species

Many of the species discussed in Section 3.2.7 occur at the sites proposed in Alternatives 2 and 3. A USFWS report (USFWS 2011) supporting the formulation of a Nearshore Study preferred alternative includes information on species with special status under the ESA for each of the 18 sites evaluated in this analysis. In their report, USFWS gave a species list and a list of species-specific and general conservation measures from the Programmatic Biological Assessment and Biological Opinion for Fish Passage and Restoration Actions in Washington State (NMFS and USFWS 2008). USACE, NMFS, and USFWS are revising this programmatic consultation to cover all types of actions proposed by the Nearshore Study team with expected completion in 2014. If it is not complete by the end of 2014 it is likely the Service will issue an extension (USFWS has already done so). Table 5-7 summarizes the federally threatened and endangered species that occur in or around the proposed project sites.

5.2.7.1 *Alternative 1 – No-Action Alternative*

ESA-listed species at the sites would continue to be limited by shoreline stressors that impede natural, habitat-forming processes. These inhibited processes have implications that ascend trophic levels. Chinook, Hood Canal chum, steelhead, and bull trout would continue to be limited by sub-optimal rearing and foraging habitat at the site locations, as well as lack of suitable habitat for prey species like forage fish. Southern Resident killer whales, which are dependent on these salmonids, would, by trophic association, also be limited by this lack of habitat. ESA-listed rockfish would not likely be affected, since they are typically associated with rocky substrate in deeper water and are more vulnerable to fishing pressure than shoreline stressors. However, the persistence of stressors that inhibit processes necessary for healthy kelp and eelgrass beds, which serve as nurseries, may continue to limit juvenile rockfish. Species recovery plans and salmon restoration efforts would aid in improving habitat for ESA-listed species, but would not be the wide-scale process-based restoration effort that is proposed in Alternatives 2 and 3.

5.2.7.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

Construction impacts on rare, threatened, and endangered species would be similar to those discussed for fish, mammals, and birds in previous sections. Primary impacts would be elevated turbidity from excavation, and noise and vibration associated with pile driving. Both of these impacts could cause a behavioral response of fleeing or delayed migration, and/or physiological damage. These impacts would be minimized by adhering to the conservation measures recommended by USFWS and NMFS, including working during designated periods when ESA-listed species are least likely to be present and during low tides.

Positive effects on ESA-listed species would be similar to those discussed for fish, birds, and mammals in previous sections. The removal of stressors along over 70 miles of shoreline at these 11 sites would increase habitat-forming processes for many ESA-listed species, leading to responses at many trophic levels. Removing tidal barriers, fill, and armoring would increase foraging and rearing habitat for juvenile salmonids (5,517 acres of tidal wetlands), as well as increase sediment delivery and nutrient transport to encourage spawning of forage fish (an important prey item for salmon) on beaches and kelp and eelgrass beds. Eulachon are present at two of the 11 sites and would see habitat benefits from restoration. Improvements in kelp and eelgrass beds would provide better nurseries for juvenile ESA-listed salmonids and rockfish. Removal of shoreline armoring would increase sediment delivery for forage fish spawning and create shallow water habitat for the migration of juvenile Chinook salmon. These improvements in habitat for forage fish and salmon would lead to an increase in prey base for marbled murrelet, humpback whales, and Southern Resident killer whales. This alternative has no sites in Hood Canal; therefore, ESA-listed summer chum here would not see benefits.

Other species that are rare but not ESA-listed include coho salmon, northern abalone, sea otters, California buttercup, and sharpfruited peppergrass. While coho salmon would certainly benefit from the increased rearing habitat, the other species are not likely to be affected since they tend to occupy rocky shorelines. Project sites in Hood Canal and southern Puget Sound where wetlands would be restored could improve water quality for Olympia oysters (a depleted species that were once common in Puget Sound), as results of this project combine synergistically with results of other recovery efforts.

5.2.7.3 *Alternative 3 – 18 Sites*

Construction impacts to ESA-listed species would be similar to those for Alternative 2, but to a greater extent due to the larger number and scale of the sites and their locations. Alternative 3 has more sites in Hood Canal and in northern Puget Sound, where there tends to be higher numbers of ESA-listed species because of the proximity to the Strait of Juan de Fuca and Strait of Georgia with their greater biodiversity. Since Hood Canal summer chum, eulachon, and green sturgeon are present at more sites in this alternative, they see more impacts from construction activities; conversely, they would gain more long-term benefits. Benefits to other species would be similar to those discussed for Alternative 2 but to a greater degree due to substantially more acreage of restored tidal wetlands and much longer length of shoreline stressors removed. Table 5-7 summarizes federally listed threatened and endangered species and critical habitat occurring in or around the project sites included in Alternatives 2 and 3.

Table 5-7. Federally Listed Threatened and Endangered Species and Critical Habitat Occurring in or around the Project Sites

		Project Site	Bocaccio	Canary Rockfish	Yelloweye Rockfish	Eulachon	Hood Canal Summer Chum		Puget Sound Chinook Salmon		Coastal/ Puget Sound Bull Trout		Puget Sound Steelhead	Green Sturgeon	Southern Resident Killer Whale		Humpback Whale	Marbled Murrelet	Golden Paint Brush
							Sp	CH	Sp	CH	Sp	CH			Sp	CH			
Alternative 3	Alternative 2	Beaconsfield Feeder Bluff	x	x	x				x	x	x	x	x		x		x	x	
Alternative 3	Alternative 2	Deepwater Slough							x	x	x	x	x						
Alternative 3	Alternative 2	Deer Harbor Estuary	x	x	x	x			x	x			x	x	x	x	x	x	
Alternative 3	Alternative 2	Dugualla Bay	x	x	x				x	x	x	x	x		x			x	
Alternative 3	Alternative 2	Everett Marshland							x	x	x	x	x						
Alternative 3	Alternative 2	Livingston Bay	x	x	x				x	x	x	x	x		x			x	
Alternative 3	Alternative 2	Milltown Island							x	x	x	x	x						
Alternative 3	Alternative 2	Nooksack River Delta	x	x	x	x			x	x	x	x	x	x	x	x	x	x	
Alternative 3	Alternative 2	North Fork Skagit River Delta							x	x	x	x	x						
Alternative 3	Alternative 2	Spencer Island							x	x	x	x	x						
Alternative 3	Alternative 2	Telegraph Slough	x	x	x				x	x	x	x	x						
Alternative 3		Big Beef Creek Estuary	x	x	x		x	x	x	x	x		x		x		x	x	
Alternative 3		Duckabush River Estuary	x	x	x	x	x	x	x	x	x	x	x		x		x	x	
Alternative 3		Harper Estuary	x	x	x				x	x	x	x	x		x		x	x	
Alternative 3		Point Whitney Lagoon	x	x	x	x	x	x	x	x	x	x	x		x		x	x	
Alternative 3		Snow Creek and Salmon Creek Estuary	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Alternative 3		Tahuya River Estuary	x	x	x		x	x	x	x	x	x	x		x		x	x	
Alternative 3		WDNR Budd Inlet Beach	x	x	x				x	x	x		x		x			x	

Sp-species, CH-critical habitat. If CH is not listed underneath a given species then it is not present at any of the project sites.

5.3 CULTURAL RESOURCES

In this section, impacts to cultural resources and historic properties are discussed in the context of the regulations implementing Section 106 of the National Historic Preservation Act (NHPA)(36 CFR 800). Section 106 requires Federal agencies to take into account the effects of its actions on historic properties. Historic properties are cultural resources that are eligible for or listed on the National Register of Historic Places (National Register). As described in Section 3.3, cultural resources at a minimum must be 50 years old or older to be considered eligible for the National Register, although more recent properties with exceptional significance may be considered. Each of the 18 proposed sites was analyzed for its potential to affect cultural resources. The analysis is broken down broadly by the categories of places or properties for which specific information exists in the available records or has been provided through consultation: prehistoric and historic archaeological resources, and historic buildings and structures.

5.3.1 Archaeological Resources

5.3.1.1 *Alternative 1 – No-Action Alternative*

The No-Action Alternative would have no immediate effect on prehistoric archaeological resources. Artificial and natural processes may continue to erode and deteriorate known archaeological resources, while exposing previously undiscovered sites and isolated artifacts. There would be no change in the current management condition affecting archaeological resources; Federal actions or undertakings would continue to be reviewed in accordance with Section 106 of the NHPA.

5.3.1.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

This alternative has a significant potential to impact prehistoric archaeological resources, although not as great as Alternative 3 because there are fewer restoration sites. For the eleven restoration sites included in the TSP, cultural resource surveys have been conducted within portions of ten sites. The exception is the Beaconsfield Feeder Bluff site. Six of the restoration sites contain previously recorded archaeological sites. Of the 32 previously recorded archaeological sites within the TSP, only one is eligible to the NRHP; the remaining 31 archaeological sites are unevaluated. Deer Harbor contains one lithic scatter site. Dugualla Bay contains six shell midden sites. Livingston Bay contains one shell midden site. The Nooksack River Delta restoration site contains 20 unevaluated archaeological sites ranging from shell middens, lithic scatters, a possible ethnohistoric village, human burials, and historic trash scatters. The North Fork Skagit River Delta contains two sites: one site, a pre-contact habitation site, is a contributing element to Fishtown Archaeological District located adjacent to the restoration site; the second site is shell midden. The Everett Marshland site contains one lithic scatter. The Spencer Island site contains a shell midden along the eastern border of the project area. As the locations of most of the proposed sites present a moderate to high potential for archaeological resources to exist, a comprehensive inventory and National Register evaluation of all prehistoric archaeological resources and traditional cultural properties at each site would need to be completed; inventory work for each site should be conducted no more than five years in advance of construction. The Corps would consult with the State Historic Preservation Officer (SHPO) and other interested parties regarding future identification and evaluation strategies, and develop and implement mitigation measures prior to construction where adverse effects could not be avoided. The Corps has prepared a draft Cultural Resources Plan (see Appendix D) that proposes guidelines on identification and evaluation of sites, as well as the resolution of any adverse effects that are identified.

5.3.1.3 *Alternative 3 – 18 Sites*

This alternative has a significant potential to impact prehistoric archaeological resources. This alternative contains seven additional restoration sites (Big Beef Creek Estuary, Duckabush River Estuary, Harper Estuary, Point Whitney Lagoon, Snow Creek and Salmon Creek Estuary, Tahuya River Estuary and WNDR Budd Inlet Beach) compared to Alternative 2. Of these seven additional restoration sites all but one (Point Whitney Lagoon) have had previous cultural resource surveys conducted within portions of the restoration sites. One archaeological site (remnants of a historic fence and fruit tree) has been recorded in the Duckabush River Estuary but has not been formally evaluated.

5.3.2 Historic Buildings and Structures

5.3.2.1 *Alternative 1 – No-Action Alternative*

The No-Action Alternative would have no immediate effect on historic buildings and structures. The built environment at sites, however, would not remain static but would continue to evolve. Adverse impacts unrelated to the Federal action that are expected to occur to some buildings and structures include non-compatible modifications, deterioration due to neglect, abandonment, and possible damage from flooding or other natural disasters. Other buildings and structures will likely be maintained and/or restored in manners consistent with the Secretary of Interior’s guidelines and standards for the treatment of historic properties. The number of potential historic properties will increase as buildings and structures reach the 50-year hallmark for National Register consideration. There would be no change in the current management condition affecting historic buildings and structures; Federal actions or undertakings would continue to be reviewed in accordance with Section 106 of the NHPA.

5.3.2.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

This alternative has potential for significant impact on historic buildings and structures. Nine of the restoration sites contain previously recorded historic structures as well as historic structures not currently recorded but are known to exist. Livingston Bay contains four previously inventoried historic structures: these include the John P. and Annie Larson Farm (eligible to the NRHP), the John Hanson House (requires further evaluation), and two non eligible structures.

Dugualla Bay contains the Dugualla Lake dike and pumping system which was reportedly constructed in the 1910s to 1920s. Deepwater Slough contains the Deepwater Slough levee system. The levee system has been recommended ineligible for inclusion on the NRHP; however, the levee system has not been formally evaluated. The Nooksack River Delta site contains nine previously inventoried historic properties. Of the nine properties, three are ineligible (one levee and two residences), one has possibly been demolished (barn), and three are unevaluated (Janet's House, Howell House and the Kwina Lough Levee). Of the remaining two resources at the Nooksack River Delta site, the Hovander Homestead is listed on the NRHP and the Hovander Barn is listed on the Washington Heritage Barn Register (WHBR). The North Fork Skagit River Delta site contains a total of 19 buildings. In addition, an unevaluated historic granary and a historic farming complex which contains a barn listed on the WHBR are located within the North Fork Skagit River Delta restoration area. Two sites included in this alternative (Spencer Island and Telegraph Slough) contain levees. The Spencer Island levees have been inventoried but will need to be formally evaluated. The Telegraph Slough levees will need to be inventoried and evaluated. The Everett Marshland site contains a historic barn, a historic bridge proposed for removal, and the Marshland Dike and Ditch System (recommended ineligible but not formally evaluated). Finally, the Milltown Island site contains a dike that has been recommended ineligible to NRHP but has not been formally evaluated.

5.3.2.3 *Alternative 3 – 18 Sites*

Alternative 3 has greater potential impact on historic buildings and structures due to having more proposed sites. Alternative 3 contains the same historic properties as Alternative 2 but includes additional historic resources at four additional sites. Four of the restoration sites in this alternative contain either previously recorded historic structures or historic structures not currently recorded but are known to exist. The Duckabush site contains the Highway 101 causeway, including two bridges. Of the two bridges on the causeway one is listed in the NRHP. The second bridge has been inventoried and recommended ineligible but has not been formally evaluated. The Snow Creek and Salmon Creek Estuary contains a possible mill site, sections of Highway 101, and an abandoned segment of the Port Angeles & Western railway. The Tahuya River Estuary site contains a collapsed structure, a road bridge, and wood pilings. These structures have been inventoried but not formally evaluated. In addition, based on the previous land use there is a high likelihood that a sawmill may be located within the restoration area. Finally, the WNDR Budd Inlet Beach site contains the previously inventoried marine station dock which has been recommended not eligible to the NRHP. This restoration site also contains a marine laboratory and concrete bulkhead which need to be inventoried.

A comprehensive inventory and National Register evaluation of all built-environment resources at each site would need to be completed; inventory work for each site should be conducted no more than five years in advance of construction. The Corps would consult with the SHPO and other interested parties regarding future identification and evaluation strategies, and develop and implement mitigation measures prior to construction where adverse effects could not be avoided.

The Corps has prepared a draft Cultural Resources Plan (see Appendix D) that proposes guidelines on identification and evaluation of sites, as well as the resolution of any adverse effects that are identified.

5.4 SOCIO-ECONOMIC RESOURCES AND HUMAN ENVIRONMENT

This section discusses effects to the significant socioeconomic resources in the Nearshore Study area. The two periods considered when analyzing effects are the likely period of construction lasting approximately six months to two years depending on the scope of each site, and the 50-year period of analysis for ecosystem benefits. The spatial scale of analysis is different for each resource type as some effects would be Sound-wide and others would only occur at the site level.

5.4.1 Shoreline Ownership and Land Use

As described in detail in Section 3.4.1, land uses around the nearshore zone include residential areas, public and private recreational properties, industrial sites, agricultural areas, aquaculture, and publicly and privately held boat launching sites among other uses. This section analyzes potential effects to properties at the proposed sites.

5.4.1.1 *Alternative 1 – No-Action Alternative*

The No-Action Alternative would have no effect to shoreline ownership or land use. With no ecosystem restoration at the proposed sites, property owners may elect to install or strengthen shoreline armoring as a response to sea level change. Such modifications would further reduce natural ecosystem processes that are already degraded.

5.4.1.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

This alternative would not involve any condemnation of properties or takings by the government, and no sites would move forward without necessary land ownership or easements in place. Three of the 11 sites are wholly or mostly in public ownership. Five of the 11 sites are wholly or mostly in private ownership. The remaining three involve a mix of public and private ownership. Many lands associated with the Nooksack River Delta are in tribal jurisdiction and would require close coordination with the Lummi Nation. Additionally, at least three of the sites (North Fork Skagit River Delta, Beaconsfield Feeder Bluff, and Everett Marshland) have known challenges with securing landowner support. Any proposed sites that cannot acquire necessary land ownership or easements would not be constructed. During the pre-construction, engineering and design (PED) phase, site designs may be modified to avoid effects to landowners who are unwilling to accept changes to their properties. Assuming all landowner issues were resolvable through agreements or avoidance, all project lands would become public lands or include easements to allow proposed activities to occur. Compared to Alternative 3, this alternative does not take full advantage of opportunities associated with public land for high priority restoration and protection. Land use changes expected from this alternative would result from converting agricultural lands to wetlands as well. Land use changes expected to result from this alternative are shown in Table 5-8.

5.4.1.3 *Alternative 3 – 18 Sites*

As with Alternative 2, this alternative would not involve any condemnation of properties or takings by the government, and no sites would move forward without necessary land ownership or easements in place. A significant portion of all acreage involved for this alternative occurs on publicly held lands, although some private property occurs within the site design footprints. Six of the 18 sites in this alternative are wholly or mostly in public ownership. Six other sites are wholly or mostly in private ownership and the remaining six are a mix of public and private ownership. In general, the sites that are primarily in private ownership are smaller in size and complexity. Most of the larger and more complex sites encompass an even mix of public and privately owned lands. Some properties may already have easements, or may involve property acquisition into fee simple ownership by the government, but only through purchases from willing landowners.

Many of the northern sites in areas like Skagit and Snohomish counties include lands being used for agricultural purposes, which has historically been an incompatible land use with restoration activities. Loss of farmland has been a controversial subject, with local ordinances to achieve "no net loss of farmlands." For each of the 18 sites, current land use and the expected land use changes due to this restoration project are listed in Table 5-8.

Table 5-8. Land Use Changes Anticipated at Proposed Project Sites

Project Site	Current Land Use Within and Surrounding Site Boundaries[1]	Change in Land Use Due to Restoration
Beaconsfield Feeder Bluff	Forest, medium to low density development	None
Big Beef Creek Estuary	Forest, low density development	None
Deepwater Slough	Agriculture, wetlands	Agriculture to wetland
Deer Harbor Estuary	Low density development, grassland, wetlands	None
Duckabush River Estuary	Forest, low density development, recreation	None
Dugualla Bay	Forest, low density development, agriculture, wetlands	Agriculture to wetland
Everett Marshland	Agriculture, wetlands	Agriculture to wetland
Harper Estuary	Forest, low density development, wetlands	None
Livingston Bay	Low density development, agriculture, wetlands	Agriculture to wetland
Milltown Island	Agriculture, wetlands	Agriculture to wetland
Nooksack River Delta	Forest, low to medium density development, agriculture, wetlands	Agriculture to wetland
North Fork Skagit River Delta	Agriculture	Agriculture to wetland
Point Whitney Lagoon	Forest, wetlands, recreation	Recreation to wetland

Snow Creek and Salmon Creek Estuary	Low density development, agriculture, wetlands	None
Spencer Island	Agriculture, wetlands	None
Tahuya River Estuary	Forest, low to medium density development	None
Telegraph Slough	Agriculture, wetlands	Agriculture to wetland
WDNR Budd Inlet Beach	Forest, low density development	Low intensity development to wetland

[1]-Information obtained from MRLC Consortium Viewer 2012 (www.mrlc.gov/viewerjs/).
Shaded sites are included in Alternative 3, but not Alternative 2.

5.4.2 Public Access and Recreation

Public access is important to the residents of the State of Washington and was included as an overarching policy of the 1971 Shoreline Management Act. Local communities often reflect this interest during public comment periods and design charrettes for proposed projects. Restoration and protection efforts in the nearshore zone are opportunities to improve public access and recreation in areas that may have had limited or informal access before. A challenge with public access and recreation opportunities for the Nearshore Study is to make sure it meets the needs of the user groups for an area and still allows for process-based ecosystem restoration at a site. To achieve both goals, in some instances, access sites or recreational features must be relocated.

5.4.2.1 *Alternative 1 – No-Action Alternative*

The No-Action Alternative would have no addition or subtraction of public access points to the shoreline. Many of Puget Sound's recreation opportunities rely on natural resources such as whale watching, bird watching, fishing, and shellfishing, as described in Section 3.4.2. Aspects of each of these resources are in decline throughout the region, and to take no action toward restoring nearshore ecosystem processes would mean that these downward trends could continue. Loss of the natural resources that are the target of recreational activities would lead to decline in numbers of individuals participating in those activities. Not only would this have an immeasurable impact on families whose traditions surround these activities, but this would also have the indirect effect of decreasing revenue to the local and regional economies that rely on sales of goods and services related to recreational activities.

5.4.2.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

Alternative 2 would not significantly affect long-term public access. During construction activities, some access and recreation sites may be temporarily closed. Dike-top trails associated with two of the 11 sites would replace or improve existing conditions for walking and bird watching; however, there would be no major addition of public recreation opportunity in this alternative. Restoration of 5,348 acres of tidal wetlands would support fish and wildlife species and associated recreational opportunities such as increased bird watching opportunities; the increased salmon habitat could be presumed to assist with recovery of diminished populations thereby adding potential for increased sportfishing. Finally, there is a chance for potential displacement or substitution of recreation opportunities associated with this alternative. Waterfowl hunting opportunities may be displaced by new or different recreation opportunities (e.g., bird watching) at some of the sites included in this alternative, and two marinas would be removed. These are Blake's Marina on the North Fork of the Skagit River and Twin Bridges Marina as part of the Telegraph Slough restoration site.

5.4.2.3 *Alternative 3 – 18 Sites*

Alternative 3 would improve public access to the shoreline. During construction activities, some access and recreation sites may be temporarily closed. Many of the sites include work that would make visiting the shoreline easier, and a more enjoyable experience for those who value natural shorelines. The proposed activities at the Point Whitney Lagoon site would increase beach area available for public and tribal access by removing infrastructure and fill, and relocating the parking area off the spit. Pedestrian beach access would be maintained but would require walking from an upland parking area. The Snow Creek and Salmon Creek Estuary site would include a pedestrian trail feature that would replace an abandoned railroad grade that some use for walking and birding activities. This new segment of trail would serve as a portion of the proposed 130-mile long, multi-purpose, Olympic Discovery Trail that will eventually extend from Port Townsend to the Pacific Ocean. Two other sites include dike-top trails in which restoration work would replace or improve existing conditions and would support activities such as walking and bird watching. The Harper Estuary site would involve relocation of a boat launch. The overall restoration of 5,517 acres of tidal wetlands would have the same types of associated recreational opportunity increases as Alternative 2, but to a greater extent. Finally, there is a chance for potential displacement or substitution of recreation opportunities associated with this alternative. Waterfowl hunting opportunities may be displaced by new or different recreation opportunities (e.g., bird watching) at some of the sites included in this alternative, and two marinas would be removed. These are Blake's Marina on the North Fork of the Skagit River and Twin Bridges Marina as part of the Telegraph Slough restoration site.

5.4.3 Commercial Fisheries and Aquaculture

The Puget Sound offers an unparalleled opportunity for commercial harvest of marine species, which supports a lucrative industry that caters to customers around the world. Improving, or at a minimum, maintaining harvest levels is imperative for sustaining this sector of the economy and has a direct influence on the quality of life for residents who earn their living in this sector.

5.4.3.1 *Alternative 1 – No-Action Alternative*

Commercial fisheries for finfish have been declining in recent years while commercial shellfish harvests have been relatively stable. The No-Action Alternative would have no effect on the decline of commercially harvested species, especially salmon. Additionally, this alternative would maintain degraded conditions that have reduced shellfish growing habitat. Sediment transport processes would remain inhibited. Moreover, this alternative would fail to provide the important water filtration afforded by increased wetlands, which is critical to keeping uncontaminated shellfish beds. The No-Action Alternative could have indirect economic consequences to commercial fisheries and aquaculture.

5.4.3.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

Alternative 2 would provide significant benefits to salmon rearing habitat, which assists with population recovery. Removal of armoring, tidal barriers, and artificial fill in river deltas, embayments, and beaches would provide more shallow water habitat for juvenile salmon migration, increase eelgrass beds that are critical nursery areas, and provide more spawning beaches for forage fish, an important prey item for salmon. Benefits to multiple aspects of salmon ecology would assist with recovery of this important commercially harvested resource.

The shellfish aquaculture industry has been expanding operations into available suitable habitat around Puget Sound. Restoring important ecosystem processes of the nearshore zone could help to restore important landforms such as beaches and mudflats, and could help enhance and expand areas available for shellfish growing. Dugualla Bay supported native oyster populations before it was diked. Restoration at the site may allow recolonization by native oysters. Removal of shoreline armoring and tidal barriers would benefit clams, oysters, and crabs by increasing sediment delivery and appropriate grain size distribution. Two of the 11 sites in this alternative have geoduck, Dungeness crab, hard clam, and oyster populations in close enough proximity that they might experience direct benefits.

5.4.3.3 *Alternative 3 – 18 Sites*

Benefits of Alternative 3 would be similar to those in Alternative 2, but to a greater extent due to having a substantially longer length of stressors removed, creating more acreage for invertebrates to colonize. This opportunity includes the potential shellfish production benefits at the Tahuya River Estuary and Point Whitney Lagoon sites. Proposed activities at the Tahuya River Estuary site are anticipated to improve shellfish production in the lower estuary by increasing transport of coarse material downstream. The Point Whitney Lagoon site supports a native oyster population within the lagoon as well as tribal commercial, ceremonial, and subsistence and public recreational harvest on tidelands. While there is concern regarding reduced infrastructure as well as a change to hydraulics and salinity to support shellfish aquaculture at this site (i.e., compatibility of restoration efforts with ongoing shellfish production activities), negative impacts can be largely avoided with proper planning, and a long-term increase in shellfish may be realized. Five of the 18 sites in this alternative have geoduck, Dungeness crab, hard clam, and oyster populations in close enough proximity that they might experience direct benefits.

5.4.4 Transportation

The areas of analysis for impacts to transportation are each restoration site. This scale is selected because none of the 18 proposed sites individually or collectively would affect broad-scale transportation issues in the Nearshore Study area, but individual sites could affect localized traffic around their community. Many of the proposed sites would affect transportation infrastructure, mainly because this is one of the major stressors that has caused degradation to the nearshore environment. In general, transportation components of the proposed sites involve lengthening roadway bridges to restore ecosystem processes to function as they did in historical nearshore conditions. Table 5-9 provides a summary of the transportation infrastructure that would be modified for each of the 18 proposed sites in the final array of alternatives.

Table 5-9. Transportation Infrastructure Affected

Site	Transportation Infrastructure
Beaconsfield Feeder Bluff	• None
Big Beef Creek Estuary	• Lengthen Seabeck Highway NW bridge and realign roadway
Deepwater Slough	• None
Deer Harbor Estuary	• Lengthen Channel Road Bridge and realign roadway
Duckabush River Estuary	• Lengthen Highway 101 bridge and realign highway
Dugualla Bay	• Lengthen Highway 20 bridge and realign highway • Lengthen Dike Road bridge and realign roadway
Everett Marshland	• Construct two new bridges on Lowell-Snohomish Road and realign roadway • Lengthen BNSF Railway bridge
Harper Estuary	• Construct new bridge at SE Olympiad Drive
Livingston Bay	• None
Milltown Island	• None
Nooksack River Delta	• Construct new bridge on Ferndale Road and realign roadway • Construct new bridge on Slater Road and realign roadway • Raise portions of Slater Road and Marine Drive • Construct new bridge on Hillaire Road and realign roadway • Construct new bridge on Imhoff Road and realign roadway • Construct new bridge on Haxton Way and realign roadway • Construct new bridge on Kwina Road and realign roadway
North Fork Skagit River Delta	• None
Point Whitney Lagoon	• None
Snow Creek and Salmon Creek Estuary	• Lengthen Highway 101 bridge and realign highway • Remove abandoned railway bridge and embankment
Spencer Island	• None
Tahuya River Estuary	• Lengthen NE North Shore Road bridge and realign roadway • Relocate helipad
Telegraph Slough	• Lengthen Highway 20 bridge and realign highway • Lengthen BNSF Railway
WDNR Budd Inlet Beach	• None

Shaded sites are included in Alternative 3, but not Alternative 2.
Bridge construction costs are classified as LERRDs.

5.4.4.1 *Alternative 1 – No-Action Alternative*

Under the No-Action Alternative, transportation infrastructure within the nearshore environment would not be replaced or modified. The roads, highways, bridges, and lengths of railway in the area of analysis would deteriorate as they age, requiring continued maintenance and repair. Some of this infrastructure within the zones of tidal influence may need to be modified in response to sea-level changes associated with climate change.

5.4.4.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

Alternative 2 would involve the replacement and/or modification of transportation infrastructure including roadways and bridges to restore nearshore ecosystem processes. This proposal involves modification of transportation infrastructure at five of the 11 sites. These modifications involve seven road bridge sites including three new bridges and associated road realignments as well as reconstruction of two railway bridges.

Detour routes and/or temporary structures would be developed to ensure that vehicle and rail traffic can still pass through sites during construction. Since designs are at the conceptual level, it is not yet possible to estimate duration of construction or the detour route. During the construction period, drivers may experience inconvenience due to traffic detours, but when completed, transportation infrastructure would be back in place and traffic would flow as normal.

5.4.4.3 *Alternative 3 – 18 Sites*

Alternative 3 would involve the replacement and/or modification of transportation infrastructure including roadways, bridges, and rail lines and associated bridges, to restore nearshore ecosystem processes. Alternative 3 involves modifying transportation infrastructure at 10 proposed sites, including constructing 17 bridges (nine new and eight reconstructions) and associated road realignments, and two railway bridge sites. In addition, one abandoned railway site (a bridge with embankment) would be removed. While bridge and roadway reconstruction and realignment would have significant ecosystem benefits, these project components constitute significant proportions of overall project costs, which is one of the reasons this alternative was not selected as the preferred alternative.

5.4.5 Public Safety

NEPA requires that public safety be considered in the alternatives analysis of Federal proposals. The Corps anticipates no reduction in public safety from the proposed project as all applicable laws, regulations, and codes will be complied with during design and construction phases.

5.4.5.1 *Alternative 1 – No-Action Alternative*

Under the No-Action Alternative, public safety infrastructure within the nearshore environment would not be modified or improved and will require ongoing maintenance and repair. Levees are typically under the responsibility of local diking districts or counties that provide maintenance.

The Corps would not alter any levees for ecosystem restoration under the No-Action Alternative; any changes to these levees for public safety are and would continue to be the responsibility of the levee owners. Transportation infrastructure and utilities in the study area such as bridges, roads, railroads, conduits and pipelines would require continued maintenance, repair or replacement to insure public safety.

5.4.5.2 *Alternative 2 – 11 Sites (Preferred Alternative)*

For any management measures or site features that may be relevant to public safety, the Corps would apply all current engineering and design regulations to achieve no reduction in any aspects of public safety. All such features are considered and discussed in detail in Appendix B – Engineering Appendix.

Alternative 2 would involve the replacement and/or modification of various components of infrastructure that have public safety criteria including armoring, utilities, roads, bridges for vehicles or trains, and levees. As described in Section 4.6, for each of the restoration sites in which the Corps is proposing to breach a levee and construct a new levee, the new levee will maintain the same level of flood protection as the levee it is replacing. Alternative 2 includes five sites in which a new or setback levee would be constructed to protect public or private property from inundation that could result from the restoration work.

This alternative includes two sites, Beaconsfield Feeder Bluff and Dugualla Bay, where existing shoreline armoring is proposed for removal. Neither project would have any effect on public safety.

This proposal involves modification of road alignments at four of the 11 sites, at Deer Harbor Estuary, Dugualla Bay, Everett Marshlands, and Nooksack River Delta. Each modification would conform to current road design safety standards applicable to the type and size of roadway being modified. There would be no reduction to public safety at any of these sites; in fact, conforming to updated standards would likely improve safety.

Alternative 2 includes twelve road bridges and reconstruction of two railway bridges. One of these bridges is a section of Highway 20 at Telegraph Slough. Each modification would conform to current bridge design safety standards applicable to the type and size of bridge being modified. There would be no reduction to public safety at any of these sites; in fact, conforming to updated standards would likely improve safety and will allow for predicted sea level change.

Alternative 2 contains two sites that would affect utility corridors. These are along State Route 20 at the Telegraph Slough site and at the Everett Marshland with work within the Lowell-Snohomish River Road prism. More detailed information on these sites can be found in Appendix B – Engineering Appendix. The Corps anticipates no impacts to public safety and the resulting project may actually improve conditions relevant to public safety as all modifications would conform to current design safety standards.

One benefit of wetland restoration is increased usage by waterfowl; however, bird and other wildlife that are attracted to wetlands can pose a risk to air traffic. The Dugualla Bay site is approximately one mile east of Ault Field, part of Naval Air Station Whidbey Island. The proposed restoration at this site would change the site from a freshwater lake to an estuary connected to Skagit Bay. According to the Navy's Bird/Animal Aircraft Strike Hazard (BASH) program, there are a variety of measures that help minimize risk to aircraft from bird and animal strikes. The Corps would work closely with the Navy and the BASH program manager to ensure that any change in bird usage of the tidal area is in compliance with the BASH program.

5.4.5.3 *Alternative 3 – 18 Sites*

Alternative 3 would involve the replacement and/or modification of a greater number than Alternative 2 of components of infrastructure that have public safety criteria including roadways, bridges, and levees to restore nearshore ecosystem processes.

Alternative 3 contains the same five sites as Alternative 2 with new levees, and no additional sites in which levees would be constructed. The same is true for the need for utility relocations; Alternative 3 has no additional sites that affect major utility corridors beyond those already discussed for Alternative 2.

There are two additional sites in Alternative 3 that involve armoring that would be removed. At the Snow Creek and Salmon Creek estuary the armoring removal would not threaten any infrastructure. Removal of armor at Big Beef Creek Estuary is associated with the bridge proposed for replacement. The new bridge would have all appropriate protection measures required for new construction.

Alternative 3 involves modifying one additional road alignment other than the three included in Alternative 2. This involves permanent removal of approximately 425 feet of SE Olympiad Drive and associated fill that is bisecting the freshwater marsh and saltwater estuarine area at Harper Estuary. Closure of this section of road would require a traffic analysis assessing impacts to local residences and emergency services to maintain the same level of public safety.

This alternative includes constructing 16 bridges (3 new and 13 reconstructions) and three railway bridges. Two of these bridges are sections of Highway 101, at the Duckabush River estuary and at the Snow Creek and Salmon Creek estuary. Transportation infrastructure would meet all current safety criteria and designs will allow for predicted sea level change.

Alternative 3 does not include any additional sites where wetland restoration is proposed in the vicinity of an airfield.

5.5 SUMMARY OF ENVIRONMENTAL CONSEQUENCES

This section summarizes the expected effects on significant environmental resources described in preceding sections. Table 5-10 provides a summary of these effects in comparative format. In addition to the comparison of environmental effects of the alternatives, NEPA requires consideration of certain other aspects of any Federal project requiring an EIS (40 CFR 1502.16). These include the following:

- Adverse environmental effects that cannot be avoided should the proposal be implemented
- The relationship between short-term uses of the human environment and the maintenance and enhancement of long-term productivity
- Any irreversible or irretrievable commitments of resources
- Any areas of controversy and unresolved issues

The *adverse environmental effects that cannot be avoided* include a risk, although it has a low likelihood, that some chemical contaminants could be released during ground-disturbing activities at some of the sites. Construction contractors would be required to follow strict protocols for handling hazardous materials to minimize the risk of releases occurring. Implementing the restoration action would result in unavoidable impacts to cultural resources as detailed in section 5.3. The Corps has developed a draft cultural resources plan that provides a framework and commitments the Corps proposes to incorporate into either a memorandum of agreement executed pursuant to 36 C.F.R.§ 800.6, a programmatic agreement executed pursuant to 36 C.F.R. § 800.14(b), or the documents used by the Corps to comply with the National Environmental Policy Act pursuant to 36 C.F.R. § 800.8. The Corps is consulting with the State Historic Preservation Officer (SHPO) and the Advisory Council on Historic Preservation (ACHP) on the appropriate mechanism to conclude the agency's Section 106 responsibilities. The draft cultural resources plan provides a path forward for future identification, evaluation and assessment of effects. The Corps will consult with the SHPO, ACHP and Tribes on appropriate mitigation measures on a case-by-case basis. Additionally, underwater noise may cause unavoidable harm to aquatic animals at the individual level, but not likely at the population level (See section 5.7 for mitigation measures for underwater noise).

The *short-term uses of the human environment* would ultimately benefit the maintenance and enhancement of long-term productivity of the ecological resources of the Puget Sound region. Some of the short-term uses of resources would include a temporary closure of some public access points for the duration of construction, and some land would be cleared for access and staging. There would be no long-term negative effects to productivity; in fact, the purpose is to restore the natural processes that support productivity and the resilience of the ecosystem to support biological resources and goods and services that humans value. A net increase in vegetation would result in an increase in primary biological productivity and could increase capacity for carbon sequestration (absorption).

The *irreversible or irretrievable commitments of resources* for implementation of the proposed action would involve the commitment of natural and human-made resources for removal of stressors and rebuilding of critical infrastructure that must be replaced within the nearshore zone. The significant irretrievable commitment of resources would largely be due to all of the construction materials required for modification of critical infrastructure that must remain in the nearshore zone including highway realignments, bridge replacements, and road relocations. As shown in the GHG emissions analysis, Alternative 2 would involve approximately 6.7 million gallons of diesel fuel burned resulting in 74,000 tons of CO_2 emissions. Alternative 3 would involve more diesel and related emissions at approximately 7.4 million gallons of diesel fuel burned resulting in 82,000 tons of CO_2 emissions. The historical structures and archaeological sites at the restoration sites are cultural resources that are non-renewable and would be either removed (structures), buried, or destroyed (archaeological sites) to successfully restore ecosystem processes. The impact to structures and artifacts is an irreversible commitment of these resources. For any unavoidable adverse effects (removal, burial, or destruction) to National Register eligible structures, the Corps will consult on a case-by-case basis with the SHPO, ACHP, Tribes, and other interested parties.

There are no *areas of controversy or unresolved issues* among the Federal, State, or local agencies consulted during this project. Some controversy has arisen through individual property owners who have voiced concerns regarding potential effects to their properties that may result from the proposed restoration. During the pre-construction, engineering, and design (PED) phase, hydraulic engineers would perform hydrologic and hydraulic measurements and modeling to determine probability of risk to potentially affected properties. Subsequent site designs would reflect the results to avoid and minimize risks. Site design phases would take landowner willingness into account—reflected by design modifications—and sites would only go forward at locations with amenable landowners. Table 5-10 provides a comparison of how each alternative would affect the significant resources of the nearshore zone as described in detail in Sections 5.1 through 5.4.

Table 5-10 Summary of Environmental Consequences

		ALTERNATIVE 1 No Action	ALTERNATIVE 2 11 Sites (Preferred Alternative)	ALTERNATIVE 3 18 Sites
PHYSICAL ENVIRONMENT: NEARSHORE PROCESSES & STRUCTURE				
Nearshore Processes	Short-Term Construction Effects	N/A	Immediate removal of stressors, some immediate restoration of processes	Immediate removal of stressors, some immediate restoration of processes
	Long-Term Project Effects	Continued decline of EFG&S due to impaired processes.	Restores target processes with improved EFG&S on 5,348 acres of wetlands. Restores 5.5 acres of sediment delivery on a beach.	Restores target processes and improves EFG&S on 5,517 acres of wetlands. Restores 7.5 acres of sediment delivery on beaches.
Geologic and Physiographic Setting	Short-Term Construction Effects	N/A	Immediate removal of 75,162 feet of shoreline stressors	Immediate removal of 113,094 feet of shoreline stressors
	Long-Term Project Effects	Continued influence of artificial landforms. Continued decrease in length and complexity of the shoreline	Reduces length of stressors by 29% along the total of 394,087 feet of shoreline of all proposed sites	Reduces length of stressors by 36% along the total of 394,087 feet of shoreline of all proposed sites
Oceanography	Short-Term Construction Effects	N/A	Localized and temporary impacts to currents due to location of temporary work structures, less so than Alternative 3. Immediate benefits of freshwater inputs and distributary channels at 10 of 11 sites.	Localized and temporary impacts to currents due to location of temporary work structures. Immediate benefits of freshwater inputs and distributary channels at 16 of 18 sites.
	Long-Term Project Effects	No effects to oceanography. Dikes in river deltas will continue to channelize fresh water input and inhibit freshwater mixing.	Restoration of 5,348 acres of tidally influenced wetlands. Freshwater influence restored at 5 of 11 sites.	Restoration of 5,517 acres of tidally influenced wetlands. Freshwater influence restored at 10 of 18 sites.
Water Quality	Short-Term Construction Effects	N/A	Same effects as Alternative 3, but less risk due to smaller number and size of projects.	Risk of fuel spill and encountering undocumented sources of contaminants. Tidal inundation of farmland with short-term releases fecal col., turbidity, DO, nutrients.

		ALTERNATIVE 1 No Action	ALTERNATIVE 2 11 Sites (Preferred Alternative)	ALTERNATIVE 3 18 Sites
PHYSICAL ENVIRONMENT: NEARSHORE PROCESSES & STRUCTURE (continued)				
Water Quality	Long-Term Project Effects	Water quality will continue to decline as watersheds experience development and associated non-point source pollution.	Increase in water quality due to 5,348 acres of wetlands added. Benefits similar to Alternative 3, but smaller magnitude due to smaller number and size of sites.	Improved water quality due to 5,517 acres of wetlands added, which would filter run-off and non-point source pollution. Added riparian shading would lower water temperatures.
Sedimentation & Erosion	Short-Term Construction Effects	N/A	Anticipate short-term release of sediment from excavation and stressor removal	Anticipate short-term release of sediment from excavation and stressor removal
	Long-Term Project Effects	Remain impaired due to stressors such as shoreline armoring	Restored sediment delivery and transport due to removal of 77,796 linear feet of stressors.	Restored sediment delivery and transport due to removal of 115,718 linear feet of stressors.
HTRW	Short-Term Construction Effects	N/A	Removal of contamination during construction.	Removal of contamination during construction.
	Long-Term Project Effects	Sites with HTRW may not receive State lead restoration attention	Same effects as Alternative 3, but less benefit due to smaller number and size of projects.	Benefits from removing underground storage tanks or other contaminated soils.
Greenhouse Gas Emissions	Short-Term Construction Effects	N/A	Estimated 74,053 tons of GHG emissions from construction activities	Estimated 82,276 tons of GHG emissions from construction activities
	Long-Term Project Effects	N/A	GHG absorption expected (less than Alternative 3) as vegetation establishes; difficult to estimate	GHG absorption expected as vegetation establishes; may offset construction effects
Underwater Noise	Short-Term Construction Effects	N/A	5 projects have noise-producing activities that may cause behavior disruption or harm to aquatic species	10 projects have noise-producing activities that may cause behavior disruption or harm to aquatic species
	Long-Term Project Effects	N/A	Low likelihood for harm to birds or marine mammals, or loss of few fish in close proximity to pile driving.	Greater likelihood for harm to birds or marine mammals, or loss of few fish in close proximity to pile driving.

		ALTERNATIVE 1 No Action	ALTERNATIVE 2 11 Sites (Preferred Alternative)	ALTERNATIVE 3 18 Sites
BIOLOGICAL ENVIRONMENT: NEARSHORE FUNCTIONS				
Vegetation	Short-Term Construction Effects	N/A	Similar impacts to those described for Alternative 3, but to a lesser extent due to fewer and smaller projects.	Temporary turbidity disturbance to kelp, eelgrass, and nearby wetlands. Riparian vegetation structures would be removed from structures.
	Long-Term Project Effects	Marine submerged and riparian vegetation would stay limited by diminished sediment delivery and shading of overwater structures. Tidal wetlands would remain constrained by fill and dikes.	Less freshwater marsh loss than Alternative 3, but less tidal wetlands restored and less riparian planting. Less benefit to kelp and eelgrass due to less length of stressors removed than in Alternative 3.	Minor loss of freshwater marsh plants from restoring tidal inundation. 5,517 acres of tidal wetlands restored. Riparian planting at several projects. Sediment delivery benefits to eelgrass and kelp.
Shellfish & Other Macroinvertebrates	Short-Term Construction Effects	N/A	Similar to those described for Alternative 3, but to a lesser extent due to less bottom disturbance and less dredging.	Temporary increases in turbidity, dredging, and removal of shoreline stressors would cause disturbance to benthic and epibenthic communities.
	Long-Term Project Effects	Lack of suitable habitat in diked and filled intertidal areas, lack of sediment supply for substrate, and siltation and pollution from run-off would continue to limit shellfish and invertebrates.	Transition to brackish guild where tidal inundation is restored. Benefits to eelgrass support invertebrate diversity. Armor removal and riparian plants benefit upper intertidal and backshore invertebrates.	Similar to those described for Alternative 2, but to a greater extent due to more area of estuarine habitat restored and longer length of shoreline stressors removed.
Fish	Short-Term Construction Effects	N/A	Turbidity from excavation and dredging, and noise and vibration from pile driving could cause animals to flee, delay migration, or cause physical harm.	Similar to those described for Alternative 2, but to a greater extent due to more excavation, more pile driving, and more dredging.

		ALTERNATIVE 1 No Action	ALTERNATIVE 2 11 Sites (Preferred Alternative)	ALTERNATIVE 3 18 Sites
BIOLOGICAL ENVIRONMENT: NEARSHORE FUNCTIONS (continued)				
Fish (continued)	Long-Term Project Effects	Fish would remain limited by lack of estuarine habitat for them or their prey due to filled and diked wetlands, and lack of shallow water habitat and spawning substrate along armored shorelines.	5,348 acres of estuarine habitat restored for anadromous fish rearing and foraging. Removal of shoreline stressors creates shallow water habitat for migration corridors, spawning beaches, and benefits kelp and eelgrass.	Similar to those described for Alternative 2, but to greater extent due to more estuarine habitat restores and longer length of stressors removed.
Birds	Short-Term Construction Effects	N/A	Disturbance from noise from pile driving and operation of heavy equipment	Similar Alternative 2, but to a greater extent due to more pile driving and heavy equipment.
	Long-Term Project Effects	Birds would remain limited by lack of estuarine foraging habitat. No effect to migratory species that use farm fields	Additional foraging opportunities due to the 5,348 acres of restored estuarine habitat. Transition from freshwater species to brackish guild.	Similar to those described for Alternative 2, but to a greater extent due to more estuarine habitat being restored.
Mammals	Short-Term Construction Effects	N/A	Pile driving noise may disturb marine mammals in locating prey, flee response, or temporary hearing loss	Similar to those described for Alternative 2, but to a greater extent due to more pile driving.
	Long-Term Project Effects	Marine mammals dependent on nearshore species would continue to suffer from limited resources due to lack of suitable habitat for their prey.	Added prey base, including forage fish and salmonids, due to the increase in quantity and quality of habitat for these prey species.	Similar to those described for Alternative 2, but to a greater extent due to more new estuarine habitat created for their prey.
Invasive Species	Short-Term Construction Effects	N/A	Less vegetative ground cover for a short duration; overall benefit to stop the spread of invasive species	Invasive removal similar to Alternative 2, although to a greater degree due to more sites
	Long-Term Project Effects	Invasive species would continue to exploit human-made structures and outcompete native species. No opportunity to remove invasive species	Would result in planting and natural repopulation with native species; would stop the spread from these sources	Same as those described for Alternative 2, but to a greater extent due to the removal of more invasive vegetation.

		ALTERNATIVE 1 No Action	ALTERNATIVE 2 11 Sites (Preferred Alternative)	ALTERNATIVE 3 18 Sites
BIOLOGICAL ENVIRONMENT: NEARSHORE FUNCTIONS (continued)				
Rare, Threatened, and Endangered Species	Short-Term Construction Effects	N/A	Same effects as described for fish, birds, and mammals - primarily from turbidity and noise from excavation and pile driving.	Same as those described for Alternative 2, but to a greater extent due to more excavation and pile driving.
	Long-Term Project Effects	Filled, diked, and armored shoreline would continue to limit salmonid rearing and forage fish (preferred prey) habitat. Lack of suitable prey habitat would continue to limit food sources for ESA species.	Listed salmonids would benefit from 5,348 of restored estuarine habitat. Shallow water habitat created by removing shoreline armoring would enhance migration corridors. Higher trophic level species benefit from restored habitat of their prey base.	Same as those described for Alternative 2, but to a greater extent due more estuarine habitat being restored and sites where there are more ESA-listed species that would benefit from stressor removal.
CULTURAL RESOURCES				
Archaeological Resources	Short-Term Construction Effects	N/A	Potential to affect or encounter known or unknown archaeological resources	Same as Alternative 2, although to a greater degree due to larger number and size of sites
	Long-Term Project Effects	Future development could impact both known and unknown archaeological resources.	Work would affect 32 known archaeological sites at several restoration sites. Risk of damage to resources due to erosion.	Same as Alternative 2, although to a greater degree due to larger number and size of sites
Historic Buildings & Structures	Short-Term Construction Effects	N/A	N/A	N/A
	Long-Term Project Effects	Future developments would likely result in both adverse and positive impacts to historic buildings and structures.	Loss of potential historic properties including levees, residential, and agricultural structures (i.e. historic barns, historic granary, and residences) sections of railroad line, bridges, dike systems, marine laboratory, and many agricultural, residential, and buildings.	Same as Alternative 2, with potential impacts to additional historic properties including, the Highway 101 causeway, and marine laboratory.

		ALTERNATIVE 1 No Action	ALTERNATIVE 2 11 Sites (Preferred Alternative)	ALTERNATIVE 3 18 Sites
SOCIO-ECONOMIC RESOURCES				
Shoreline Ownership & Land Use	Short-Term Construction Effects	N/A	Property purchase or construction easements from willing land owners will need to occur prior to construction.	Property purchase or construction easements from willing land owners will need to occur prior to construction.
	Long-Term Project Effects	No change to shoreline ownership and land-use except by regulatory mechanisms.	Permanent increase in publicly owned lands and/or changes of land use to conservation easement.	Permanent increase in publicly owned lands and/or changes of land use to conservation easement across greater area than Alternative 2.
Public Access & Recreation	Short-Term Construction Effects	N/A	Present access and recreation opportunities may be temporarily limited or closed during construction.	Present access and recreation opportunities may be temporarily limited or closed during construction.
	Long-Term Project Effects	May continue downward trend in loss of natural resources, access, and recreation opportunities	Improvements to beach access limited to replacement of two dike-top trails. One boat ramp will be removed.	Improved pedestrian access at four sites. One boat ramp removed and one relocated. Adds length to the Olympic Discovery Trail.
Commercial Fisheries & Aquaculture	Short-Term Construction Effects	N/A	Not likely to affect commercial fisheries or aquaculture during construction.	Not likely to affect commercial fisheries or aquaculture during construction.
	Long-Term Project Effects	Continued decline of commercial finfish and shellfish populations due to habitat degradation and loss.	Significant benefits to commercial fish and shellfish species by increasing habitat and improving water quality, but less than Alternative 3.	Significant benefits to commercial fish and shellfish species by increasing habitat and improving water quality.
Transportation	Short-Term Construction Effects	N/A	Road closures, vehicle traffic re-routing	Road closures, vehicle traffic rerouting, and 1 railroad bypass
	Long-Term Project Effects	No direct impacts to transportation. Vulnerable infrastructure may experience occasional or prolonged loss of use due to sea level change (e.g., overtopping, flooding).	No change to transportation. Structures would be less vulnerable to sea level change (may be larger or higher roads/bridges)	No change to transportation. Structures would be less vulnerable to sea level change (may be larger or higher roads/bridges). Bridge removal at Harper would add 1 mile to drive around.

5.6 CUMULATIVE EFFECTS OF THE PREFERRED ALTERNATIVE

Cumulative effects can result from the incremental effects of the proposed action when added to the effects of other past, present, and future actions, regardless of which government agency or private entity undertakes such actions. When effects that are individually minor combine over space or time, the cumulative effects can be significant.

5.6.1 Cumulative Effects Analysis Methodology

The cumulative effects analysis incorporates information from a variety of sources. Each proposed restoration site is described in a conceptual design report and these descriptions were examined to evaluate environmental effects expected at each site. Then records from local entities were reviewed to determine the combined effects expected from restoring sites in each sub-basin. The time scale for analysis of cumulative effects includes projects 10 years past, active projects, and projects planned for the next 10 years. The spatial scale of analysis for each site is its sub-basin. Effects from past, present, and reasonably foreseeable future projects within these sub-basins were quantified by examining records available through the following sources: Washington State Department of Transportation database (WSDOT 2012); Puget Sound Regional Council's Transportation 2040 Plan (PSRC 2010); Lead Entity Habitat Work Schedule Public Portal map with descriptions of completed, active, and proposed restoration projects (WDFW et al. 2012); and the Corps' database of Clean Water Act Section 404 permits issued for restoration projects within tidally influenced areas (USACE 2012b). In addition, the Corps contacted the WDFW watershed stewards in the six sub-basins that contain the 18 sites for their input into the cumulative effects analysis. After analyzing each of these sources, a cumulative effects analysis was compiled for each proposed site in combination with expected effects from other actions in the same sub-basin.

5.6.2 Summary of Past, Present, and Future Actions and Cumulative Effects by Sub-basin

Each of the six sub-basins where one or more of the total 18 proposed restoration sites are located[5] was analyzed for cumulative effects based on the temporal and spatial scales described above and analysis results for each sub-basin are summarized in the following sections.

5.6.2.1 *South Central Puget Sound Sub-basin*

Negative effects to ecological processes in the South Central Puget Sound Sub-basin are a result of nearly continuous shoreline armoring and filling of tidally influenced areas, primarily for industry in the large river deltas near the cities of Seattle (Green/Duwamish River) and Tacoma (Puyallup River). Two of the proposed sites occur in this sub-basin: Beaconsfield feeder bluff south of Seattle, and Harper Estuary on the Kitsap Peninsula.

[5] No restoration sites are proposed in the North Central Puget Sound Sub-basin.

In the past 10 years, there have been 40 completed projects restoring and protecting nearshore landforms in the South Central Sub-basin and the Corps has issued 69 Nationwide 27 permits under Section 404 of the Clean Water Act. There are 24 active restoration and protection projects and another 20 similar proposed actions. The Corps' Green Duwamish River Ecosystem Restoration Program, a congressionally authorized project, has restored several acres of tidally influenced habitat in the Duwamish estuary and lower Green River. The Corps has completed Phase 1 and will complete Phase 2 soon at a large beach restoration project at Seahurst Park.

Restoration at Beaconsfield Feeder Bluff and Harper Estuary in combination with other restoration actions along the shoreline and in the Duwamish and Puyallup River deltas would restore natural beach profiles and substrate, as well as wetland habitat and offset past and ongoing development in the basin. Cumulative effects to ecological and other resources within this sub-basin are summarized in Table 5-11.

Table 5-11. Cumulative Effects Expected in the South Central Puget Sound Sub-basin

What cumulative effects could occur within the South Central Puget Sound Sub-basin from Nearshore Study-identified work combined with other past, present, and future actions?	
Ecological Resources	Although other projects in the sub-basin may occur concurrently with Beaconsfield Feeder Bluff and Harper Estuary, work would occur during allowable work periods and low tides to minimize turbidity and noise. Incremental cumulative effects of construction would be temporary. Long-term cumulative effects include increased beach-building sediment for eelgrass beds, forage fish, and shellfish, and increased tidal wetlands benefitting salmon and birds.
Socioeconomics	Other temporary beach closures and boat ramp removal in the sub-basin are unlikely; therefore, cumulative effects on recreation would be minimal. Job opportunities would arise from construction of these restoration sites and others in the basin, which may extend to individuals outside of this sub-basin. Long-term cumulative effects would include improved habitat for economically important resources like salmon and shellfish.
Transportation	Beaconsfield has no transportation infrastructure within the proposed site boundaries. Harper Estuary would require a temporary closure of SE Olympiad Drive, but this is not a major thoroughfare and there are alternate routes. Other projects that would affect traffic in the sub-basin would likely occur during construction at or near the Harper Estuary site, but few would occur in this area of the Kitsap Peninsula; therefore, potential for cumulative transportation effects is low.
Cultural Resources	Archaeological resources within this sub-basin have been highly impacted by industrial expansion and shoreline use over many decades, exposing a number of sites to both disturbance and loss of integrity. Intact historic and prehistoric resources from this area could be significant due to the role this sub-basin has played in the development of western Washington as well as regionally in the Pacific Northwest. Restoration actions that expose these shoreline resources to further degradation would contribute to this cumulative loss. Potential for cumulative effects to the sub-basin's built environment is low. No standing buildings are present at either site.

Air Quality	The only Clean Air Act non-attainment zone in Puget Sound is located in the South Central Puget Sound Sub-basin near Tacoma. Emissions from various industries, automobiles, and wood burning stoves in the densely populated areas of Seattle and Tacoma have all contributed to degraded air quality, particularly during thermal inversion events. Emissions from the operation of heavy equipment during construction at Beaconsfield and Harper Estuary have potential for cumulative effects on air quality. However, this diminished air quality would only endure for the construction period and would not be a permanent effect of the project.

The Corps of Engineers Civil Works branch has an ongoing General Investigation (GI) project on the Puyallup River that is looking at potential ways to reduce flooding in the basin. Measures that are being evaluated as a part of this GI include levee setbacks, construction of new levees, and dredging. The Corps of Engineers Regulatory Branch has issued numerous Nationwide Permit 13 bank stabilization permits (hundreds) in the Lake Washington, Duwamish, Puyallup, and Kitsap County watersheds over the past 10 to 20 years and with an even greater amount of individual permits that are likely related to shoreline development (both on Puget Sound and along its rivers). Over 100 WSDOT transportation projects have occurred in King and Kitsap counties in the past few years, and another 46 are active, ranging from bridge painting to I-5 improvements. In Pierce County, 24 WSDOT projects have been completed, and 22 are active, including the construction of the new Tacoma Narrows Bridge (spanning the Sound between Pierce and Kitsap counties). However, none of these projects is near the two proposed restoration sites in this sub-basin.

5.6.2.2 *South Puget Sound Sub-basin*

Negative effects to ecological processes in the South Puget Sound Sub-basin are a result of shoreline armoring, diking and filling of small coastal embayments, damming and filling of the Deschutes River Estuary, and diking of the Nisqually River Estuary. One of the proposed sites is in this sub-basin: WDNR Budd Inlet Beach.

In the past 10 years, there have been 43 projects restoring a variety of habitats along the shoreline of the South Puget Sound Sub-basin, with 31 Nationwide 27 permits issued. A large restoration effort in the area included restoring tidal inundation to several hundred acres of wetlands in the Nisqually River delta. Another 16 active restoration actions and 10 similar proposed actions occur in this sub-basin. The Corps of Engineers Regulatory Branch has issued numerous (50-100) Nationwide Permit 13 bank stabilization permits and roughly half that amount of individual permits (likely related to development) over the past 10 to 20 years, most of which were located along the Puget Sound shoreline. In Pierce County, 24 WSDOT projects have been completed and 22 are active, such as adding high occupancy vehicle (HOV) lanes to reduce congestion on Interstate 5 and State Route 16, and rail, arterial, rapid transit, and highway improvements and additions. No other major projects are scheduled, but increased vehicle use is expected as well as heavy population growth in the surrounding areas.

Restoration in this sub-basin would improve coastal embayments and restore tidal influence to wetlands in large river deltas. Cumulative effects to ecological and other resources expected within this sub-basin are summarized in Table 5-12.

Table 5-12. Cumulative Effects Expected in the South Puget Sound Sub-basin

What cumulative effects could occur in the South Puget Sound Sub-basin from Nearshore Study-identified work combined with other past, present, and future actions?	
Ecological Resources	Elevated turbidity is expected during construction, but there would not likely be multiple actions increasing turbidity in the same period, so cumulative effects are unlikely. The long-term cumulative effects of improving small embayments in combination with large-scale efforts like the Nisqually River delta restoration would improve habitat and water quality for commercially important shellfish and salmon, as well other species of fish, invertebrates, and birds.
Socioeconomics	Shellfish harvest is an important industry in the sub-basin, which would directly benefit from increased intertidal habitat and improved water quality. Increased habitat for salmon would benefit the regional economy as well. Job opportunities would arise from construction at these restoration sites as well as others in the basin, which may extend to individuals outside of the sub-basin.
Transportation	Transportation actions that would require road closures likely would occur in the sub-basin during construction; therefore, cumulative effects are possible. These effects would be temporary, limited to the duration of construction.
Cultural Resources	The South Puget Sound is extremely rich in both prehistoric and historic archaeological resources due to the high number of villages and historic settlements, such as Fort Nisqually, throughout the sub-basin. Past industrial development and transportation projects have contributed to the loss of substantial data collection opportunities in the sub-basin, and the proposed restoration actions include the potential loss of important sites that are contributing elements of a registered archaeological district with both local and national significance. At the WDNR Budd Inlet Beach site, removal of the marine laboratory, concrete bulkhead, and wood pier would potentially contribute to the ongoing loss of historic-age waterfront structures in the sub-basin. Loss of historic properties in the sub-basin is primarily attributable to modern industrial development, urban sprawl, demolition by neglect, and railroad and highway modernization projects; these activities will continue in the near future.

5.6.2.3 *Whidbey Sub-basin*

Negative effects to ecological processes in the Whidbey Sub-basin are a result of past and present diking for agriculture in the Skagit, Stillaguamish, and Snohomish Rivers, and on Whidbey Island, and extensive fill in the Snohomish Estuary due to urbanization in the City of Everett. Eight of the proposed sites are located in the Whidbey Sub-basin; four are in the Skagit River Delta (Deepwater Slough, Milltown, North Fork, and Telegraph Slough) and two are in the Snohomish River Delta (Everett Marshland and Spencer Island). The other two occur on Whidbey and Camano Islands (Dugualla Bay and Livingston Bay, respectively).

There are many opportunities for restoration in the Whidbey Sub-basin since most of the surrounding land use is not residential or commercial development. Most of these restoration efforts are focused around the three major river deltas (Skagit, Stillaguamish, and Snohomish), led by entities such as Snohomish County, Skagit Fisheries Enhancement Group, and the Nature Conservancy. In the past 10 years, there have been 20 completed projects restoring and protecting a variety of shoreline habitats in the Whidbey Sub-basin, including several large-scale restoration efforts like Union Slough and Diking District 6 in the Snohomish River delta, and phase 1 of Deepwater and Fisher Sloughs in the Skagit River delta. There are 18 active restoration actions, including Qwuloolt in the Snohomish River, and 13 similar proposed actions such as McElroy Slough in the Skagit River and Biringer Farms in the Snohomish River Delta.

The Corps of Engineers Civil Works branch has an ongoing GI project in the Skagit River basin investigating ways to reduce flooding in the basin. Measures that are being evaluated as a part of this GI are improving and raising existing levees, constructing new levees, and constructing bypass channel to divert floodwaters to the nearshore zone. In the past 10 to 20 years the Corps of Engineers Regulatory Branch has issued roughly 50 Nationwide Permit 13 bank stabilization permits and over twice as many individual permits (likely associated with development), which are scattered throughout the basin, but many are concentrated in the City of Everett on the Snohomish River, along the Skagit River, and Padilla Bay. In Skagit and Snohomish Counties, WSDOT has 87 completed projects and 34 active projects, many of which are in and around the City of Everett. These projects include widened lanes on SR 20, armoring the Skagit River along SR 20 and SR 530, storm water treatment, creating wetlands, adding large woody debris, and improving fish passage in the Snohomish River delta.

The cumulative effects of multiple restoration actions in these river deltas and the surrounding areas, including those in the preferred alternative, would provide wetland habitat and coastal embayments and help offset the negative impacts of past and ongoing development in the basin. Cumulative effects to ecological and other resources expected within this sub-basin are summarized in Table 5-13.

Table 5-13. Cumulative Effects Expected in the Whidbey Sub-basin

What cumulative effects could occur within the Whidbey Sub-basin from Nearshore Study-identified work combined with other past, present, and future actions?	
Ecological Resources	Although other projects in the sub-basin may occur concurrently with the construction at the seven sites in this sub-basin included in the preferred alternative, work would occur during allowable work periods and low tides to minimize effects of turbidity and noise. The incremental cumulative effects of construction of these sites would be temporary. Long-term cumulative effects of multiple restoration actions in this sub-basin would support large populations of salmon, and resident and migratory birds, as well as commercially important shellfish. Since the three rivers in this sub-basin support large runs of salmon, particularly the Skagit, restoration efforts could aid in the recovery of Southern Resident killer whales by supporting their prey.

Socioeconomics	Restoration of tidally influenced marshes may decrease abundance of freshwater waterfowl for hunting and limit access for recreation. However, increases in recreational fishing could result from the improvements in habitat. There is a growing concern in Snohomish and Skagit Counties over loss of farmland in the highly fertile floodplains and deltas of Skagit, Snohomish, and Stillaguamish Rivers mostly due to development, but also because of restoration. Large-scale restoration efforts in these river deltas, including those in the preferred alternative, may have cumulative effects to croplands. Job opportunities would arise from construction of these restoration sites as well as others in the basin, which may extend to individuals outside of the Whidbey sub-basin.
Transportation	Three of the sites would affect roads, and two would require work on the BNSF railway. Other construction in this sub-basin would likely be concurrent with restoration work and concentrated around the City of Everett, potentially causing cumulative effects. However, these effects would be temporary, limited to the duration of construction.
Cultural Resources	The Whidbey sub-basin is extremely rich in archaeological resources, and contains some of the earliest and rarest archaeology sites in western Washington. Despite industrial growth and the extensive land modification in this sub-basin due to agriculture and tidal reclamation, the region was used extensively ethnographically, and has a high potential to yield substantive data about early historic interactions with tribal groups and agricultural development. Loss of sites due to proposed restoration actions would continue to add to the accelerated degradation of archaeological data in the Whidbey sub-basin that has been lost due to development and expansion. Potential for cumulative effects to the sub-basin's built environment is high. Restoration activities would contribute markedly to the ongoing adverse impact on the historic agricultural landscape including impacts to levee systems located at Deepwater Slough, Telegraph Slough, Everett Marshland, Spencer Island, Milltown, and Dugualla Bay. Other resources that could be affected include historic structures such as barns (North Fork) transportation related resources such as bridges (Everett Marshland) and historic residences such as the John Hanson House (Livingston Bay). Losses of historic properties here are primarily attributable to industrial development, urban sprawl, demolition by neglect, and railroad modernization projects; these activities will continue in the near future.

5.6.2.4 *San Juan Islands/Georgia Strait Sub-basin*

Many areas in the San Juan Islands/Georgia Strait Sub-basin are unchanged from historical conditions, largely due to the dominance of rocky shorelines in the San Juan Islands making alterations difficult. Shoreline alterations are a result of diking in the Nooksack River delta, armoring around the City of Bellingham, and the restriction of coastal embayments by nearshore roads in the San Juan Islands. Two of the proposed sites are located in this sub-basin: Deer Harbor Estuary on Orcas Island and the Nooksack River Delta near the Canadian border.

In the past 10 years, there have been 19 completed projects restoring habitat in the San Juan Islands/Georgia Strait Sub-basin, with 26 Nationwide 27 permits issued. These projects include actions in the Nooksack Delta like Smuggler's Slough implemented by the Lummi Nation, salt marsh restoration near the City of Bellingham, and a few small-scale projects in the San Juan Islands implemented by the Friends of the San Juans restoring pocket beaches and embayments. There are nine active restoration and protection actions and five similar proposed actions. The Corps of Engineers Regulatory branch has issued approximately 30 to 40 Nationwide 13 Bank Stabilization permits and 50 to 100 individual permits in the last 10 to 20 years in the basin, many of which are concentrated in Anacortes, Bellingham, and harbors in the San Juan Islands. WSDOT completed 25 projects in the last 10 years that involved widening roads and replacing bridges and culverts, including the realignment of a road away from the Nooksack River; another 11 projects are active. No major road improvements with potential effects are planned in the area other than widening Mt. Baker Road and replacing culverts in northern Orcas Island.

The cumulative effects of large-scale restoration in the Nooksack River and smaller projects in the San Juan Islands would provide wetland habitat and coastal embayments and help offset past and ongoing development in the basin. Cumulative effects to ecological and other resources within this sub-basin are summarized in Table 5-14.

Table 5-14. Cumulative Effects Expected in the San Juan Islands/Strait of Georgia Sub-basin

What cumulative effects could occur within the San Juan Islands/Strait of Georgia Sub-basin from the Nearshore Study-identified work combined with other past, present, and future actions?	
Ecological Resources	Although other projects in the sub-basin may run concurrently with Nooksack and Deer Harbor Estuary, work would occur during allowable work periods and low tides to minimize cumulative effects of turbidity and noise. Large-scale restoration efforts in the Nooksack River delta combined with improvements to embayments and pocket beaches would provide rearing habitat for juvenile salmonids. Kelp and eelgrass beds should improve as sediment and nutrient inputs are restored, which would provide nursery habitat for many fish and invertebrates. Significant improvement in the Nooksack River estuary may aid in the recovery of Chinook salmon, and thus benefit Southern Resident killer whales.
Socioeconomics	Restoration of tidally influenced marshes in the Nooksack may decrease abundance of freshwater waterfowl for hunting and limit access. However, increases in recreational fishing could result from the improvements in habitat. Commercial shellfish beds in the Nooksack River delta may be affected by dike removal, but overall would benefit from increased sediment and nutrient delivery to Bellingham Bay and more wetlands that would improve water quality. Job opportunities would arise from construction of restoration sites, which may extend to individuals outside of the San Juan/Strait of Georgia sub-basin.
Transportation	Both sites in this sub-basin would affect roads. The Nooksack River delta site would require the construction of several new bridges and raising roads. Other construction in this sub-basin may be concurrent with the proposed restoration work, but not likely in the same area. Cumulative effects are possible; however, they would be limited to the duration of construction.

Cultural Resources	Due to the large volume of archaeological sites that would be affected by the proposed restoration work, (20 known archaeological sites within the Nooksack River Delta and one known site in the Deer Harbor Estuary) there is potential for significant loss of prehistoric and historic information about this sub-basin. Many of these sites, while previously identified as part of past regional studies in the sub-basin, have not been subject to thorough documentation and present an unknown amount of research potential. As restoration activities that include the removal of agricultural or flood control structures may subject resources to degradation through tidal influences, there is potential for a high density of sites from one cultural group to be lost. However, comprehensive data recovery and analysis from these sites may add to a regional understanding of prehistory throughout the sub-basin. Restoration activities at the Nooksack River delta site would contribute to the ongoing adverse impact on the sub-basin's historic agricultural landscape (levees and buildings) within the Nooksack River Delta. Cultural resource losses in the sub-basin are primarily attributable to new commercial and residential construction projects and demolition due to neglect; these activities will continue in the near future. Potential for cumulative effects to the sub-basin's built environment from restoration activities at Deer Harbor Estuary, however, is low; the only structure that may be affected there is a modern bridge.

5.6.2.5 *Hood Canal Sub-basin*

Negative effects to ecological processes in the Hood Canal Sub-basin are a result of nearshore roads such as Highway 101 restricting tidal flow at many of the tributary rivers and small creeks, diking in larger river deltas like Skokomish and Big Quilcene, and extensive armoring in the southern portions. Four proposed restoration sites are located in this sub-basin: Point Whitney Lagoon in the northern section of Hood Canal, Duckabush River Estuary, Big Beef Creek Estuary, and Tahuya River Estuary near the great bend of Hood Canal.

Restoration at Point Whitney Lagoon and Tahuya River Estuary in combination with the many other restoration actions in Hood Canal would restore tidal inundation to river deltas, and inputs of freshwater, nutrients, and sediments to the nearshore zone and help offset past and ongoing development in the basin. Cumulative effects to ecological and other resources within this sub-basin are summarized in Table 5-15.

Table 5-15. Cumulative Effects Expected in the Hood Canal Sub-basin

What cumulative effects could occur in the Hood Canal Sub-basin from Nearshore Study-identified work if combined with other past, present, and future actions?	
Ecological Resources	Although other projects in the sub-basin may be concurrent with the construction of Point Whitney Lagoon and Tahuya River Estuary, work would occur during allowable work periods and low tides to minimize cumulative effects of turbidity and noise. Restoration of wetlands in the larger river deltas and smaller embayments would benefit salmon and birds. Removing tidal barriers would increase sediment and nutrient delivery to the abundant eelgrass beds in Hood Canal, as well as provide suitable substrate for forage fish.

Socioeconomics	Restoration efforts that benefit salmon would also benefit recreational fishing. Improvements to water quality from increased wetlands would benefit the shellfish industry in Hood Canal. Job opportunities would arise from construction of these restoration sites as well as others in the basin, which may extend to individuals outside of the Hood Canal Sub-basin.
Transportation	No effects to roads would occur at Point Whitney and only one bridge replacement is necessary at the Tahuya River Estuary. No other WSDOT projects are planned in the area, so there would be little to no cumulative effects.
Cultural Resources	While limited archaeological surveys have been completed in the vicinity of the proposed sites, the shorelines of the Hood Canal sub-basin contain a variety of prehistoric shell middens, lithic scatters, and burial sites, as well as historic logging and homesteading sites. While construction and development has been limited throughout Hood Canal, transportation projects, such as the construction of Highway 101, have impacted traditional tribal lands and archaeological sites. If sites are found within this area, their disturbance would contribute to an ongoing loss of prehistoric and historic data about the region. Restoration activities at Duckabush would markedly contribute to continued adverse effects on one of the most important transportation-related resources in the sub-basin, Highway 101. Realignment of this section of highway would result in removal of two original highway bridges, one of which is listed in the National Register of Historic Places. Losses of historic properties in the sub-basin are primarily attributable to new rural residential construction, demolition due to neglect, and highway modernization projects; these activities will continue in the near future.

In the past 10 years, there have been 44 completed projects restoring and protecting a variety of habitats in Hood Canal with 31 Nationwide 27 permits issued. There are 16 active restoration projects and 22 proposed. These projects include dike removal in larger deltas like the Big Quilcene and Skokomish Rivers, and culvert replacement in several small streams that empty into Hood Canal. The Hood Canal Salmon Recovery Group is responsible for implementing many of these projects. In addition, the Corps of Engineers Civil Works branch has an ongoing GI project aimed at restoring the Skokomish River. This GI focuses on restoring year-round fish passage, increasing habitat complexity and quantity, and reconnecting off-channel habitats.

The Corps of Engineers Regulatory branch has issued approximately 50 Nationwide 13 Bank Stabilization permits and an equal amount of individual permits in the last 10 to 20 years in the Hood Canal basin, many of which are along the shoreline of Hood Canal. No major road improvements with potential effects are planned in the area. WSDOT has completed 24 projects in Kitsap and Jefferson Counties, such as repairing the Hood Canal Bridge, removing creosote dolphins, upgrading culverts to fish friendly structures, and adding truck lanes. No such projects are proposed to occur near the proposed restoration sites in the near future.

5.6.2.6 *Strait of Juan de Fuca Sub-basin*

Other than roads, much of the shoreline of the Strait of Juan de Fuca is free of stressors. A few areas like Ediz Hook and the shoreline along Port Angeles are armored. Negative effects in this sub-basin are largely due to fish blockages and tidal barriers on larger rivers such as Elwha and Dungeness, as well as the many smaller creeks that flow directly into the Strait and Discovery and Sequim Bays. Only one site in the preferred alternative occurs in this sub-basin: restoration at Snow and Salmon Creeks on the south shore of Discovery Bay.

The Corps of Engineers Regulatory branch has issued approximately 10 Nationwide 13 Bank Stabilization permits and twice as many individual permits in the last 10 to 20 years in the basin, many of which are concentrated around Port Angeles. In the past 10 years, there have been 45 completed projects restoring and protecting a variety of habitats along the shore and waterways of the Strait of Juan de Fuca. There are also 26 active and 19 similar proposed actions. These projects include removal of the Elwha and Glines Canyon Dams, removal of fill at Ediz Hook, and dike breaching on the Dungeness River. WSDOT has completed five projects in Clallam County, and one is active. The expansion and widening of Highway 101 to ease congestion west of Sequim is underway.

The cumulative effects of Nearshore Study-identified actions combined with other restoration actions in this sub-basin would provide more wetland habitat and access to upstream spawning habitat for anadromous fish, as well as increases in sediment and nutrient input to the nearshore zones of Sequim and Discovery Bays and the Strait of Juan de Fuca. It would also help offset past and ongoing development in the basin. Cumulative effects to ecological and other resources within this sub-basin are summarized Table 5-16.

Table 5-16. Cumulative Effects Expected in the Strait of Juan de Fuca Sub-basin

What cumulative effects could occur in the Strait of Juan de Fuca Sub-basin from Nearshore Study-identified work if combined with other past, present, and future actions?	
Ecological Resources	Short-term turbidity may arise during construction of Snow/Salmon Creek Estuary, but other turbidity-generating actions are not likely occurring in the sub-basin, particularly in Discovery Bay. Long-term cumulative effects of restoring fish passage and removing tidal barriers would provide rearing habitat for juvenile salmonids and access to spawning habitat upstream. Additional sediment and nutrient delivery would benefit eelgrass and kelp beds, providing valuable complex habitat for many species including forage fish and nursery habitat for juvenile fish.
Socioeconomics	Restoration efforts that aid in salmon recovery and benefit eelgrass and kelp beds would also benefit recreational fishing. Job opportunities would arise from construction of these restoration sites as well as others in the basin, which may extend to individuals outside of the Strait of Juan de Fuca Sub-basin.
Transportation	Highway 101 and SR 20 would remain open during construction and work would not coincide with other transportation interruptions. Given the low number of WSDOT projects in this sub-basin, there is little potential for cumulative transportation effects.

Cultural Resources	While there are no known archaeological sites at Snow/Salmon Creek Estuary, Discovery Bay has traditional significance to the Jamestown S'Klallam Tribe, and may contain both prehistoric and historic resources. If a site is found within the restoration area, its loss would contribute to an ongoing degradation of intact prehistoric village sites within the sub-basin, such as Tse-whit-zen in Port Angeles, that have occurred during modern expansion into traditional tribal areas. Restoration activities at the Snow/Salmon Creek Estuary site would contribute to continued adverse effects on two of the most important transportation-related resources in the sub-basin, Highway 101 and the abandoned segment of the Port Angeles and Western railroad. Additionally, the sub-basin would see continuing decline of its historic agricultural landscape due to the loss of farmstead buildings and structures and rural residences. Losses of historic properties in the sub-basin are primarily attributable to new rural residential construction, demolition due to neglect, and highway modernization projects; these activities will continue in the near future.

5.6.3 Summary of Direct and Indirect Effects with Synergistic and Countervailing Interactions

Interactive effects may be additive, countervailing (the net cumulative effect is less than the sum of the individual effects), or synergistic (the net cumulative effect is greater than the sum of the individual effects).

Ecological Resources – Negative effects during construction would only endure for brief periods and would vary depending on the resource. Benefits of restoration activities within each sub-basin would be countervailing to the construction effects, and the cumulative benefits of restoration along with other restoration actions described in the analysis above would be additive around Puget Sound.

Socioeconomics – Negative cumulative effects include loss of one or more marinas with the associated decrease in revenue for affected localities, potential decrease in area or relocation of area where waterfowl hunting is accessible on foot, and potential decrease in area available for shellfish growing pending further analysis at the Nooksack River Delta site. Across all Nearshore Study-identified restoration sites, in conjunction with other restoration actions around Puget Sound, total shellfish growing areas are expected to have a net increase. Other cumulative benefits include improved resiliency and adaptation to sea level change across various nearshore landforms and habitat types as well as the replaced infrastructure – an early pro-active investment that should preclude more expensive emergency reactions. In addition, the restoration sites are expected to provide a significant addition to habitat capacity for juvenile salmon rearing, which is expected to result in an increase in fish populations and therefore commercial, sport, and tribal fishing opportunities.

Transportation – Some traffic disruptions and temporary detours could increase commute times for residents at the affected localities for the duration of construction. One road would be permanently closed, which would add to the drive time for several residents. The overall improved traffic flow at each site involving roadwork would be a cumulative benefit and is expected to be a countervailing effect to the temporary traffic disruptions. Other cumulative benefits of multiple sites would include reduced susceptibility to road closures due to flooding, and early adaptation to anticipated sea level change.

Cultural Resources – The proposed restoration sites have varying degrees of probability for encountering buried, undocumented artifacts. If such cultural resources are encountered at multiple sites, this would constitute a cumulative effect of disturbance to multiple resources around Puget Sound. Restoration of tidal influences has the indirect effect of continuing the erosion of certain archaeological sites, especially those periodically exposed and subject to wave and wind erosion such as shell middens. Artifacts from sites may erode from their original contexts, lose scientific value, or be exposed for incidental collecting by beach visitors. Mitigation measures for these impacts would be assessed on a site-specific basis and may include archaeological data recovery and site avoidance. However, the loss of valuable cultural resources associated with archaeological sites cannot be entirely mitigated.

Potential for cumulative effects to the historic-age built environment around Puget Sound ranges from low to high depending on sub-basin. Some sites have no historic-age buildings or structures while other areas have important structures related to historic-age industrial and waterfront-related resources, historic agricultural landscapes including dikes and farmstead buildings and structures, Northern Pacific Railroad mainline with historic bridges, and Highway 101 with historic bridges. The Puget Sound region has been experiencing significant losses attributable to urban sprawl, modernizing and industrial development projects, demolition due to neglect, new commercial and residential construction, and railroad and highway modernization projects.

5.6.4 Cumulative Effects Comparison of Alternatives

The No-Action Alternative has no cumulative effects associated with restoring nearshore landforms; however, it can be inferred that the continued lack of functioning nearshore processes is having the cumulative effect of overall degraded ecosystem functions in Puget Sound. The trajectory for this effect is a continued decline of ecological resources, which influences socioeconomics and recreation quality throughout the region.

Alternative 3 would add more acreage of wetlands and remove more linear feet of stressors than Alternative 2 would accomplish. Therefore, Alternative 3, combined within other previous and ongoing restoration efforts in the Puget Sound, has potential for greater positive cumulative effects to ecological resources. Positive cumulative effects on socioeconomics of Alternative 3 are greater than Alternative 2 due to the improvements in habitat for many commercially valuable species; however, Alternative 3 has potential for greater negative cumulative effects to agricultural lands. Negative cumulative effects to transportation are greater in Alternative 3 due to the temporary closure of more roads; however, the overall benefits of road and bridge updates and improvements are assumed to outweigh the minor effect of temporary road closures. Alternative 3 has nearly twice as many restoration sites as Alternative 2 with certain removal of historic-age structures and likelihood of encountering cultural resources during site restoration activities. All appropriate mitigation would be conducted according to the Cultural Resources Plan in Appendix D; however, some loss is anticipated.

5.7 MITIGATION MEASURES

NEPA regulations at 40 CFR 1500.2(f) state that Federal agencies shall, to the fullest extent possible, use all practicable means consistent with the requirements of the Act and other essential considerations of national policy to restore and enhance the quality of the human environment, and avoid or minimize any possible adverse effects of their actions on the quality of the human environment. Furthermore, at 40 CFR 1508.20, NEPA defines mitigation to include avoiding impacts by not taking an action, minimizing the magnitude, rectifying the impact through restoring the resource, reducing the impact over the life of the action, or compensating for the impact. Agencies are required to identify and include in the action all relevant and reasonable mitigation measures that could reduce negative effects of the action.

Implementation of either of the two alternatives would involve multiple ecosystem restoration sites with construction in proximity to ecological resources. Through the analysis of effects of each of the 18 proposed sites, certain potential adverse effects were identified. Each of the 18 proposed sites would have short-term construction-related effects with varying spatial and temporal scales and degrees of intensity. Construction designs would include practices that avoid and minimize effects to affected significant resources. When avoidance and minimization are not feasible, mitigation is necessary. This section describes methods to mitigate adverse construction effects of the proposed restoration sites.

5.7.1 Standard Practices to Mitigate Negative Effects of Construction

Specific measurable and enforceable mitigation measures would be developed for each site based on the specific impacts of the project. All site designs and construction timing would include the following standard measures:

- The Corps would schedule in-water work to occur during designated periods (sometimes known as fish windows) consistent with recommended periods established by WDFW per Washington Administrative Code (WAC) 220-110-271.
- The Corps would schedule work outside of bird nesting season except where unavoidable.
- Each construction contractor would be required to prepare an Environmental Protection Plan for approval by the Corps.
- Traffic alterations would be designed to minimize impediments, with the shortest and least disruptive detours possible, and in coordination with the relevant transportation agency(s).

- Bridge reconstruction would provide adequate clearances for navigation of recreational boats on navigable rivers to the extent practicable.

5.7.2 Best Management Practices to Protect Water Quality

Restoration sites in the nearshore zone would involve, by necessity, some in-water work and significant areas of ground clearing. Protecting water quality from storm water runoff would require implementation of best management practices (BMPs) to avoid excessive runoff and elevated turbidity in the receiving water body. As completed sites evolve, they would contribute sediments to the nearshore zone by design; however, it is important to avoid excessive pulses of sediment during the construction phase that are more than what the surrounding biota can easily tolerate. Every site would have a Stormwater Pollution Prevention Plan, which includes a Temporary Erosion and Sedimentation Control Plan, approved by a Corps staff biologist. Construction contractors would be required to obtain a Construction Stormwater Permit under Section 402 of the Clean Water Act. Standard construction stormwater BMPs can be incorporated into site designs, operational procedures, and physical measures on site. The following are some examples of frequently used BMPs:

- Minimize area of ground disturbance and vegetation clearing.
- Use the site's natural contours to minimize run-off and erosion.
- Do not expose the entire site at one time; avoid bare soils during rainy months.
- Stabilize erodible surfaces with mulch, compost, seeding, or sod.
- Use features such as silt fences, gravel filter berms, silt dikes, check dams, and gravel bags for interception and dissipation of turbid runoff water.

5.7.3 Mitigation Measures for Effects of Greenhouse Gas Emissions

There are no legal requirements to mitigate for GHG emissions; however, BMPs are available for fuel and material conservation during construction. Such BMPs include the following:

- Maximizing use of construction materials that are reused or that have a high percentage of recycled material content, such as recycled asphalt pavement, concrete, and steel.
- Obtaining construction materials and equipment from local producers or vendors to minimize energy use for shipping.
- Encouraging construction personnel to carpool or use a crew shuttle van.
- Turning off equipment when not in use to reduce idling.
- Maintaining equipment in good working order to maximize fuel efficiency.
- Routing truck traffic through areas where the number of stops and delays would be minimized, and using off-peak travel times to maximize fuel efficiency.
- Scheduling construction activities during daytime hours or during summer months when daylight hours are the longest to minimize the need for artificial light.
- Implementing emission-control technologies for construction equipment.
- Using ultra low sulfur (for air quality) and biodiesel fuels in construction equipment.

- Using warm mix asphalt or cool pavement rather than hot mix asphalt.
- Using renewable energy produced onsite or offsite. For example, using solar-powered generators to supply electricity for field offices and construction lighting.

5.7.4 Mitigation Measures for Underwater Noise Effects

As described in Section 5.1.8, certain project sites would have noise-producing activities that have potential for adverse effects to aquatic species. Construction methods would incorporate as many mitigation measures as feasible to reduce noise effects to below harmful thresholds. Pile drivers can use shielding and dampening methods and materials at the point of impact; bubble curtains use controlled, specially sized air bubbles to dampen the sound pressure waves to minimize effects on aquatic life. Additionally, sound-absorptive mats called sound aprons made of rubber, lead-filled fabric, or plastic layers can be hung around the noise source to help shield the aquatic environment from excessive noise. Construction timing can avoid exposure of animals to sound by observing designated periods to schedule the noise-inducing activities for times when the animals are not likely present, and by limiting work to low tides take advantage of the way shallow water attenuates low frequencies and to reduce the area of effect. Marine mammal and bird monitoring plans can be implemented to alert construction teams when the animals are nearby and work should stop until the animals leave.

5.7.5 Best Management Practices and Mitigation Measures for Cultural Resources

The Corps is currently consulting with the SHPO and the Advisory Council on Historic Preservation on the appropriate mechanism to conclude the agency's Section 106 responsibilities. The Corps has developed a draft cultural resources plan that provides a framework and commitments the Corps proposes to incorporate into either a memorandum of Agreement executed pursuant to 36 C.F.R.§ 800.6, a programmatic agreement executed pursuant to 36 C.F.R. § 800.14(b), or the documents used by the Corps to comply with the National Environmental Policy Act pursuant to 36 C.F.R. 800.8. The draft cultural resources plan provides a path forward for future identification, evaluation and assessment of effects. The Corps will consult with the SHPO, ACHP and Tribes on appropriate mitigation measures on a case-by-case basis.

The draft cultural resources plan outlines proposed guidelines for Section 106 actions executed as Nearshore Study projects are approved and funded and restoration project designs are refined. The following best management practices for cultural resources are listed below:

- Update Historic Context for Levee Systems
- Identification of Area of Potential Effect (APE)
- Identification and Evaluation of Historic Properties:
- Updated Literature Review/Background Research
- Archaeological Survey and Testing

- Historic Age Buildings and Structures Inventory
- Traditional Cultural Property Inventory

If any cultural resources identified within the APE are eligible for the National Register listing, the Corps will make effects assessments. Should the proposed project have an adverse effect on an eligible cultural resource that cannot be avoided, the Corps would work toward a resolution of adverse effects with the SHPO/ACHP, tribes, and other consulting parties. Examples of mitigation measures include but are not limited to the following:

- Data Recovery
- HABS/HAER Documentation
- Development of Public Outreach
- Museum/Traveling exhibits
- Public talks
- Educational material prepared for local schools
- Interactive websites

6 TENTATIVELY SELECTED PLAN

Sites included in the TSP range from six to 1,800 acres with costs ranging from $4 million to over $300 million per site. The total area of the proposed sites is 5,354 acres, and the estimated cost of all these sites is approximately $1.1billion.

There are no costs or features (local betterments) over the National Ecosystem Restoration (NER) Plan that have been identified for implementation.

6.1 Description of Tentatively Selected Plan

Based on the Nearshore Study results over more than 10 years, the Corps is proposing a suite of ecosystem restoration sites throughout the Puget Sound nearshore zone. The types of features identified for restoration include freshwater and tidal wetlands, coastal embayments, intertidal mudflats, estuarine tidal channels, beaches, and coastal bluffs. Restoration of these features and the natural processes that sustain them requires removal of anthropogenic stressors that have reduced ecosystem functions in the nearshore zone. The proposed restoration measures remove stressors such as shoreline armoring and bank stabilization, tidal barriers, wetland fill, overwater structures, and tidal channel restrictions including levees to allow natural processes to recover.

The TSP includes 11 sites that, taken together, address all four of the formulated strategies for process-based restoration. The TSP would restore 5,354 acres of tidally influenced wetlands and would remove 75,172 feet of stressors from the nearshore zone, restoring the natural processes that support VECs and promoting the ecosystem structures and functions provided by wetlands, kelp and eelgrass beds, and riparian vegetation.

The 11 sites included in the TSP are geographically representative of a large portion of the study area, with a majority of sites focused around the Skagit and Snohomish River Deltas, with one site on the stretch of shoreline between Tacoma and Seattle (Beaconsfield) and one to the north in the San Juan Islands (Deer Harbor). Sites included in the TSP are located in four of the seven sub-basins around Puget Sound, with eight of the 11 sites located in one sub-basin (Whidbey). The TSP includes seven sites in major river deltas, one beach site, one open coastal inlet site, and two barrier embayment sites. All 11 sites of the TSP include critical habitat for ESA-listed species.

Please reference Sections 4.6 and 6.2 for detailed information regarding the 11 sites in the TSP. A map of the 11 sites included in the TSP is presented in Figure 6-1.

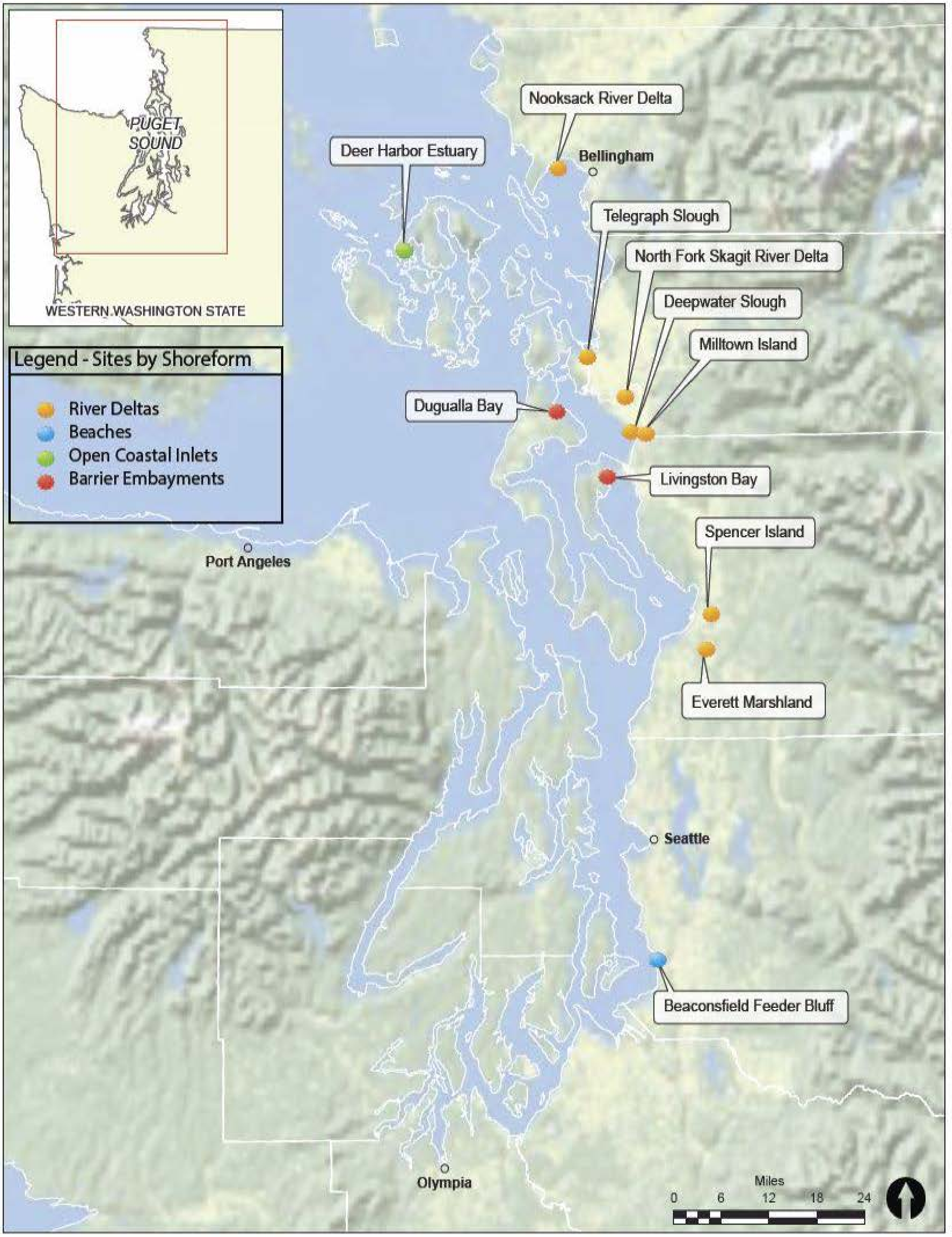


Figure 6-1. Geographic Locations of the Sites included in the Tentatively Selected Plan

6.2 Sites Included in the Tentatively Selected Plan

The following sections provide additional information about each of the 11 sites of the TSP. Specific design details about each site can be found in Appendix A (Restoration Site Fact Sheets) and Appendix B (Engineering Appendix).

6.2.1 Beaconsfield Feeder Bluff

The Beaconsfield Feeder Bluff is located north of Marine View Park in Normandy Park, Wash. The bluff restoration site is composed of several narrow residential parcels along 1,000 feet of shoreline. About 80 percent contains intermittent concrete vertical bulkheads and rock revetment armoring. This armoring blocks sand and gravel movement necessary to sustain beach structure and function. The proposed project should provide a sediment source to the degraded drift cell by restoring a connection between the feeder bluff and beach.

Ecosystem Restoration Benefits

- Restore sand and gravel beaches that can serve as spawning grounds for forage fish, such as surf smelt and Pacific sand lance, key elements of the marine food chain
- Re-establish intertidal and shallow subtidal areas to encourage kelp and eelgrass growth, increasing nearshore productivity for fish, birds and other marine species
- Improve shoreline resiliency for environmental response to changes like rising sea levels and increasing storm frequencies

Significance

- Limited beach restoration opportunities exist along the 27 percent of Puget Sound's armored shoreline, making this site unique and valuable. It is the only Tentatively Selected Plan beach site and is located in the most armored sub-basin
- Benefits of site restoration extend well beyond the the immediate area of this project
- As the only south Puget Sound site, it improves the Tentatively Selected Plan's geographic scope
- Improves Endangered Species Act-listed Chinook salmon and bull trout critical habitat

Key Design Elements

The proposed restoration involves acquiring parcels abutting the shoreline and removing 660 linear feet of bulkhead and rock revetment shoreline armoring. Some shore armor will be left in place to protect a house at the top of the bluff and return walls will be constructed at the remaining bulkhead ends. Portions of the beach will be re-graded to create a more natural beach profile. Figure 6-2 depects the key design elements at Beaconsfield Feeder Bluff.

Site Summary Statistics

- Acres: 5.5

- Total Project Cost: $4.4M

As Figure 6-3 depicts, this site restores several processes including wave action, tidal exchange, longshore and cross-shore sediment transport, sediment delivery, shoreline retreat, and mass-wasting. Restoration of this site provides benefits to ESA critical habitat for Chinook salmon and bull trout as well as direct benefits to great blue herons, hardclams, geoducks, forage fish, salmon, cutthroat trout, eelgrass, crabs, and many marine birds.

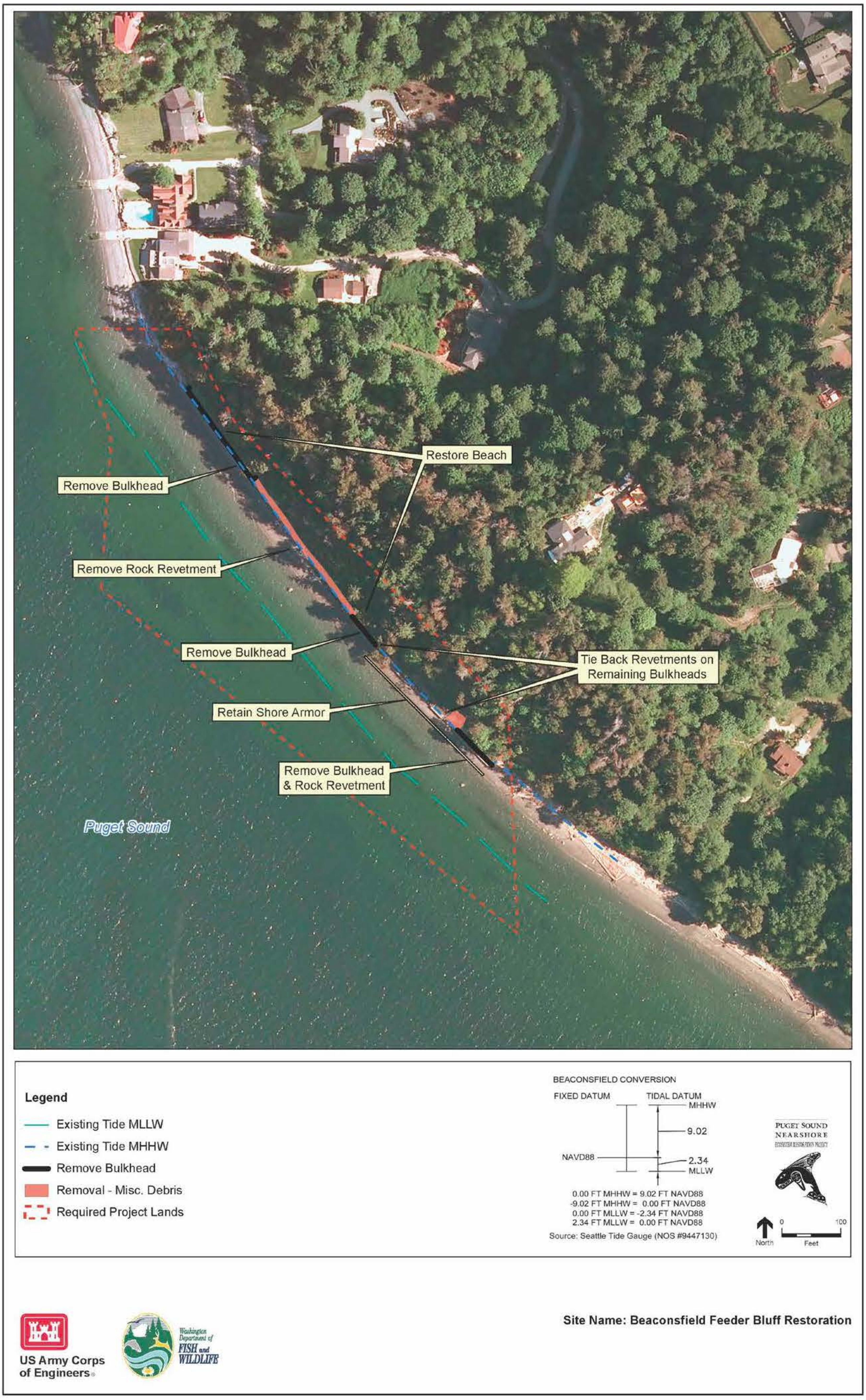
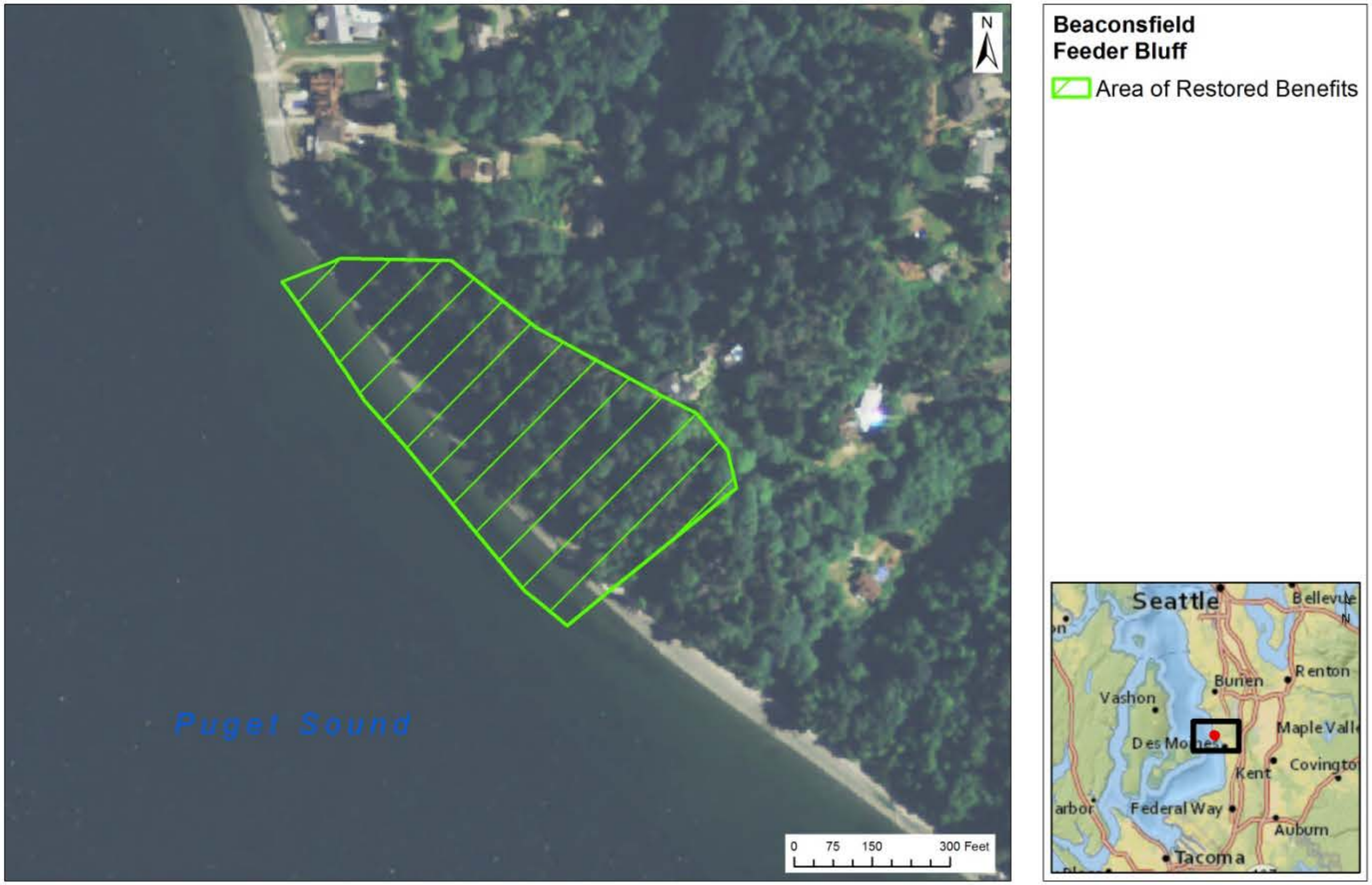


Figure 6-2. Beaconsfield Feeder Bluff - Key Design Elements



Beaconsfield Feeder Bluff	
Shoreform type:	Beach
Processes restored:	wave action, tidal exchange, longshore and cross-shore sediment transport, sediment delivery, shoreline retreat, mass-wasting
Species directly associated:	great blue heron, hardclam, geoduck, forage fish, salmon, cutthroat trout, eelgrass, crabs, many marine birds
Species indirectly associated:	marbled murrelet, steelhead trout, harbor seals, killer whales
ESA Critical Habitat:	Chinook salmon, bull trout
Acres of wetlands restored:	no wetlands at this site

Restored Benefits:
Beaconsfield Feeder Bluff

Figure 6-3. Restoration Benefits at Beaconsfield Feeder Bluff

6.2.2 Deepwater Slough

The Deepwater Slough project is located on the South Fork Skagit River downstream from Conway, Wash. Deepwater Slough is a small channel between Freshwater and Steamboat Sloughs. The project area includes two islands on either side of Deepwater Slough. Diking, ditching and filling for agriculture greatly diminished the Skagit River delta freshwater and estuarine wetlands and tidal channels. Washington Department of Fish and Wildlife (WDFW) manages the site as a wildlife area, with some areas actively farmed for crop production and wildlife enhancement. Site restoration involves levee removal, restoring tidal hydrology to diked areas and reconnecting the historic tidal channel system on both sides of Deepwater Slough. These actions will restore 270 acres of scarce tidal freshwater wetlands in the Skagit River delta. Plantings on the low natural levee will expand the riparian corridor.

Ecosystem Restoration Benefits

- Restore highly productive tidal wetland habitats that support biodiversity and provide connectivity between the land and sea
- Restore a large river delta providing valuable nursery habitat for juvenile threatened salmon species increasing their survival and supporting Puget Sound population recovery
- Improve estuary water quality
- Improve resiliency of the shoreline to respond to changes in the environment such as rising sea levels and increasing storm events

Significance

- Included in Puget Sound Chinook Salmon Federal Recovery Plan
- Phase 2 of highly-successful Phase 1 site restoration
- Together, the Deepwater and Milltown projects complete the lower South Fork Skagit River restoration
- Site improves juvenile salmon rearing habitat and capacity, limiting factors in the lower Skagit River

Key Design Elements

The restoration plan includes a combination of levee lowering and breaching around Deepwater West and East islands. Planting riparian vegetation on lowered levees and digging new channels will expand the riparian woodland corridor. The pedestrian bridge extending between the islands will be removed after levee lowering. Figure 6-4 depicts the key design elements at Deepwater Slough.

S***ite Summary Statistics***

- Acres: 270

- Total Project Cost: $9.9M

As Figure 6-5 depicts, this site restores several processes including sediment transport, freshwater input, tidal exchange, channel migration, marsh accretion, overbank deposition, and natural levee formation. Restoration of this site provides benefits to ESA critical habitat for Chinook salmon and bull trout as well as direct benefits to bald eagles, waterfowl, salmon, bull trout, and steelhead.

Some areas of Deepwater Slough have already been restored; these are shown in Figure 6-3 as Phase I. The Phase I restoration was completed in 2000 and involved dike removal in the southern portion of the project site. Deepwater Slough is adjacent to Milltown Island, another site recommended in the TSP and located on the opposite side of Steamboat Slough. Restoration of either site is not dependent on the other; restoration actions are intended to be complementary. In addition, the Skagit River General Investigation Feasibility Study is recommending flood risk management actions well upstream of the Deepwater Slough project site. Ecosystem restoration actions proposed as part of the Nearshore TSP are independent from the Skagit flood risk management recommendations.

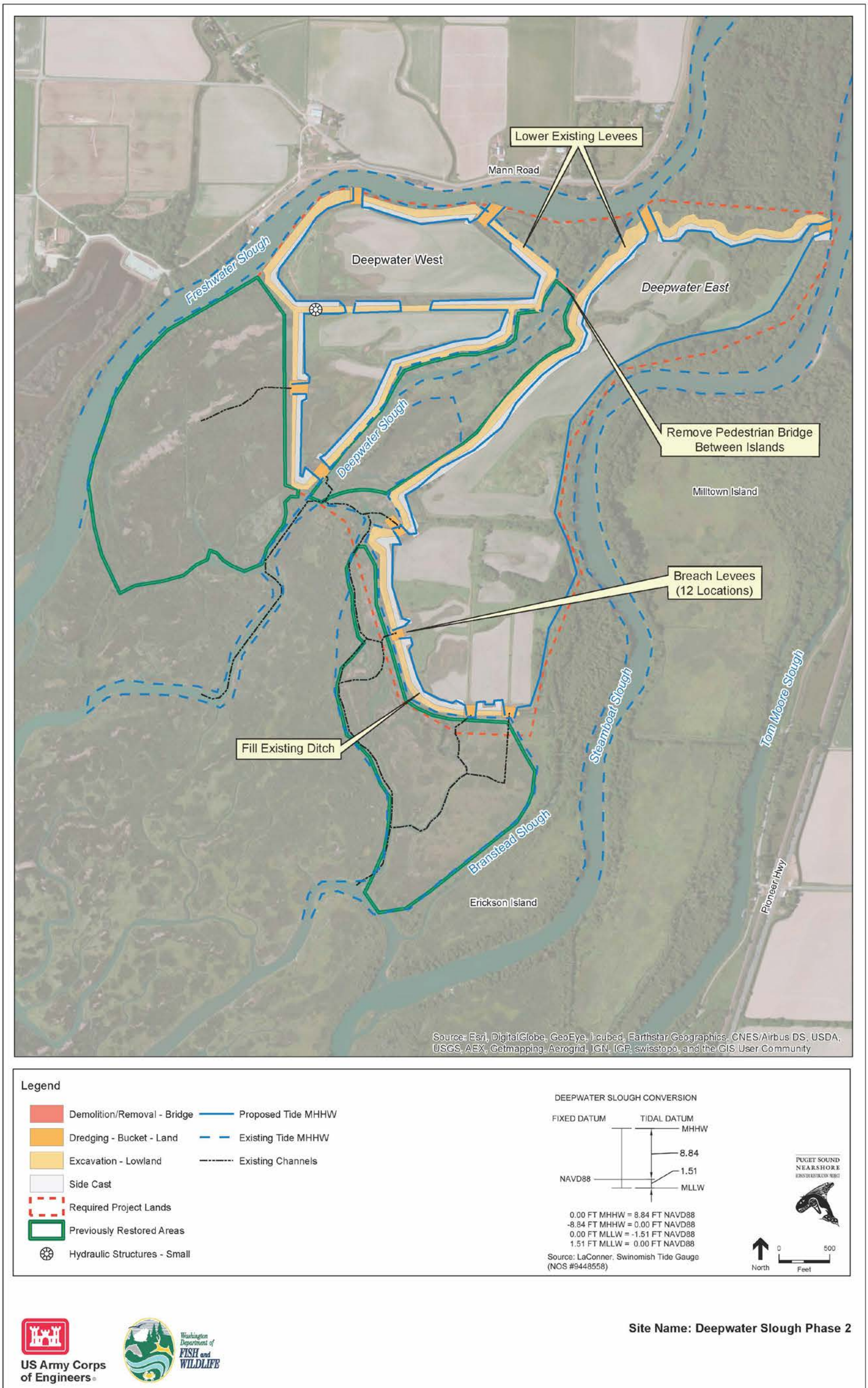
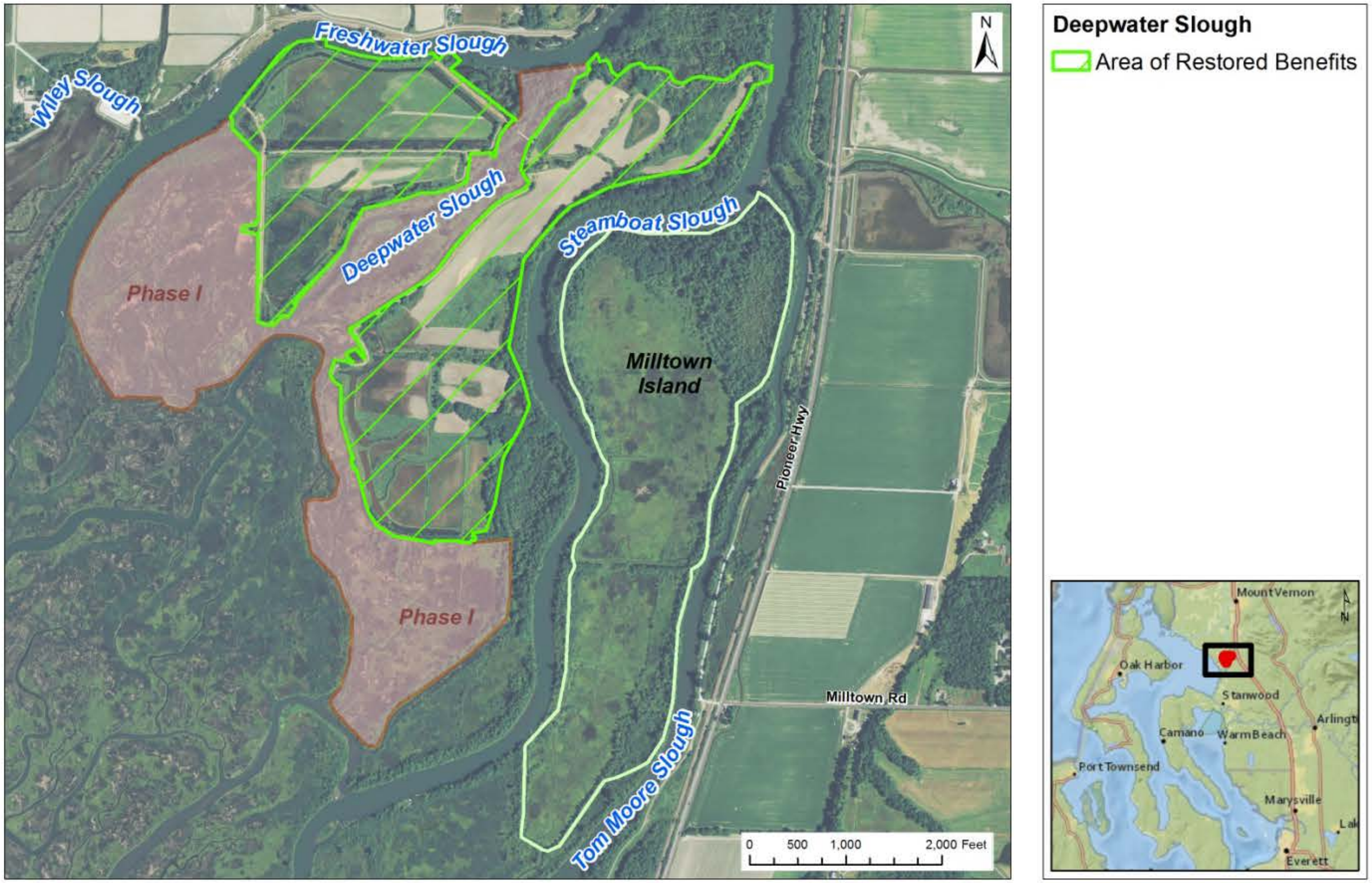


Figure 6-4. Deepwater Slough – Key Design Elements



Deepwater Slough	
Shoreform type:	Large River Delta
Processes restored:	sediment transport, freshwater input, tidal exchange, channel migration, marsh accretion, overbank deposition, natural levee formation
Species directly associated:	bald eagle, waterfowl, salmon, bull trout, steelhead
Species indirectly associated:	green sturgeon, Steller sea lion, eulachon, marbled murrelet, lamprey
ESA Critical Habitat:	Chinook salmon, bull trout
Acres of wetlands restored:	270

Restored Benefits:
Deepwater Slough

Figure 6-5. Restoration Benefits at Deepwater Slough

6.2.3 Deer Harbor Estuary

Deer Harbor includes the largest estuary on Orcas Island. The Cayou Valley Lagoon, also known as Deer Harbor Lagoon or Slough, is an open coastal inlet north of the Channel Road bridge. Tidal flushing from the larger bay into the northern inlet is limited by fill and Channel Road bridge armoring. These constrain the inlet mouth to less than half its historical width. This constriction altered the tidal prism and freshwater flows leading to sedimentation and loss of intertidal marsh, mudflats, and tidal channels. The proposed Deer Harbor Estuary restoration entails widening the inlet mouth to allow full tidal flushing and freshwater flows, restoring 16 acres of tidally influenced marsh and mudflats. Fish passage will also improve in the estuary.

Ecosystem Restoration Benefits

- Restore coastal embayment that provides valuable nursery habitat for juvenile threatened salmon species, increasing survival and supporting Puget Sound population recovery
- Restore intertidal and shallow subtidal habitat areas for recreationally- and culturally-important shellfish
- Re-establish intertidal and shallow subtidal areas to encourage kelp and eelgrass growth, increasing nearshore productivity for fish, birds, and other marine species
- Improve estuary water quality

Significance

- Restoring the largest estuary on Orcas Island will support young fish from many nearby river systems
- Restoration will support native oyster beds
- As the only San Juan County site, it improves the TSP's geographic scope

Key Design Elements

The restoration will return the estuary width opening to predevelopment conditions. It entails removing the existing 50-foot timber Channel Road bridge including fill and riprap under it. A new 110-foot long bridge across the estuary opening allows for complete tidal exchange, sediment supply and transport, and natural tidal channel formation. Figure 6-6 depicts the key design elements at Deer Harbor Estuary.

Site Summary Statistics

- Acres: 16
- Total Project Cost: $8.2 M

As Figure 6-7 depicts, this site restores several processes including tidal exchange, tidal channel formation, inlet formation, marsh accretion, sediment transport, freshwater inflow, and estuarine mixing. Restoration of this site provides benefits to ESA critical habitat for Chinook salmon as well as direct benefits to bald eagles, forage fish, salmon, and eelgrass.

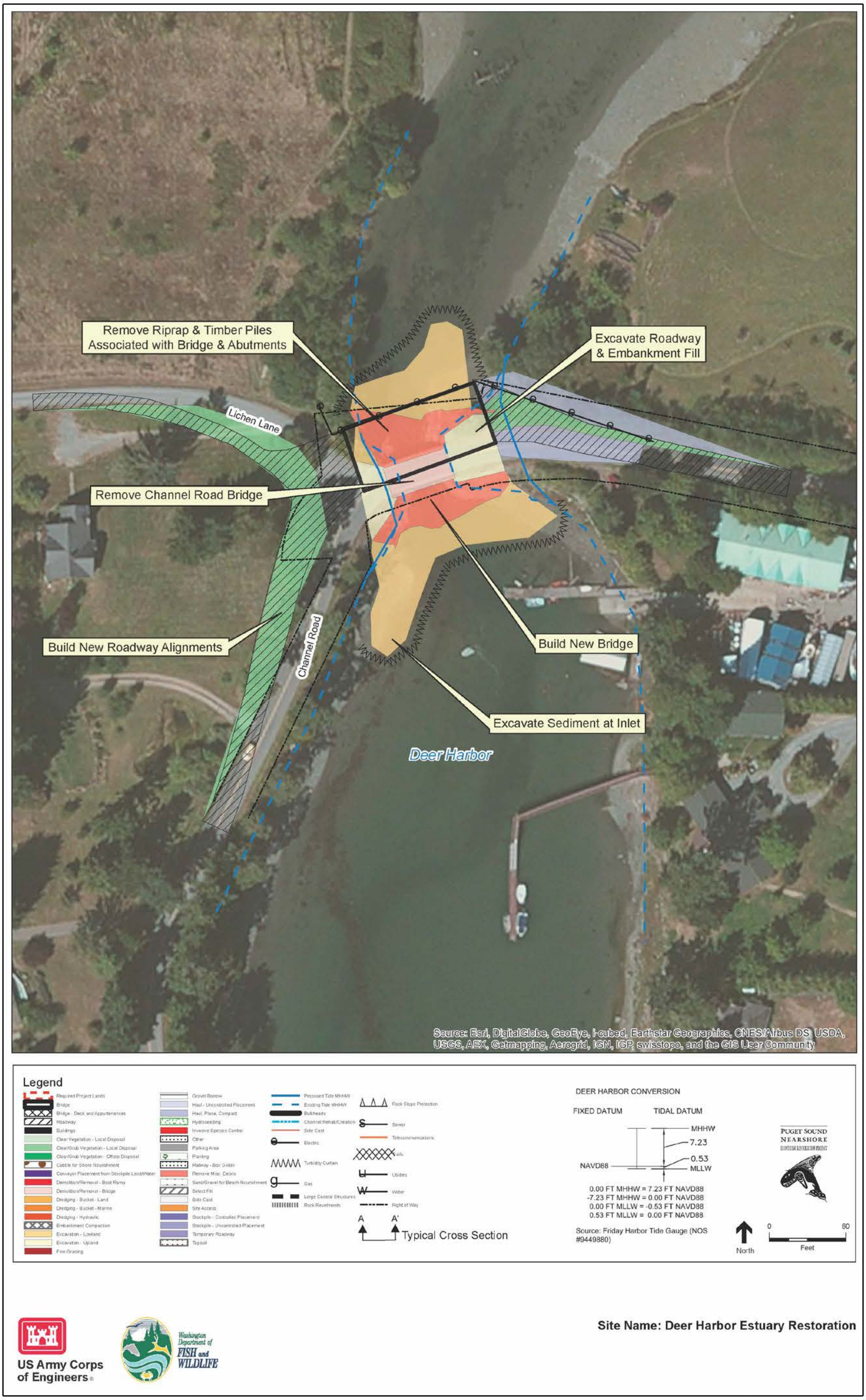
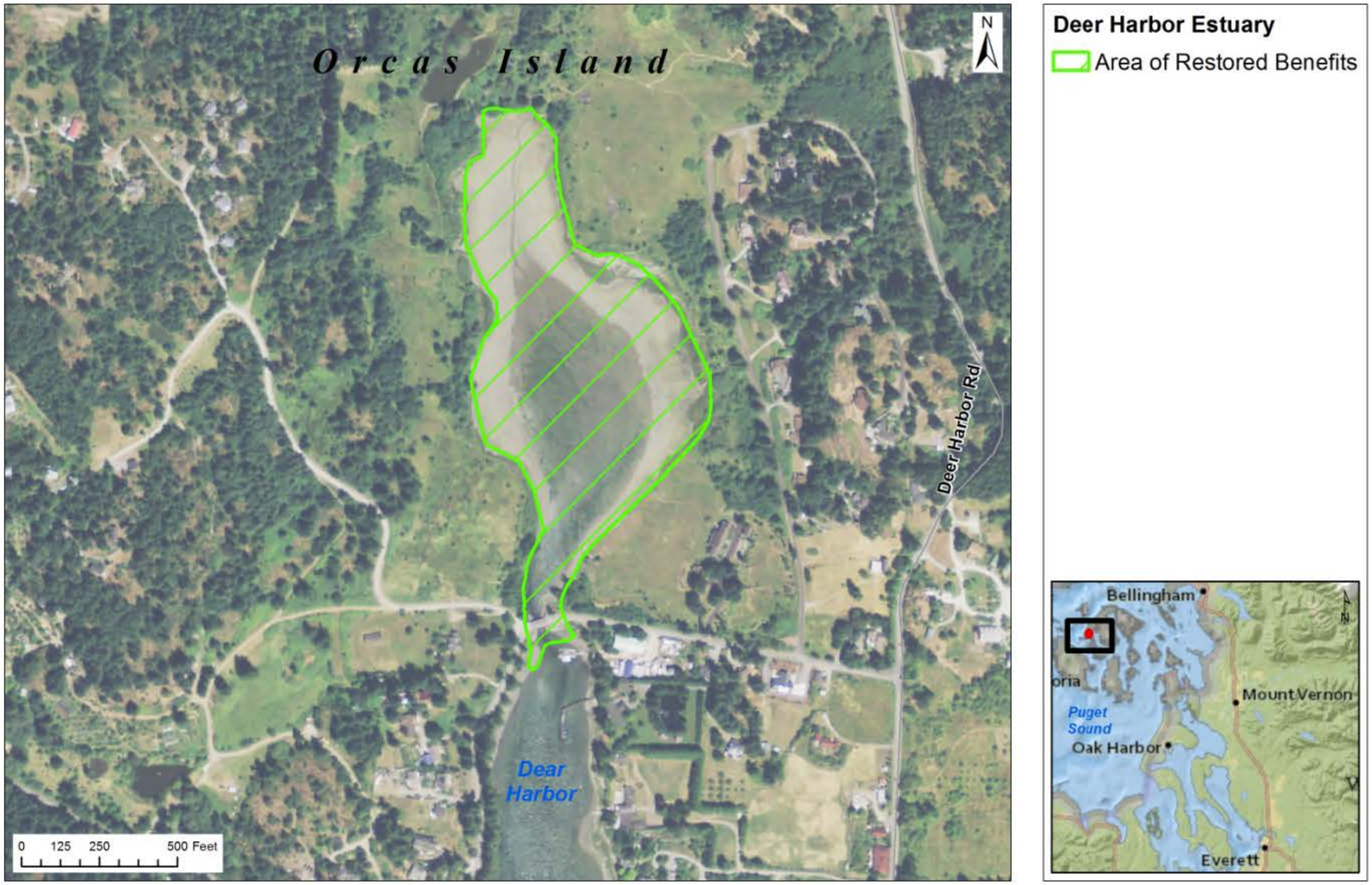


Figure 6-6. Deer Harbor Estuary – Key Design Elements



Deer Harbor Estuary	
Shoreform type:	Open Coastal Inlet
Processes restored:	tidal exchange, tidal channel formation, inlet formation, marsh accretion, sediment transport, freshwater inflow, estuarine mixing
Species directly associated:	bald eagle, forage fish, salmon, eelgrass
Species indirectly associated:	eelgrass, crabs, geoduck, oysters, clams, flatfish, harbor seals, great blue heron, shorebirds, waterfowl
ESA Critical Habitat:	Chinoook salmon
Acres of wetlands restored:	16

Restored Benefits:
Deer Harbor Estuary

Figure 6-7. Restoration Benefits at Deer Harbor Estuary

6.2.4 Dugualla Bay

Dugualla Bay is located on northeast Whidbey Island in western Skagit Bay. The action area includes part of Naval Air Station Whidbey Island, Dugualla Lake and the lower Dugualla Creek. A former estuary and salt marsh, the area is now separated from Dugualla Bay's marine waters by Dike Road, a causeway that functions as a levee. To create agricultural land, the causeway, a tide gate and pump station system were built at the historic barrier embayment inlet. This eliminated tidal inundation, converting the estuary into freshwater Dugualla Lake and restricting fish access from Puget Sound. The proposed restoration will remove tidal hydrology barriers in Dugualla Bay, allowing tidal exchange between Dugualla Lake and bay, restoring 572 acres of salt marsh and mudflats. It also improves connection with the surrounding floodplain and allows fish to access the system.

Ecosystem Restoration Benefits

- Restore coastal embayment that provides valuable nursery habitat for juvenile threatened salmon species increasing their survival and supporting Puget Sound population recovery
- Restore intertidal and shallow subtidal areas for recreationally- and culturally-important shellfish
- Increase shoreline area, length and complexity

Significance

- Provides critical estuary habitat in the Whidbey basin, where about 80 percent of estuary habitat is no longer accessible
- Included in Puget Sound Chinook Salmon Federal Recovery Plan
- Site will be used by roughly half of the out migrating North Fork Skagit juvenile salmon
- Adds more than five times the shoreline length to existing, available nearshore habitat

Key Design Elements

The restoration returns historical tidal inundation to Dugualla Bay by removing the tide gate and pumping system, excavating a starter channel, and allowing tidal flow into the existing lake. Two barrier beaches, historically defining the tidal channel entrance, will be created and a new 750-foot-long bridge will allow vehicle passage along Dike Road. Portions of the road will be raised out of the newly inundated floodplain. A 200-foot-long bridge will replace a culvert under State Route 20. Figure 6-8 depects the key design elements at Dugualla Bay.

Site Summary Statistics

- Acres: 572
- Total Project Cost: $92.2 M

As Figure 6-9 depicts, this site restores a number of processes including tidal exchange, tidal channel formation, inlet formation, marsh accretion, sediment transport, freshwater inflow, and estuarine mixing. Restoration of this site provides benefits to ESA critical habitat for Chinook salmon and bull trout as well as direct benefits to clams, crabs, oysters, flatfish, great blue herons, and shorebirds.

The US Fish and Wildlife Service (2011) report on the preliminary environmental contaminant evaluation reported that lead was detected in sediment samples collected from Dugualla Lake (outside of the proposed project footprint) with concentrations below the MTCA Method A cleanup standard. One site is on the WDOE Confirmed and Suspected Contaminated Sites list and the Hazardous Sites list. Additionally, this project site is near the Whidbey Naval Air Station. It is not known what retrofits may be required at the Naval Air Station to accommodate the site restoration; additional coordination between the Nearshore Study, non-Federal sponsor, and the Naval Air Station will need to occur before site designs are finalized.

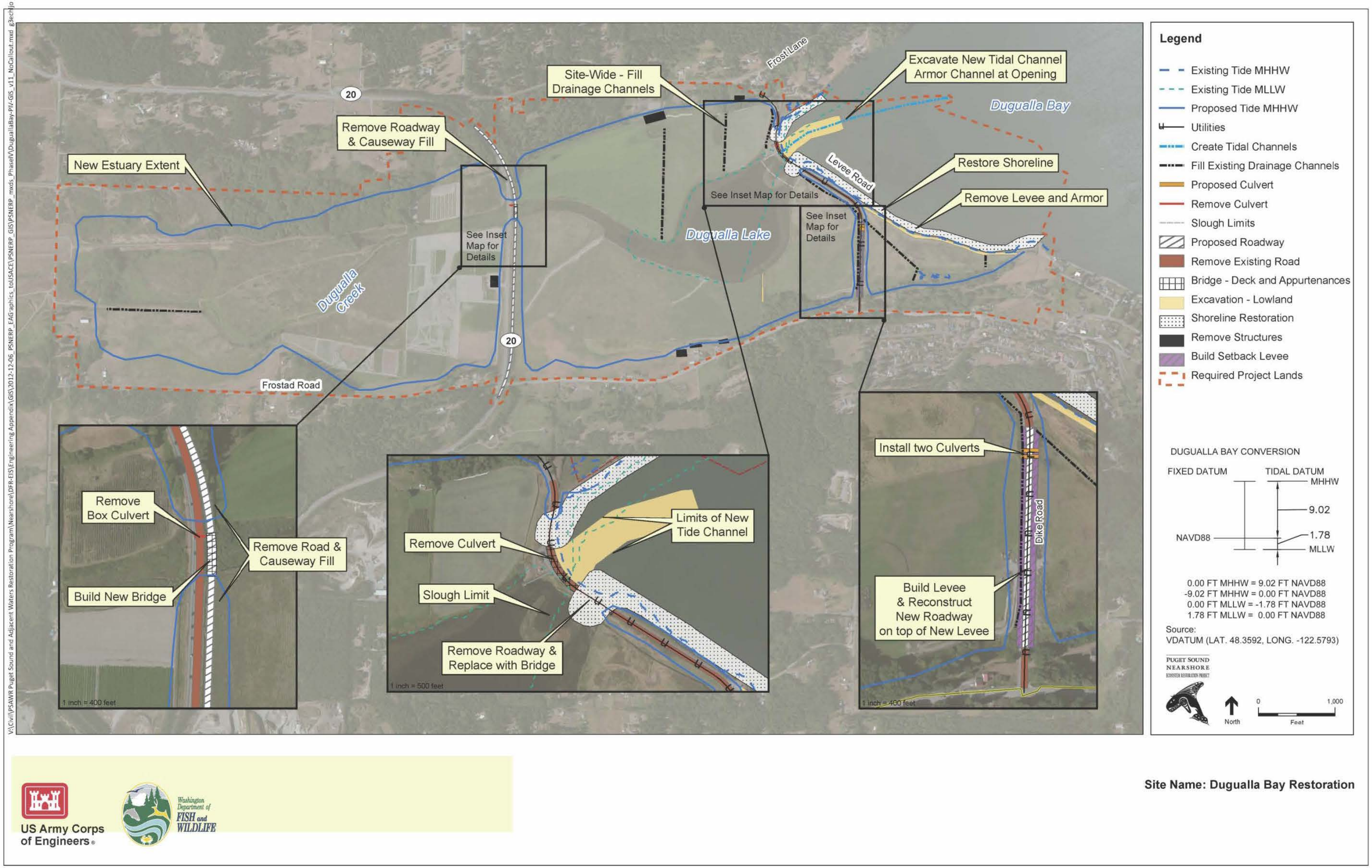
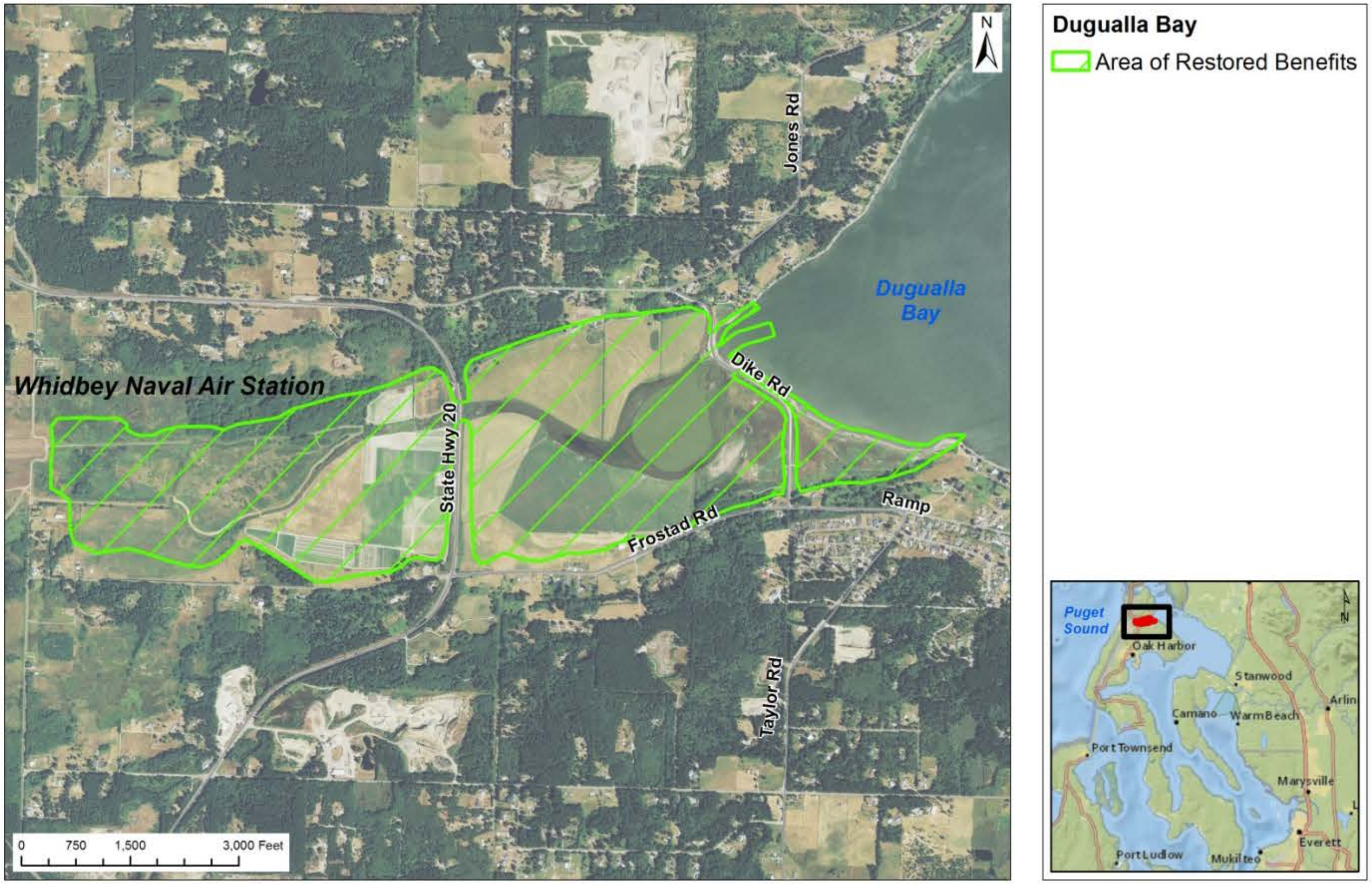


Figure 6-8. Dugualla Bay – Key Design Elements



Dugualla Bay	
Shoreform type:	Barrier Embayment
Processes restored:	tidal exchange, tidal channel formation, inlet formation, marsh accretion, sediment transport, freshwater inflow, estuarine mixing
Species directly associated:	bald eagle, waterfowl, forage fish, cutthroat trout, eelgrass
Species indirectly associated:	clams, crabs, oysters, flatfish, great blue heron, shorebirds
ESA Critical Habitat:	Chinook salmon, bull trout
Acres of wetlands restored:	572

Restored Benefits:
Dugualla Bay

Figure 6-9. Restoration Benefits at Dugualla Bay

6.2.5 Everett Marshland

The Everett Marshland site is located along Snohomish River's west bank near the Ebey Slough fork. Most of the site is within Everett city limits. Although in the river's 100-year floodplain, the action area is completely cut off from tidal hydrology by levees and drainage structures installed to support agricultural land use. The area is also bisected by the Burlington Northern Santa Fe (BNSF) railroad running generally northwest and southeast, with utility corridors running east and west. This project restores tidal hydrology and channel-forming processes to 829 acres of tidal freshwater wetlands, reconnecting the site to the Snohomish River. This is accomplished by relocating levees and roadways, altering and filling drainage canals, restoring tidal channels and reconnecting streams to the tidal area.

Ecosystem Restoration Benefits

- Restore highly productive tidal freshwater wetland habitats that support biodiversity and provide connectivity between land and sea
- Restore large river delta that provides valuable nursery habitat for juvenile threatened salmon, increasing their survival and supporting Puget Sound population recovery
- Improve estuary water quality
- Increase shoreline area, length and complexity
- Improve resiliency of the shoreline to respond to changes in the environment such as rising sea levels and increasing storm events

Significance

- More than 80 percent of the Snohomish estuary is leveed, with only 18 percent of historical wetlands remaining
- Provides floodplain forest and swamp wetlands, the most absent from the Snohomish system, and critical for out-migrating fish.
- Located on the Snohomish River's mainstem, the site will benefit all out-migrating fish
- Builds on previous Federal, state, tribal, local and non-government restoration investments, including Corps projects at Qwuloolt and Union Slough.
- Included in Puget Sound Chinook Salmon Federal Recovery Plan
- Adds more than three times the shoreline length to existing, available nearshore habitat

Key Design Elements

The restoration removes 1.5 miles of levee along the Snohomish River and Lowell-Snohomish River Road, which re-introduces tidal influence to diked farmlands. The road will align with the BNSF railroad and multiple new bridges will allow tidal flow beneath the road and railroad embankment. The Marshland Pump Station and flood gates will relocate to the site's south end.

Excavation of multiple starter channels in the area will initiate tidal slough channel development. New levees will protect regional transmission lines and gas pipelines west of BNSF's railroad. Figure 6-10 depicts the key design elements at Everett Marshland.

Site Summary Statistics

- Acres: 829
- Total Project Cost: $328 M

As Figure 6-11 depicts, this site restores several processes including sediment transport, freshwater input, tidal exchange, channel migration, marsh accretion, overbank deposition, and natural levee formation. Restoration of this site provides benefits to ESA critical habitat for Chinook salmon and bull trout as well as direct benefits to green sturgeon, Steller sea lion, eulachon, marbled murrelets, and lamprey.

There are two clean-up sites near the project footprint that are listed in the WDOE cleanup database: The Rotary Park site is located on both sides of Lowell Snohomish River Road; the Rotary Park public site boundaries are known but the location of a former creosote plant and suspected landfill boundaries within this site are unknown. The Simpson Paper Company Pulp Plant is located to the north of the project area and is under commercial and residential development as Riverside Redevelopment. Both sites are outside the current project footprint.

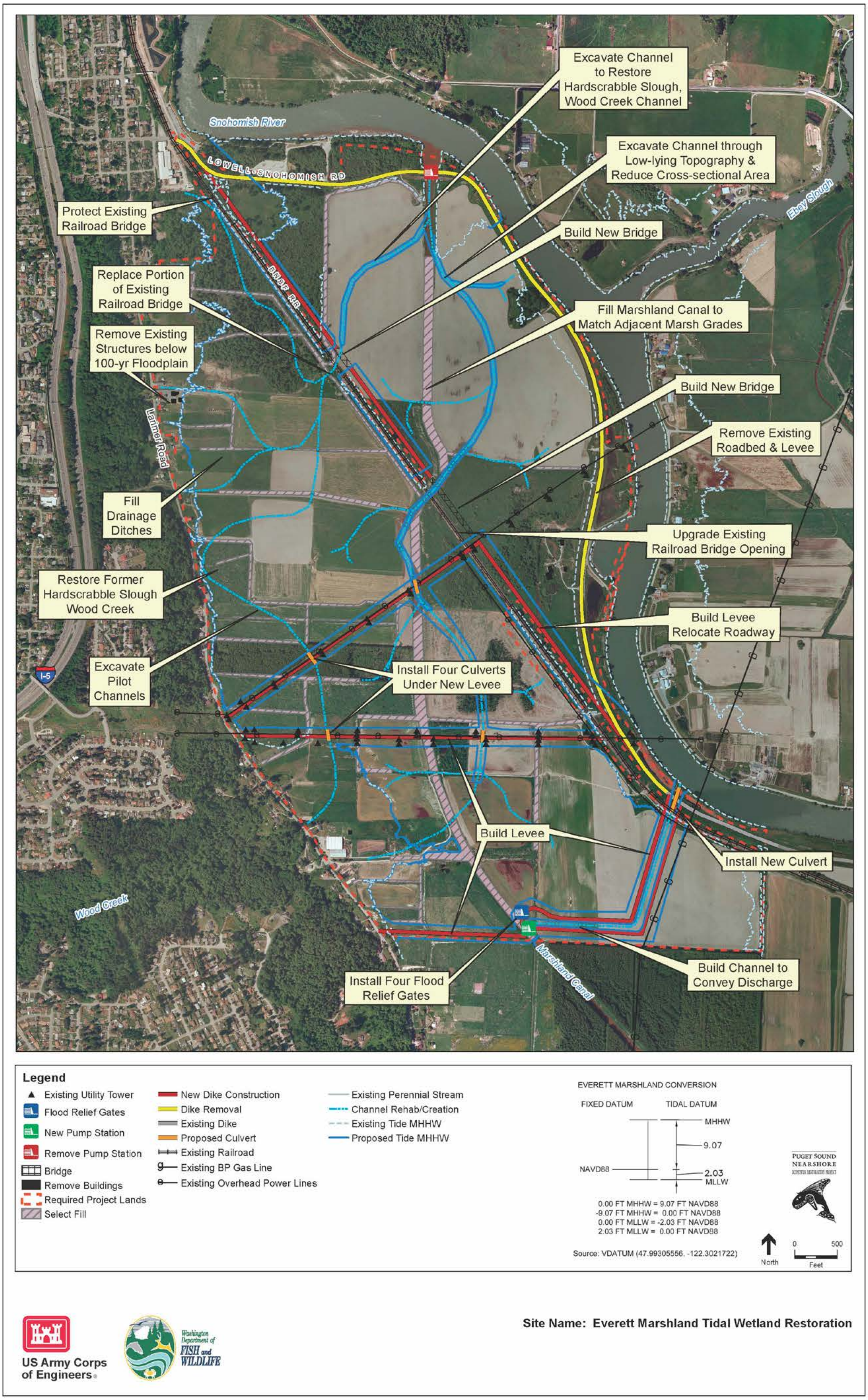
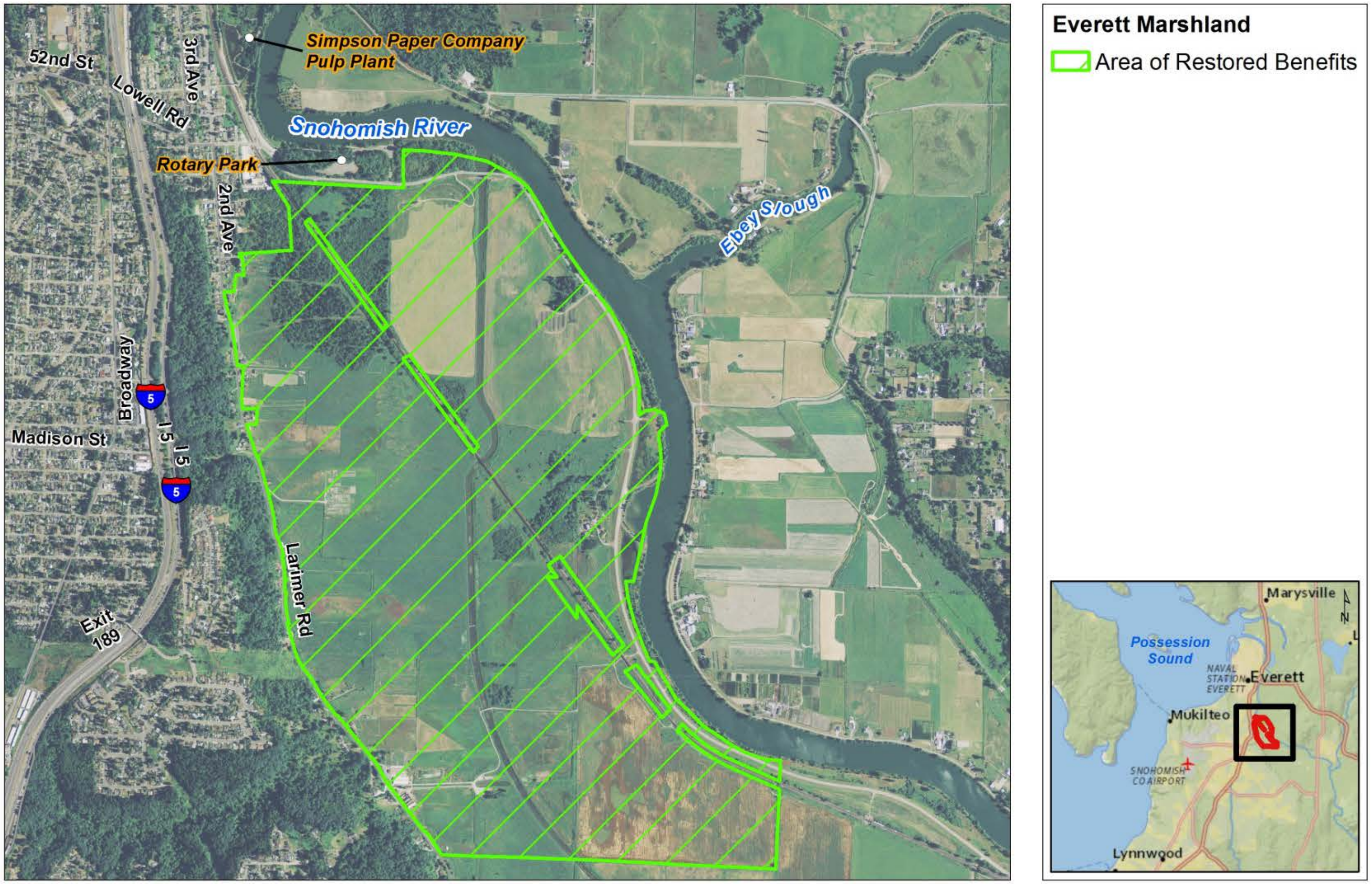


Figure 6-10. Everett Marshland – Key Design Elements



Everett Marshland	
Shoreform type:	Large River Delta
Processes restored:	sediment transport, freshwater input, tidal exchange, channel migration, marsh accretion, overbank deposition, natural levee formation
Species directly associated:	bald eagle, purple martin, salmon, bull trout, steelhead
Species indirectly associated:	green sturgeon, Steller sea lion, eulachon, marbled murrelet, lamprey
ESA Critical Habitat:	Chinook salmon, bull trout
Acres of wetlands restored:	829

Restored Benefits:
Everett Marshland

Figure 6-11. Restoration Benefits at Everett Marshland

6.2.6 Livingston Bay

Livingston Bay is a closed barrier embayment next to Port Susan Bay near the Stillaguamish River delta on Camano Island's southeast side. Extensive diking and drainage of Livingston Bay occurred for agricultural proposes. This blocked exchange of tidal waters, sediment and organic debris between Livingston and Port Susan Bays. Site restoration involves removing diking to open Livingston Bay to tidal flow, restoring 239 acres of tidal marsh. The action will allow exchange of sediment and organic debris, the evolution of tidal channels and fish access.

Ecosystem Restoration Benefits

- Restore coastal embayment that provides valuable nursery habitat for juvenile threatened salmon species, increasing survival and supporting Puget Sound population recovery
- Improve estuary water quality
- Increase shoreline area, length and complexity
- Improve resiliency of the shoreline to respond to changes in the environment such as rising sea levels and increasing storm events

Significance

- Provides critical estuary habitat in the Whidbey basin, where about 80 percent of estuary habitat is no longer accessible
- Included in the Puget Sound Chinook Salmon Federal Recovery Plan
- Requires minimal infrastructure to complete significant habitat improvements
- Adds more than three times the shoreline length to existing, available nearshore habitat

Key Design Elements

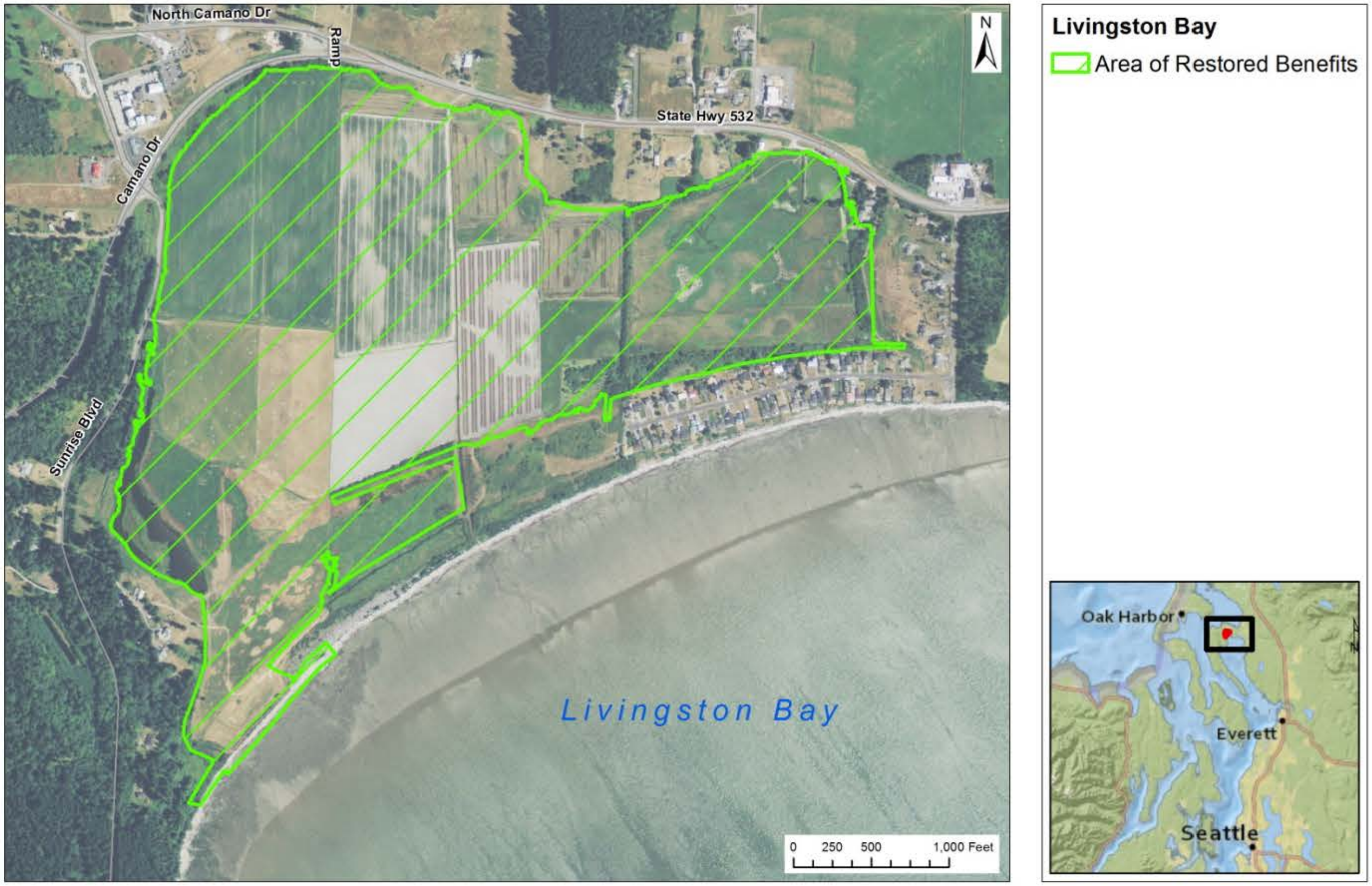
The restoration creates an opening at the western end of Livingston bay. A network of excavated starter channels will initiate tidal marsh development. Internal drainage ditches will be filled and levees lowered. A 2-foot high berm constructed along East Livingston Bay Shore Drive's north side prevents inundation of the Livingston Bay Community. Riparian vegetation will be planted on levee slopes. Figure 6-12 depicts the key design elements at Livingston Bay.

Site Summary Statistics

- Acres: 239
- Total Project Cost: $13.1 M

As Figure 6-13 depicts, this site restores several processes including tidal exchange, tidal channel formation, inlet formation, and marsh accretion. Restoration of this site provides benefits to ESA critical habitat for Chinook salmon and bull trout as well as direct benefits to bald eagles, harbor seals, waterfowl, forage fish, and eelgrass, and indirect benefits to gray whales.

Figure 6-12. Livingston Bay – Key Design Elements



Livingston Bay	
Shoreform type:	Barrier Embayment
Processes restored:	tidal exchange, tidal channel formation, inlet formation, marsh accretion
Species directly associated:	bald eagle, harbor seal, waterfowl, gray whale, forage fish, eelgrass
Species indirectly associated:	clams, crabs, oysters, flatfish, great blue heron, waterfowl
ESA Critical Habitat:	Chinook salmon, bull trout
Acres of wetlands restored:	239

Restored Benefits:
Livingston Bay

Figure 6-13. Restoration Benefits at Livingston Bay

6.2.7 Milltown Island

Milltown Island, on the South Fork Skagit River delta, is part of Washington Department of Fish and Wildlife's 17,000-acre Skagit Wildlife Area. This island was historically used for agriculture after construction of perimeter levees, a central cross levee and drainage channels. This diking hydrologically disconnected the site from the Skagit River, resulting in a loss of tidal marsh and channels. The island's southern portion, which isn't diked, consists of about 100 acres of tidal marsh. The proposed restoration action will remove sections of the perimeter levees, restoring tidal and freshwater hydrology to the island's 214-acre interior marsh. Restoring tidal and riverine processes will form, scour and expand the levee breaches and marsh channels within the island's former agricultural areas.

Ecosystem Restoration Benefits

- Restore highly-productive tidal freshwater wetland habitats, supporting biodiversity and providing land and sea connectivity
- Restore large river delta that provides valuable nursery habitat for juvenile threatened salmon species, increasing survival and supporting Puget Sound population recovery
- Improve estuary water quality

Significance

- Included in the Puget Sound Chinook Salmon Federal Recovery Plan
- Phase 2 of highly-successful Phase 1 site restoration
- Together, the Deepwater and Milltown projects complete the lower South Fork Skagit River restoration

Key Design Elements

The restoration creates three breaches in the levee on Milltown Island's west side along Steamboat Slough. Controlled blasting is proposed to create the levee openings instead of excavation. This process was used during previous Milltown Island restoration efforts. The restoration work will also excavate interior island channels focusing on the west side near the new levee breaches. Figure 6-14 depicts the key design elements at Milltown Island.

Site Summary Statistics

- Acres Restored: 214
- Total Project Cost: $4 M

As Figure 6-15 depicts, this site restores several processes including sediment transport, freshwater input, tidal exchange, channel migration, marsh accretion, overbank deposition, and natural levee formation. Restoration of this site provides benefits to ESA critical habitat for

Chinook salmon and bull trout as well as direct benefits to green sturgeon, Steller sea lion, eulachon, marbled murrelets, and lamprey.

Milltown Island is also adjacent to Deepwater Slough, another site recommended in the TSP. Restoration of either site is not dependent on the other; restoration actions are intended to be complementary. In addition, the Skagit River General Investigation Feasibility Study is recommending flood risk management actions well upstream of the Milltown Island project site. Ecosystem restoration actions proposed as part of the Nearshore TSP are independent from the Skagit flood risk management recommendations.

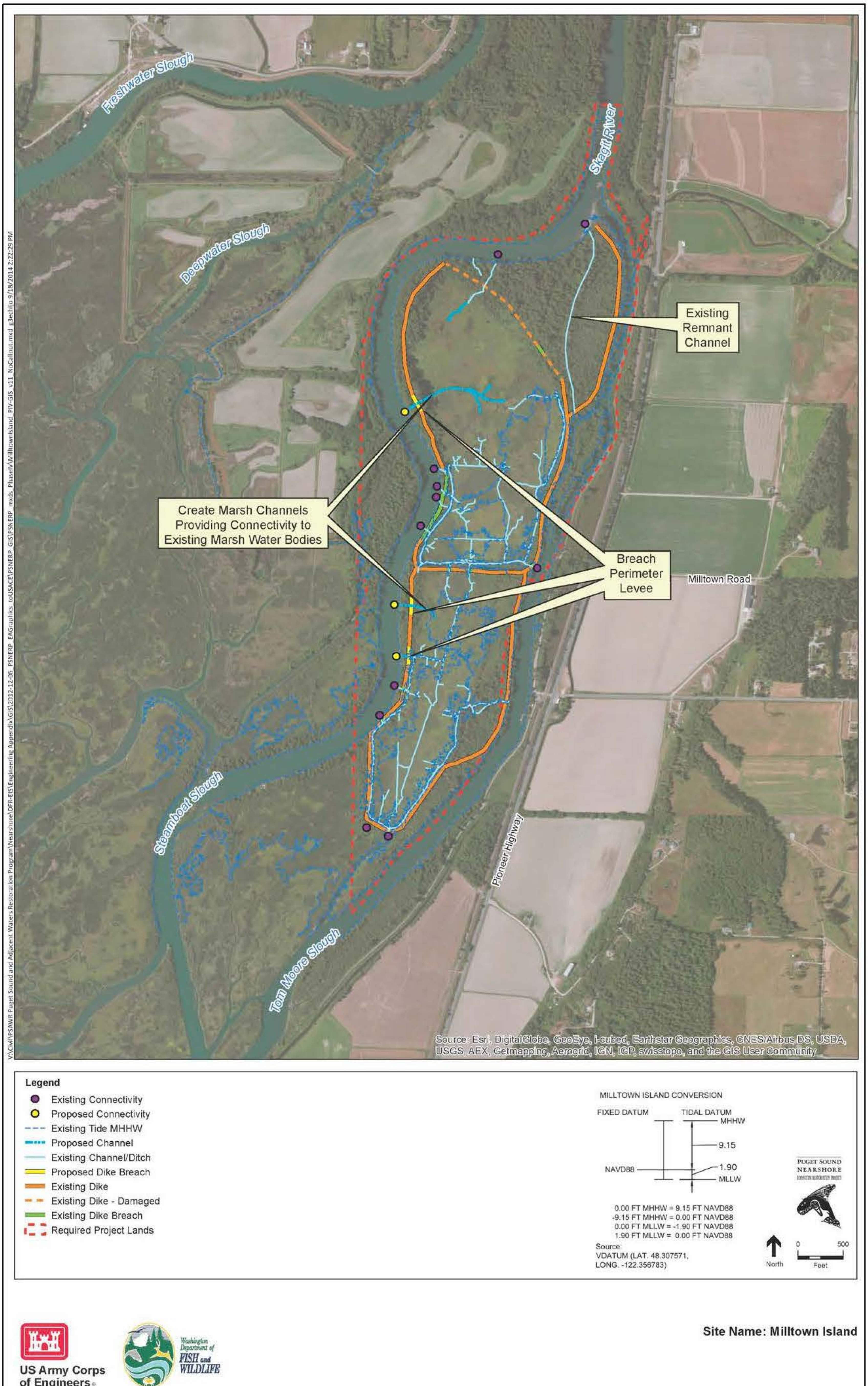
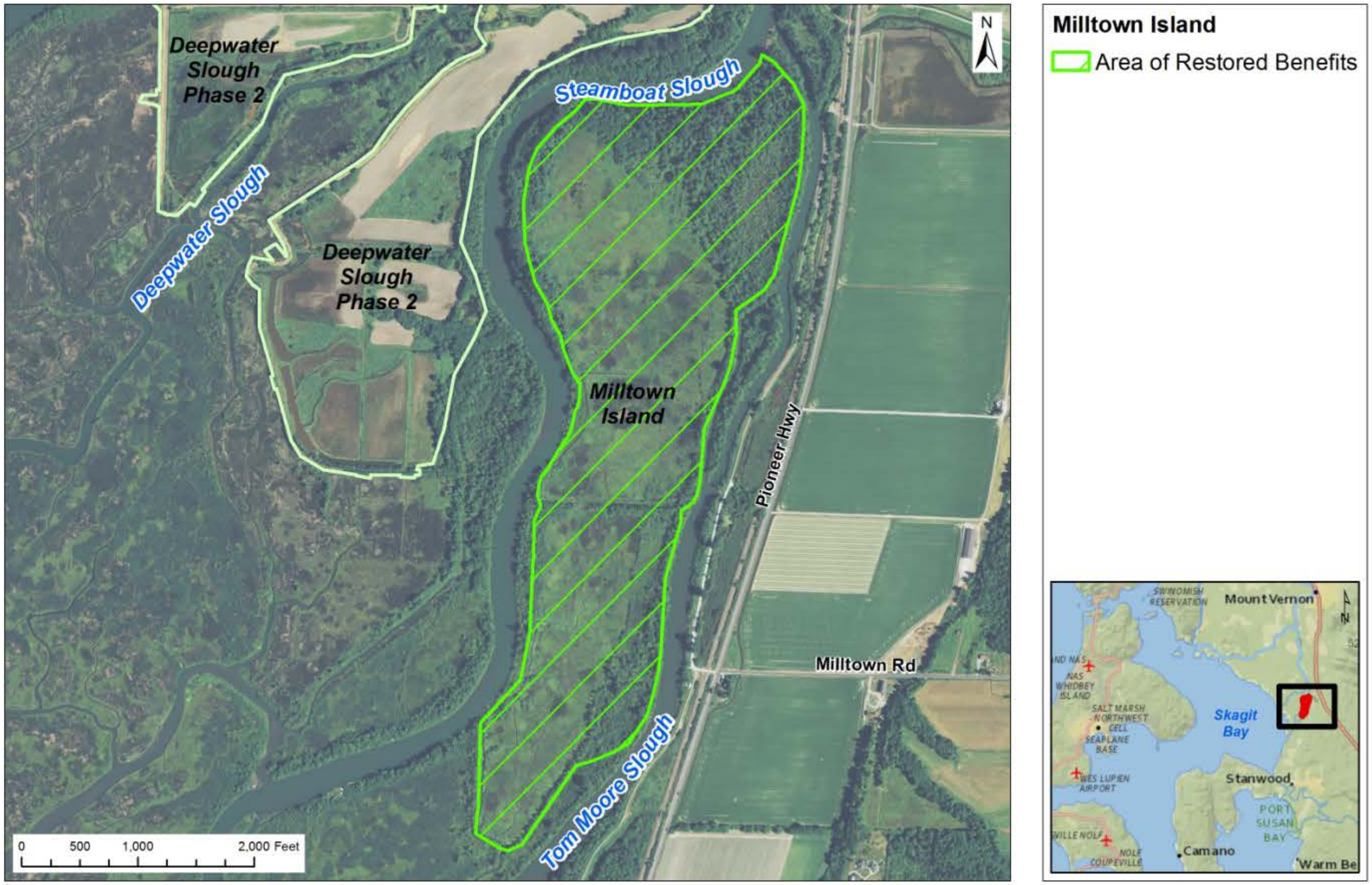


Figure 6-14. Milltown Island – Key Design Elements



Restored Benefits:
Milltown Island

Milltown Island	
Shoreform type:	Large River Delta
Processes restored:	sediment transport, freshwater input, tidal exchange, channel migration, marsh accretion, overbank deposition, natural levee formation
Species directly associated:	bald eagle, salmon, bull trout, steelhead,
Species indirectly associated:	green sturgeon, Steller sea lion, eulachon, marbled murrelet, lamprey
ESA Critical Habitat:	Chinook salmon, bull trout
Acres of wetlands restored:	214

Figure 6-15. Restoration Benefits at Milltown Island

6.2.8 Nooksack River Delta

The Nooksack River delta is located on the Lummi Nation lands north of Bellingham, Wash. It includes nearly all of the Nooksack and Lummi River estuaries below Ferndale, Wash. The Nooksack and Lummi River flow paths have been modified since the mid-19th century, beginning with active removal of large wood, draining, diking and levee construction. Today, substantial surface water diversions, groundwater withdrawals and drainage activities within the Nooksack River watershed impact the magnitude, timing and duration of delta surface water flows. The proposed restoration modifies levees, roads and other hydrological barriers, restoring delta riverine and tidal flow, as well as sediment transport and delivery processes. All told, it restores 1,807 acres of scarce tidal freshwater wetlands. The restoration complements, but doesn't depend on, the proposed Lummi Nation Wetland and Habitat Bank project (Lummi Nation 2008). Mitigation bank features are not included in the proposed Federal project footprint.

Ecosystem Restoration Benefits

- Restore large river delta that provides valuable nursery habitat for juvenile threatened salmon species, increasing survival and supporting Puget Sound population recovery
- Re-establish intertidal and shallow subtidal areas to encourage kelp and eelgrass growth, increasing nearshore productivity for fish, birds and other marine species
- Improve connectivity to nearshore and adjacent uplands
- Increase shoreline area, length and complexity
- Improve resiliency of the shoreline to respond to changes in the environment such as rising sea levels and increasing storm events

Significance

- Builds on Lummi Nation's existing, planned mitigation bank projects to restore the delta
- Strong tribal support for Nooksack Delta restoration
- Central to Whatcom County's comprehensive approach to managing flooding and restoring estuary habitat in the lower Nooksack River
- Supports Puget Sound Chinook Salmon Recovery Plan
- Provides 25 percent of Puget Sound Action Agenda's 2020 estuarine habitat recovery goal in a single project

Key Design Elements

The restoration includes partial levee removal along both Nooksack River banks and levee construction on North Red River Road. The Lummi River channel will be dredged and graded to reconnect it to Nooksack River flows. Old agricultural ditches will be filled and tidal channels recreated. Several roads will be raised on bridges to allow more tidal flows across the delta. Figure 6-16 depicts the key design elements at the Nooksack River Delta.

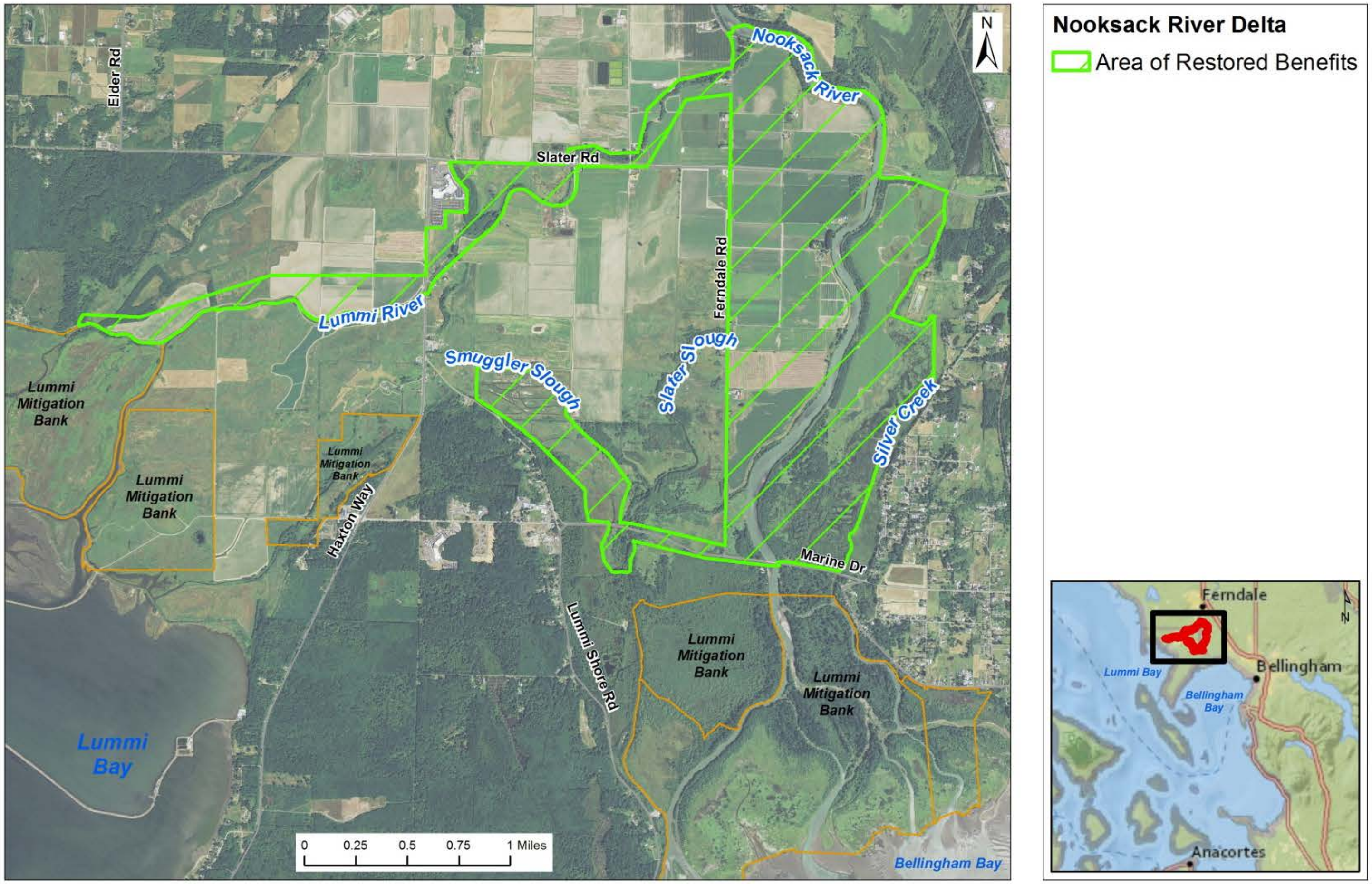
Site Summary Statistics

- Acres Restored: 1807
- Total Project Cost: $260 M

As Figure 6-17 depicts, this site restores a number of processes including sediment transport, freshwater input, tidal exchange, channel migration, marsh accretion, and longshore sediment transport. Restoration of this site provides benefits to ESA critical habitat for Chinook salmon and bull trout as well as direct benefits to peregrine falcons, bald eagles, shorebirds, waterfowl, crabs, forage fish, salmon, and eelgrass.

The restoration is intended to complement, but not depend on, the implementation of the proposed Lummi Nation Wetland and Habitat Bank (Lummi Nation 2008). The mitigation bank features would be constructed by the Lummi Nation and would not be implemented as part of a federally funded restoration project; mitigation bank features are not included in the proposed Federal project footprint. Additional analysis and coordination will occur to confirm the boundaries and requirements of the mitigation bank and to ensure no ecosystem restoration features that are cost-shared in the recommended plan are located on mitigation bank lands.

Figure 6-16. Nooksack River Delta – Key Design Elements



Restored Benefits:
Nooksack River Delta

Nooksack River Delta	
Shoreform type:	Large River Delta
Processes restored:	sediment transport, freshwater input, tidal exchange, channel migration, marsh accretion, longshore sediment transport
Species directly associated:	peregrine falcon, bald eagle, shorebirds and waterfowl, crabs, forage fish, salmon, eelgrass
Species indirectly associated:	green sturgeon, Steller sea lion, eulachon, marbled murrelet, lamprey, killer whale
ESA Critical Habitat:	Chinook salmon, bull trout
Acres of wetlands restored:	1,807

Figure 6-17. Restoration Benefits at Nooksack River Delta

6.2.9 North Fork Skagit River Delta

The North Fork Skagit River empties into Skagit Bay south (downstream) from La Conner, Wash. The proposed action is located between the former Dry Slough inlet and the western levee system's end near Rawlins Road. Extensive North Fork diking caused substantial loss of tidal wetlands and associated tidal channels. River levees reduced the floodplain area and constrained the river channel. The proposed restoration builds a levee on the river's south side, restores natural levees and restores 256 acres of scarce tidal freshwater marsh.

Ecosystem Restoration Benefits

- Restore highly productive tidal freshwater wetland habitats that support biodiversity and provide connectivity between land and sea
- Restore large river delta that provides valuable nursery habitat for juvenile threatened salmon species, increasing survival and supporting Puget Sound population recovery
- Re-establish shorebird foraging and resting tidal flat habitats for large flocks of Dunlin, Great Blue Herons and other marine birds
- Improve nearshore and adjacent uplands connectivity
- Improve estuary water quality

Significance

- Included in the Puget Sound Chinook Salmon Federal Recovery Plan
- Provides habitat on the lower North Fork Skagit River, where limited restoration opportunities and estuary habitats exist
- Complements Skagit General Investigation Tentatively Selected Plan in overlapping study areas

Key Design Elements

The restoration proposal lowers 13,000 feet of levee along the North Fork Skagit River south bank. Work will remove several structures and construct a levee along Rawlins Road as well as lower 3,140 feet of levee along the north bank. Existing topography provides flood risk management without a levee on the river's north side. Breaches in the lowered levees and excavated channels allow for water to access the newly restored floodplain. Replanting lowered levees will restore a natural riparian corridor along the river. Figure 6-18 depicts the key design elements at North Fork Skagit River Delta.

Site Summary Statistics

- Acres Restored: 256
- Total Project Cost: $102.3 M

As Figure 6-19 depicts, this site restores several processes including sediment transport, freshwater input, tidal exchange, channel migration, marsh accretion, overbank deposition, and natural levee formation. Restoration of this site provides benefits to ESA critical habitat for Chinook salmon and bull trout as well as direct benefits to bald eagles, waterfowl, western toads, salmon, bull trout, and steelhead.

A single, unconfirmed report has indicated that a historic landfill or dump may exist within the project footprint. However, there are no known active cleanup sites within the project footprint and no site records listed on the WDOE clean-up site database. If future analyses (including a Phase II HTRW Assessment) indicate there are unresolvable HTRW concerns within the project area, the HTRW site will be avoided.

Finally, the Skagit River General Investigation Feasibility Study is recommending flood risk management actions well upstream of the North Fork Skagit River project site. Ecosystem restoration actions proposed as part of the Nearshore TSP are independent from the Skagit flood risk management recommendations.

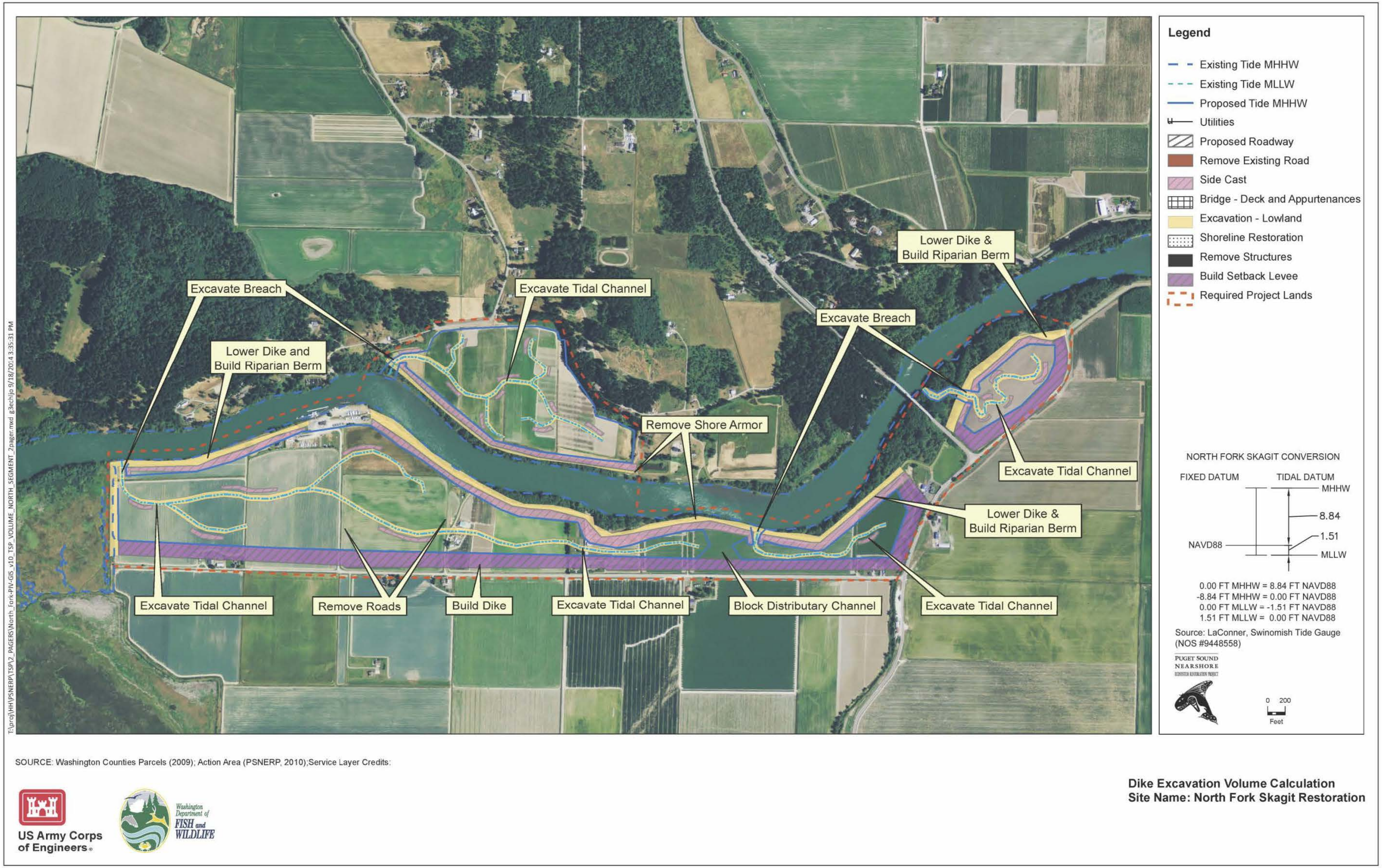
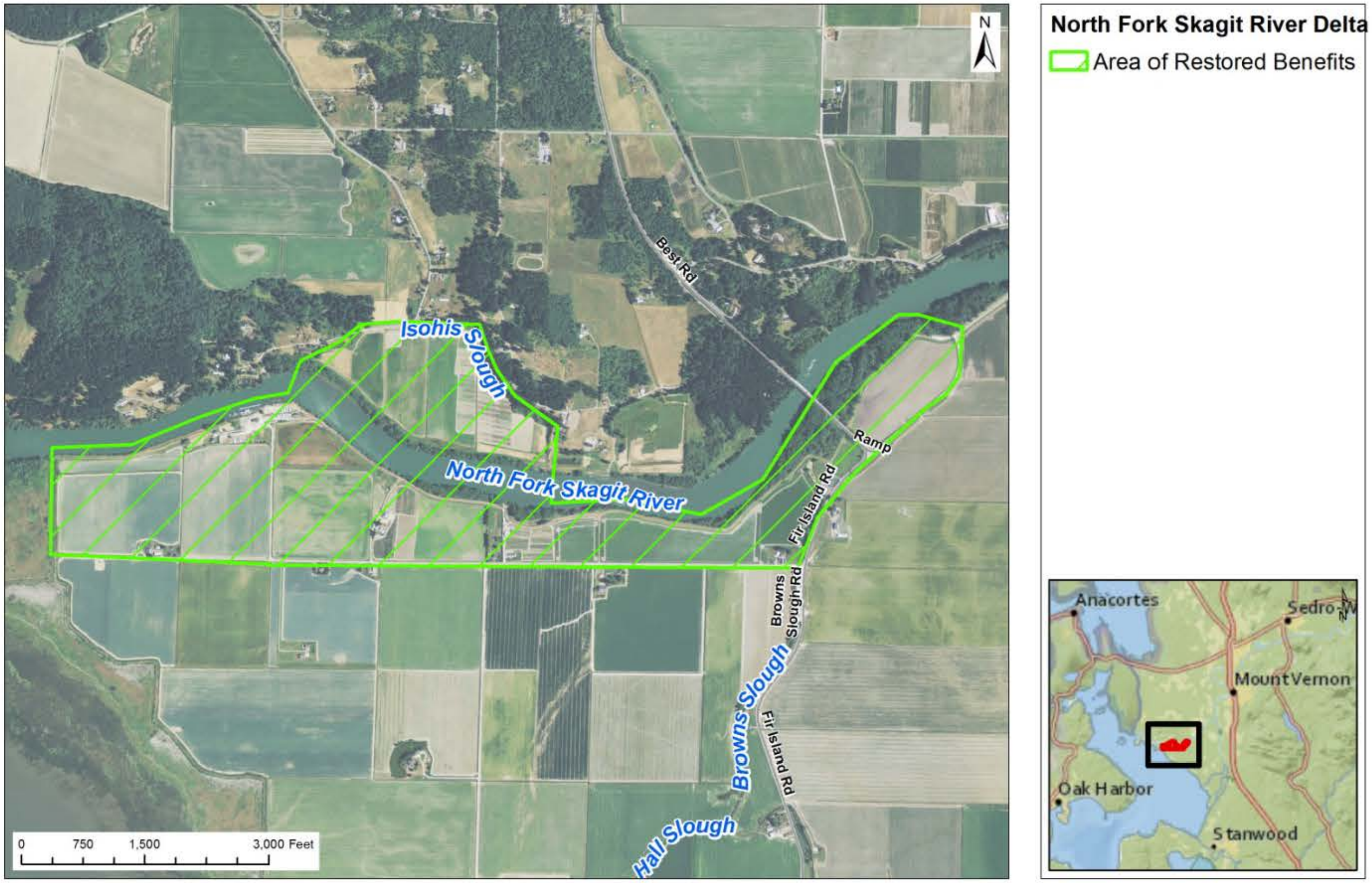


Figure 6-18. North Fork Skagit River Delta – Key Design Elements



North Fork Skagit River Delta	
Shoreform type:	Large River Delta
Processes restored:	sediment transport, freshwater input, tidal exchange, channel migration, marsh accretion, overbank deposition, natural levee formation
Species directly associated:	bald eagle, waterfowl, western toad, salmon, bull trout, steelhead
Species indirectly associated:	green sturgeon, Steller sea lion, eulachon, marbled murrelet, lamprey
ESA Critical Habitat:	Chinook salmon, bull trout
Acres of wetlands restored	256

Restored Benefits:
North Fork Skagit River Delta

Figure 6-19. Restoration Benefits at North Fork Skagit River Delta

6.2.10 Spencer Island

Spencer Island is located in the Snohomish River estuary between Union and Steamboat Sloughs near Everett, Wash. Diking and drainage for grazing has lead to the loss of tidally influenced wetlands and distributary channels. Existing levees, with current small levee breaches, and an existing field drainage system prevented full tidal hydrology restoration and tidal channel network development. Snohomish County and Washington Department of Fish and Wildlife manage the site as a popular undeveloped recreation park and wildlife management area. The proposed action lowers and breaches levees, restoring full estuarine processes and seasonal riverine flooding. Restoration actions will reestablish conditions necessary to recreate 213 acres of rare tidal freshwater marsh.

Ecosystem Restoration Benefits

- Restore large river delta that provides valuable nursery habitat for juvenile threatened salmon species, increasing survival and supporting Puget Sound population recovery
- Restore highly productive tidal freshwater wetland habitats that support biodiversity and provide connectivity between land and sea
- Improve estuary water quality
- Improve public access to shore and recreational opportunities

Significance

- Completes previous restoration work and complements other slough system restoration work
- Included in the Puget Sound Chinook Salmon Federal Recovery Plan
- Restored wetland area provides Trumpeter Swan habitat and filtration of agricultural pollutants

Key Design Elements

The restoration expands two existing levee breaches and adds a third, allowing more tidal flow to enter the island interior. The interior island tidal channel network should form over time with the increased tidal prism. Existing Steamboat and Union Slough levees will be lowered and planted to create a riparian woodland corridor. A pedestrian bridge will be replaced across the Union Slough southern breach to maintain the existing public access trail. Figure 6-20 depicts the key design elements at Spencer Island.

Site Summary Statistics

- Acres Restored: 313
- Total Project Cost: $6.5 M

As Figure 6-21 depicts, this site restores several processes including sediment transport, freshwater input, tidal exchange, channel migration, marsh accretion, overbank deposition, and natural levee formation. Restoration of this site provides benefits to ESA critical habitat for Chinook salmon and bull trout as well as direct benefits to great blue herons, bald eagles, waterfowl, salmon, bull trout, and steelhead.

The Spencer Island site is adjacent to the Union Slough Continuing Authorities Program (CAP) Section 1135 Project. Restoration of either site is not dependent on the other; restoration actions are intended to be complementary. In addition, removal and breaching of dikes at Spencer Island is not anticipated to have an adverse impact on the tidal exchange necessary for restoration at the Union Slough site.

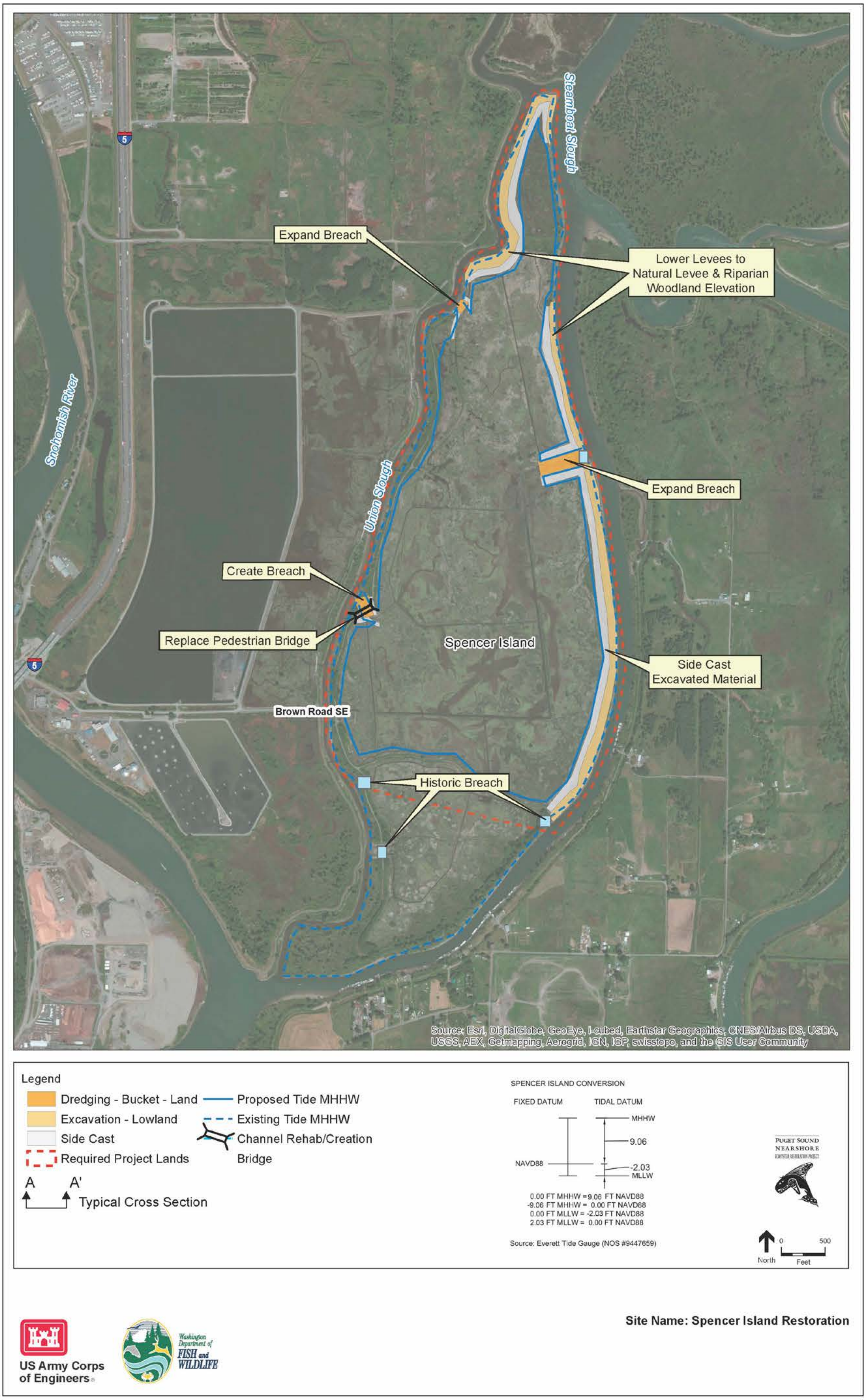
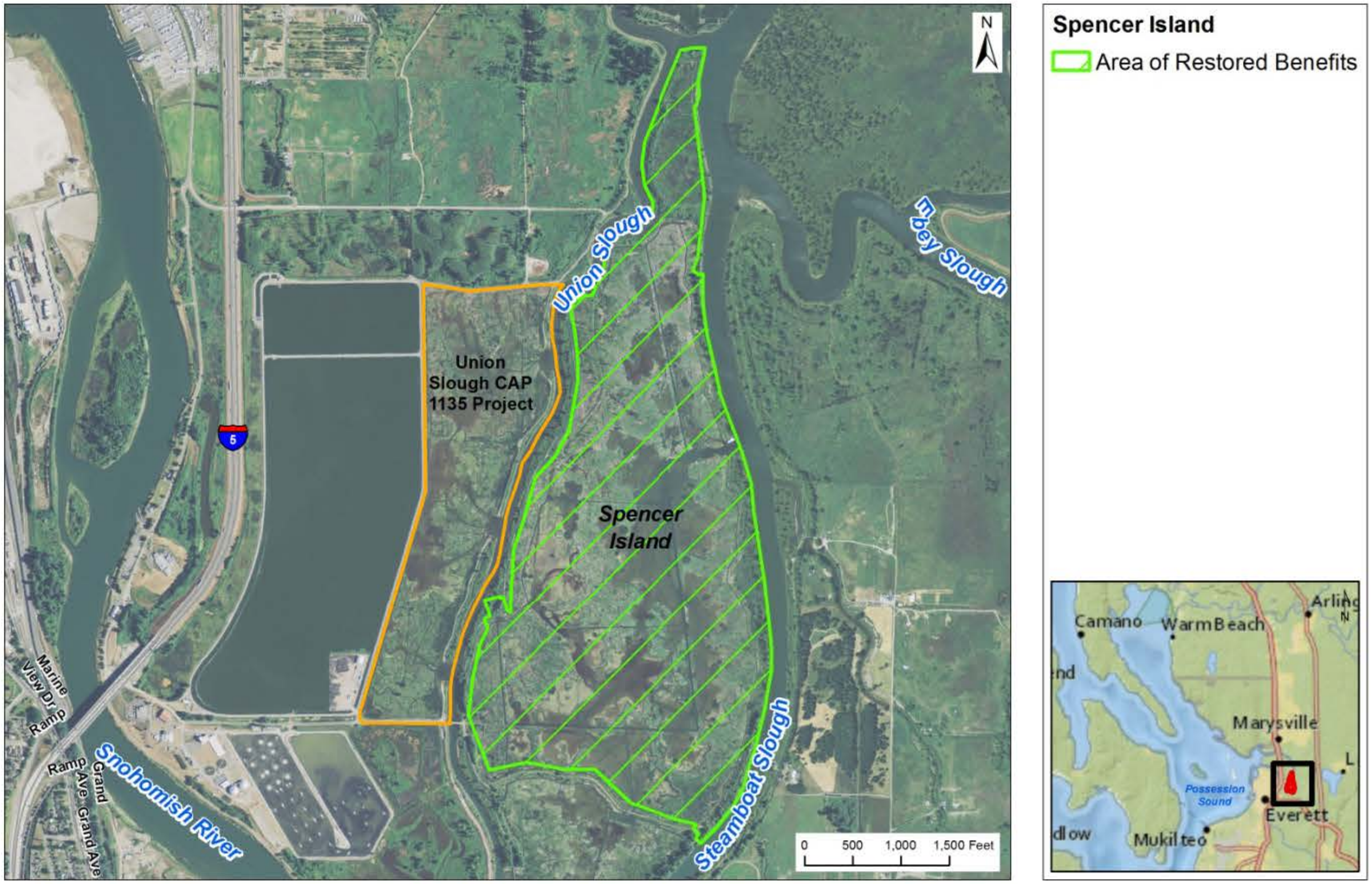


Figure 6-20. Spencer Island – Key Design Elements



Spencer Island	
Shoreform type:	Large River Delta
Processes restored:	sediment transport, freshwater input, tidal exchange, channel migration, marsh accretion, overbank deposition, natural levee formation
Species directly associated:	great blue heron, bald eagle, waterfowl, salmon, bull trout, steelhead
Species indirectly associated:	green sturgeon, Steller sea lion, eulachon, marbled murrelet, lamprey
ESA Critical Habitat:	Chinook salmon, bull trout
Acres of wetlands restored:	313

Restored Benefits:
Spencer Island

PUGET SOUND NEARSHORE

Figure 6-21. Restoration Benefits at Spencer Island

6.2.11 Telegraph Slough

Telegraph Slough is located in a diked area between Swinomish Channel and Padilla Bay. Major regional road and railway transportation and utility infrastructure bisects the site in an east and west direction. Tidal influence, blocked by State Route 20 and adjacent BNSF railroad, is limited to a small historical slough remnant north of the highway. South of this highway, Telegraph Slough and three other distributary channels are cutoff from Swinomish Channel and Padilla Bay. A series of tide gates drain the Slough's south portion to the Swinomish Channel. Most of the land outside public road rights-of-way is privately owned and in agricultural use or largely abandoned. Levees turned the area into a freshwater marsh, dominated by invasive species in the south and limited salt marsh and mudflat area north of State Route 20. This project aims to restore tidal hydrology and channel-forming processes to historic distributary slough channels connecting Swinomish Channel to Padilla Bay, restore tidal hydrology to diked farmland that was historically estuarine marsh, and increase freshwater inputs to Padilla Bay by constructing bridges at causeway crossings, removing levees and creating and reconnecting channels.

Ecosystem Restoration Benefits

- Restore large river delta that provides valuable nursery habitat for juvenile threatened salmon species, increasing survival and supporting Puget Sound population recovery
- Restore sand and gravel beaches that serve as spawning grounds for forage fish, such as surf smelt and Pacific sand lance, key elements of the marine food chain
- Re-establish intertidal and shallow subtidal areas to encourage kelp and eelgrass growth, increasing nearshore productivity for fish, birds and other marine species

Significance

- Opens another fish pathway into Padilla Bay, a National Estuarine Research Reserve with the largest existing Puget Sound eelgrass meadow
- Provides restoration beneficial to fish and wildlife using the North Fork Skagit River, where opportunities are limited
- Included in the Puget Sound Chinook Salmon Federal Recovery Plan
- Increases juvenile salmon rearing habitat
- More than doubles existing nearshore shoreline habitat available

Key Design Elements

The restoration removes most of the levees along Telegraph Slough, Padilla Bay and eastern Swinomish Channel. Levee removal requires raising the railroad and State Route 20 between Swinomish Channel to Telegraph Slough to keep them above the inundation and wave action limits. The railroad and State Route 20 will cross the Slough on elevated long-span bridges. A new levee along east and south Telegraph Slough will contain flood flows and extreme tides.

Levee removal restores about 832 acres of former salt marsh to tidal influence. Figure 6-22 depicts the key design elements at Telegraph Slough.

Site Summary Statistics

- Acres Restored: 832
- Total Project Cost: $297.7 M

As Figure 6-23 depicts, this site restores several processes including sediment transport, freshwater input, tidal exchange, channel migration, marsh accretion, overbank deposition, and natural levee formation. Restoration of this site provides benefits to ESA critical habitat for Chinook salmon and bull trout as well as direct benefits to harbor seals, great blue herons, bald eagles, waterfowl, forage fish, eelgrass, and kelp.

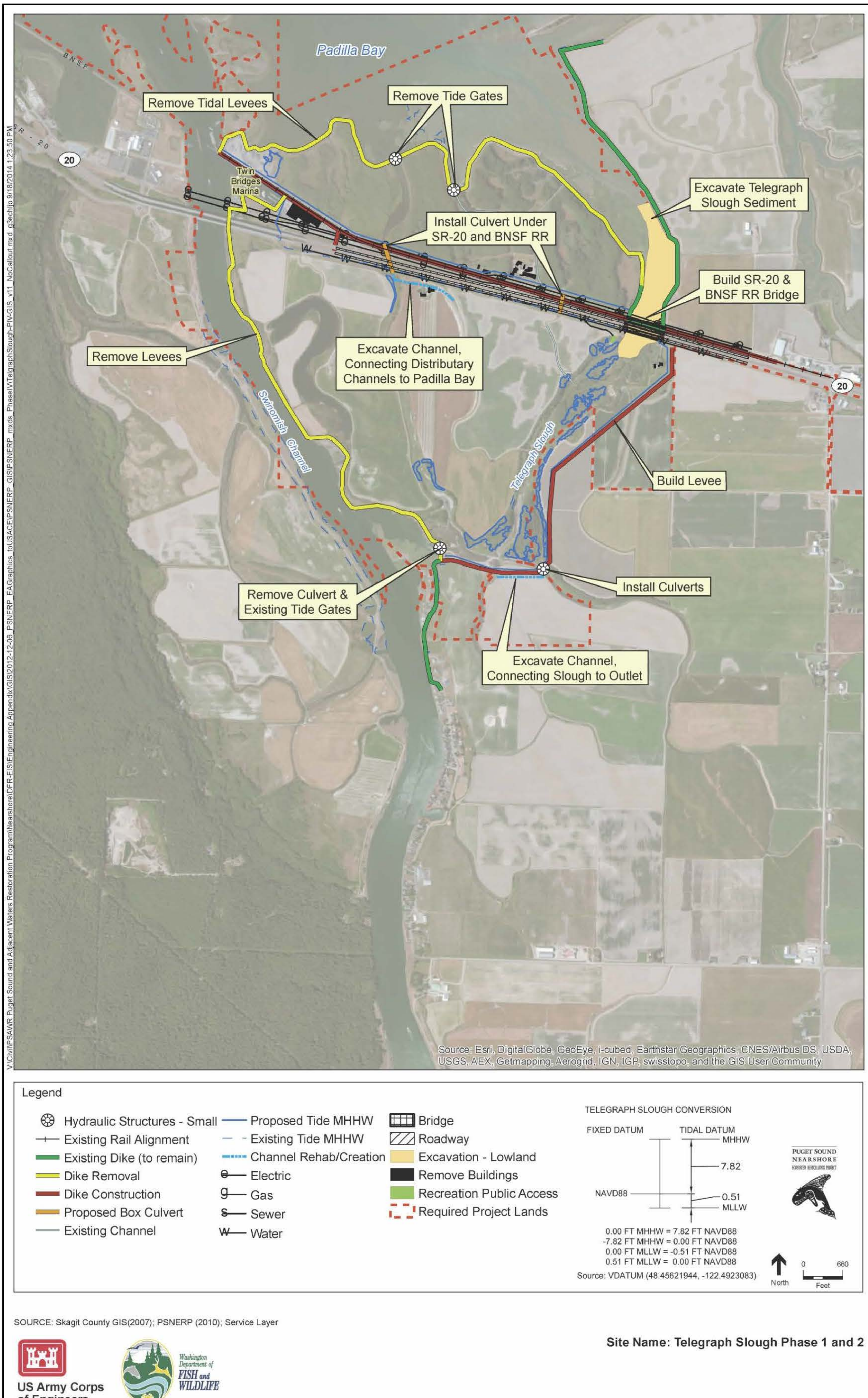
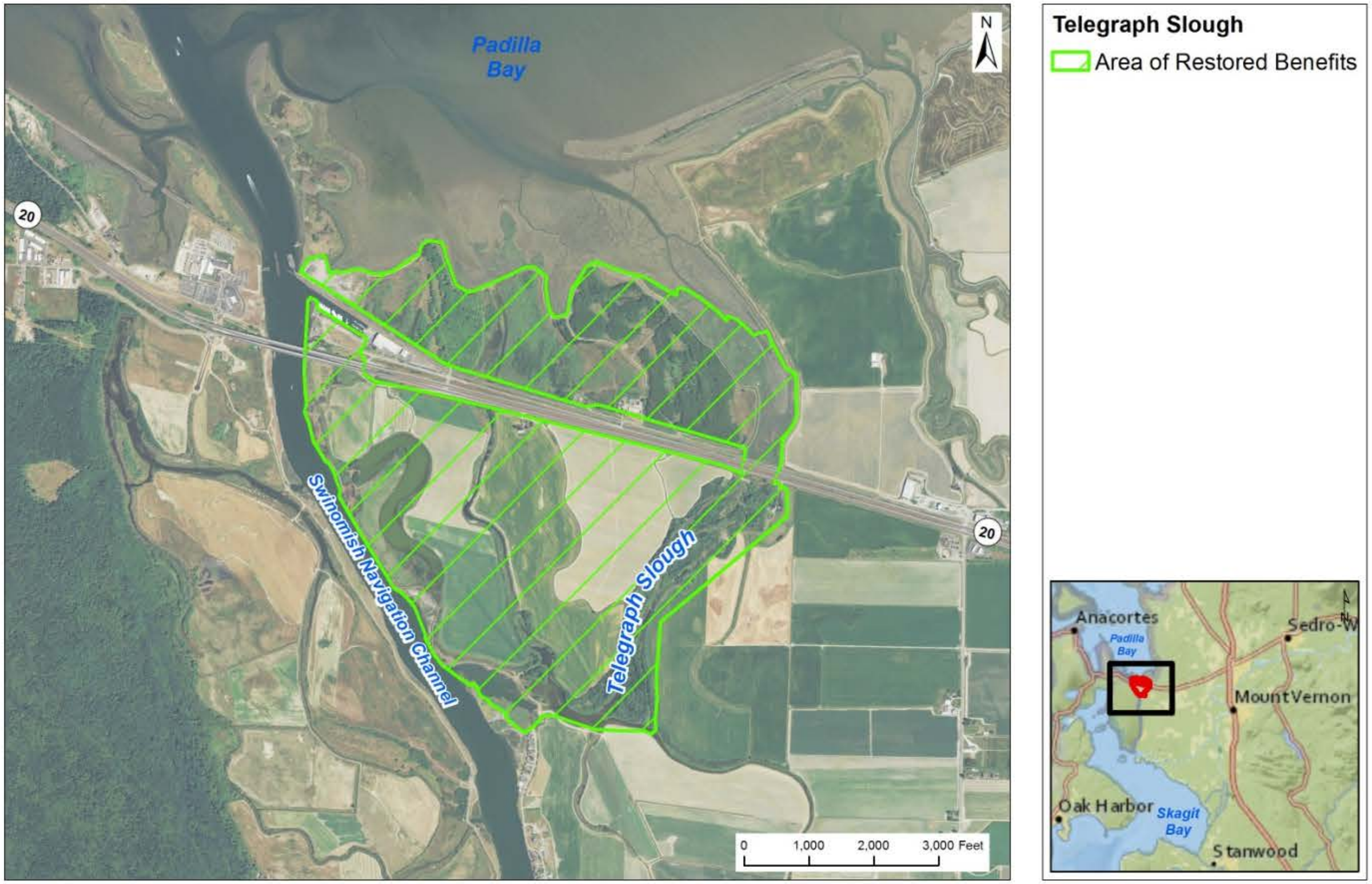


Figure 6-22. Telegraph Slough – Key Design Elements



Telegraph Slough	
Shoreform type:	Large River Delta
Processes restored:	sediment transport, freshwater input, tidal exchange, channel migration, marsh accretion, overbank deposition, natural levee formation
Species directly associated:	harbor seal, great blue heron, bald eagle, waterfowl, forage fish, eelgrass, kelp
Species indirectly associated:	green sturgeon, Steller sea lion, eulachon, marbled murrelet, lamprey
ESA Critical Habitat:	Chinook salmon, bull trout
Acres of wetlands restored:	832

Restored Benefits:
Telegraph Slough

Figure 6-23. Restoration Benefits at Telegraph Slough

6.3 Comprehensive Restoration Efforts in Puget Sound

Restoring the health of Puget Sound will involve more than process-based restoration of the nearshore zone. The work presented in this feasibility study must be paired with efforts to address water quality, land use management, environmental contaminants, and stormwater among other issues. Local, state, tribal, and Federal agencies, along with concerned citizens, nonprofit organizations, ports, and businesses recognize the need to identify nearshore ecosystem problems, evaluate potential solutions, and to restore and protect the critical ecosystem services of the nearshore zone. The proposed actions in the Nearshore Study are integral to this comprehensive restoration effort.

The Federal and State plan to accomplish Puget Sound recovery is the Puget Sound Action Agenda. The Action Agenda is prepared by the Puget Sound Partnership (PSP), a state agency, but is endorsed by the U.S. Environmental Protection Agency for this estuary of national significance under the National Estuary Program. In consultation with other state agencies, Federal agencies, tribal governments, industry representatives, and others, the PSP has documented priorities for Puget Sound recovery and implementing the restoration actions proposed by the Nearshore Study is identified in the Action Agenda as a near-term priority for Puget Sound recovery. In addition, authorization and implementation of the sites included in the TSP would significantly contribute to the Action Agenda target of restoring 7,380 acres of estuarine habitat by 2020.

The Nearshore Study is also highlighted in a multi-agency (Federal) Action Plan that addresses the protection and restoration of Puget Sound and the Washington coast. The Action Plan responds to recent concerns raised by Western Washington Treaty Tribes about continued habitat losses and associated diminishment of fishery resources.

As of 2014, 13 fish and marine mammal species in Puget Sound are listed as threatened or endangered or identified as candidate species under the ESA. Within the Study area, there are three listed endangered species and 10 threatened species. Recovery plans for eight of the ESA-listed species have been or are being developed by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Fish and Wildlife Service. Actions proposed by the Nearshore Study support salmon recovery consistent with NOAA’s salmon recovery plans.

6.4 Design and Construction Considerations

The Study team has taken a common-sense and risk-based approach to the designs developed in the feasibility phase. The conceptual designs included in this feasibility report are detailed enough to support certifiable cost estimates and and defensible Section 902 cost limit. However, some data and analysis required by ER 1110-2-1150 (Engineering and Design for Civil Works Projects; USACE 1999b) will be postponed until PED. Similarly, a full value engineering study will be conducted on an individual project basis in PED during the next phase of design development. Real estate gross appraisals and other documentation will be appropriately scaled for the current level of design.

The Study team has taken a conservative approach to developing cost estimates and scaling design features. Additionally, on a site-by-site basis, a robust cost-risk analysis and associated contingencies were applied to manage the risks or uncertainties. The Study team has identified the necessary studies and data collection to be performed in PED to manage site-specific risks and uncertainties. The Study team developed a project risk register to identify and help manage risks associated with this approach. In addition, site-specific risk registers were developed to inform cost estimate contingency rates and a summary of site-specific risks is included in the Engineering Appendix. A full description of each site, proposed construction features, risk/uncertainty, and additional studies to be completed in the future is also discussed in the Engineering Appendix.

6.4.1 Design and Construction Considerations: Induced Flooding

Five of the eleven sites recommended for inclusion in the TSP have levees as project features. These levees are included as project features to provide flood risk management to nearby land, structures, or infrastructure as existing levees are breached, degraded, or fully removed to restore ecosystem structures, functions, and processes at each site. To confirm the need for levees at each site (versus acquisition of property or easements), the Study team examined the effects of induced flooding at each site, the estimated value of real estate interests that may be susceptible to induced flooding, as well as the estimated costs for construction of levees.

Table 6-1. Levee Summary*

Site	Type of flooding	Current Level of protection (years)	Estimated Level of protection without dike	Estimated area protected by levee (acres)	Real estate value of area protected by dike ($1,000s)	Cost of levee ($1,000s)
Livingston Bay	Coastal	1 to 2	Daily	7.4 (~26 houses)	$7,020	$311
Telegraph Slough	Coastal	1 to 2	Daily	10,000	$127,600	$5,733
North Fork Skagit River Delta	Riverine	25	5 yrs*	6,700	$93,800	$31,738
Everett Marshland	Riverine	10	<10 yrs*	4,700	$46,530	$1,807
Nooksack River Delta	Riverine	5 – 10*	<5 – 10 yrs*	3,900	$15,600	$106,042

*Based on available data and best professional judgment.

The following sections provide a site-by-site examination of induced flooding.

Livingston Bay

Approximately 26 residential houses would be protected by the proposed berm at Livingston Bay, covering an area of 7.4 acres. Preliminary real estate evaluation indicates the value of the area protected by the proposed berm is approximately $7 million. The estimated cost of the berm is $311k. Because acquisition of affected real estate would be significantly more costly than building the proposed berm, the Study team determined that construction of the berm at this site is the preferred method to achieve the ecosystem restoration benefits at Livingston Bay.

Telegraph Slough

Approximately 10,000 acres of land will be at risk of inundation if the dike is removed at Telegraph Slough. If the existing levee is removed and not replaced with a new levee, induced flooding will occur in the town of La Conner, a popular tourist destination in Western Washington State. Preliminary real estate evaluation indicates the value of the area protected by the proposed levee is approximately $128 million. The estimated cost of the levee is $5.7 million. Because acquisition of affected real estate would be more costly than building the proposed levee, the Study team determined that construction of the levee at this site is the preferred method to achieve the ecosystem restoration benefits at Telegraph Slough.

North Fork Skagit River Delta

Approximately 6,700 acres of land – primarily Fir Island – will be at risk of inundation if the existing levee is removed at the North Fork Skagit River Delta Site. Preliminary real estate evaluation indicates the value of the area protected by the proposed levee is approximately $94 million. The estimated cost of the levee is $32 million. Because acquisition of affected real estate would be significantly more costly than building the proposed levee, the Study team determined that construction of the levee at this site is the preferred method to achieve the ecosystem restoration benefits at the North Fork Skagit River Delta.

Everett Marshland

Approximately 4,700 acres of land will be at risk of inundation if the levee is removed at Everett Marshland. Preliminary real estate evaluation indicates the value of the area protected by the proposed levee is approximately $47 million. The estimated cost of the levee is $2 million. Because acquisition of affected real estate would be significantly more costly than building the proposed levee, the Study team determined that construction of the levee at this site is the preferred method to achieve the ecosystem restoration benefits at Everett Marshland.

Nooksack River Delta

Approximately 3,900 acres of land – including 2,800 acres on Lummi Nation lands – will be at risk of inundation if the levee is removed at the Nooksack River Delta site. Preliminary real estate evaluation indicates the value of the area protected by the proposed levee system is approximately $16 million; however, this number is subjective because most of the affected property is on Tribal land. The estimated cost of the site-wide levee system is $106 million. Although construction of the levee system would be more costly than acquiring affected real estate, there are Environmental Justice concerns associated with induced flooding on Lummi Nation lands, property, and structures. To ensure the proposed project is not adversely affecting minority and low income populations from disproportionately high and adverse effects, the Study team determined that construction of the levee system at this site is the preferred method to achieve the ecosystem restoration benefits at the Nooksack River Delta site.

6.5 Real Estate Considerations

Typically for a feasibility phase of this type of study, designs are at a feasibility-level and the hydrological and hydraulic (H&H) modeling data is available, which is critical to development of gross appraisals to meet Uniform Standards of Professional Appraisal Practice (USPAP). Without formal H&H modeling, the Corps Real Estate specialists are unable to identify standard/non-standard estates or perform takings analysis for utility/facility relocations. As a result, for the purposes of the Nearshore Study feasibility effort, the fee simple value is being assigned to all properties, resulting in a high level of cost uncertainty. Contingency rates ranging from 15-35% have been added to estimated real estate values to mitigate this uncertainty.

The Real Estate team recommended that real estate valuation for all 11 sites be performed using cost estimates for the feasibility phase, with gross appraisals to be completed during PED when adequate design and modeling work is available. The Study team has received concurrence on this approach in the form of two waivers from Corps headquarters (signed 10 July 2012 and 21 December 2012)[6]. The PDT has identified and documented the necessary tasks to be undertaken in PED to reduce site-specific risks and uncertainties and has developed a project risk register to identify and help manage risks associated with this approach.

The Study team is moving forward with a strategy to secure design agreements for specific sites, which will initiate additional survey, modeling, and design during the PED phase; this approach is consistent with the process outlined in the two waivers received from Corps headquarters. The additional design and engineering work will be used to develop gross appraisals to meet the requirements outlined in EC 405-1-04 (Real Estate Handbook), to finalize the Real Estate Plan for each site, and to support the development of the Project Partnership Agreement (PPA) with the Non-Federal Sponsor. Greater certainty can be achieved following the requested authorization, and site-specific uncertainty can be resolved through identified follow-up studies and evaluations.

[6] Based on a waiver from HQUSACE, cost estimates were performed for 10 of the 11 sites included in the TSP. A Gross Appraisal format was used for one of the sites (Livingston Bay), based solely on the high percentage of preliminary real estate costs in relation to the overall project cost for this particular site.

6.6 Monitoring and Adaptive Management

To provide the necessary post-construction monitoring that will verify implementation and effectiveness of the management measures, the Corps will implement the Nearshore Study's proposed Monitoring and Adaptive Management Plan (Monitoring Plan) along with the site-specific monitoring plans for each of the 11 TSP sites. The Corps' Implementation Guidance for Section 2039 of the Water Resources Development Act of 2007 defines monitoring as "the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits" and state that "the law allows for but does not require a 10-year cost shared monitoring plan (USACE 2009a). Even the most strategically planned restoration actions can yield unexpected results. Monitoring documents and diagnoses these results especially in the early, formative stages of a project and provides information useful for taking corrective action. In this way, it reduces the risk of failure and enables effective, responsive management of restoration actions. Typical Corps monitoring plans contain monitoring parameters that are tied to evaluation of project objectives. These parameters have set performance targets that, if not met, will trigger an adaptive management action.

The Monitoring and Adaptive Management Plan (Appendix E) is a framework for development of site-specific monitoring and adaptive management plans based on the restoration strategy that is primary for the site—river delta, barrier embayment, coastal inlet, or beach. The goals of the monitoring plan are to determine whether the management measures applied to the sites are producing the desired effects, determine whether corrective action is needed to improve effectiveness, and reduce risks and uncertainties in subsequent projects by increasing understanding of the links between restoration actions and outcomes.

The four restoration strategies would use management measures to restore processes, which in turn would generate a series of structural and functional responses specific to the landform type. These responses constitute a set of predicted ecological outcomes that would indicate the performance of a restoration site. Performance is documented through an evaluation of monitoring results as compared against these predicted outcomes. Thus, the predicted outcomes serve as strategy-specific objectives. To achieve the monitoring goals stated above, effectiveness monitoring of restoration sites must answer the question, "Do these management measures restore these processes to achieve these objectives?"

Processes are inherently difficult to measure and quantify directly, and on their own do not tell the full story of restoration success. As a result, structural and functional responses typically are monitored as indicators of restored processes. Strategy-specific conceptual models define the causal relationships between restored processes and structural and functional responses. The Monitoring Plan establishes indicators and metrics for each strategy that must be monitored to evaluate whether they follow a predicted response. This response is developed from the best scientific understanding of how the system will evolve following restoration site implementation.

Metrics for each indicator are selected to provide enough information to track an indicator through its predicted response, as well as to explain why when performance reflected by an indicator is or is not developing as predicted. Each indicator in the Monitoring and Adaptive Management Plan is presented in appendix E along with its predicted response and the metrics required to monitor it. Contingency plans are also presented in Appendix E; these can be used as management responses to unfavorable monitoring results. These responses describe information that must be considered to explain the unfavorable results, and potential corrective actions to help reverse them and move the system toward success.

6.7 Consideration of Climate Change

In the Pacific Northwest, climatic changes are expected to trend towards warmer, wetter winters and hotter, drier summers. Models developed by the University of Washington Climate Impacts Group (CIG) predict the following scenarios for Pacific Northwest temperatures in the 21st century (as compared to the 20th): 1) the rate of change will be greater, 2) the total amount of change will be greater[7], 3) all seasons will be warmer, especially in the months of June through August, 4) the average annual temperature will likely exceed the range of average annual temperatures during the 20th century, and 5) changes in nearshore sea surface temperatures, though smaller than on land, are likely to substantially exceed inter-annual variability. The CIG precipitation models predict the following scenarios for the 21st century (as compared to the 20th): 1) The projected change in average annual precipitation is near zero, 2) existing seasonal patterns could be emphasized, with a decrease in summer and an increase in winter, and 3) average annual precipitation will likely stay within the range of 20th century annual average precipitation (Climate Impacts Group 2008). Most of this precipitation is expected to fall as rain and not snow, causing lower flows in the summer (due to lack of snow melt) and higher flows in the winters (due to increased rain) in the many rivers and streams that empty into Puget Sound. In addition to changes in precipitation and air temperatures, predicted estimates for sea level change in Puget Sound range from low estimates of 0.14 feet to very high estimates of 2.24 feet between 2015 and 2065. This range incorporates higher sea level rises expected in the south Puget Sound around Olympia and Tacoma and lower expected rises in the north Puget Sound around Friday Harbor and Bellingham Bay. More detailed information and analysis on climate change and how it may affect the Puget Sound basin is incorporated in section 3.6 (Future without-Project Conditions).

Proposed restoration at most of the 11 sites included in the TSP will provide increased resiliency to climate change effects, particularly sea level change. The conceptual design reports for these sites address risk of sea level change using low, intermediate, and high scenarios developed for Corps coastal investigations (USACE 2009b). The removal of nearshore stressors such as dikes,

[7] Projected to increase 2.0 °F by the decade of the 2020s, 3.2 °F by the decade of the 2040s, and 5.3 °F by the decade of the 2080s, relative to 1970-1999 average temperature (Mote and Salathe 2009)

armoring, and causeways will result in the creation and/or restoration of 5,348 acres of tidally influenced wetlands. With shoreline stressors removed, these wetlands should be able to adjust to changing geomorphic processes associated with changing sea levels; shifting landward, if there is room, as water rises and sediment accretes (so long as sediment source and delivery remain). These wetlands will function as a buffer from increased storm surge and provide storage capacity during flooding events. Wetland habitats will become even more essential to nearshore-dependent species that will be subject to the stress of increased temperature, varying velocities in rivers, and ocean acidification. In addition, the augmented infrastructure, such as replacements of causeways with wide-span bridges at many of the sites, will better withstand the increased storm surges and flooding events that are expected to occur in the coming century. Although the site designs are currently only at a conceptual level, further design iterations will ensure that these structures can withstand the predicted climatic changes and rising seas in the region.

6.8 Economic/Cost Summary

Based on October 2014 price levels, the estimated project cost is $1,126,340,000 (with contingency), which includes monitoring costs of $5,799,000 and adaptive management costs of $17,398,000 (before contingency). In accordance with the cost share provisions in Section 103(c) of the Water Resources Development Act (WRDA) of 1986, as amended {33 U.S.C. 2213(c)}, the Federal share of the project first cost is estimated to be $693,092,000 and the non-Federal share is estimated to be $433,278,000, which includes a 65% Federal and 35% non-Federal cost-share for restoration features. The non-Federal costs include the value of lands, easements, rights of-way, relocations, and dredged or excavated material disposal areas (LERRD) estimated to be $433,278,000. The LERRD estimate exceeds the 35% non-Federal cost share for restoration features by $39,059,000, and these excess LERRD are not cost-shared and are a non-Federal responsibility. The overall cost-share of the estimated cost is 62% Federal and 38% non-Federal. Table 6-2 outlines the project first costs of the TSP at the October 2014 price level. Table 6-5 displays the cost-share information for the TSP based on project first costs at the October 2014 price level.

Table 6-2. Estimated Costs of the TSP

Project Cost Component	Project First Cost (in $1,000, Oct 2014 price level)
Construction and Real Estate	
Construction Costs	$297,527
Real Estate Costs (including relocations)	$358,942
Contingency	$227,179
Planning, Engineering and Design (PED)	$130,149
Construction Management (CM)	$89,347
Monitoring	$5,799
Adaptive Management	$17,398
Total Estimated Cost	$1,126,340

Table 6-3. Cost-Share Estimate of the TSP

	Federal Cost ($1,000, Oct 2014 price level)	Non-Federal Cost ($1,000, Oct 2014 price level)
LERRD (non-Federal cost creditable up to 35% of non-Federal cost share for Ecosystem Restoration features)	$0	$394,219
Excess LERRDs (100% non-Federal)	$0	$39,059
Ecosystem Restoration, less excess LERRDs (65% Federal/35% non-Federal)	$693,062	$0
Total Cost Share	$693,062	$433,278
Overall Cost Share Percentage	62%	38%

Table 6-4 provides an economic summary of the TSP. Interest during construction was computed using estimated project costs at the October 2014 price level, anticipated construction durations for each of the 11 TSP sites (they range from one year to six years each), and the current Federal discount rate (3.5% for fiscal year 2014), bringing total investment costs to $1,189,463,000. Operations and maintenance expenses have been estimated for the 11 sites and detailed O&M manuals will be developed for each site during the PED phase. Annual costs were updated using the current cost estimate at the October 2014 price level. Total average annual cost is estimated at $50,788,000, with an average annual cost of $28,000 per AAHU.

Table 6-4. Economic Summary of the TSP

	Cost and Benefit Summary of TSP (Oct 2014 price level)
Interest Rate (Fiscal Year 2014)	3.50%
Interest Rate, Monthly	0.29%
Construction Period, Years	22
Period of Analysis, Years	50
Estimated Cost	$1,126,340,000
Interest During Construction	$63,123,000
Investment Cost	$1,189,463,000
Average Annual Cost	
Amortized Cost	$50,751,000
OMRR&R	$37,000
Total Annual Cost	$50,788,000
Average Annual Benefits	
Average Annual Habitat Units (AAHUs)	1806.8
Average Annual Cost/AAHU	$28,000

* O&M costs have been estimated for the 11 sites recommended in the TSP and are based on the changes in O&M estimated in Table 2-2. Detailed O&M manuals will be developed for each site during the PED phase.

First costs for authorization purposes are estimated at $1.1 billion (October 2014 price level) and the fully funded cost estimate to the mid-point of construction is estimated at $1.7 billion.

6.9 Implementation Requirements

The following sections outline the requirements for implementation of the TSP.

6.9.1 Non-Federal Sponsor

The Washington Department of Fish and Wildlife (WDFW) is the non-Federal sponsor for the feasibility phase of the Nearshore Study. After project authorization, it is anticipated that the Corps will partner with WDFW to construct the 11 sites authorized in this study. Once a non-Federal partner is confirmed for construction, work-in-kind (WIK) credit provisions will be established and funding summaries will be developed for each year of design and construction.

Because there is substantial interest in restoration of the nearshore zone, local Puget Sound restoration organizations continue to work diligently to identify the resources needed to complete projects. Of the over 500 projects initially considered for inclusion in the Nearshore Study's TSP, some have been able to leverage resources and opportunities to result in completed projects while many others are simply too large or complex to reasonably assume that would ever be an option. While all 11 sites of the TSP are proposed for authorization, the Nearshore Study will continue working closely with non-Federal project proponents as these comprehensive restoration efforts continue.

6.9.2 Institutional Requirements

The schedule for project implementation assumes authorization in a future Water Resources Development Act. After project authorization, the project would be eligible for construction funding. The project would be considered for inclusion in the President's budget based on national priorities, magnitude of the Federal commitment, economic and environmental feasibility, level of local support, willingness of the non-Federal partner to fund its share of the project cost, and the budget constraints at the time of funding. Once Congress appropriates Federal construction funds, the Corps and the non-Federal partner(s) would enter into a project partnership agreement (PPA). This project partnership agreement would define the Federal and non-Federal responsibilities for implementing, operating, and maintaining the project.

The Corps would officially request the non-Federal partner(s) to acquire the necessary real estate immediately after the signing of the project partnership agreement. The advertisement of the construction contract would follow the certification of the real estate. The final acceptance and transfer of the project to the non-Federal partner(s) would follow the delivery of an operations and maintenance manual and as-built drawings. The draft construction sequencing schedule for project implementation is shown in Table 6-5.

Table 6-5. Draft Construction Sequencing Schedule[8].

Site	Construction Period (years)	Estimated Construction Start Date
Deepwater Slough	1	2017
Spencer Island	2	2018
Milltown Island	2	2019
Nooksack River Delta	6	2024
Livingston Bay	1	2029
Everett Marshland	3	2030
Beaconsfield Feeder Bluff	1	2031
Deer Harbor Estuary	1	2033
Telegraph Slough	3	2034
Dugualla Bay	2	2035
North Fork Skagit River Delta	2	2036

[8] This construction sequencing schedule is for planning purposes only.

6.9.3 Operation, Maintenance, and Replacement Requirements

After completion of construction, the non-Federal sponsor(s) will assume operation and maintenance (O&M) responsibility for the entire project footprint. The non-Federal sponsor is responsible for all long-term project operations, maintenance, repairs, replacements, and rehabilitations following completion of construction. O&M costs have been estimated for the 11 sites recommended in the TSP. Detailed O&M manuals will be developed for each site during the PED phase.

7 ENVIRONMENTAL COMPLIANCE OF THE TENTATIVELY SELECTED PLAN*

7.1 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969

The National Environmental Policy Act (NEPA) (42 U.S.C. §4321 et seq.) commits Federal agencies to considering, documenting, and publicly disclosing the environmental effects of their actions. NEPA-required documents must provide detailed information regarding the proposed action and alternatives, the environmental impacts of the alternatives, appropriate mitigation measures, and any adverse environmental impacts that cannot be avoided if the proposal is implemented. Agencies are required to demonstrate that decision makers have considered these factors prior to undertaking actions.

This Draft Feasibility Report/Environmental Impact Statement (DFR/EIS) is intended to achieve NEPA compliance for the proposed project. Before preparing this document, the Corps published a Notice of Intent to prepare an EIS in the Federal Register on October 2, 2009, and held four scoping meetings in different regions of the Puget Sound area. All comments received to date were considered in determining whether it will be in the public interest to proceed with the proposed project.

7.2 ENDANGERED SPECIES ACT OF 1973

The Endangered Species Act (ESA) (16 U.S.C. §1531-1544), Section 7(a) requires that Federal agencies consult with the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), as appropriate, to ensure that proposed actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their critical habitats.

ESA consultation will be completed via a Programmatic Biological Opinion. A Programmatic Biological Assessment was prepared and a Biological Opinion for Fish Passage and Restoration Actions in Washington State was issued to the Corps' Seattle District in 2008, and coverage under this Biological Opinion has been extended through 2019. NMFS and USFWS are revising this programmatic consultation to specifically cover the actions proposed by the Nearshore Study. The reissuance of this programmatic consultation with explicit inclusion of all Nearshore Study sites and features is anticipated to occur in early 2015 and will be in place prior to the final report. The Corps received letters from NMFS and USFWS indicating their support for using this process for ESA consultation.

7.3 FEDERAL WATER POLLUTION CONTROL ACT OF 1972 (CLEAN WATER ACT)

The Clean Water Act (33 U.S.C. §1251 et seq.) requires Federal agencies to protect waters of the United States. The regulation implementing the Act disallows the placement of dredged or fill material into water unless it can be demonstrated there are no practical alternatives that are less environmentally damaging. The sections of the Clean Water Act (CWA) that apply to the Nearshore Study proposal are 401 regarding discharges to waterways, 402 regarding discharges of stormwater, and 404 regarding fill material in waters and wetlands.

Section 401

Any project that involves placing dredged or fill material in waters of the United States or wetlands, or mechanized clearing of wetlands requires a water quality certification from the state agency as delegated by the U.S. Environmental Protection Agency (EPA). For most sites of the Nearshore Study, the delegated authority is WDOE. For the Nooksack site, the EPA has delegated authority to the Lummi Nation. While Nearshore Study restoration site designs are based largely on removal of human-made stressors from the nearshore zone, there will be significant disturbance of sediments and substrates at each site and certain sites will have side-cast material as pilot channels are excavated. The Corps has initiated coordination with WDOE and the Lummi Nation to certify that the proposed Federal action will not violate established water quality standards. The Corps anticipates receiving a letter from WDOE and from the Lummi Nation with assurance that the project sites can be certified under Section 401.

Section 402

The National Pollutant Discharge Elimination System (NPDES), controls discharges into waters of the United States. In 1987, the Clean Water Act was amended to require the EPA to establish a program to address stormwater discharges. In response, the EPA promulgated the NPDES stormwater permit application regulations. These regulations require that facilities or construction sites with stormwater discharges from a site that is one acre or larger apply for an NPDES permit. NPDES permits, issued by either the EPA or an authorized state/tribe, contain industry-specific, technology-based, and/or water-quality-based limits, and establish pollutant monitoring and reporting requirements.

The Corps will ensure that each restoration site is covered by a Section 402 Construction Stormwater General Permit. Once the notification is submitted to EPA, permit coverage under the Construction General Permit begins seven days later. Best management practices for erosion and sedimentation control will be included in the design for each restoration site.

Section 404

In 1972, Section 404 established a program to regulate the discharge of dredged or fill material into the navigable waters of the United States. Much earlier, the Rivers and Harbors Act of 1899 (33 U.S.C. §403) defined navigable waters of the United States as “those waters that are subject to the ebb and flow of the tides and/or are presently used, or have been used in the past, or may be susceptible to use to transport interstate or foreign commerce.” The Clean Water Act built on this and defined waters of the United States to include tributaries to navigable waters, interstate wetlands, wetlands that could affect interstate or foreign commerce, and wetlands adjacent to other waters of the United States. The fundamental principle of the program is that no discharge of dredged or fill material should be permitted if there is a practicable alternative that would be less damaging to aquatic resources or if significant degradation would occur to the nation's waters. To comply with Section 404, it is necessary to avoid negative effects to wetlands wherever practicable, minimize effects where they are unavoidable, and compensate for effects in some cases.

The Nearshore Study TSP has undergone a Section 404(b)(1) evaluation. See Appendix J.

7.4 NATIONAL HISTORIC PRESERVATION ACT

The National Historic Preservation Act (NHPA) of 1966 (16 U.S.C. §470), as amended through 1992 (Public Law 102-575), establishes preservation as a national policy and directs the Federal government to provide leadership in preserving, restoring and maintaining the nation's historic and cultural environment. Section 106 of NHPA is of particular relevance to the Nearshore Study. It requires Federal agencies to account for the indirect, direct, and cumulative effects of their undertakings on Historic Properties (i.e., archaeological sites, Traditional Cultural Properties, buildings, structures, objects, districts, and landscapes listed in or eligible for listing in the National Register of Historic Places). Undertakings include actions that are federally funded, mandated, permitted, licensed, or otherwise regulated. Section 106 and its implementing regulations at 36 CFR 800 establish procedures for Federal agencies to follow in identifying Historic Properties and assessing and resolving effects of their undertaking on them, in consultation with State Historic Preservation Officers (SHPO), Indian tribes, Native Hawaiians, and the Advisory Council for Historic Preservation (ACHP), as appropriate. Other parties may participate in the Section 106 consultation process, including but not limited to applicants for Federal assistance, permit and license applicants, certified local governments, and other groups or individuals with an economic, social, or cultural interest in the project. Maximum public involvement in the process is encouraged.

The Corps is currently consulting with the SHPO and the ACHP on the appropriate mechanism to conclude the agency's Section 106 responsibilities. The Corps has developed a draft cultural resources plan (Appendix D) that provides a framework and commitments the Corps proposes to incorporate into either a memorandum of agreement executed pursuant to 36 C.F.R. § 800.6, a programmatic agreement executed pursuant to 36 C.F.R. § 800.14(b), or the documents used by the Corps to comply with the National Environmental Policy Act pursuant to 36 C.F.R. 800.8. The draft cultural resources plan provides a path forward for future identification, evaluation and assessment of effects. The Corps will consult with the SHPO, ACHP and Tribes on appropriate mitigation measures on a case-by-case basis. Letters were sent on March 5, 2013 to the SHPO and ACHP detailing the project. The letter stated that the Corps was exploring the possibility of developing a PA or MOA to defer identification and evaluation until specific aspects or location of alternatives were more fully defined, but also requested advice and guidance on the appropriate mechanism to fulfill the agency's Section 106 responsibilities. The SHPO responded

April 3, 2013 stating that they looked forward to consulting with Corps. The ACHP responded March 22, 2013 stating that they would participate in consultation.

7.5 FEDERAL TREATY OBLIGATIONS

The Federal trust responsibility to Native American tribes is a protection and preservation of land and certain rights for them. Treaties with the tribes are the supreme law of the land, superior to State laws, and equal to Federal laws. The trust responsibility is derived from the special relationship between the U.S. and Native American Indian tribes, first defined by U.S. Supreme Court Chief Justice John Marshall in Cherokee Nation v. Georgia, 30 U.S. 1 (5 Pet.) (1831). Later, in Seminole Nation v. United States, 316 U.S. §286 (1942), the Supreme Court noted that the U.S. "has charged itself with moral obligations of the highest responsibility and trust" toward Native American Indian tribes. The scope of the Federal trust responsibility is broad and incumbent upon all Federal agencies. The U.S. government has an obligation to protect tribal land, assets, resources, and rights, as well as a duty to carry out the mandates of Federal law with respect to Indian tribes.

Tribes have had representation in the Nearshore Study planning phase through the Northwest Indian Fisheries Commission, as well as the Lummi Nation's participation on the Steering Committee. The Nearshore Study team anticipates that the proposed ecosystem restoration would have significant benefits to salmonid and shellfish resources, which are of economic and cultural value to the tribes within the project area. Implementation of the recommended plan would improve the affected nearshore areas, ultimately benefiting Puget Sound tribes and maintaining the Federal government's trust responsibility to them.

7.6 EXECUTIVE ORDER 13175, CONSULTATION AND COORDINATION WITH INDIAN TRIBAL GOVERNMENTS

Executive Order 13175 (6 November 2000) reaffirmed the Federal government's commitment to a government-to-government relationship with Indian tribes, and directed Federal agencies to establish procedures to consult and collaborate with tribal governments when new agency regulations would have tribal implications. The Corps has a government-to-government consultation policy to facilitate the interchange between decision makers to obtain mutually acceptable decisions. In accordance with this Executive Order, the Corps has engaged in regular and meaningful consultation and collaboration with Puget Sound's federally recognized tribes throughout the course of the study.

7.7 BALD AND GOLDEN EAGLE PROTECTION ACT

The Bald and Golden Eagle Protection Act (16 U.S.C. §668-668c), enacted in 1940 and amended several times since then, prohibits anyone without a permit issued by the Secretary of the Interior from "taking" eagles including their parts, nests, or eggs. The Act applies criminal penalties for persons who "take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or any manner, any [bald or golden] eagle alive or dead, or any part, nest, or egg thereof." The Act defines "take" as "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb."

Construction activities associated with the proposed actions may disturb bald and golden eagles due to elevated noise levels and presence of heavy machinery. The Corps would avoid and minimize impacts through construction timing windows for each site identified containing or in close proximity to a breeding area, and, if nests and/or roosts are nearby, monitor and coordinate with USFWS. Seven of the 11 TSP sites were identified through consultation of the WDFW Priority Habitats and Species database to either contain a bald eagle breeding area or to have a breeding area within the 660-foot buffer zone of the project footprint

7.8 CLEAN AIR ACT

The Clean Air Act (CAA) as Amended (42 U.S.C. §7401, et seq.) prohibits Federal agencies from approving any action that does not conform to an approved State or Federal implementation plan. Three agencies have jurisdiction over air quality in the project area: EPA, WDOE, and the Puget Sound Clean Air Agency. The EPA sets standards for concentrations of pollutants in outdoor air and the State establishes regulations that govern contaminant emissions from air pollution sources. In accordance with the CAA and its amendments, National Ambient Air Quality Standards (NAAQS) have been established by EPA for several criteria pollutants including lead (Pb), ozone (O_3), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and particulates with aerodynamic diameters of less than 10 and less than 2.5 microns (PM_{10} and $PM_{2.5}$). Construction activities associated with the proposal will create air emissions, but these are not expected to affect implementation of Washington's CAA implementation plan.

Washington uses air-monitoring data to determine whether air quality in the State meets the national standards. Areas where the standards are met are designated as attainment areas, and areas where the standards are exceeded are designated as nonattainment areas (NAA). There is one nonattainment area in Washington State, the Tacoma-Pierce County Nonattainment Area (also known as Wapato Hills – Puyallup River Valley PM2.5 NAA). WDOE is developing a State implementation plan for bringing the area back into attainment. Under the CAA General Conformity Rule (Section 176(c)(4)), Federal agencies are prohibited from approving any action that causes or contributes to a violation of a NAAQS in a nonattainment area. This will not be a concern on this project, as none of the proposed actions would occur in the nonattainment area.

Construction sites of the magnitude included in the proposed plan are not typically a concern in attainment areas. The estimated emissions for the sites included in the proposed project may be more thoroughly assessed as part of the environmental assessment under NEPA for each construction site. At this point, however, it is expected that all of the actions will meet the standards set forth by the EPA and implemented by Washington State.

7.9 COASTAL ZONE MANAGEMENT ACT

The Coastal Zone Management Act (CZMA) of 1972 as amended (16 U.S.C. §1451-1464) requires Federal agencies to carry out their activities in a manner that is consistent to the maximum extent practicable with the enforceable policies of the approved State Coastal Zone Management Program. The aim of the act is to "preserve, protect, develop, and where possible, to restore or enhance the resources of the nation's coastal zone." The delegated authority for review of consistency with the Coastal Zone Management Program is WDOE. In compliance with State law, each of the 15 coastal counties in Washington has developed its own Shoreline Master Program in compliance with the State Shoreline Management Act.

The Corps expects to be substantively consistent with the enforceable polices of each county's Shoreline Master Program. The Corps has initiated coordination with the Department of Ecology and will prepare a CZMA Consistency Determination for each site according to the relevant county or local code.

7.10 FISH AND WILDLIFE COORDINATION ACT

The Fish and Wildlife Coordination Act of 1934 as amended (16 U.S.C. §661-667e) ensures that fish and wildlife conservation is given equal consideration as is given to other features of water-resource development programs through planning, development, maintenance, and coordination of wildlife conservation and rehabilitation. This law provides that whenever the waters of any stream or other body of water are proposed to be impounded, diverted, deepened or otherwise controlled or modified, the Corps shall consult with the USFWS and NMFS as appropriate, and the agency administering the wildlife resources of the state. The consultation shall consider conservation of wildlife resources with the view of preventing loss of and damages to such resources as well as providing for development and improvement in connection with such water resources development. Any reports and recommendations of the wildlife agencies shall be included in authorization documents for construction or modification of projects. The Corps shall consider the reports and recommendations of the wildlife agencies and include such justifiable means and measures for wildlife mitigation or enhancement as the Corps finds should be adopted to obtain maximum overall project benefits. Recommendations provided by the USFWS in Coordination Act Reports must be specifically addressed in Corps feasibility reports.

The Corps initiated consultation with USFWS in 2002 shortly after the start of the Nearshore Study's Feasibility Phase. USFWS has provided three Planning Aid Letters in 2005, 2007, and 2011, and has provided a USFWS biologist to be a member of the Nearshore Science Team and the Nearshore Steering Committee. USFWS has been supportive of Nearshore Study efforts and the Corps has been incorporating USFWS technical advice into project planning, strategies, objectives, site screening, and conceptual designs. The Corps expects a Coordination Act Report from USFWS in late 2014. NMFS has been equally supportive of the Nearshore Study, but has not had such a direct role in project participation. NMFS has had representation on the Nearshore

Study's steering committee and has been a participating organization since early in the Feasibility Phase. In addition, NMFS contributed to an analysis of affected threatened and endangered species and provided conservation measures to implement during restoration work.

7.11 MAGNUSON-STEVENS SUSTAINABLE FISHERIES AND CONSERVATION ACT

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), (16 U.S.C. §1801 et. seq.) requires Federal agencies to consult with NMFS on activities that may adversely affect Essential Fish Habitat (EFH). The objective of an EFH assessment is to determine whether the proposed action(s) "may adversely affect" designated EFH for relevant commercial, federally managed fisheries species within the proposed action area. The assessment also describes conservation measures proposed to avoid, minimize, or otherwise offset potential adverse effects to designated EFH resulting from the proposed action.

EFH includes those waters and substrate necessary for fish spawning, breeding, feeding, or growth to maturity. Important features of essential habitat for spawning, rearing, and migration include adequate substrate composition, water quality (e.g. dissolved oxygen, pH, temperature, etc.), water quantity, water depth and velocity, channel gradient and stability, food, cover, habitat (e.g., large woody debris, pools, channel complexity, aquatic vegetation), access and passage, and floodplain and habitat connectivity. Adverse effects to EFH include the direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects to EFH may result from actions occurring within outside EFH, and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810).

EFH consultation will be completed via the Programmatic Biological Opinion, which will be completed prior to the final report. The updated Programmatic Biological Opinion will include EFH for coastal pelagic fish, groundfish, and salmon. Although habitat disturbance may have temporary adverse effects to designated EFH, the conservation measures to address ESA concerns should be adequate to avoid, minimize, or otherwise offset potential adverse impacts to the EFH. The proposed restoration sites would result in long-term benefits to salmonids as well as other species with designated EFH.

7.12 MARINE MAMMAL PROTECTION ACT

The Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. §1361-1407) restricts harassment of marine mammals and requires interagency consultation in conjunction with the ESA consultation for Federal activities. All marine mammals are protected under the MMPA regardless of whether they are endangered, threatened, or depleted. Marine mammal species that are observed in Puget Sound include harbor seal (*Phoca vitulina*), killer whale (*Orcinus orca*), Steller sea lion (*Eumetopias jubatus*), Northern elephant seal (*Mirounga angustirostris*), California sea lion (*Zalophus californianus*), harbor porpoise (*Phocoena phocoena*), Dall's porpoise (*Phocoenoides dalli*), Minke whale (*Balaenoptera acutorostrata*), and gray whale (*Eschrichtius robustus*) (Orca Network 2011).

The primary concern for protection of marine mammals during Nearshore Study implementation will be underwater noise from construction sites, which is described in detail in Section 5.1.8. The Corps will consult with NMFS on effects to marine mammals in conjunction with the ESA Section 7 consultation. The Corps anticipates implementing all practicable conservation measures and adhering to a marine mammal monitoring plan. For all restoration sites in which the sound levels are predicted to be louder than the acoustic thresholds for harassment of marine mammals, the Corps will use BMPs as described in section 5.7.4. as appropriate for each site.

7.13 MIGRATORY BIRD TREATY ACT

The Migratory Bird Treaty Act of 1918 (16 U.S.C. §703-712), as amended in 1989, implements various treaties and conventions between the U.S. and Canada, Japan, Mexico, and the former Soviet Union for the protection of migratory birds. Under the Act it is unlawful to hunt, take, capture, or kill; attempt to take, capture, or kill; possess, offer to sell, barter, purchase, deliver or cause to be shipped, exported, imported, transported, carried or received any migratory bird, part, nest, egg or product, manufactured or not.

The proposed work will not result in the hunt, take, capture, or killing of migratory birds. Construction activities may disturb migratory birds due to elevated noise levels and presence of large machinery. These effects will be minimized by removing large trees prior to April 1 when the typical nesting season begins, and surveying the sites before and during construction for nests. Once the preferred alternative is authorized and the individual sites receive appropriation, migratory bird monitoring plans would be developed during the engineering and design phase.

7.14 HAZARDOUS, TOXIC, AND RADIOLOGICAL WASTE LAWS

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) is designed to clean up sites contaminated with hazardous substances; remediating abandoned hazardous waste sites, by establishing legal liability, as well as a trust fund for cleanup activities. CERCLA, called "Superfund", provides broad Federal authority to clean up releases or threatened releases of hazardous substances that may endanger public health or the environment. The law authorized the EPA to identify parties responsible for contamination of sites and compel the parties to clean up the sites. Where responsible parties cannot be found, EPA is authorized to clean up sites itself, using a special trust fund. In 1986, the Superfund Amendments and Reauthorization Act (SARA) established a trust fund to pay for cleanup of leaking underground storage tanks and other leaking waste storage facilities where responsible parties cannot be identified.

The Resource Conservation and Recovery Act (RCRA) gives the EPA the authority to control hazardous waste from "cradle-to-grave." This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA sets forth a framework for the management of non-hazardous solid wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances. In 1984, Congress expanded the scope of RCRA with the enactment of Hazardous and Solid Waste Amendments. The amendments strengthened the law by covering small quantity generators of hazardous waste and establishing requirements for hazardous waste incinerators, and the closing of substandard landfills. In general, CERCLA applies to contaminated sites, while RCRA's focus is on controlling the ongoing generation and management of particular waste streams. RCRA, like CERCLA, has provisions to require cleanup of contaminated sites that occurred in the past.

The Toxic Substances Control Act (TSCA) of 1976 provides EPA with authority to require reporting, record-keeping, and testing requirements, and restrictions relating to chemical substances and/or mixtures. Certain substances are generally excluded from TSCA, including, among others, food, drugs, cosmetics, and pesticides. TSCA addresses the production, importation, use, and disposal of specific chemicals including polychlorinated biphenyls (PCBs), asbestos, radon, and lead-based paint.

None of the proposed restoration sites are on the EPA NPL list. If chemical contaminants or regulated substances are found on a particular site proposed for restoration, the Corps will comply with RCRA, CERCLA, and TSCA requirements and coordinate with the local sponsor to ensure that remediation actions are taken as necessary. HTRW sites within any of the proposed project footprints will be avoided in accordance with ER 1165-2-132 Section 6 “Construction of Civil Works projects in HTRW-contaminated areas should be avoided where practicable.”

7.15 THE GENERAL BRIDGE ACT

The General Bridge Act of 1946 (33 U.S.C. §525-533) prohibits the construction of any bridge across navigable waters of the United States unless first authorized by the Coast Guard. The Coast Guard approves the location and clearances of bridges through the issuance of bridge permits or permit amendments, under the authority of the General Bridge Act of 1946, Section 9 of the Rivers and Harbors Act of 1899, and other statutes. New construction, reconstruction, or modification of a bridge or causeway over navigable waters of the United States requires permit issuance from the Coast Guard. A bridge permit is the written approval of the location and plans of the bridge or causeway to be constructed or modified.

Five of the restoration sites in the Tentatively Selected Plan will involve reconstruction or modification of a bridge, which will require a permit from the Coast Guard. The Corps will design and build each bridge reconstruction or causeway according to Coast Guard regulations. All new bridges will maintain or improve navigability.

7.16 EXECUTIVE ORDER 12898 ENVIRONMENTAL JUSTICE

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" provides that each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. Environmental justice concerns may arise from impacts on the natural and physical environment, such as human health or ecological impacts on minority populations, low-income populations, and Indian tribes or from related social or economic impacts.

The NEPA procedures are important in identifying and addressing environmental justice concerns. The Corps evaluated the location and design of each restoration site to determine whether they would affect minority populations, low-income populations, and Indian tribes. The EPA Environmental Justice Viewer was used to determine whether minority populations, low-income populations, or Indian tribes are present in the proposed restoration areas. This evaluation found that the proposed restoration areas were either within park limits with no residents nearby or the demographics of the nearby populations were mostly non-minority and above poverty levels, with one exception. One site is located within Lummi Nation lands.

Coordination of the proposed site with key stakeholders including the Lummi Nation has occurred throughout the planning process. Any effects of the proposed restoration to key stakeholders would be positive in nature. In the case of the Indian tribal land, the proposed restoration would improve the affected nearshore area to the benefit of the tribe. Therefore, in accordance with Title III of the Civil Rights Act of 1964 and Executive Order 12898, it has been determined that the project would not directly or through contractual or other arrangements, use criteria, methods, or practices that discriminate on the basis of race, color, or national origin, nor would it have a disproportionate effect on minority or low-income communities.

7.17 EXECUTIVE ORDER 11988 FLOODPLAIN MANAGEMENT

EPA implementing procedures for EO 11988 are outlined in "Statement of Procedures on Floodplain Management and Wetlands Protection," 40 CFR 6 (January 5, 1979).Executive Order 11988 requires Federal agencies to recognize the significant values of floodplains and to consider the public benefits that would be realized from restoring and preserving floodplains. It is the general policy of the Corps to formulate projects that, to the extent possible, avoid or minimize adverse impacts associated with use of the base floodplain and avoid inducing development in the base floodplain unless there is no practicable alternative that meets the project purpose. Per the procedures outlined in ER 1165-2-26 (Implementation of Executive Order 11988 on Flood Plain Management), the Corps has analyzed the potential effects of the TSP on the overall floodplain management of the study area. Some of the proposed actions are in the base floodplain and there are no practicable alternatives to the action. The public has been advised of the proposed action and the Corps has requested their comments on the TSP. Chapter 5 outlines beneficial and adverse effects of the action. A discussion of benefits to natural floodplain values including restoration of fish and wildlife values (e.g., wetlands, marshes, and related natural habitat) is also included in Chapter 5. The proposed ecosystem restoration is not anticipated to induce development of the floodplain or to otherwise adversely affect any floodplain, since no land use changes are expected to result from the project that would enhance development conditions. The Corps has recommended the plan that is most responsive to the study's planning objectives and is consistent with the requirements of this Executive Order.

The TSP has been formulated to ensure flood heights in the study area will not be affected. Coordination with the Federal Emergency Management Agency (FEMA) is ongoing; if required, a no-rise certificate will be obtained prior to signature of the Chief's Report.

7.18 EXECUTIVE ORDER 11990 PROTECTION OF WETLANDS

Executive Order 11990 entitled Protection of Wetlands, dated May 24, 1977, requires Federal agencies to take action to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction and to preserve the values of wetlands, and to prescribe procedures to implement the policies and procedures of this Executive Order. In addition, Federal agencies shall incorporate floodplain management goals and wetlands protection considerations into its planning, regulatory, and decision making processes.

One of the primary goals of this project is to restore intertidal wetlands along the Puget Sound shoreline that have been lost due to the presence of dikes, fill, and armoring. The proposed actions would be largely beneficial to wetlands. The exception is the potential impacts to freshwater wetlands that have established due to interrupted tidal flow. Once stressors such as dikes and berms are removed, salt water will inundate these freshwater wetlands and they would slowly transition to emergent brackish marsh. This transition would likely cause a functional increase in habitat and water quality. Any action potentially affecting a wetland will be evaluated by Corps biologists and closely coordinated with the WDOE.

8 PUBLIC INVOLVEMENT & PEER REVIEW

Stakeholder involvement and agency coordination have been vital components of the Nearshore Study since its start in 2001. The relationships among the Study team and the many member organizations are an important facet of a collaborative planning approach to stakeholder involvement. Stakeholders are integral in helping provide input for defining restoration opportunities, objectives, and constraints, and for developing restoration strategies, which ultimately support development of the range of alternatives to be analyzed for feasibility and environmental compliance. Federal and State agencies have also participated in the National Environmental Policy Act (NEPA) process, including a process to integrate State Environmental Policy Act (SEPA) requirements with the NEPA process. In accordance with Engineering Circular 1105-2-409 (Planning in a Collaborative Environment; USACE 2005), representatives of Federal and State agencies have been invited to be members of the Project Delivery Team and the other Nearshore Study teams.

8.1 PROJECT DELIVERY TEAM

The Project Delivery Team (PDT) is a multi-disciplinary, multi-agency team responsible for the successful development and execution of all aspects of the study. The PDT comprises six standing teams, with agency, non-governmental organization and other representatives serving on the Executive Committee (EC), Steering Committee (StC), Project Management Team (PMT), Nearshore Science Team (NST), Implementation Team (IT), and Stakeholder Involvement Team (SIT). Composition of the teams appears in Table 8-1 and Table 8-2. The PDT facilitates the interagency collaboration and coordination necessary for study execution and successful delivery of a quality product. In addition to formal review requirements prescribed in Corps policy, NEPA-required coordination with Federal and State agencies and tribes is facilitated through the PDT. The PDT can expand and contract as necessary to include all necessary expertise, ad hoc teams, and work groups for study execution.

8.1.1 Executive Committee

The role of the Executive Committee is to oversee implementation of the project; to receive progress reports from the Steering Committee; and to serve as an advocate for the Nearshore Study in international, Federal, State, tribal, and local government forums. The Executive Committee provides broad policy oversight and interagency/governmental coordination at executive levels of leadership.

Executive Committee Co-chairs:

- District Commander, U.S. Army Corps of Engineers – Seattle District
- Director, Washington Department of Fish and Wildlife

Table 8-1. Nearshore Study team Composition

Organization	EC	StC	IT	SIT	PMT
FEDERAL GOVERNMENT PARTNERS					
NOAA – NW Fisheries Science Center	■				
NOAA – Restoration Center		■	■		
U.S. Army Corps of Engineers – Seattle District	■	■	■	■	■
U.S. Department of Energy - Pacific NW National Laboratory	■	■			
U.S. Environmental Protection Agency	■	■			
U.S. Fish and Wildlife Service	■		■		
U.S. Geological Survey	■				
U.S. Navy Region Northwest	■	■			
TRIBAL PARTNERS					
Northwest Indian Fisheries Commission	■	■			
STATE GOVERNMENT PARTNERS					
Puget Sound Partnership	■	■	■		
Washington Department of Fish and Wildlife	■	■	■	■	■
Washington State Department of Ecology	■				
Washington State Department of Natural Resources	■	■			
Washington State Recreation and Conservation Office	■	■	■		
NON-GOVERNMENTAL ORGANIZATION PARTNERS					
The Nature Conservancy		■	■		
People for Puget Sound	■		■		
OTHER PARTNERS					
Local Government (represented by Pierce County)		■			
Northwest Straits Commission	■	■			
Salmon Recovery Lead Entities (represented by Green/Duwamish Watershed WRIA[1] 9)		■			
Taylor Shellfish Company		■			
University of Washington College of Ocean and Fishery Sciences			■		■
Washington Public Ports Association		■			

[1] Water Resource Inventory Area (WRIA)

8.1.2 Steering Committee

The role of the Steering Committee is to guide implementation of the project management plan, to develop any proposed changes to the project management plan, to advise and recommend actions to the project managers related to the implementation of the project management plan, to maintain a set of policies and procedures, and to report to the Executive Committee. The Steering Committee works to provide operational support and guidance to the PMT in completing the Nearshore Study, as well as insuring effective integration of products and results into activities outside of the Nearshore Study.

Steering Committee Co-chairs:

- Federal Project Manager, U.S. Army Corps of Engineers – Seattle District
- Local Project Manager, Washington Department of Fish and Wildlife

8.1.3 Nearshore Science Team

The role of the Nearshore Science Team (NST) is to identify, develop or acquire, and present the best scientific information available to the PDT for use in implementation of the Nearshore Study. The NST works at the direction of the PMT. NST membership is based on area of scientific expertise (discipline) as shown in Table 8-2, rather than agency or organizational affiliation. The NST works to ensure that the Nearshore Study is informed by best available science. They have also helped ensure that peer-review is effectively implemented for rigorous evaluation of study technical products and the program's use of internally and externally developed scientific information.

Table 8-2. Nearshore Science Team Composition and Expertise

DISCIPLINES	AFFILIATION
Nearshore Science Team Lead	
Intertidal Ecology and Habitats	University of Washington - School of Aquatic and Fishery Sciences
Nearshore Science Team Members	
Zoology, Marine Ecology	University of Washington - Friday Harbor Laboratories
Nutrient Dynamics	University of Washington - Applied Physics Laboratory
Biology	NOAA Fisheries Science Center
Shoreline Geology, Marine Sediment Dynamics	Washington State Department of Ecology
Oceanography, Coastal Geology	U.S. Geological Survey
Sediment Geochemistry	King County Department of Natural Resources
Social Science	University of Washington - School of Marine and Environmental Affairs
Nearshore Restoration	U.S. Fish and Wildlife Service
Spatial Modeling, Data Management	University of Washington - School of Oceanography
Marine Plants, Ecology	Washington Department of Natural Resources
Corps Liaison	
Environmental Science, Salmonid Ecology	U.S. Army Corps of Engineers – Seattle District

8.1.4 Implementation Team

The role of the Implementation Team (IT) is to develop an approach to the identification, evaluation, and assessment of potential restoration and protection projects and actions, and to identify opportunities at specific geographic locations to apply and test Nearshore Study products, guidance, and principles. The IT works to transfer scientific and technical products to the implementation of the Nearshore Study, including selection and evaluation of potential sites, and to restoration and protection work external to the Nearshore Study.

Implementation Team Leads:

- Washington Department of Fish and Wildlife
- U.S. Army Corps of Engineers – Seattle District

8.1.5 Project Management Team

The Project Management Team (PMT) comprises leads from the Implementation Team, Nearshore Science Team, and the Federal and local project managers. This group works to ensure coordination of activities across the program and make collective decisions on allocation of program resources toward critical path tasks.

8.1.6 Stakeholder Involvement Team

The role of the Stakeholder Involvement Team is to implement the Stakeholder Involvement Plan, which has four objectives: 1) fostering broad program understanding and support, 2) developing and reviewing restoration and protection goals and objectives, 3) involving stakeholders in the NEPA process, and 4) developing and advancing a Puget Sound Nearshore Study project site list.

8.2 AGENCY COORDINATION

Preparation of this DFR/EIS is being coordinated with appropriate congressional, Federal, State, and local interests as well as environmental groups and other interested parties. Since the original cost-sharing agreement was signed in September 2001, many Federal, local, and State agencies, as well as non-governmental organizations beyond the U.S. Army Corps of Engineers and Washington Department of Fish and Wildlife have joined the Nearshore Study team as shown in Section 8.1. Their participation has broadened the base of Federal and local support, and expanded the technical and financial resources being applied to the general investigation and the broader activities of the Nearshore Study.

8.2.1 Federal Cooperating Agencies

While many Federal agencies have extensively participated in early Nearshore Study activities, next steps of the investigation involve documenting the plan formulation process and Study results in this DFR/EIS for review and submission to Corps Headquarters. The Council for

Environmental Quality regulations for implementing NEPA encourage agencies to formally agree to “cooperating agency” status, thus ensuring their expertise will be applied when formulating feasible alternative plans. EPA had expressed willingness to consider a cooperating agency role; however, they declined upon formal invitation.

8.2.2 Tribal Coordination

The Corps has engaged in formal and informal coordination with the federally recognized tribes of the Puget Sound throughout the feasibility phase. Coordination with tribes is ongoing and the Corps will continue to offer opportunities to meet informally or through government-to-government meetings. Tribal coordination will continue throughout the feasibility phase, preconstruction engineering and design, and construction in accordance with Executive Order 13175 Consultation and Coordination with Indian Tribal Governments.

8.2.3 Agency Views

Many Nearshore Study partners, the Washington State Governor, and five Congressmen have provided letters that express their perspectives on the study, including the following in order of receipt:

- U.S. Environmental Protection Agency (EPA)
- Washington State Department of Ecology (WDOE)
- Skagit County (Skagit)
- U.S. Fish and Wildlife Service (USFWS)
- Washington Department of Fish and Wildlife (WDFW)
- People For Puget Sound (PFPS)
- Northwest Straits Commission (NWSC)
- The Nature Conservancy (TNC)
- Washington State Department of Natural Resources (DNR)
- University of Washington (UW)
- King County (King)
- Puget Sound Salmon Recovery Lead Entities (LE)
- U.S. Geological Survey (USGS)
- Puget Sound Partnership (PSP)
- Washington State Recreation and Conservation Office (RCO)
- Governor Christine Gregoire, State of Washington
- Representatives Inslee, Dicks, Reichert, McDermott, and Smith

8.3 PUBLIC INVOLVEMENT ACTIVITIES

8.3.1 Study Website

The Nearshore Study maintains a website (*www.pugetsoundnearshore.org*), which serves as the primary resource for information including study background, events, technical reports, program documents, and progress of the study. The site is updated as new products and reports are released. The site underwent a major update in June 2012 to make it more interesting and more usable by the public. The Nearshore Data Site (*www.psnerp.ekosystem.us/*) is a complementary website that includes a geospatial mapping feature to view proposed activities and relevant data layers derived from Nearshore Study technical products.

8.3.2 Stakeholder Involvement and Site Visits

The success of Corps planning efforts depends to a great extent on establishing partnerships with project proponents and other key stakeholders. Since the inception of the Nearshore Study, team members have met and developed relationships with public officials, congressional members and staff, members of non-governmental organizations, Federal partners, tribal government representatives, and local and State agencies. During the site selection process, the Nearshore Study team conducted site conversations with proponent(s) to ground-truth and fact-check project details. Prior to development of the conceptual designs for 36 sites, Nearshore Study team members as well as design consultants and project proponents met onsite to view and tour accessible lands to gain an understanding of on-the-ground conditions and constraints.

Project proponents were included in review of the draft conceptual design reports and their comments were incorporated into the final product. In early June 2012, project proponents and associated salmon recovery lead entity coordinators were notified via U.S. mail of their project's status with regard to the TSP for the DFR/EIS. Project proponents were offered an opportunity to meet with Nearshore Study team to better understand what it means for their project site to be part of the TSP. Next steps include a more comprehensive landowner and public outreach plan tailored to each of the TSP sites. This outreach work will use input from each project proponent and advocates and will follow the Nearshore Study's Stakeholder Outreach and Involvement Plan for Potential Restoration Projects (ESA 2011a).

8.3.3 Media Coverage

The Nearshore Study and its partner agencies have received positive media coverage since project inception. Coverage includes feature articles from the *Associated Press, Seattle Times, Seattle PI, Daily Olympian*, and *Daily Journal of Commerce*. In 2003, the Study team organized a project-specific media event, which highlighted new technology being used to obtain bathymetric data to improve nearshore zone mapping in Puget Sound. Since the establishment of the Puget Sound Partnership (PSP) in 2007, the Study team has coordinated media contact and other broad stakeholder engagement with PSP staff to ensure consistency of messaging, aligning the concerted work to support broader Puget Sound recovery actions.

8.3.4 Conferences/Workshops

Nearshore Study team members and associates have represented the Nearshore Study at numerous national and local conferences, ensuring that the Nearshore Study remains relevant and current in ecosystem-based restoration. This participation has brought positive recognition for the science-base and technical rigor of the Nearshore Study. Conference participation includes the Restore America's Estuaries Conference, the Salish Sea Ecosystem Conference (formerly the Puget Sound - Georgia Basin Conference), the International Conference on Ecology and Transportation, the Corps' and The Nature Conservancy's National Partnership Conference, the National Conference for Ecosystem Restoration, Coastal Habitats in Puget Sound (U.S. Geological Survey sponsored workshops), Salmon Recovery Conference (WA Recreation and Conservation Office sponsored), and the Coastal Zone Conference. Additionally, Nearshore Study team members have given informational presentations to the Mason County Shoreline Technical Advisory Group and the Pacific Coast Joint Venture Steering Committee.

8.3.5 Nearshore Study Sponsored Workshops

The Nearshore Study has held several retreats and workshops, including a Science Symposium, three Strategic Science Peer Review Panels, Valued Ecosystem Component Workshops, Shoreline Armoring Work Group, Navigating the Nearshore Workshop, Problems and Opportunities, Existing and Future Conditions Workshop, Informational Day for Restoration Practitioners, Evaluation and Screening Criteria Workshop, and a Restoration Strategies and Alternative Development Workshop. These workshops are typically organized as "all-hands" events, providing an opportunity for integrating the diverse perspectives and expertise represented by the membership of the Steering Committee, Nearshore Science Team, and Implementation Team. Many workshops have included participation from outside these Nearshore Study teams, helping to broaden the input that has informed the Nearshore Study.

The Nearshore Study team held workshops throughout the Puget Sound in September 2009 that were attended by city and county planning staff, tribal government representatives, non-profit staff, and some consultants. The purposes of these workshops were to: 1) engage the Puget Sound restoration community; 2) provide an overview of the Nearshore Study and its approach to delivering nearshore zone analyses and strategies; and, 3) share the results of the Nearshore Study's Change Analysis, which are useful to a broader audience beyond the Nearshore Study.

8.3.6 NEPA Scoping*

Scoping is a critical component of the overall public involvement program to solicit input from affected Federal, State, and local agencies; tribes; and interested stakeholders. The NEPA scoping process is designed to provide an early and open means of determining the scope of issues (problems, needs, and opportunities) to be identified and addressed in the environmental impact statement (EIS). The Nearshore Study NEPA/SEPA scoping process was conducted jointly with the Washington Department of Fish and Wildlife (WDFW).

An initial scoping meeting was held in October 2001 after completion of the Reconnaissance Phase. However, the NEPA/SEPA scoping process formally commenced on October 26, 2009. A Notice of Intent was published in the Federal Register on October 2, 2009 (Vol. 74, No. 190). The public comment period ran from October 26 to December 10, 2009. The Corps and WDFW held four public meetings in strategic locations around Puget Sound, and placed public notices in prominent sections of 14 major newspapers. The notice was emailed to a broad range of stakeholder groups and posted on the Nearshore Study and Puget Sound Partnership websites. The public scoping meetings were held in the evening to minimize conflicts with standard work schedules. An open house preceded the formal presentation where eight displays and a handout were available, followed by a question and answer period that was recorded and transcribed. The dates and locations of the public scoping meetings were as follows:

- Oct. 26, 2009: Des Moines, Highline Community College (14 people)
- Oct. 28, 2009: Port Townsend, Fort Worden State Park (7 people)
- Nov. 3, 2009: Lacey, Lacey Community Center (15 people)
- Nov. 10, 2009: Mount Vernon, Skagit Station (24 people)

During the comment period, 35 comments were received, of which one was in a letter, nine in comment cards submitted during the scoping meetings, and 25 articulated during the scoping meetings. Comments were evaluated for recurring themes, which were identified as key issues to address in the EIS. The 12 identified themes are listed in Table 8-3.

Following publication of the Notice of Intent, the Corps received a scoping letter from the EPA on December 10, 2009, pursuant to EPA's responsibilities under NEPA and Section 309 of the Clean Air Act. This letter states that Puget Sound recovery is a priority for EPA and that the agency fully supports this effort. The major points in EPA's support letter recommended that the Nearshore Study team do the following: use Valued Ecosystem Components to identify objectives, optimize benefits at multiple scales while developing priorities, consider climate change in project planning, and benefit from lessons learned from other regional coastal restoration initiatives. As identified throughout this document and other supporting documents completed for the Nearshore Study, each of these recommendations has been implemented.

Table 8-3. Summary of Type of Scoping Comments Received

Theme	Number of Comments
General project questions	20
Shoreline management	5
Floodplain development	1
Harvesting energy	1
Water quality	1
Removal of armoring	1
Participation in prioritization of restoration actions	1
Impacts of railroads on nearshore habitats	1
Projects should increase jobs	1
Funding for projects with multiple purposes	1
Global warming should be considered	1
Sustainability of beaches where sediment is brought in	1

8.3.7 Draft EIS Public Comment Period*

The public comment period, during which any person or organization may comment on the DFR/EIS, is mandated by State and Federal laws. For the Nearshore study, the draft FR/EIS public comment period will formally run for 45 days beginning in October 2014 and ending in December 2014. The Corps will consider all comments received during the comment period. The complete list of comments regarding the draft FR/EIS and the Corps' responses will be included as an appendix to the Final FR/EIS.

The Study team will host at least one public hearing in November 2014. In addition to accepting comments during the public hearings, comments will be accepted via mail, fax, or email.

8.4 PEER REVIEW

From early in this general investigation, the Puget Sound Nearshore Study team built a rigorous peer review process into all elements – study planning, technical reports, and report development – and plans to continue these practices as an integral component of the plan's implementation. Peer review was designed to meet all pertinent Corps policies (e.g. Engineering Circulars (EC) including EC 1165-2-214). In 2007, the "Peer Review Plan for Feasibility Study of Puget Sound Marine Nearshore Habitat Restoration, WA" (Peer Review Plan; USACE 2007) was developed by the Nearshore Study's Nearshore Science Team and approved by the Corps Ecosystem Restoration Planning Center of Expertise (ECO-PCX). This plan requires external review of the project's technical reports, as well as more comprehensive strategic science and programmatic peer review that includes external review of the sufficiency of science used in the Nearshore Study and the application of science, by an independent Strategic Science Peer Review Panel (SSPRP; refer to section 8.4.3).

8.4.1 Corps Review Policy

EC 1165-2-214 identifies specific procedures that must be followed to ensure the quality and credibility of Corps decision documents (USACE 2012). The Nearshore Study has adhered to this guidance and completed multiple rounds of District Quality Control (DQC) and Agency Technical Review (ATR) on feasibility phase deliverables. This Draft Feasibility Report/Environmental Impact Statement (DFR/EIS) will undergo DQC, ATR, and Independent External Peer Review (IEPR). Once complete, DQC, ATR, and IEPR review reports will be submitted to Corps headquarters with the Final Feasibility Report/EIS.

In accordance with guidelines set by the Corps for planning and ecosystem output models (e.g., ER 1165-2-501 [USACE 1999c] and EC 1105-2-412 [USACE 2011b]), Seattle District has received approval for one-time use of a planning model. The Puget Sound Nearshore Ecosystem Output Model is a regional model developed by members of the Nearshore PDT and the

Nearshore Science Team. The model was used to generate net benefit scores for the array of actions under consideration by the Nearshore Study. A documentation report (Appendix G) that explains the model has undergone peer review by the SSPRP. The model review plan was submitted to the ECO-PCX in June 2012 and received one-time use approval in November 2012.

8.4.2 Technical Report Peer Review

Consistent with the Peer Review Plan, primary program documents developed during the Nearshore Study have undergone peer review. Typically for draft technical reports, two to four subject matter experts outside of the project are engaged as anonymous reviewers by a member of the PDT, who provides the reviewers' comments to the report's primary author. Following revisions to address comments, the technical report is assigned a document number and published on the Nearshore Study's website. On the website, supporting documents used to inform the Nearshore Study, but which did not receive those peer review procedures, are clearly distinguished from peer-reviewed technical reports.

8.4.3 Strategic Science Peer Review Panel

Integral to the Nearshore Study, a continuous peer-review process provides guidance to ensure that the Nearshore Study is following the best available science. To provide a broad overview of application of scientific principles and information in completing the Nearshore Study, the NST recommended that potential panel members have experience in large-scale coastal restoration actions and the following disciplines be explicitly represented in external review:

- coastal geomorphology
- estuarine/coastal ecology
- restoration planning, monitoring, and assessment
- landscape ecology
- coastal/estuarine oceanography/sediment transport
- social science

The SSPRP convened in the summer of 2008 to provide independent review and input to the Nearshore Study. In convening the SSPRP, the NST and PMT identified potential panel chairpersons. The SSPRP Chair was selected based on international recognition for scientific excellence and extensive experience in other national ecosystem restoration programs. SSPRP members were selected based on each person's identified area of expertise, in consultation with the SSPRP Chair. The role of the SSPRP is based on the Nearshore Study's Peer Review Plan with modifications based on recommendations from the SSPRP and experience from other large-scale restoration programs.

Procedures and schedules for the SSPRP review are coordinated through the Chair. The SSPRP Chair communicates annually with the rest of the Panel to determine which Nearshore Study documents were due for review and who among the Panel members would take the lead for each, based on their expertise. In addition to review of the program's application of science, the SSPRP reviewed complex program documents, including the Ecosystem Output Model and the Feasibility Scoping Meeting submittal package. Drafts were distributed to the Panel members with at least two months allowed for review; the Chair coordinated the review summary in all cases, usually with a conference call among the SSPRP members. Additional full-group reviews were provided during periodic on-site, multi-day SSPRP programmatic workshops with the Nearshore Science Team and Project Management Team, which also included attendance by other members of the Nearshore Study team, such as the Steering Committee. These comprehensive SSPRP workshops were convened in June 2008, May 2009, and November 2011.

9 RECOMMENDATIONS

The following text will be included in the final report, pending public review, policy review, technical reviews, and subsequent comments and revisions:

I recommend that the tentatively selected plan for ecosystem restoration for the Puget Sound Nearshore Ecosystem Restoration Project area as generally described in this report be authorized for implementation as a Federal project, with such modifications thereof as in the discretion of the Commander, USACE may be advisable. The estimated first cost of the recommended plan is $1,126,340,000 (October 2014 price level). The Federal portion of the estimated first cost is $693,062,000. The non-Federal partners shall, prior to implementation, agree to perform the following items of local cooperation:

1. Provide 35 percent of total project costs as further specified below:
    a. Provide 25 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;
    b. Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs;
    c. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the project;
    d. Provide, during construction, any additional funds necessary to make its total contribution equal to 35 percent of total project costs;
    e. Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefore, to meet any of the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized;

2. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the project, hinder operation and maintenance of the project, or interfere with the project’s proper function;

3. Shall not use the project or lands, easements, and rights-of-way required for the project as a wetlands bank or mitigation credit for any other project;

4. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

5. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

6. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

7. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

8. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

9. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq.*);

10. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

11. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;

12. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

13. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

The recommendations contained herein reflect the information available at this time and current departmental policies governing the formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of the national civil works construction program or the perspective of higher levels within the executive branch. Consequently, the recommendations may be modified before they are transmitted to Congress for authorization and/or implementation funding. However, prior to transmittal to Congress, the State of Washington, interested Federal agencies, and other parties will be advised of any significant modifications in the recommendations and will be afforded an opportunity to comment further.

JOHN G. BUCK
Colonel, Corps of Engineers
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12 ANNOTATED BIBLIOGRAPHY

Except where prohibited by law, these documents are available upon request by sending an e-mail request to *pugetsoundnearshore@dfw.wa.gov*. When an electronic version is available, a hyperlink to the document will be included below. All of these documents are incorporated by reference according to 40 CFR 1502.21 except for those denoted by an asterisk (*) as they are not available for public distribution, or in the cases of appendices that are summarized herein.

Puget Sound Nearshore Ecosystem Restoration Project Technical Reports

Principles for Strategic Conservation and Restoration

This report summarizes principles of landscape ecology and conservation biology that are applicable to the conservation and restoration of nearshore ecosystems in the Puget Sound and are intended to guide the prioritization of sites and actions by the Nearshore Study team and others. The result is eleven principles derived from the literature organized into three hierarchical scales: 1) Overarching Principles; 2) Landscape Level Principles; and 3) Site-Specific Principles.

Available at:
www.pugetsoundnearshore.org/technical_papers/conservation_and_restoration_principles.pdf

Historical Change and Impairment of Puget Sound Shorelines: Atlas and Interpretation of Puget Sound Nearshore Ecosystem Restoration Project Change Analysis

This report is a comprehensive, spatially-explicit analysis (Change Analysis) of net changes to nearshore ecosystems of Puget Sound—its beaches, estuaries, and deltas—since its earliest industrial development. These quantitative changes in the structure of Puget Sound's shorelines are indicators of qualitative change to nearshore ecosystem processes. Because historical documentation of nearshore ecosystem processes does not exist per se, we used the observed physical changes to the shoreline, Nearshore Study conceptual models, and other sources of understanding about the relationship among nearshore ecosystem processes, structures, and functions to interpret the levels and types of impairment of nearshore ecosystem processes. Our approach was to systematically quantify historical change in the physical structure of Puget Sound's shorelines over the past approximately 150 years, between the earliest land surveys of the General Land Office and U.S. Coast and Geodetic Survey (1850s–1890s) and present conditions (2000–2006).

Historical change was analyzed in four categories, 1) Landform Transition (Tier 1): changes in landform class, either among natural geomorphic classes or to classifications of artificial or absent; 2) Shoreline Alterations (Tier 2): changes in historically documented attributes, such as wetlands, or current anthropogenic modifications (considered stressors) along the shoreline; 3) Adjacent Upland Change (Tier 3): anthropogenic changes within 200 meters of the adjoining uplands; and 4) Watershed Area Change (Tier 4): anthropogenic changes in the drainage area. The four categories of nearshore change (tiers) were related to shifts in the benefits of natural nearshore ecosystems to humans and their communities. The results of this analysis can be used to inform restoration and preservation planning experts about the types, extent, and consequences of changes to Puget Sound's shoreline.

Available at: *www.pugetsoundnearshore.org/technical_papers/change_analysis.pdf*

Implications of Observed Anthropogenic Changes to the Nearshore Ecosystems in Puget Sound

This report by the Nearshore Study Nearshore Science Team presents a synthesis of the most significant physical changes to the nearshore ecosystems of Puget Sound and implications of these changes to ecosystem functions, goods, and services. Documented historical changes to the shoreline environment of Puget Sound have caused widespread losses in connectivity, increased fragmentation of the landscape and simplification of nearshore landscapes. These impacts have disrupted many nearshore ecosystem processes that support important species and have impaired the system's capacity to support biological diversity and production.

Available at:
www.pugetsoundnearshore.org/technical_papers/implications_of_observed_ns_change.pdf

Strategic Needs Assessment: Analysis of Nearshore Ecosystem Process Degradation in Puget Sound

This report characterizes the impacts of shoreline and watershed alterations on nearshore ecosystem processes, identifies the potential causes of observed ecosystem degradation, and assesses which of the identified problems most need to be addressed through restoration and protection actions. To support this strategic needs assessment, a spatially explicit evaluation framework was created and applied to characterize the extent to which the observed distribution of stressors has degraded each of the 11 nearshore ecosystem processes evaluated.

Available at:
www.pugetsoundnearshore.org/technical_papers/strategic_needs_assessment_final.pdf

Strategies for Nearshore Protection and Restoration in Puget Sound

This report, commonly called the "Strategies Report" integrates change analysis and estimated process degradation, under a simple restoration and protection planning model. This model offers a framework for the management of Puget Sound nearshore ecosystems. We identify a set of delta, beach, barrier embayment and coastal inlet sites. Sites differ in their historical potential to provide ecosystem services. Restoration and protection planning should consider the operation of critical ecosystem processes at the site scale. The intensity and character of site degradation both indicates the potential for restoration, but creates risk in that restoration efforts may be undermined by degradation of critical ecosystem processes. The development of landscape strategies and conservation actions can be informed by these large-scale assessments. We provide suggestions for incorporating Nearshore Study data into restoration planning. Our framework and assessments point to groups of large complex sites, where there may be exceptional opportunities for large-scale ecosystem restoration or protection.

Available at:
www.pugetsoundnearshore.org/technical_papers/psnerp_strategies_maps_lowres.pdf

U.S. Fish and Wildlife Service Reports

This is a series of four documents produced by the USFWS with contractor support to supplement Nearshore Study conceptual design work and includes the following:

PSNERP Strategic Restoration Conceptual Design Preliminary Environmental Contaminants, Cultural Resource, and Endangered Species Site Evaluations.
This report provides baseline information on environmental contaminants, cultural resources, endangered species and conservation measures for 36 candidate restoration sites under consideration by the Nearshore Study team. Environmental Site Assessment Level 1 Survey Checklists were also completed for each of the 36 sites.

A Cultural Resources Assessment of the Puget Sound Nearshore Ecosystem Restoration Projects (PSNERP) Area, NW Washington, Task 1. Literature and Data Review and Synthesis*
This report presents the results of cultural resource record/literature searches for 36 candidate restoration sites under consideration by the Nearshore Study team. An assessment of the potential for cultural resources within each project area is made based on a review of the environmental, cultural, and archaeological data, and recommendations are provided on where future archaeological efforts should be made for each of the 36 action areas. By law, sensitive cultural resource information is not available for public release.

A Cultural Resources Assessment of the Puget Sound Nearshore Ecosystem Restoration Projects (PSNERP) Area, NW Washington, Task 2: Historic Context of Agricultural Dikes.
This report is a regional-scale historic context of late nineteenth and early twentieth century agricultural development within the Puget Sound region of NW Washington. This effort documents the history of development of dikes built in the region, and proposed evaluation criteria to use as a management tool for the USFWS and other to use for future compliance with Section 106 of the National Historic Preservation Act.

Cultural Resources Field Inventory for 15 Action Areas within the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) Area, NW Washington*
This report presents the finding of both surface surveys and subsurface investigations concentrated on project components within areas previously determined to have high to moderate probabilities for cultural resources. The purpose of the inventory was to provide (1) descriptions of cultural resources in the area of potential effect (APE) for Nearshore Study undertakings, (2)

determinations concerning the eligibility of cultural resources to the National Register of Historic Places (NHRP) and the Washington Heritage Register (WHR), and (3) recommendations on how to avoid or mitigate impacts to historic properties. This report was completed for subset of the 36 candidate restoration sites, and only on lands where access had been granted by the landowner. By law, sensitive cultural resource information is not available for public release.