Puget Sound Nearshore Ecosystem Restoration Project

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Strategic Restoration Conceptual Engineering — Design Report

May 2012 — Final

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Cover photo: Lilliwaup Estuary (ESA)

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Acronyms and Abbreviations

ACR	Action Characterization Report
AASHTO	American Association of State Highway and Transportation Officials
BNSF	Burlington Northern Santa Fe
BPA	Bonneville Power Administration
CCC	Civilian Conservation Corps
CDT	Concept Design Team
cfs	Cubic feet per second
CMP	Corrugated metal pipe
CY	Cubic yards
DEM	Digital Elevation Model
EHW	Extreme high water
ELJ	Engineered log jam
FEMA	Federal Emergency Management Agency
GI	General Investigation
GIS	Geographic information system
GLO	General Land Office
H-Sheet	Hydrographic sheet
HDPE	High-density polyethylene
I-5	Interstate 5
LF	Linear feet
LiDAR	Light Detection and Ranging
LLTK	Long Live the Kings
LOTT	Lacey-Olympia-Tumwater-Thurston
LWD	Large woody debris
MHHW	Mean higher high water
MHW	Mean high water
MLW	Mean low water
MLLW	Mean lower low water
mph	Miles per hour
MSL	Mean sea level
MTL	Mean tide line
NAVD	North American Vertical Datum
NAS	Naval Air Station
NER	National Ecosystem Restoration
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NPDES	National Pollutant Discharge Elimination System
ppt	Parts per trillion
PSE	Puget Sound Energy
PSNERP	Puget Sound Nearshore Ecosystem Restoration Project
PUD	Public Utility District
SF	Square feet
SLR	Sea level rise

T-Sheet	Topographic sheet
U&A	Usual and Accustomed
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UW	University of Washington
VLM	Vertical land movement
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WPCF	Water pollution control facility
WRDA	Water Resources Development Act
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation
WSEL	Water surface elevation
WWTP	Wastewater treatment plant

INTRODUCTION

Background

The Washington Department of Fish and Wildlife (WDFW) and the U.S. Army Corps of Engineers (USACE) co-lead PSNERP, a General Investigation (GI) of Puget Sound. PSNERP was initiated to: (1) evaluate significant ecosystem degradation in the Puget Sound Basin; (2) formulate, evaluate, and screen potential strategies to address these problems; and (3) identify actions and projects to restore and preserve critical nearshore habitat. One aim of this multifaceted GI is to secure substantial federal funding (under the Water Resources Development Act or WRDA) for projects that restore the Puget Sound nearshore.

This report presents engineering design concepts for a suite of potential nearshore restoration *actions* that may be eligible for authorization through WRDA[1]. PSNERP will use the conceptual design information to assess the costs and benefits of each restoration action and formulate a comprehensive plan for restoring the Puget Sound nearshore. The plan will analyze future conditions with and without a strategic nearshore restoration project. This will allow the USACE and WDFW to compare the benefits of implementing nearshore restoration with the future conditions if no action is taken. The ecological and socioeconomic effects of restoration will be expressed in terms of change in ecosystem outputs. The USACE will use this information to select a portfolio of restoration actions that meet federal cost-effectiveness criteria. The selected actions will be evaluated further to verify their suitability for the National Ecosystem Restoration (NER) Plan proposed to be authorized for implementation.

All of the restoration actions described in this conceptual engineering design report will have the potential to provide important ecological benefits regardless of whether they are deemed appropriate for federal authorization. Some of the actions may be more suitable for implementation at the local level through non-federal programs or partnerships. Report authors and PSNERP team members anticipate that the design information provided by the report will support not only potential implementation of projects through WRDA, but also implementation through other federal and non-federal programs, authorities, and funding sources.

This report was prepared by a team of engineering firms led by Environmental Science Associates (ESA). WDFW hired this team to provide concept-level (10%) design services for an initial suite of candidate restoration actions. ESA's team (referred to here as the Concept Design Team or CDT) includes ESA PWA (formerly Phillip Williams Associates, now a fully owned subsidiary of ESA); Anchor QEA; Coastal Geologic Services (CGS); KPFF; and Pacific Survey and Engineering (PSE). Completion of conceptual designs and review of the report was supported by PSNERP team members, project proponents who initially identified the potential restoration actions, and USACE technical experts.

[1] This report uses the term *action* instead of *project* to denote individual restoration efforts that occur within a larger site. For some sites, such as the Skagit River delta, several actions may be proposed. The area where an action is proposed is referred to as the *action area.*

Selection and Screening of Candidate Restoration Actions

The candidate restoration actions PSNERP selected for conceptual design were drawn from PSNERP's analysis of process-based nearshore restoration needs, and from a list of existing restoration opportunities identified by restoration proponents from various governmental and non-governmental organizations throughout the Puget Sound Basin (Figure 1 and Table 1). Each action represents a location where one or more restoration measures can be applied to improve the integrity and resilience of the nearshore ecosystem. According to PSNERP analysis of Puget Sound conditions and program guidance documents, implementing these actions will help achieve nearshore conservation strategies upon which the comprehensive restoration plan for Puget Sound is based (Cereghino et al. 2012) (Table 2).

Figure 1. Location of PSNERP Candidate Restoration Actions

Table 1. PSNERP's Candidate Restoration Actions, Local Proponents, and CDT Lead Designer

Action ID	Action Name	Project Proponent	CDT Lead Designer
1499	Beaconsfield Feeder Bluff Restoration	City of Normandy Park	CGS
1256	Big Beef Causeway Replacement and Estuary Restoration	Hood Canal Coordinating Council	CGS with KPFF
1076	Big Quilcene Delta Cone Removal	Hood Canal Coordinating Council	Anchor with KPFF
1074	Big Quilcene Estuary South Bank Levee Removal	Hood Canal Coordinating Council	
1077	Big Quilcene Lower Mainstem Levee Removal	Hood Canal Coordinating Council	
1078	Big Quilcene River	Hood Canal Coordinating Council	
1801	Chambers Bay Estuarine and Riparian Enhancement	South Puget Sound Salmon Enhancement Group	Anchor with KPFF
1642	Chuckanut Estuary Restoration	City of Bellingham	Anchor with KPFF
1101	Deepwater Slough Phase 2	Washington Dept. of Fish & Wildlife	ESA PWA
1648	Deer Harbor Estuary Restoration	People for Puget Sound	CGS
1003	Deschutes River Estuary Restoration	Squaxin Island Tribe	ESA PWA
1012	Duckabush Causeway Replacement and Estuary Restoration	Hood Canal Coordinating Council	ESA PWA with KPFF
1609	Dugualla Bay Restoration	Skagit River Systems Cooperative	Anchor with KPFF
1126	Everett Marshland Tidal Wetland Restoration	City of Everett	Anchor
1127	Everett Riverfront Wetland Complexes	City of Everett	ESA
1047	Hamma Hamma Causeway Replacement and Estuary Restoration	Hood Canal Salmon Enhancement Group	Anchor with KPFF
1505	Harper Estuary Restoration Design and Construction	Kitsap County	KPFF/ESA
1447	John's Creek Estuary Restoration Project	Cascade Land Conservancy	Anchor
1552	Kilisut Harbor / Oak Bay Reconnection	Jamestown S'Klallam Tribe	CGS
1346	Lilliwaup Causeway Replacement and Estuary Restoration	Hood Canal Coordinating Council	PWA with KPFF
1618	Livingston Bay - Diked Farmland & Nearshore Habitat	Whidbey Camano Land Trust	ESA PWA
1092	McGlinn Island Causeway	Skagit River Systems Cooperative	ESA PWA
1091	Milltown Island	Skagit River Systems Cooperative	Anchor with KPFF
1457	Mission Creek Estuary Reconnection	City of Olympia	ESA

Action ID	Action Name	Project Proponent	CDT Lead Designer
1190	Nearshore Restoration Strategy for Twin Rivers	Lower Elwha Tribe	CGS
1055	Nooksack River Estuary	Whatcom Action Area Local Integrating Organization	ESA/PWA
1102	North Fork Levee Setback	Skagit Watershed Council	ESA PWA w KPFF
1379	Point Whitney	Washington Dept. of Fish & Wildlife	ESA PWA
1136	Quilceda Estuary Restoration	Tulalip Tribes	ESA
1467	Sequalitchew Creek Culvert	South Puget Sound Salmon Enhancement Group	Anchor with KPFF
1142	Smith Island Estuary Restoration	Snohomish County	Anchor
1805	Snohomish Estuary Mainstem Connectivity	Tulalip Tribes	ESA
1230	Snow Creek and Salmon Creek Estuary Restoration	North Olympic Salmon Coalition, Hood Canal Coordinating Council, Jefferson County Conservation District	ESA PWA with KPFF
1149	Spencer Island Restoration	Snohomish County, Ducks Unlimited	ESA PWA
1404	Tahuya Causeway Replacement and Estuary Restoration	Mason County	Anchor with KPFF
1633	Telegraph Slough - Phase 1	Skagit River System Cooperative	Anchor with KPFF
1635	Telegraph Slough Phase 2	Skagit Watershed Council, Washington Dept. of Fish and Wildlife	
1421	Twanoh State Park Beach Restoration	Washington State Parks	CGS
1237	Washington Harbor Tidal Hydrology Restoration Project	Jamestown S'Klallam Tribe	Anchor with KPFF
1684	WDNR Marine Lab Bulkhead Softening	Washington Dept. of Natural Resources	CGS
1261	Black Point Lagoon	Hood Canal Coordinating Council	NA
1271	Cattail Causeway Replacement and Estuary Restoration	Naval Base Bangor	NA
1286	Devil's Hole Creek	Naval Base Bangor	NA
1004	Garfield Creek Delta Restoration	City of Olympia	NA
1005	Indian/Moxlie Creek Delta Restoration	City of Olympia	NA
1131	Maulsby Swamp Mudflats/Enhanced Connection	City of Everett	NA

NA indicates action failed screening criteria and was not carried forward to 10% design

Table 2. Description of PSNERP's Restoration Strategies for Puget Sound

#	Strategy Name	Description
1	River Delta	Protect and restore freshwater input and tidal processes where major river floodplains meet marine waters.
2	Beach	Protect and restore sediment input and transport processes to littoral drift cells where bluff erosion sustains beach structure.
3	Barrier Embayment	Protect and restore sediment input and transport processes to littoral drift cells where bluff erosion sustains barrier beaches that form barrier embayments and restore the tidal flow processes within these partially closed systems.
4	Coastal Inlet	Protect and restore tidal flow processes in coastal inlets, and protect and restore freshwater input and detritus transport processes within these open embayment systems.

The CDT visited each action location and met with the local restoration proponents to review and document restoration goals and opportunities at each locale. Following the field visits, the CDT identified initial restoration alternatives for each potential action and summarized the findings in a series of Action Characterization Reports (ACRs), which were delivered to PSNERP in October 2010 (Appendix A). Each ACR describes the potential restoration opportunities in terms of ecological effectiveness and engineering feasibility. Based on the initial action characterization results, the CDT evaluated each action using primary and secondary screening criteria to determine if the action was appropriate for 10% engineering design (Table 3).

Table 3. Screening Criteria Used to Identify Actions that are Suitable for 10% Design

Fatal Flaws: A *No response* on any question results in a *No Go* determination. Otherwise, the action is recommended for 10% design.

1	Criterion	Yes	No
1a	The local proponent has not precluded PSNERP's involvement in the concept design.		
1b	The candidate action is sufficiently described and spatially defined to enable us to design restoration alternatives and determine quantity estimates.		
1c	The candidate action is consistent with one or more PSNERP restoration strategies, and an alternative can be described which addresses one or more of the associated restoration objectives.		

Additional Criteria: A *No response* on one or more questions means the action may not be suitable for 10% design. If the action has all *Yes* responses, the action is recommended for 10% design.

2	Criterion	Yes	No
2a	There is an alternative for this action that could restore ecosystem processes to a substantial portion of their historic (less degraded) state.		
2b	The restored action area will support a broad representation of nearshore ecosystem components appropriate for that geomorphic setting.		
2c	There are no obvious and significant problems external to the action area that would jeopardize the restoration outcome.		
2d	The contributing basin provides for flood discharge, wood recruitment, organism dispersal and sediment supply to support the restored system.		
2e	The restored action area will form a contiguous large patch that is well connected to a surrounding terrestrial and marine landscape.		
2f	The restored ecosystem components within the action area will be internally connected in a way that allows for the unconstrained movement of organisms, water, and sediments.		

Six actions did not meet the screening criteria and were not recommended for further design work (Appendix A). After reviewing the ACRs and preliminary screening results with the local proponents, PSNERP elected to carry 40 of the original 46 candidate actions forward to 10% design. In addition, multiple actions at the Big Quilcene River site were combined into one action, and two phases of the Telegraph Slough action were combined into one; this brought the total number of actions being carried forward to 10% design from 40 to 36. Each of these 36 actions is described in a subsequent chapter of this report.

Restoration Design within PSNERP's Framework

PSNERP's restoration strategies are aimed at restoring damaged or degraded ecosystem processes. Process-based restoration involves making intentional changes to an ecosystem to allow erosion, accretion, tidal exchange, accumulation of wood debris, and other natural process to occur. Process-based restoration is often 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 the entire ecosystem. It is anticipated that process-based restoration will deliver benefits to the diverse array of species that rely upon nearshore ecosystems in a manner that is sustainable and reduces the need for future interventions at the restored site. PSNERP has documented representative relationships between "valued ecosystem components", including juvenile salmonids, forage fish, and shorebirds, as part of a series of technical reports, available on the program website (http://www.pugetsoundnearshore.org/technical_reports.htm).

In PSNERP's framework, each candidate restoration action involves removing one or more ecosystem *stressors* using specific *management measures*. Stressors are physical alterations that interrupt, preclude, or displace nearshore processes. PSNERP documented the presence of the following stressors throughout Puget Sound as part of the Strategic Needs Assessment (Schlenger et al. 2011): nearshore fill, tidal barriers, shoreline armoring, railroads, nearshore roads, marinas, breakwaters and jetties, overwater structures, dams, stream crossings, impervious surfaces, and land cover development.

PSNERP used stressor information to calculate a *degradation score* for a series of nearshore analysis units. The CDT supplemented this relatively coarse scale information on stressors with additional site-specific information gathered during the field investigations to create restoration concepts for each action. The design concepts presented here document the amount of each stressor to be removed at each action location. PSNERP will use the information concerning stressor removal to recalculate the degradation scores and quantify the benefits of each restoration alternative.

Management measures are the restoration, rehabilitation, and enhancement activities (as well as protection, management, and regulatory endeavors) that remove stressors to recover or improve nearshore ecosystems. PSNERP defined 21 management measures for protecting and restoring Puget Sound (Clancy et al. 2009; http://www.pugetsoundnearshore.org/technical_papers/management_measures.pdf). Each candidate restoration action involves applying one or more of these management measures to achieve the site-specific restoration objectives. The measures that are the primary focus of this conceptual design report are the ones that have the most direct effect on nearshore processes and require in-depth engineering analysis, including:

- Topography Restoration: dredging, fill removal, or addition of surface material so that the physical structure of beaches, shorelines, and tidal wetlands can be restored.
- Armor Removal or Modification: removal of coastal erosion protection structures, including rock revetments, bulkheads, and retaining walls, to reinitiate sediment delivery and transport within beach systems.
- Hydraulic Modification: modification of culverts, tide gates, or levees to improve tidal or fluvial connectivity and the associated conditions in marsh and lagoon habitats.

- Berm or Dike Removal or Modification: removal of structures to restore tidal inundation and restoration of tidal wetland ecosystems.
- Channel Rehabilitation or Creation: restoration or creation of tidal, alluvial, and distributary channels to restore the natural movement and exchange of water, sediment, and/or detritus.

Other management measures such as Beach Nourishment, Contaminant Removal/ Remediation, Debris Removal, Groin Removal, Invasive Species Control, Large Wood Placement, Physical Exclusion, Overwater Structure Removal or Modification, Species/ Habitat Enhancement, Substrate Modification, Reintroduction of Native Animals, and Revegetation are used for some actions depending on the specific restoration opportunities available. Management measures such as Public Outreach/ Education, Habitat Protection Policies and Regulations, and Property Acquisition and Conservation are common to all actions.

Definition of Conceptual (10%) Design

Conceptual (10%) design is the first step in the restoration design sequence. Typically projects move from the concept stage (10%) to preliminary design (35%) to final design (which often involves 60, 90, and 100% design plans). While there are no precise definitions for 10% design, conceptual design generally involves identifying site-scale restoration alternatives for an action area and comparing them in terms of their relative costs, benefits, and feasibility. Action area boundaries were estimated to represent the area affected by the proposed restoration actions. A more precise, but still approximate, estimate of the lands required for construction (referred to as required project lands) was also calculated for each action. The action area and required project lands boundaries are shown in the figures and drawings that accompany each action. For purposes of this contract, 10% design involves the following:

- Describing site conditions and restoration opportunities;
- Describing how specific management measures will be applied to remove stressors and restore processes;
- Identifying the potential need for land acquisition;
- Describing the primary design considerations that might affect feasibility, cost and/or success of the project;
- Describing the ecological evolution of the restored site;
- Quantifying the type and amount of stressor removal at each action area;
- Describing uncertainties and/or risks associated with property acquisition, flooding, weak soils, contamination, etc.;
- Assessing risks caused by projected sea level change;
- Describing additional information needs; and
- Estimating quantities for all the major design elements.

A major goal of the 10% design process is defining data gaps and uncertainties that will need to be addressed in subsequent design phases, since detailed site investigations are typically not performed at the conceptual design stage. Subsequent design studies could include, for example, property boundary surveys, topographic surveys, geotechnical analyses, contaminant tests, cultural resources assessments, and hydrodynamic models.

Ideally, the conceptual design process enables a project proponent to select a preferred alternative for each action that can be developed in more detail during the later design stages.

To ensure that a feasible and effective restoration alternative can be found for each of PSNERP's candidate actions, the CDT attempted to identify a broad spectrum of what might be possible within each action area. Thus, each action is represented in terms of a *full restoration* alternative and a *partial restoration* alternative. Bracketing a wide range of restoration possibilities for each action in this way bolsters PSNERP's ability to:

- Identify the combination of restoration measures that maximizes ecosystem benefits compared to costs, consistent with federal ecosystem restoration objectives;
- Select a subset of actions to move forward to preliminary design (35%); and
- Secure authorization for federal funding sufficient to implement a comprehensive restoration plan for Puget Sound (even though the plan may be scaled back as the design progresses).

Definition of Full Restoration

For each candidate action, the full restoration alternative is designed to maximize ecological benefits by fully removing stressors—regardless of cost. As a result, the full restoration alternative for each action is not necessarily the most cost effective way to restore the site. Optimizing ecological benefits means that in some cases, the full restoration includes activities such as excavation of starter channels or tidal channels to trigger natural processes and accelerate site evolution. For planning purposes, the full restoration alternative assumes that private properties can be acquired and that most infrastructure such as secondary roads and local utilities can be modified, relocated, or removed to fully restore processes. Major infrastructure such as regional transmission lines, state highways, and railroads are treated as constraints to full restoration and addressed accordingly. Although these assumptions are important for fully delineating the scope of federal authority that would be needed to implement these actions using WRDA appropriations, PSNERP recognizes that the full restoration alternative may not be appropriate for some actions. In particular, PSNERP recognizes that acquisition of private lands and infrastructure relocation hinge on landowner willingness, stakeholder support, and myriad other factors that have not been fully investigated at the concept design stage.

Full restoration as presented here involves applying specific process-based management measures to remove the causes of process degradation, which vary depending on the strategy/shoreform (Table 4). The description of a full restoration alternative is intended to assist the planning process by describing a site's near-maximum potential. In most cases, PSNERP recognizes that site-specific feasible, cost-effective, and socially acceptable alternatives may be scaled back through subsequent steps in the design process.

Table 4. Full Restoration Objectives, Target Processes, and Associated Management Measures

Full Restoration Objective	Target Processes (primary in bold)	Management Measures
River Deltas - Ecosystem processes can be fully restored by removing the dominant stressors to a degree that allows undegraded tidal flows and freshwater inputs necessary to support a full range of delta ecosystem processes, focusing on the reestablishment of complex wetlands that include oligohaline transition and tidal freshwater components	**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	Berm or dike removal, frequently complemented by channel rehabilitation, and topographic restoration
Beaches - Ecosystem processes can be fully restored by removing or modifying barriers to the movement of sediment from source (bluffs) to sinks (beaches) to a degree that allows the full range of beach processes	**Sediment supply** Sediment transport Erosion and accretion of sediments Detritus recruitment and retention	Armor removal Groin removal (where cross-shore structures impound sediment, and starve down-drift beaches)
Embayments - Ecosystem processes can be fully restored by removing the dominant stressors to a degree that allows undegraded tidal flows necessary to support a full range of embayment ecosystem processes	**Sediment supply** **Sediment transport** **Tidal flow** Erosion and accretion of sediments Detritus recruitment and retention Tidal channel formation and maintenance	Armor removal Groin removal Berm or dike removal (in some settings) Topographic restoration (where embayments have been filled) Channel rehabilitation Hydraulic modification (where restoration of natural tidal channel formation and maintenance processes is constrained)
Coastal Inlets - Ecosystem processes can be fully restored by removing the dominant stressors to a degree that allows undegraded tidal flows and freshwater inputs necessary to support a full range of coastal inlet ecosystem processes	**Tidal flow** **Freshwater input** (including alluvial sediment delivery) Tidal channel formation and maintenance Detritus recruitment and retention	Berm or dike removal Topographic restoration (where inlets have been filled) Hydraulic modification (for restoring tidal flow in some settings but may not provide a full range of ecosystem processes)

Definition of Partial Restoration

Each candidate action is also represented by a partial restoration alternative. The partial restoration alternative differs from full restoration in that it: (1) generally does not fully remove stressors, and (2) is typically more constrained in terms of the scope, scale, and/or complexity of restoration features involved. Partial restoration alternatives typically involve fewer management measures, have smaller or more constrained tidal openings, have a smaller footprint, and/or require less property acquisition than full restoration. In some cases, the partial restoration alternative is configured to take advantage of properties that are believed to have willing owners (which needs to be confirmed). Partial restoration generally reflects the local proponent's needs and desires and may include public access features such as trails, boat launches, and other amenities that are necessary to satisfy local interests.

As an example, the full restoration alternative for the Chuckanut Estuary Restoration action (Chapter 5, #1642) involves removing the existing railroad berm crossing the estuary and replacing it with a bridge. The partial restoration alternative, by comparison, removes only 290 feet of the berm. The smaller opening in the partial restoration alternative was sized to provide the desired tidal velocities and complexity of tidal circulation and wave action within the estuary, while minimizing the engineering complexities associated with replacing over 2,000 linear feet of an active railroad line. Despite not achieving full removal of stressors, the CDT attempted to define partial restoration alternatives for this and other actions which would:

- Support a wide range of ecosystem processes;
- Provide wide representation of ecosystem components appropriate for the shoreform;
- Include contiguous large patches that are well connected to each other and to a surrounding alluvial, terrestrial, and marine landscape;
- Be internally connected to allow for the unconstrained movement of organisms, water, and sediments; and
- Ensure adequate flood discharge, wood recruitment, organism dispersal, and sediment supply to support functions.

Report Organization and Design Assumptions

Each of the following 36 chapters of this report describes the 10% design concept for a candidate restoration action. Each chapter includes background information on the action area, historical maps, an overview of the design concept, and details for the major restoration features. The text is organized to emphasize issues that are important to PSNERP's restoration framework: stressors and management measures. Plan view and cross section drawings depicting the key design elements are provided for the full and partial restoration alternatives for each action. A digital geodatabase also accompanies this report. The geodatabase has additional geospatial information on the restoration features and elements for ach action, which in some cases is not depicted easily on the (two-dimensional) plan view or cross section drawings. An engineer's estimate of quantities is also provided for each action and each alternative. Additional maps depicting current and historic shoreform type for each action area are included in Appendix D.

This report presents design concepts to support development of a comprehensive restoration plan for Puget Sound; these designs are not ready for construction. The designs are intended to help PSNERP determine the least-costly way of attaining its Sound-wide restoration objectives.

This report does not identify or address all of the social, political, or economic implications of the proposed restoration actions. That work will occur as part of subsequent design and analysis.

Design Elements Common to All Actions

The restoration actions described in this report share a number of common elements and have some similar underlying design assumptions. This section describes those commonalities to minimize repetition of information in each of the design chapters that follow.

Rail, Roadway, and Bridge Standards

Many of the actions involve replacement or modifications of transportation facilities such as railroads, roadways, and bridges. For the 10% design, the CDT assumes that all road and bridge work will conform to Washington State Department of Transportation (WSDOT) standards and comply with local agency requirements. Rail modifications would need to be coordinated with rail operators including Burlington Northern Santa Fe (BNSF) and will conform to their standards. Deviations, if needed, would be identified in subsequent stages of design.

The 10% design work focused primarily on identifying feasible horizontal alignments for proposed rail, road, and bridge improvements. The CDT developed general standards for establishing bridge elevations based on available topographic data (mainly LiDAR) and assumptions about clearance needs. In most cases the lead designer assumed a bridge height of extreme high water (EHW) +3 feet, or mean higher high water (MHHW) +3 feet (Table 5). Bridge elevations may need to be adjusted during subsequent design stages to account for sea level change and other factors.

Table 5. Methods for Establishing Bridge Elevations (ft) for 10% Design (NAV88)

Action	MHHW	EHW	STRUCTURE DEPTH	DECK ELEV.	METHOD FOR ESTABLISHING BRIDGE ELEV.
Big Quilcene					
Full		29.8	5'-2"	38.0	EHW + 3 FT
Partial		22.7	5'-2"	39.0	EHW + 3 FT
Big Beef Causeway Replacement and Estuary Restoration					
	13.47		5'-2"	23.0	MHHW + 3 FT
Chambers Bay Estuarine and Riparian Enhancement					
Road		15		25.9	EHW + 3 FT
Rail		16.5	8'-7"	28.1	
Chuckanut Estuary Restoration					
West End		12.7	4'-2"	16.6	0' clear (bottom of

Action	MHHW	EHW	STRUCTURE DEPTH	DECK ELEV.	METHOD FOR ESTABLISHING BRIDGE ELEV.
					girder at EHW)
East End		12.7	4'-2"	18.0	EHW +1.1 clear
Deer Harbor					
	7.23		5'-2"	15.55	MHHW + 3 FT
Deschutes River Estuary Restoration					
	10.43		5'-2"	18.6	MHHW + 3 FT
Duckabush Causeway Replacement and Estuary Restoration					
Full	8.87		5'-2"	18.5 (min.)	MHHW + 3 FT
Partial	8.87		6'-6"	18.5 (min.)	MHHW + 3 FT
Dugualla Bay Restoration					
Full		12.8	6'-6"	22.3	EHW + 3 FT
Partial		12.8	5'-2"	21.0	EHW + 3 FT
Everett Marshland Tidal Wetland Restoration					
Full - Road A		23.0	5'-2"	23.0	These bridges will be inundated at the 5-yr event of the Snohomish River
Full - Road B		24.0	5'-2"	23.0	
Full - Rail 2		23.0	4'-2"	23.0	
Partial - Road C		25.0	5'-2"	18.0	
Partial - Road D		23.0	5'-2"	21.0	
Partial - Rail 2		23	4'-2"	24.0	
Partial - Rail 3		23.0	4'-2"	23.0	
Partial - Rail 5		24.5	4'-2"	24.0	
Hamma Hamma Causeway Replacement and Estuary Restoration					
Full		12.0	3'-6"	21	Exceeds EHW + 3 FT
Partial		12.0	3'-6"	20	Exceeds EHW + 3 FT
Kilisut Harbor / Oak Bay Reconnection					
	7.40		5'-2"	15.57	MHHW + 3 FT
Lilliwaup Causeway Replacement and Estuary Restoration					
	8.87		5'-2"	17.04	MHHW + 3 FT
McGlinn Island Causeway					
Full	8.84		6'-6"	18.34	MHHW + 3 FT
Nooksack River Estuary					*County Standard for River System is 10-yr flood +2' clear*
Several Structures - Shallow Girder Section	8.2		6'-6"	17.7	MHHW + 3 FT
Several Structures - Thick Girder Section	8.2		5'-2"	16.4	MHHW + 3 FT
Sequalitchew Creek					
Full		unknown	8'-7"	match existing	Exceeds EHW + 3 FT
Snohomish Estuary Mainstem Connectivity					*County Standard for*

Action	MHHW	EHW	STRUCTURE DEPTH	DECK ELEV.	METHOD FOR ESTABLISHING BRIDGE ELEV.
					River System is 10-yr flood +2' clear
Full (three bridges)	9.2		5'-2"	22.2	Exceeds MHHW + 3 FT
Partial (three bridges)	9.2		6'-6"	25	Exceeds MHHW + 3 FT
Snow and Salmon Creek					*Unknown if EHW includes SLR*
Full	7.41	10.8	5'-2"	19.0	EHW + 3 FT
Partial	7.41	10.8	6'-6"	20.3	EHW + 3 FT
Tahuya Causeway Replacement and Estuary Restoration					
		14.1	3'-6"	20.6	EHW + 3 FT
Telegraph Slough - Phase 1 & 2					
Road		14.0	6'-6"	23.5	EHW + 3 FT
Rail		14.0	4'-2"	21.2	EHW + 3 FT
Washington Harbor					
		11.5	5'-2"	19.7	EHW + 3 FT

Public Outreach and Property Acquisition

None of the actions could be successfully implemented without extensive coordination with the local proponents, affected property owners, and other stakeholders. As a result, public education/outreach is a common component of all the restoration actions described here. Federal ecosystem restoration principles (USACE ER 1105-2-100) require collaboration and coordination with federal and non-federal partners, with those who have an interest in the restoration, and with the public. Public engagement must include disseminating information about proposed activities, understanding the public's needs and concerns, and consulting members of the public before decisions are reached. PSNERP is committed to ongoing coordination with affected stakeholders throughout the subsequent stages of the design process.

Public outreach and stakeholder engagement are especially critical for those actions that could adversely affect established recreational and/or commercial uses. Some of the actions (e.g., Deepwater Slough, #1101) occur on public lands that are popular recreational waterfowl hunting areas. Other actions (e.g., Hamma Hamma Causeway, #1047; Point Whitney Lagoon, #1379) could jeopardize commercial or recreational shellfish production and harvest. Dam removals at Chambers Bay (#1801) and Deschutes Estuary (#1003) would affect public resources, water rights, and other amenities that have large constituencies. If these or other actions with significant social, political, or economic implications move forward, PSNERP intends to work closely with affected stakeholders to evaluate potential tradeoffs, mitigate adverse impacts, and secure support for implementation.

All but a few of the actions would require acquisition or conservation of private property through purchase, easement, or other means (some of the actions are located wholly on state or publicly owned land). In the case of several actions, the potential property acquisition/conservation needs could be substantial if the full restoration alternative or some version of it were carried forward. The CDT attempted to identify the required project lands including lands to be acquired for each action based on readily available parcel data so that property needs could be considered when selecting a preferred alternative and weighing overall costs and benefits. The CDT determined the area of required projects lands by estimating the area directly affected by proposed construction activities including access and staging. Property requirements also depend on the area of potential hydraulic effect (i.e., area influenced by inundation or flooding following restoration) associated with each action, as hydraulic considerations may trigger the need for additional acquisition or easements (e.g., flowage easements). For most actions, the area of potential hydraulic effect is the same as the construction footprint, but for some actions the potential hydraulic effect extends beyond the area needed for construction. The required project lands area (i.e., the construction footprint) and the area of potential hydraulic effect are depicted on the plan view drawings for each action and/or in the geodatabase that corresponds to the project.

The willingness of property owners to make their lands available for restoration is often unknown at this point, and will need to be assessed during subsequent design stages. Federal ecosystem restoration principles specify that land acquisition should be minimized (generally not more than 25% of total project costs).

Regulatory Compliance and Permitting

All of the actions involve work in wetlands, waters of the state/waters of the U.S., and other sensitive or protected habitats. The actions will therefore need to comply with multiple and sometimes overlapping local, state, and federal laws, including but not limited to:

- National Environmental Policy Act
- State Environmental Policy Act
- Clean Water Act Sections 404 and 401
- National Pollutant Discharge Elimination System
- Endangered Species Act
- National Historic Preservation Act
- State Hydraulic Code
- State Shoreline Management Act
- Local Development Codes and Critical Areas Ordinances

The specific permits required and agencies involved will vary depending on the location and nature of the work associated with each action. A complete description of the permit/regulatory needs will be determined during subsequent design stages. Even though the proposed restoration actions will have beneficial effects on nearshore resources, impacts of construction (e.g., pile driving, excavation, dewatering, etc.) will need to be fully evaluated pursuant to applicable statutes and policies.

All of the actions that involve work below the ordinary high water mark of any waterbody will need to adhere to timing restrictions mandated by state and federal agencies. The restrictions are designed to prevent in-water construction activity during periods of salmonid migration and/or forage fish spawning. Regulatory agencies determine specific "windows" when in-water work is allowed on a case-by-case basis depending on the location of the work and the species present. Table 6 provides the approximate work "windows" for estuarine/saltwater habitats in Puget Sound.

Table 6. In-Water Work Windows for Estuarine/ Saltwater Habitats in Puget Sound

Species	Allowed in-water work window (approximate)
Salmon and bull trout	July to March
Herring	April to January
Sand lance	March to October
Surf smelt	April to September

Sea Level Change Risk Analysis

PSNERP is required to consider the effects of projected changes in sea level on proposed restoration actions[2]. To fulfill this requirement, the CDT qualitatively evaluated each action and each restoration alternative in terms of three scenarios that USACE uses for coastal investigations: "low," "intermediate," and "high" (Table 7). Local sea level rise change is produced by the combined effects of global sea level rise and local factors such as vertical land movement (VLM) (e.g., tectonic movement, isostatic rebound) and seasonal ocean elevation changes due to atmospheric circulation effects (Mote et al. 2008). Due to the position of tectonic plates, rates of VLM vary around Puget Sound with some areas experiencing uplift and others undergoing subsidence. Areas of uplift, such as the northwest portion of the Olympic Peninsula along the Strait of Juan de Fuca, may exceed projected sea level rise rates and result in a decrease in sea level (as shown in Table 7). SLR projections for each action will be refined using localized tide gauge data during later design stages.

The data represented in these scenarios are coarse approximations of sea level trends for a period of 50 years into the future with changes that may be nearly imperceptible from year to year. For these and other reasons, readers are advised not to place too much significance on absolute numbers, or significant digits, in this rapidly evolving area of scientific study.

[2] See Corps of Engineers Circular EC 1165-2-211 regarding "Incorporating Sea-Level Change Considerations in Civil Works Programs"(140.194.76.129/publications/eng-circulars/ec1165-2-211/entire.pdf).

Table 7. Puget Sound Nearshore Sea Level Change Analysis (centimeters increase (+) during the period of analysis, 2015 – 2065)

	Low Scenario (Extrapolate Historical)	Intermediate Scenario (Global SLR – VLM= Net SLR)			High Scenario (Global SLR – VLM= Net SLR))		
Puget Sound Sub-basin	Net SLR	Global SLR	VLM	Net SLR	Global SLR	VLM	Net SLR
Strait of Juan de Fuca	-8	21	17	4	63	17	46
San Juan Islands and Strait of Georgia	-8	21	17	4	63	17	46
Hood Canal	-8	21	17	4	63	17	46
Whidbey	-8	21	17	4	63	17	46
North Central Puget Sound	-8	21	17	4	63	17	46
South Central Puget Sound	13	21	-2	23	63	-2	65
South Puget Sound	13	21	-2	23	63	-2	65

Cultural/Historical Resources, Contaminant Surveys, and Endangered Species Act Consultation

The U.S. Fish and Wildlife Service (USFWS) is supporting the conceptual design process by performing the following services for each candidate action:

- Conducting Level I Environmental Contaminant Surveys, including record searches, onsite interviews, and assessments for each action area;
- Researching, identifying, and documenting cultural and historic resources to provide baseline information to expedite future compliance with Section 106 of the National Historic Preservation Act; and
- Developing information about the presence of Endangered Species Act-listed species and species of concern in each action area and providing guidelines for future project implementation.

The results of this work will be reported in a separate document to be completed in 2011. As a result, this design report contains minimal information about these specific topics pending completion of the USFWS study. The presence of Endangered Species Act-listed species and species of concern, contaminated soils, and cultural resources is reported for each action area where known, but this information should be considered preliminary and subject to future investigation and verification.

Best Management Practices

All of the actions will involve earthwork and exposure of bare ground. The conceptual designs assume that standard best management practices will be implemented to control erosion and sedimentation and ensure construction areas are stabilized as needed to prevent adverse impacts. PSNERP will prepare standard temporary erosion and sediment control plans for all actions later in the design process. Specific measures will vary depending on the location and nature of the work associated with each action. In addition, specific measures may be required under action-specific permit requirements.

A complete description of best management practices will be determined during subsequent design stages.

Monitoring

Each restoration action has associated monitoring needs and opportunities that are necessary for achieving success. Monitoring is essential for informing our understanding of restoration as a science, and for providing accountability to project proponents and stakeholders.

Although it is difficult at the conceptual design stage to identify all of the monitoring opportunities and needs that a given action presents, the CDT attempted to identify preliminary performance indicators for each candidate action that could provide valuable information for assessing and documenting restoration outcomes.

The CDT developed a standard list of monitoring parameters based on information in PSNERP's management measures technical report concerning restoration evaluation (Table 8). Using professional judgment, the CDT noted which of these parameters might constitute a key performance metric based on the nature of the restoration being proposed, the action area conditions, and other specific factors. This information should be considered preliminary, pending development of a more comprehensive and programmatic nearshore restoration monitoring program for Puget Sound as well as a more detailed understanding of the needs and opportunities at each action area.

Table 8. Standard Monitoring Parameters Used to Denote Key Performance Indicators

Monitoring Parameter	Description
Topographic stability	Important for actions involving removal of armoring, often useful in conjunction with sediment accretion and erosion monitoring; helps assess effects of restoration on sediment processes.
Sediment accretion / erosion	Important for assessing sediment accumulation and effects on estuary morphology and habitat.
Wood accumulation	Important for documenting distribution of woody debris in restored channels and elsewhere.
Soil / substrate conditions	Important for projects involving beach or bluff restoration.
Vegetation establishment	Important for actions where revegetation is planned or where habitats are intended to transition (e.g., mudflat to marsh); also important in areas that are graded to marsh plain elevations to encourage recolonization.
Marsh surface evolution / accretion	Important for berm and levee removal actions or other restoration involving reintroduction of tidal action to blocked coastal inlets.
Tidal channel cross-section / density	Important for actions involving channel excavation or rehabilitation; also important for actions targeting increase in tidal channel density; can help to verify stability of tidal channel modifications.
Water quality (contaminants)	Important for actions that may change drainage patterns or

Monitoring Parameter	Description
	have sensitive receptor sites; important where water quality issues have been documented.
Salinity	Important where restoration alters freshwater flow; also helpful for actions where existing shellfish operations may be at risk.
Shellfish production	Important for actions where existing shellfish operations may be at risk.
Extent of invasive species	Important for action areas with existing infestations of invasive species.
Animal species richness	General parameter that provides an indication of overall ecological benefits.
Fish (salmonid) access/use	Important for many berm and levee removal actions and hydraulic modification actions where fish passage barriers are removed.
Forage fish production	Important for beach restoration projects or for action areas where restoration may alter beach characteristics.
Wildlife species use	General parameter that provides an indication of overall ecological benefits.

For estimating monitoring quantities, the CDT somewhat arbitrarily assumed that monitoring for a key performance parameter (e.g., erosion/ sedimentation, vegetation establishment, etc.) would require 5 crew-days (a crew-day is two people working 8 hours each) per year for a 5-year monitoring period. Some actions may require more or less monitoring, so this estimate should be considered preliminary (see *Approach to Quantity Estimation* below for more information).

Adaptive Management

Adaptive management is the suite of activities that must occur following a restoration action to ensure the benefits are achieved over time. Adaptive management incorporates long-term monitoring to improve scientific understanding of the effects of various restoration actions on the nearshore ecosystem.

It is challenging at the concept design stage to know what types of adaptive management these restoration actions will require, but the following general needs seem likely given the suite of actions and management measures in PSNERP's portfolio:

- Topography modifications to adjust site elevations to achieve target habitat, "jump-start" channel development, or make up for slower-than-expected erosion;
- Adjustments to channel openings to achieve target tidal prism;
- Installation of woody debris or other features to create desired structural attributes;
- Plant installation to replace dead/dying material, stabilize eroding slopes, or create habitats as topography evolves; and
- Nourishment of substrates due to erosion.

PSNERP will prepare a comprehensive adaptive management program for the suite of actions it brings forward to implementation. Additional information concerning the adaptive management needs at each action area will be prepared during the subsequent design stages.

Operations and Maintenance

Many of the restoration actions involve modifying infrastructure such as bridges, culverts, and levees. These structures will require ongoing operations and maintenance in order to maintain the benefits of the restoration action over time. The types of ongoing operations and maintenance that will be required to maintain benefits associated with the proposed restoration actions include, but are not limited to:

- Routine inspections;
- Levee repair to correct for settlement, erosion, or other signs of compromised integrity;
- Removal of debris/wrack blocking bridge and/or culvert openings;
- Scour protection around bridge pilings; and
- Mechanical adjustments to ensure properly functioning tide gates.

Restoration areas that are accessible to the public may have specific management or operational needs such as maintenance of trails, signage, docks/boat launches, or exclusionary devices (fences). A more complete understanding of the specific operations and maintenance needs associated with each action will be compiled during the subsequent design stages.

Approach to Quantity Estimation

A key component of the 10% design phase is the estimate of construction quantities. PSNERP will rely on the quantity estimates as a basis for determining likely construction costs. Because it is difficult to develop precise estimates for some quantities without the type of detailed information that typically comes later in the design process, estimates reported here assume a contingency of about +50% (30% design contingency and 20% construction contingency).

The CDT developed a standard template for estimating quantities associated with each action. Quantities are listed separately for both the full and partial restoration alternatives. Each line item has a description that provides additional information to the audience, which is assumed to be either the cost estimator or a technical reviewer. Lump sums or units of "each" are also used with detailed descriptions.

The quantity estimates can be derived from the plan and section drawings included with each action. Backup is provided via digital files used to create the plan and cross section drawings. (Digital files are available from PSNERP.)

Ideally, the quantity estimate will be in units that are compliant with cost-benefit analysis. For example, linear feet (LF) of bulkhead removal with a description of bulkhead height and material allows for more direct adjustment, if needed, to change the cost-benefit (e.g., adjust to 500 LF of bulkhead removal instead of 800 LF). More detail on the quantity estimates is provided in Appendix B.

Applied Geomorphology Guidelines and Hierarchy of Openings

The CDT developed project-specific guidelines to help standardize the design approach and aid in quality control (Appendix C). The geomorphology guidelines use empirical models calibrated with data collected from field sites and are most useful when the site parameters lie within the range of the calibration data. Parameters include tide range, sediment and vegetation, fluvial effects, salinity (which affects plant types and geomorphology), and in some cases wave and littoral climate. The guidelines are organized as follows:

1. Tides: Tide design parameters are identified for National Ocean Service tide stations selected to represent the varying tides in Puget Sound. Tide ranges are tabulated. Tidal datum conversions from Mean Lower Low Water (MLLW) to North American Vertical Datum (NAVD88) are provided at each tide station.

2. Tidal Marsh Channels: Regression lines and graphs are provided to relate channel geometry (channel cross sectional area, width and depth) to marsh area and tidal prism. A set of regressions and graphs are provided for each tide station identified in (1), based on the tide range. A procedure is provided to estimate channel geometry with combined tidal and stream discharge.

3. Tidally Influenced Fluvial Channels: Guidance for tidally influenced fluvial channels is to use historic data, remnant channel geometry, and available published data on a site-specific basis.

4. Tidal Inlets: A set of graphs are provided for tidal inlets where wave action and littoral drift affect the channel geometry and, in particular, limit the tide range. The graphs allow prediction of the tidal prism necessary for an open inlet and the size of the inlet cross section for a given tidal prism.

5. Beach Geometry: Guidance is provided to estimate the berm elevation of coarse sediment beaches.

Because so many of the restoration actions included in this report involve removing or reducing tidal barriers, the CDT also attempted to define the relative degree of benefit provided by tidal openings of different sizes and locations in terms of a benefit hierarchy (Appendix C). The benefits are described in terms of improvements in natural processes, structure, and function. By understanding how various openings impact the nearshore ecosystems, crossings of tidal and tidally influenced fluvial channels can be designed to provide maximum benefits.

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