PUGET SOUND
NEARSHORE
ECOSYSTEM RESTORATION PROJECT

Puget Sound Nearshore Ecosystem Restoration Project

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).

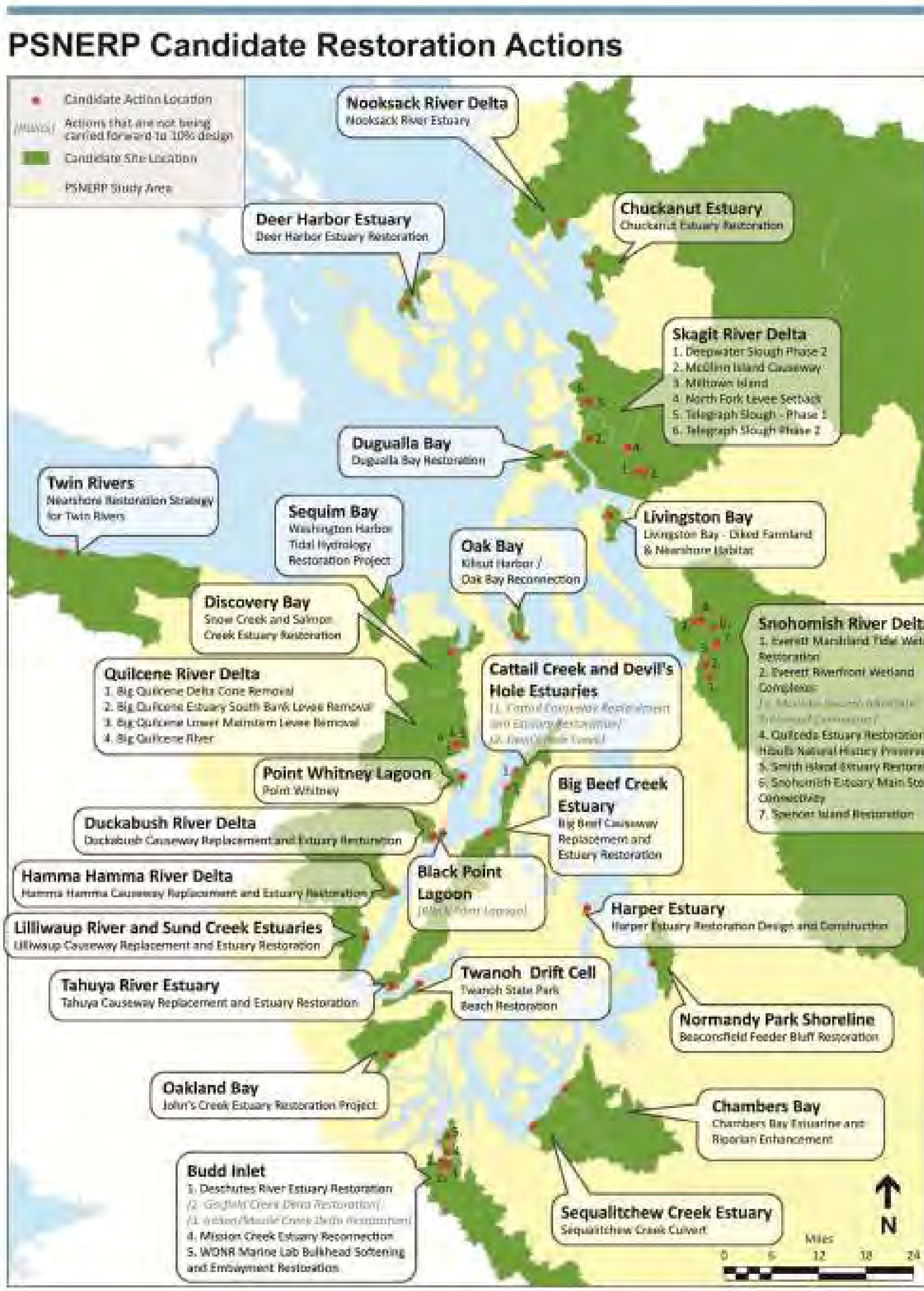

Figure 1. Location of PSNERP Candidate Restoration Actions

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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8. DESCHUTES RIVER ESTUARY RESTORATION (#1003)

Local Proponent	Squaxin Island Tribe
Delta Process Unit	DES
Shoreline Process Unit(s)	NA
Strategy(ies)	1 – River Delta
Restoration Objectives	Restore tidal processes, tidal channel formation, sediment transport, and natural hydrodynamic processes by removing a tide gate and associated stressors

8.1 Description of the Action

The action is to restore tidal dynamics to the Deschutes Estuary by removal of the 5th Avenue dam. Capitol Lake would be replaced by a functioning Deschutes Estuary that would reconnect the Deschutes River and Budd Inlet. In addition, dredging of the lakebed and primary river channel prior to restoration of the estuary would provide sediment for creation of intertidal habitat inside the restored estuary and elsewhere in Budd Inlet. Please see the Introduction chapter for important information regarding PSNERP and the context of this restoration project.

8.2 Action Area Description and Context

The Deschutes River Estuary in the South Puget Sound Subbasin is known as Capitol Lake. The lake was created by impoundment of the estuary by a tide gate in 1951. The action area is at the head of Budd Inlet and covers the historical area of the Deschutes Estuary, from Tumwater Falls in the south and extending into Budd Inlet in the north near the municipal marina of Olympia. The 346-acre action area is shown in Figure 8-1.

Figure 8-1. Action Area and Vicinity

8.2.1 Historic Condition

Historical maps of the area are provided in Figures 8-2A and 8-2B. Prior to 1869, the Deschutes River and its tributaries flowed unrestricted into Budd Inlet, where Capitol Lake now exists. The Deschutes River delta consisted of alluvial deposits, with limited areas of tidal marshes and braided channels (Hayes et al. 2008). Though the precise historical extent of tidal marsh and mudflat environments is poorly understood, a repeated theme of early observers is the extensive nature of mudflats across much of south Budd Inlet (Hayes et al. 2008). The 1873 U.S. Coast Survey of then-called Budd's Inlet shows the Deschutes Estuary as a waterway, with the first constriction of the estuary mouth near the 4th Avenue bridge. Subsequent surveys performed during the next few decades, but prior to installation of the dam, indicate the presence of mudflats as well as increasing encroachment by railroad trestles.

The Deschutes Estuary was dammed in 1951 to create a freshwater reflecting pool below the Washington State Capitol campus. Subsequently, the basin became known as Capitol Lake. The bathymetry and shape of the historic Deschutes Estuary in 1949 and modern Capitol Lake in 2004 are different. The wide tidal channel in the estuary has been replaced by less defined channels and submerged banks. The bathymetric difference between the historic estuary and the modern lake shows the most radical changes have occurred in South and Middle Basins, with bed level elevation decreases of more than

6 feet due to sedimentation. The depth of the tidal channel in North Basin also shows a large decrease of 6 to 10 feet due to sedimentation. Immediately south of the dam, depths have increased by more than 9 feet from scour generated by dam operations, creating a hole on the lake side of the dam structure. The average decrease in depth since 1949 suggests that 1.7 million CY of sediment has accumulated, or a 60% volume reduction due to filling and sedimentation within the modern lake boundary (George et al. 2006).

8.2.2 Natural Environment

Capitol Lake is at the head of Budd Inlet and is separated into four distinct but connected basins: North Basin, Middle Basin, South Basin, and Percival Cove. The 276-acre lake lies on a north-south axis, with the Deschutes River entering from the south via Tumwater Falls. South Basin has three vegetated islands; the other basins are open water. The hydrodynamics in Budd Inlet outside of Capitol Lake are marine-dominated, with a complex semi-diurnal tide that has a maximum range of 16 feet during spring tides at Gull Harbor, located 4.75 miles north of Capitol Lake on the east side of Budd Inlet. Inside the lake, there are two sources of fresh water – the Deschutes River and Percival Creek from the west.

The 57-mile Deschutes River is monitored with several USGS river gauging stations along the length of the river. The station closest to the lake is Station #12080010 at the E Street bridge in Tumwater. The annual average flow of the Deschutes River is approximately 420 cfs; however, the flow fluctuates widely within a year. A distinct wet season is observed from November to April, with episodic large flood events greater than 1,400 cfs; the largest flows on record exceed 8,000 cfs during a 50-year flood event. Other more frequent return interval flows include 3,300 cfs (2 year), 5,700 cfs (10 year), and 7,000 cfs (25 year). The river flow is approximately 105 cfs during the dry season, which spans from May to October. Percival Creek has no known gauging stations. The 1984 Capitol Lake Restoration Analysis reported the freshwater and sediment contribution of the creek to be significantly smaller than that from the Deschutes River (George et al. 2006).

The area immediately surrounding the lake varies in topography. In general, the banks are steep on the eastern side and less so along the western side of the lake. Most of the shorelines of the lake are developed, with a narrow strip of riparian vegetation remaining. The steep banks and bluffs are heavily vegetated with mixed evergreen forest typical of southern Puget Sound watersheds. Small freshwater marshes in South Basin are associated with mitigation sites. Geologic maps of the region show mostly unconsolidated alluvial deposits and glacial deposits. Volcanic and sedimentary rock beds are also found throughout the watershed.

Wildlife that use Capitol Lake include birds (52 species, including aerial-foraging, diving birds, gulls/terns, shorebirds, raptors, wading birds and waterfowl), freshwater fish (16 species), bats (4 species), aquatic or semi-aquatic mammals (5 species), and more than a dozen invertebrate species (Hayes et al. 2008). Sixteen species of wildlife are federally or state listed as endangered, threatened, or candidate species.

8.2.3 Human Environment

The modern 5th Avenue dam consists of a 16-foot-high earthen and concrete dam, an 82-foot-wide concrete structure with two radial tide gates, spillway, and a fishway supporting a causeway. The causeway extends 5th Avenue, connecting downtown Olympia to the transportation corridors on the western side of Capitol Lake. The tide gate is composed of two radial gates to regulate lake level and a fish ladder. The dam has a fish ladder, but it is a barrier to the natural migration of anadromous fish. A municipal marina is directly northeast of the dam, and the Port of Olympia is north of the marina.The BNSF railroad trestle, which existed before the dam, divides North Basin and Middle Basin. Construction of the Deschutes Parkway separated Percival Cove from Middle Basin, and completion of the I-5 overpass bridge in 1957 split South Basin from Middle Basin.

Several public spaces are contained within the original estuary boundaries – Marathon Park and Heritage Park in North Basin, the Capitol Lake Interpretative Center and Heritage Park wetland mitigation site in Middle Basin, and Tumwater Historical Park in South Basin.

8.3 Restoration Design Concept

8.3.1 Restoration Overview and Key Design Assumptions

The current configuration of the Deschutes Estuary as Capitol Lake has eliminated estuarine functions and intertidal habitat. The design concept is to restore tidal processes, tidal channel formation, sediment transport, and natural hydrodynamic processes by removing the dam and associated stressors. In addition, intertidal habitat would be created in North and Middle Basins while stabilizing vital transportation infrastructure.

Figures 8-3 through 8-8 illustrate the restoration alternatives. Removal of the 5th Avenue dam, coupled with dredging of the lakebed prior to removal, constitutes the full restoration alternative (Figure 8-3). The dredge spoils would be used to create intertidal habitat along the western side of the Deschutes Estuary and to protect the Deschutes Parkway. Excess sediment potentially can be used for other nearby projects or disposed of offsite (location to be determined). The 5th Avenue dam, currently across the mouth of the Deschutes Estuary and creating Capitol Lake, would be replaced by a 500-foot span bridge that would allow unrestricted tidal exchange with Budd Inlet. In addition, realignment of stormwater outfalls and reinforcement of concrete structures would be necessary to maintain the integrity of existing infrastructure around the current lake. Flood protection measures would be necessary around parks and other public spaces to ensure resilience from restored tidal processes, such as increased water levels and flow velocities.

Because a partial removal of the 5th Avenue dam is not possible, an alternative design for the restored estuary was developed by the Capitol Lake Adaptive Management Program and has been adapted here as the partial restoration alternative (Figure 8-4). Called the "dual basin" alternative, this option would restore tidal processes to most of the estuary. A portion of the eastern side of North Basin would become a pool impounded by a new wall or similar barrier. This barrier would be approximately 2,000 feet in length, with two water control gates or structures to manage the water level within the created pool. The pool could be freshwater or marine water, although the cost analysis and engineering design study recommended a marine water pool that allows tidally dependent circulation and flushing (Moffatt and Nichol 2007). The impact of this partial restoration option would be a reduction of the overall Deschutes Estuary area and a somewhat reduced intertidal habitat area. The impoundment would not substantially affect the hydrodynamics of the estuary.

Key design elements associated with full and partial restoration alternatives are summarized in Table 8-1.

Table 8-1. Key Design Elements

Element	Full Restoration	Partial Restoration
5th Avenue Dam	Remove dam and abutment fill	Remove dam and abutment fill
Accumulated Sediment In Middle Basin	Dredge sediment	Dredge sediment
New 5th Avenue Bridge	Construct bridge	Construct bridge
Deschutes Parkway	Stabilize roadway with dredge sediment and fill	Stabilize roadway with dredge sediment and fill
North Basin Barrier	No action	Construct barrier
Bridges	Provide scour protection to I-5 and railroad trestle bridges	Provide scour protection to I-5 and railroad trestle bridges
Trails	Elevate trails on boardwalks where necessary	Elevate trails on boardwalks where necessary
Vegetation	Plantings and emergent vegetation	Plantings and emergent vegetation

8.3.2 Restoration Features – Primary Process-Based Management Measures

Armor Removal/Modification

The return of tidal processes would require protection of existing infrastructure such as the I-5 bridge, 4th Avenue bridge, and BNSF railroad trestle. George et al. (2006) calculated current speeds during extreme hydrological events of approximately 16.7 feet per second (ft/s) at the I-5 bridge, 17.4 ft/s at the 4th Avenue bridge, and 7.9 ft/s at the railroad trestle. Moffat and Nichol (2007) used those velocity estimates to analyze the existing scour protection and assess the need for new or additional scour protection at these bridges. In addition, the new 5th Avenue bridge would require armoring. Existing riprap would be replaced with similar volumes of larger stone, although no rock sizing calculations were performed as part of the conceptual design analysis or the Moffatt and Nichol (2007) study. Quantities of armor modification are 200 feet (4th Avenue bridge), 650 feet (I-5 bridge), and 700 feet (railroad trestle). Moffatt and Nichol (2007) estimated 140 CY of material to extend the architectural cladding on the 4th Avenue bridge to the mudline. The same study estimated approximately 2,000 CY of armoring material would be needed to protect the banks of the 4th and 5th Avenues bridges.

Berm or Dike Removal/Modification - NA

Channel Rehabilitation/Creation

The accumulated sediment in the basin would be exposed to a large tide range and episodic fluvial events, which constitute large flood risks and sudden morphological changes. To alleviate these risks, the primary channel through the Deschutes Estuary would be deepened by dredging to increase the capacity of the waterway. The previous sediment management study by George et al. (2006) was referenced to determine the extent of dredging necessary to prevent filling of the downstream marina and the Port of Olympia following removal of the dam.

Most of the dredge spoils will consist of sandy silt and silty sand. The newly dredged channel would be a two-stage channel, with a wide main channel and smaller terraces grading back to the existing invert elevation of Middle Basin. The bottom width of the main channel would be approximately 275 feet, while the left bank terrace would have a width of 100 feet, and the right bank terrace a width of 50 feet. The average excavation depths for the channel dredging are 2 feet at the terraces and 6 feet at the main channel. This represents a new dredged invert elevation of approximately -12 feet MLLW (-8 feet NAVD88) for the main channel and -8 feet MLLW (-4 feet NAVD88) for the terraces.

The estuary would be reconnected with Budd Inlet under the 5th Avenue bridge by preparing the opening from the channel to the inlet. As much as possible, the historic path of the channel would be maintained, although the current configuration of North Basin would somewhat limit the sinuosity. For the partial restoration alternative, some allowance for the barrier would be required, but this would not change the dredge quantities. Approximately 410,000 CY would be removed from the channel at Middle Basin.

Groin Removal/Modification – NA

Hydraulic Modification

The 5th Avenue dam would be removed in its entirety as the primary component of both the full and partial restoration alternatives (Figures 8-3 and 8-4). The 16-foot-high earth embankment dam, two radial tide gates, a concrete fish ladder, and the concrete spillway would all be demolished.

The removal of the earth dam would entail excavation of the upland fill material, as well as dredging of the embankment below the water line. As part of the dam removal, the existing invert in this area would be lowered to better match conditions near the existing outlet and downstream area of the dam. It is anticipated that the minimum invert elevation would be approximately -20 feet MLLW (-16 feet NAVD88). The total excavation volume for upland excavation (above elevation 10 feet) is approximately 44,000 CY. It is assumed that all of the material from excavation will be hauled offsite for disposal. The total excavation volume for dredging (below elevation 10 feet) is approximately 77,000 CY. The dredged material would be reused within the action area. The dredging volume also includes an area between the 4th and 5th Avenue bridges that would be lowered to the design elevation of -20 feet MLLW (-16 feet NAVD88). The total volume of excavation required to remove the existing dam and lower the channel invert would be approximately 121,000 CY.

The removal of the 5th Avenue dam and bridge constitutes the primary restoration action. The current structure, described above, would be demolished and a new 500-foot bridge span would allow reconnection of the estuary and Puget Sound. The reestablishment of tidal flows would create a markedly different environment from the freshwater Capitol Lake. While the dam removal would be identical for both restoration alternatives, the barrier in the partial restoration alternative (Figure 8-4) would substantially alter the hydrodynamics in North Basin by affecting the free flow of water. Beyond North Basin, there would not be impacts to the hydrodynamics.

Overwater Structure Removal – NA

Topography Restoration

A significant portion of the material dredged from the Middle Basin channel would be used to reconstruct the western shore of North Basin and Middle Basin (Figures 8-5, 8-7 and 8-6). The western bank is oversteepened, eroding, and partially protected by rock and riprap. The dredged sediments would be placed on top of the rock buttress to stabilize the Deschutes Parkway road embankment. The intent of the new slope would be to utilize a portion of the dredged sediments and to create a more natural slope for the estuary. The slope restoration would allow for localized sediment erosion and accretion resulting from tidal action and vegetation of the slope in the intertidal zone.

Four typical cross sections were developed for the western shore. The typical sections vary in their dimension but are generally described as having:

- Upland topsoil placement at embankment, 3 foot depth, 3:1 side slope, terrace width of 10 to 25 feet.
- Dredge sediment placement from elevation 16 feet to varying depth (0 to -5 feet MLLW or +4 to -1 feet NAVD88).
- 25:1 slope above elevation 14 feet MLLW (10 feet NAVD88), 15:1 or 20:1 slope below elevation 14 feet MLLW (10 feet NAVD88).

Cross sectional areas for topsoil and dredge sediment were applied to the length of shore represented by each typical section. A single section was developed for the North Basin (length = 2,800 feet). Three typical sections were developed for the Middle Basin. The northern section extends from the railroad bridge to the middle of Percival Cove (length = 1,000 feet); the central section extends from the middle of Percival Cove to Lakeridge Drive SW (length = 840 feet); the southern section extends from Lakeridge Drive SW to the trail at the southern end of Middle Basin (length = 2,350 feet). The total estimated volume of topsoil to be placed at the western shore is approximately 16,000 CY. The total estimated volume of dredged sediment to be placed at the western shore is approximately 383,000 CY.

Additional dredged sediment would be placed within Percival Cove around the perimeter of the cove to rebuild the sediment-depleted system. A total volume of 50,000 CY would be placed, with an average depth of 3 feet over a 150-foot band along the intertidal shoreline.

8.3.3 Restoration Features – Additional Management Measures

Beach Nourishment – NA

Contaminant Removal/Remediation

Moffatt and Nichol (2007) estimated that up to 25% of the dredged sediment from the entrance at 5th Avenue and the Middle Basin channel could be contaminated with purple loosestrife seeds (a non-native, invasive plant species). This estimate is considered to be an upper maximum based on other studies and dredge disposal activities from the marinas.

No specific contaminant investigations were conducted as part of the conceptual design, but the estimated amount of contaminated sediment requiring offsite treatment and disposal is 54,000 CY. This amount was based in part on using the upper bound of 25% and the balance of cut and fill within the site. It was assumed that some amount of dredged sediment is contaminated and will require special handling and disposal. This amount would be removed from the estuary basin for offsite disposal during the pre-restoration dredging. Moffatt and Nichol (2008a) identified the open water disposal site for contaminated material at Commencement Bay (round trip distance 86 miles) as a likely recipient of the contaminated sediment. Other options include nearshore restoration or reuse within Budd Inlet.

Debris Removal – NA

Invasive Species Control – NA

Large Wood Placement – NA

Physical Exclusion – NA

Pollution Control – NA

Revegetation

The upper elevations along the western shore of the restored estuary sediment would be revegetated. Upland vegetation (riparian trees, shrubs, and grasses) would be planted on the upland topsoil slope and terrace. Marsh and wetland vegetation would be planted on the gently sloped portion of the placed sediment above and within the intertidal zone. The total surface area requiring revegetation is approximately 17.5 acres, with 7.9 acres in North Basin and 9.6acres in Middle Basin.

Reintroduction of Native Animals – NA

Substrate Modification – NA

Species Habitat Enhancement – NA

8.3.4 Restoration Features – Other

Slope Stabilization (Rock Buttress)

The fill upon which the Deschutes Parkway is constructed would be subject to slope failures if not protected from the tidal action of the restored estuary. The design of the rock buttress is similar to that presented in Moffatt and Nichol (2008a) with depths varying along the western shore of North and Middle Basins. The intent of the rock buttress is to stabilize the softer underlying material by weighing it down in place and provide erosion protection. The rock would be placed directly on the existing slope (Figures 8-5, 8-7 and 8-6). Excavation would be used only to key in the toe of the buttress. The rock buttress would extend from an elevation of approximately 13 feet to a depth that varies by location. The face of the buttress would have a slope of 3:1, with the interface slope of the rock and existing grade at approximately 2:1. The total volume of rock required for the buttress is approximately 65,500 CY. A typical WSDOT rock gradation would be used for the rock buttress. Though the rock has not been specifically sized, a gradation with a majority of the rock diameter at 1.0 to 2.0 feet is anticipated.

Trails and Pedestrian Bridges

A large and heavily used trail system encompasses North Basin, extending along the western side of Middle Basin, and continuing into South Basin. For the purposes of the conceptual design, trails were assumed to be either existing without any planned changes, requiring some form of improvement, or needing to be reconstructed (e.g., boardwalks, as in the case of the South Basin area trails). The total length of trails to be improved is approximately 1.3 miles, and approximately 0.2 mile of new trails would be constructed. Two pedestrian bridges would be constructed as part of the trail network.

Bulkhead – Surface Treatment

Following removal of the 5th Avenue dam, the Arc of Statehood bulkhead on the eastern side of North Basin would require additional treatment to provide protection from the effects of salt water against the concrete wall. Moffat and Nichol (2007) recommend applying an epoxy mix sealant to the concrete for protection. This is only required for the full restoration alternative (Figure 8-3). The total surface area of treatment was estimated to be 25,000 SF based on a length of 2,500 feet and an assumed total wall height of 10 feet.

Boat Launches

The canoe launch at the Capitol Lake Interpretative Park and the boat launch at Marathon Park would need to be rebuilt or relocated to account for tidal variations. This was not specifically included in the quantity estimate.

Control of Water during Construction

Moffatt and Nichol (2008a) provide a discussion of construction methods for the new 5th Avenue bridge, including the construction of a coffer dam and a 96-inch bypass pipe to move the flow of the Deschutes River around the construction site.

Stormwater Outfalls

Stormwater outfalls at Capitol Lake would require replacement or modification to protect against salt water. Additionally, stormwater outfalls along the length of Deschutes Parkway would require modification or replacement. These facilities were not identified or quantified as part of this conceptual design.

8.3.5 Land Requirements

Most of the action area is part of the Washington State Capitol Campus. The state-owned aquatic lands of the Capitol Lake basin are managed by the Washington Department of General Administration under a lease agreement from WDNR. Additional right-of-way may need to be acquired to accommodate the new roadway section (per City of Olympia standards).

8.3.6 Design Considerations

The 4th Avenue bridge, Deschutes Parkway, and I-5 bridge pose restrictions on the width of the estuary mouth, as well as the extent to which the river and tidal channels can meander. The placement of additional protection for the bridges will increase the amount of hardened shoreline. There are no access considerations.

Nine invasive species have been introduced to the action area. Seven of these exotic species (American bullfrog, common carp, brown bullhead, smallmouth bass, largemouth bass, yellow perch, and nutria) threaten native fauna and habitats. The salinity introduced by removing the dam would make habitats less suitable for these species. While reintroduction of estuarine conditions would favor the remaining two exotic species (soft-shelled clam and Manila littleneck clam), both of these serve as food for native species and are not known to negatively affect native fauna. An additional invasive species, the New Zealand mud snail, has been identified in Capitol Lake. There is significant concern about its spread to other freshwater bodies. The mud snail cannot tolerate high salinity and would be disfavored under estuarine conditions; however, the presence of the snail impacts where the dredge spoils can be deposited.

In contrast to other estuaries in Puget Sound, Budd Inlet is relatively contaminated with aromatic and chlorinated hydrocarbons in sediments and bottom-dwelling fishes (Stehr et al. 1998). The sediment in Capitol Lake would need to be analyzed for contaminant concentrations.

Lack of support for the action among some constituents creates additional considerations in terms of the timing and feasibility of this action.

8.3.7 Construction Considerations

The primary construction components are demolition of the current 5th Avenue bridge, dam, and roadway; construction of the new 5th Avenue bridge and roadway; dredging of

Middle Basin sediments and abutment fill; and placement of sediment. Placement of riprap, additional trail construction, and secondary restoration elements are also considerations, but not described for this conceptual report. Construction of the 2,000-foot tidal barrier is the only significant addition for the partial restoration alternative. All of this work could be completed within 12 months, depending on the dredge and placement methods selected. Moffatt and Nichol (2007) described a construction sequence for both the bridges and dredging. The abbreviated sequence is:

1. Construct a temporary, two-lane access road from Deschutes Parkway up the hill to the roundabout.
2. Widen the temporary access road and complete construction of the new roadway west of the bridge (including the west and south legs of the T-junction). The temporary retaining wall would remain in place as a new, permanent retaining wall is constructed to retain fill for the entire new roadway.
3. Using land-based equipment, overexcavate around the 4th Avenue bridge pier. Place pre-cast concrete cladding to match the existing piers, and place riprap scour protection around the base of the pier.
4. Construct a cofferdam around the 5th Avenue dam and extending east to the location of the planned new 5th Avenue bridge abutment on the east bank. This construction will include a 96-inch-diameter pipe for bypassing Deschutes River flow past the cofferdam.
5. Working in the dry and using conventional equipment, demolish the dam, excavate the new channel within the area encompassed by the cofferdam, and construct the east abutment of the new bridge and associated riprap scour protection.
6. Remove the cofferdam and allow tidal flow to enter the restored Deschutes Estuary. This should be performed at slack tide, during a neap tidal cycle, to decrease the immediate tidal flows through the new opening.
7. Using land-based equipment, complete demolition of the roadway and excavate the remainder of the 500-foot channel.
8. Construct the new 5th Avenue bridge across the newly opened inlet.

For the dredging, work would occur prior to dam removal. The lake has been drawn down many times over the dam's lifespan without any apparent risk to the dam integrity. Dredging would progress from one end of Deschutes Parkway to the other, with the different activities described below occurring in parallel at different parts of the roadway. One possible construction method would be to draw down the water in the lake, allowing the edge work to be carried out using land-based equipment.

1. Using land-based equipment, excavate the toe of the slope to allow the rock buttress to be keyed in. Any existing slope protection rock would be stockpiled for reuse. Place the rock buttress, working from the toe of the slope to the upper slope within each shoreline section.
2. Construct rock dikes along the toe of the slope using wide-tread or low-pressure-tired equipment working on the mudflat. The rock dike will act as an offshore containment berm for the sediments placed in step 3.
3. Use hydraulic equipment to dredge the channel, with pipeline delivery of the dredge material slurry to the slope behind the low dike. Let the slurry water (supernatant) drain back into the lake and recycle with the dredging process.

4. After the dredged materials on the slope behind the dikes drain and dry, use the wide-tread or low-pressure-tired equipment to smooth and shape it.
5. Remove the rock toe dikes. Apply any topsoil treatment to the upper slopes, together with other treatment (e.g., jute matting for short-term stabilization) that is required.
6. Hydroseed the slopes with appropriate intertidal and riparian vegetation. Plant herbaceous plugs and/or woody trees and shrubs.

For the construction of the tidal reflecting pool barrier for the partial restoration alternative, the major effort would be driving the sheet-pile wall. The steel sheet piles would be coated before installation to reduce rusting exacerbated by the saltwater environment. The sheet piles could be driven from a barge using a vibratory hammer. This works by reducing the friction between the sheet pile and the soil to enable the sheet to penetrate the soil. Once the sheet piles are driven, the pedestrian walkway can be installed.

8.4 Extent of Stressor Removal

Table 8-2 describes the amount of stressors to be removed with this action.

Table 8-2. Stressor Removal

Stressor	Full Restoration	Partial Restoration
Tidal Barrier (LF)	500	500
Fill (SF)	112,000	112,000

8.5 Expected Evolution of the Action Area

The restored Deschutes Estuary and current Capitol Lake are entirely different environments on divergent ecological paths. Without restoration, the freshwater lake will continue to accumulate sediment, leading to emergent islands in each basin (three already exist in South Basin) that may eventually merge into a freshwater marsh. The Deschutes River would be confined within the wetlands, and the habitat would be dominated by freshwater species, including the invasive flora and fauna described above. Further shifts in the topography and amount of exposed water area could negatively affect the listed species of concern, although new species may colonize the marshes. Ecologically, this system is dependent on the presence of the 5th Avenue bridge and dam.

In contrast, the restored Deschutes Estuary would function as a southern Puget Sound estuary, with tidal processes maintaining sediment transport, salinity ranges, and estuarine biodiversity. Restoring the tidal processes by removal of the tide gate would allow development of intertidal habitat, tidal channel formation, sediment and nutrient conveyance, and circulation and mixing processes for freshwater and marine water. Biological assessments anticipate a number of species would respond to the restoration action. Hayes et al. (2008) estimated that the restored estuary would positively impact 18 species of marine benthic invertebrates, 10 species of marine fishes, 8 species of anadromous fishes, and 18 species of birds. Conversion of freshwater vegetation to brackish water tolerant species would also occur at the fringes of the estuary's emergent mudflats.

Sediment naturally exported from the estuary will be an ongoing issue that will require future adaptive management decisions, including maintenance dredging options (George et al. 2006, Moffatt and Nichol 2007). Implementation of restoration actions will require the development and implementation of a sediment management plan, and a funding strategy to equitably distribute maintenance costs commensurate with benefits. For example, George et al. (2006) found increased sedimentation but only slight increases in current velocities in the port and marina downstream of the restored estuary. In addition, public education and involvement would be critical to the long-term success of the restoration action.

8.6 Uncertainties and Risks

The options to address the sediment accumulation inside Capitol Lake are the source of most uncertainties. Geomorphic changes will be rapid and widespread with the reintroduction of tidal forces to the basin (George et al. 2006). Without pre-restoration dredging, dynamic equilibrium is estimated to occur within 5 to 10 years, but with significant deposition of sediment in the downstream marina and port. The estimates of dredging and soil excavation do not balance with the placement of dredged material adjacent to Deschutes Parkway as described by Moffatt and Nichol (2007). In order to maintain the desired estuarine processes, it does not seem feasible to balance the cut and fill solely by placement of fill within the Middle and North Basins. It would be undesirable to extend the placement of the dredged material in the North and Middle Basins eastward to use more material because it would channelize the flow through the estuary, rather than maintaining the pocket-like features that otherwise would exist in the North Basin in either the full or partial restoration designs.

The suitability of the dredged material for reuse onsite will need to be verified as the design work progresses. If sediment needs to be hauled and disposed of offsite, construction costs would increase dramatically, although the access to the BNSF railroad lines would be beneficial. Some options proposed for the surplus dredged and excavated material include:

- Offsite disposal at Commencement Bay.
- Placement of a portion of the material within Percival Cove (which is a relatively sediment-starved system).
- Delivery of the material to other nearby restoration sites such as the proposed Garfield Creek or Indian/Moxlie Creek sites immediately north of the estuary.

The methods used to dredge this site are uncertain and will need to be confirmed based on subsequent analysis. Stakeholder concerns regarding potential increase of sediment flow into Budd Inlet could delay construction of the project.

In addition, differing positions exist among stakeholders regarding the use of existing railroad fill as pedestrian trails. Public access should be considered as an enhancement of the estuary restoration designs where it does impinge on the ecological functions, a perspective embraced by the project proponent.

8.6.1 Risks Associated with Projected Sea Level Change

The full tidal reconnection of the North and South Basins would open the surrounding land and facilities to the effects of sea level rise. Moffatt and Nichol (2008a) identified several specific features that would be impacted. They developed cost estimates for these items in the low-lying infrastructure study. Table 8-3 compares potential risks associated with projected sea level changes based on professional judgment.

Table 8-3. Risks of Sea Level Change

	Projected SLC		
	High (65 cm)	**Intermediate (21cm)**	**Low (13cm)**
Full Restoration	Given the urban location of the project there are a number of actions that will be required as sea level rises: Raise berm along Arc of Statehood and install stormwater pump station. Raise Deschutes Parkway near BNSF crossing, replace BNSF railroad trestle, and raise rail track west of Capitol Lake. Construct perimeter dikes for parking and restroom at Marathon Park, for parking at GA Powerhouse, and to protect the Old Brewhouse.	Negligible	Negligible
Partial Restoration	Same as full but need to raise height of tidal barrier and pedestrian footpath.	Negligible	Negligible

8.7 Potential Monitoring Opportunities

Monitoring is important for evaluating restoration success, especially for a high-visibility action affecting an iconic feature. A combination of field surveys and aerial photographs would be used to document biological and physical changes to the landscape. Monitoring data can be used to refine adaptive management and corrective actions as needed. The monitoring needs and opportunities associated with this action are summarized in Table 8-4.

Table 8-4. Monitoring Needs and Opportunities

Monitoring Parameter	Key Performance Indicator	Note
Topographic Stability	X	Monitor slope stability near dam area
Sediment Accretion / Erosion	X	Monitor to assess need for dredging
Wood Accumulation		
Soil / Substrate Conditions		
Vegetation Establishment	X	Monitor development of intertidal habitats

Monitoring Parameter	Key Performance Indicator	Note
Marsh Surface Evolution / Accretion		
Tidal Channel Cross-Section / Density	X	Monitor tidal channel formation, reestablishment of circulation and mixing processes for fresh water and marine water
Water Quality (contaminants)	X	Monitor sediment and nutrient conveyance
Salinity	X	Monitor salinity and temperature
Shellfish Production		
Extent of Invasive Species	X	Assess species response to restoration action
Animal Species Richness	X	Assess species response to restoration action
Fish (salmonids) Access/Use	X	Assess species response to restoration action
Forage Fish Production		
Wildlife Species Use	X	Assess species response to restoration action
Effectiveness of Exclusion Devices		

8.8 Information Needed for Subsequent Design

This conceptual design report represents an initial step in the restoration design sequence. The design concepts described above were developed based on readily available information without the level of site-specific survey and investigation that is necessary to support subsequent design and implementation. Substantial additional information will be required at the preliminary and later design stages to confirm the design assumptions, refine quantity estimates, address property and regulatory issues, obtain stakeholder support, and fill in data gaps. The extent to which this information is collected for preliminary design (or a later design stage) will depend upon the available budget, schedule and other factors. This section attempts to define the most essential information needs for this action.

- Utility Investigation/Survey – More detailed information on utility locations will be needed to finalize the designs. The low-lying infrastructure investigation by Moffatt and Nichol (2008b) provides some preliminary direction on utilities and sewers.
- Geotechnical Investigation – Additional geotechnical study will be required including foundation type and hydraulic engineer recommendations for scour and minimum bridge clearance over water, walls, and slopes.
- Groundwater Investigation – Additional studies regarding the existing and anticipated groundwater movement under the different restoration scenarios can expand the preliminary information provided by Moffatt and Nichol (2008b).

- Cultural Resources Investigation – Surveys for archaeological and historic resources may be required for this action area.
- Contaminant Survey – Additional investigation may be required to document the presence and extent of hazardous materials in the action area. The introductory chapter describes the Phase I site investigations that are occurring as part of this overall effort via a separate contract.

8.9 Quantity Estimates

The quantity spreadsheets for the full and partial restoration alternatives are provided in Exhibits 8-1 and 8-2.

8.10 References

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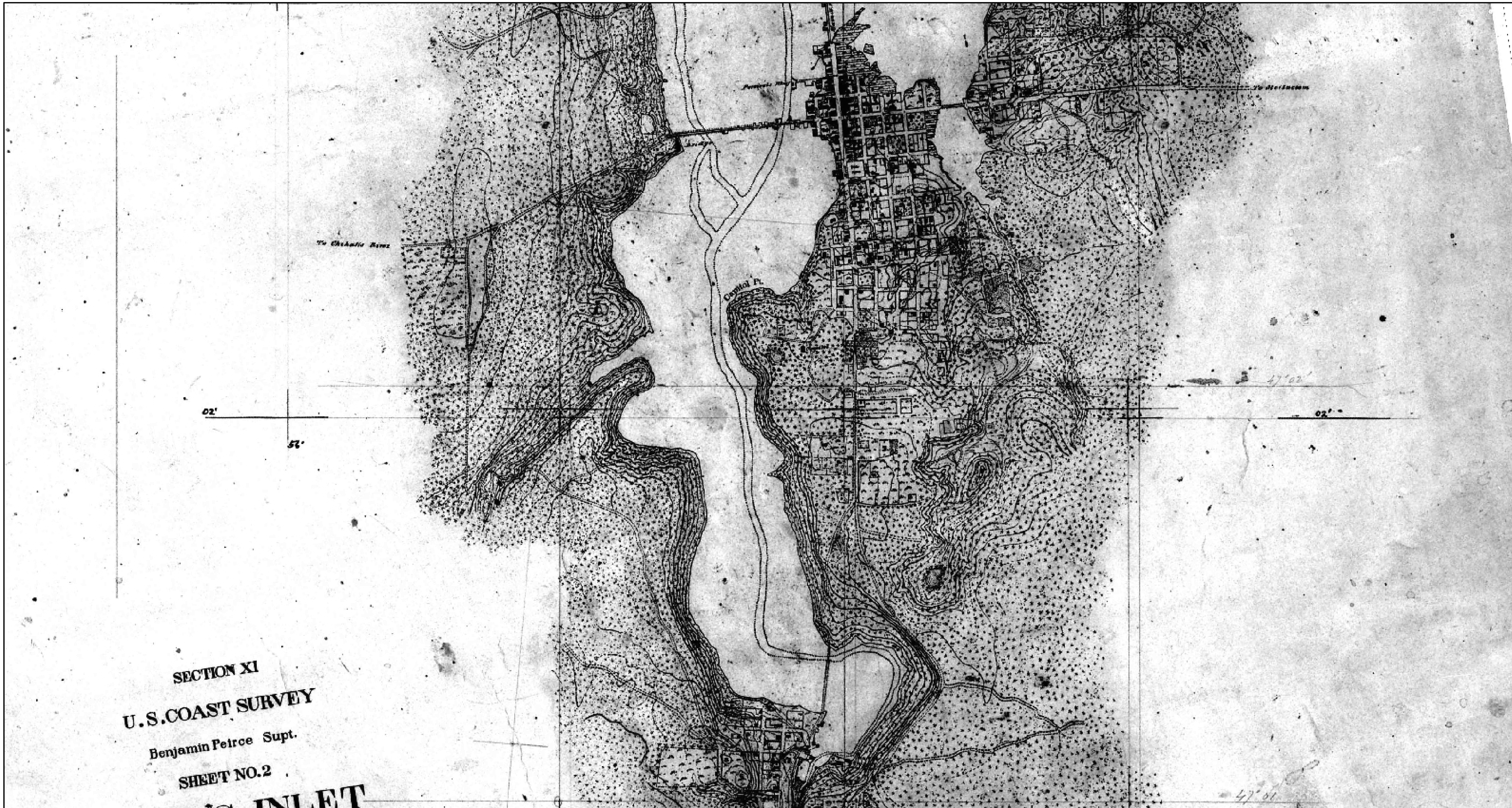

0 1,400
Feet
0 440
Meters

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet)

Action Name: Deschutes River Estuary Restoration

PSNERP ID #: 1003

Figure 8- 2A

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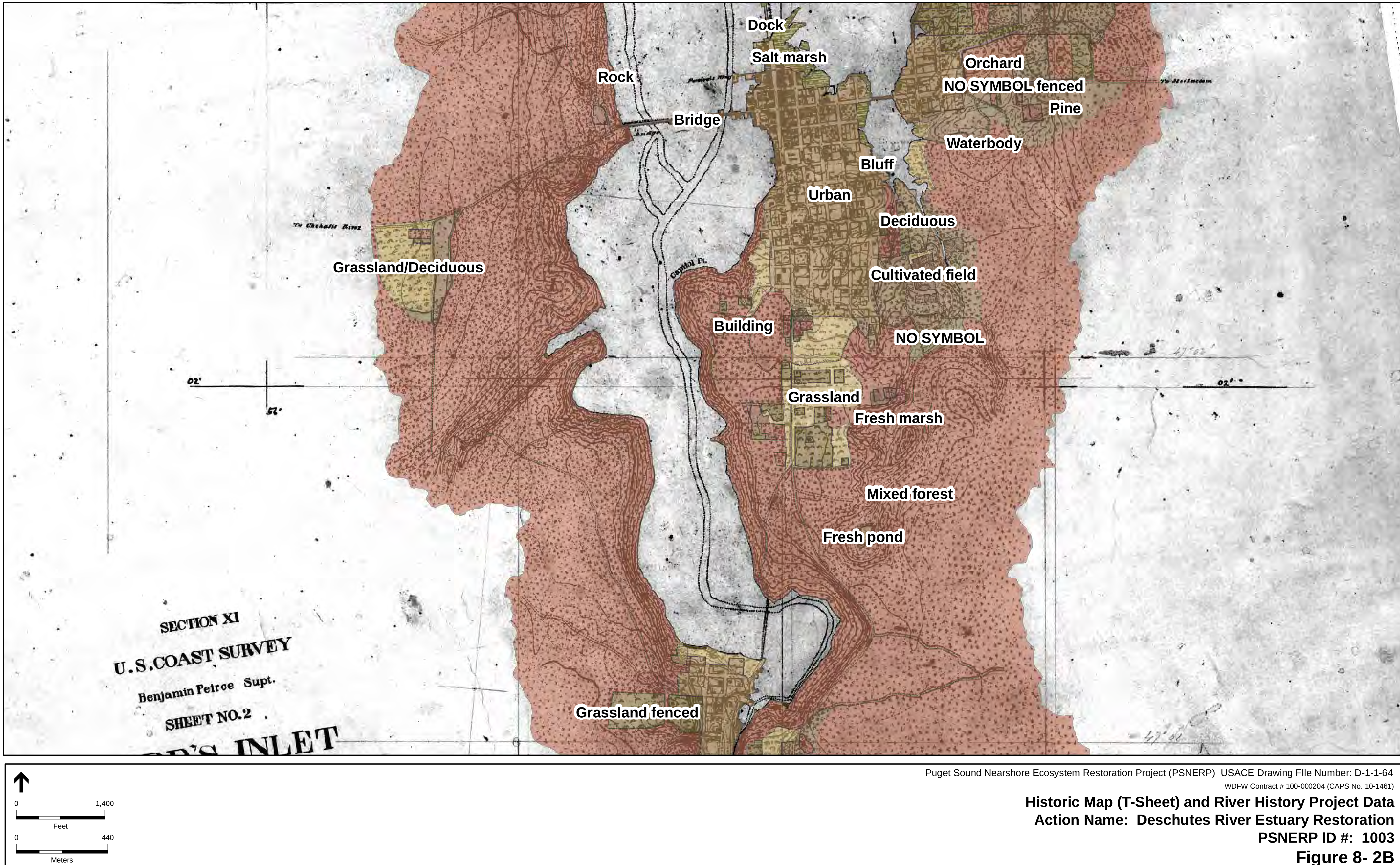

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Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing FIle Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Historic Map (T-Sheet) and River History Project Data

Action Name: Deschutes River Estuary Restoration

PSNERP ID #: 1003

Figure 8- 2B

SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); NAIP (2006)

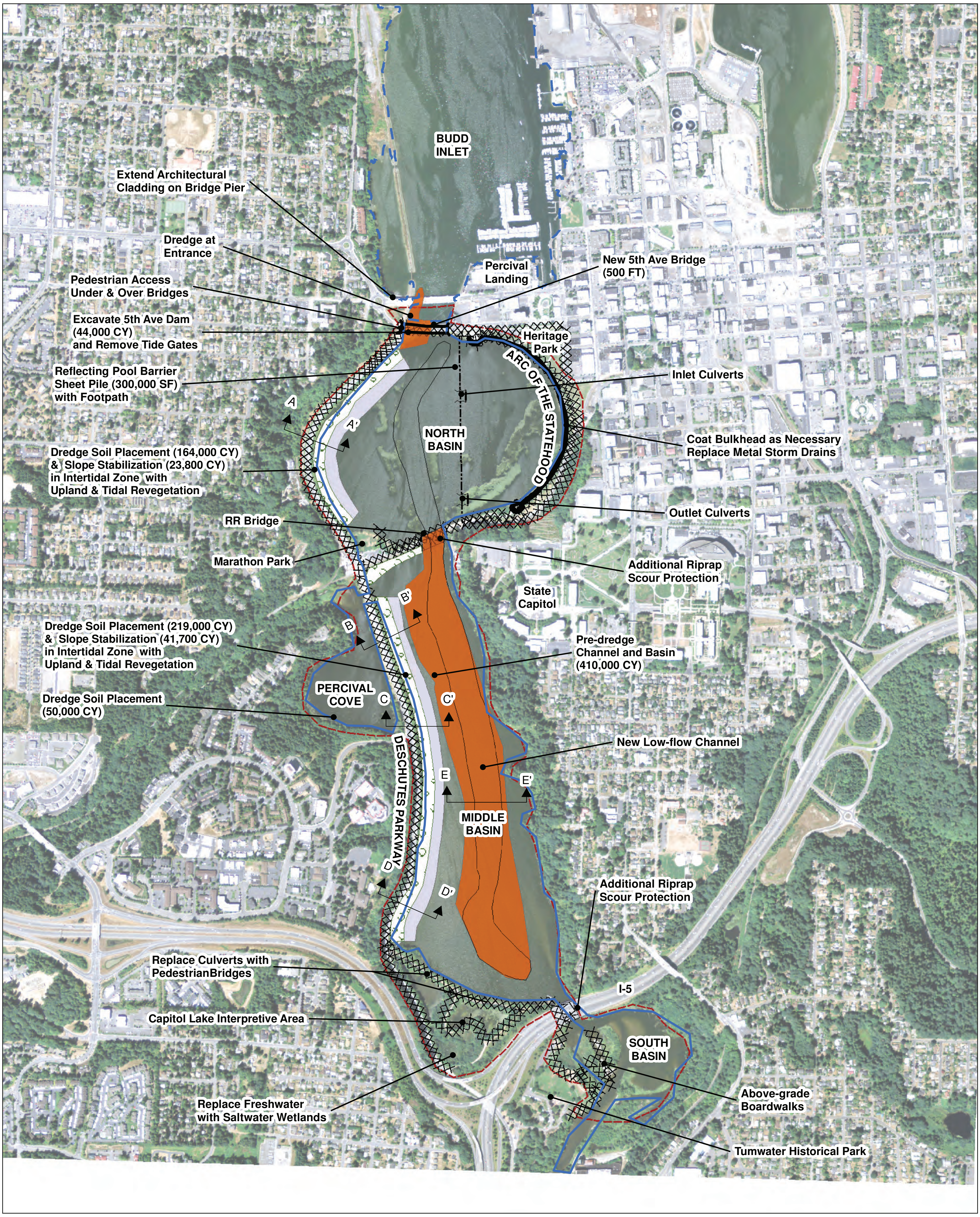
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

Lead Contractor: ESA
Design Lead: ESA PWA
Date: 2/2011

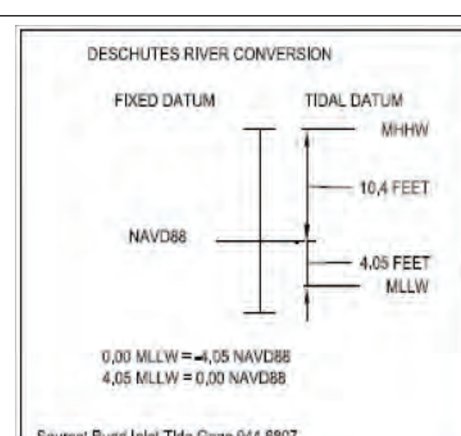
Conceptual Design Plan
Site Name: Budd Inlet
Action Name: Deschutes River Estuary Restoration
PSNERP ID #:1003
Full Restoration

Figure 8-3



Legend

- Bridge
- Dredging - Hydraulic
- Haul - Uncontrolled Placement
- Low-flow Channel
- Planting
- Required Project Lands
- Rock Slope Protection
- Water Control Structures - Culverts with Gates
- Barrier
- Bulkheads
- Existing Tide MHHW
- Proposed Tide MHHW
- Trails



North

0 340 Feet

SOURCE: Washington Public Lands Database (2006); Washington Counties Parcels (2009); NAIP (2006)

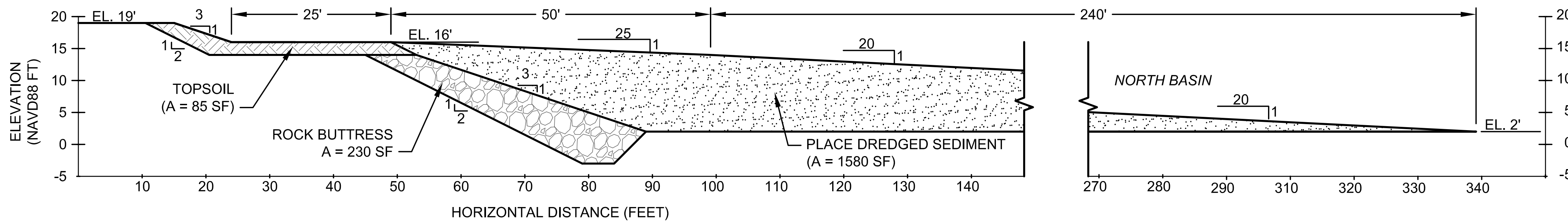
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64

WDFW Contract # 100-000204 (CAPS No. 10-1461)

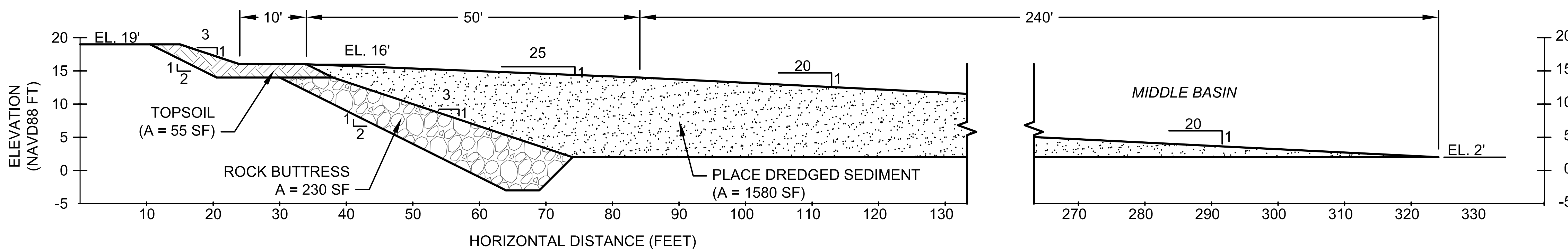
Lead Contractor: ESA
Design Lead: ESA PWA
Date: 2/2011

Conceptual Design Plan
Site Name: Budd Inlet
Action Name: Deschutes River Estuary Restoration
PSNERP ID #:1003
Partial Restoration

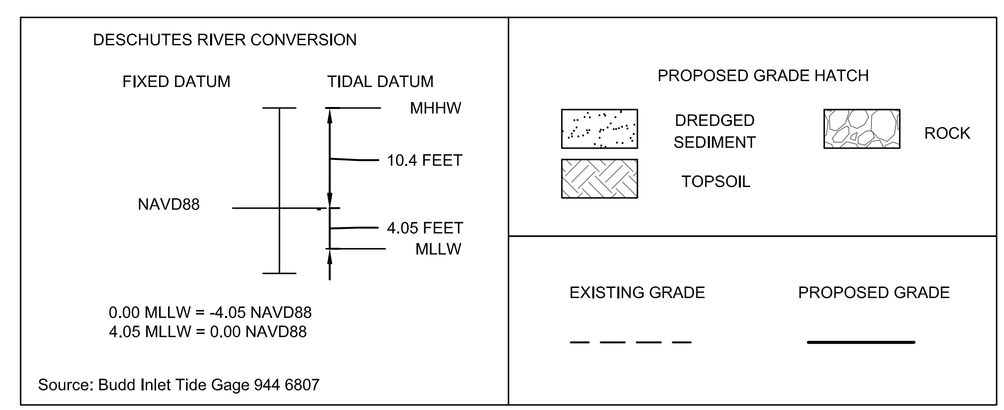
Figure 8-4



A NORTH BASIN - TYPICAL SECTION



B MIDDLE BASIN - NORTHERN TYPICAL SECTION



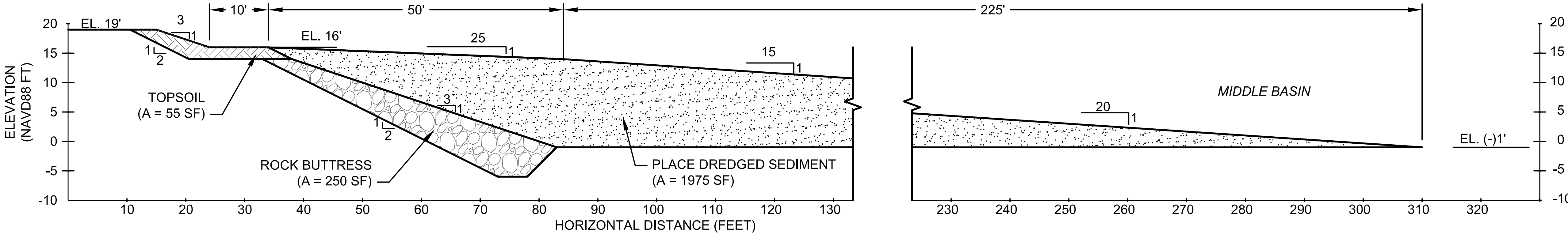
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA
Date: 3/2011

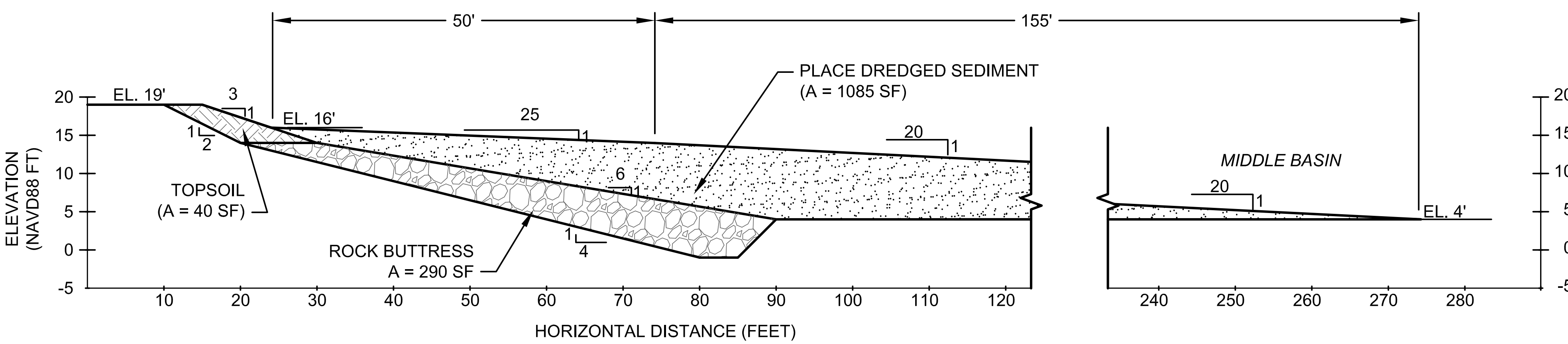
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Budd Inlet**
ACTION NAME: **Deschutes River Estuary Restoration**
PSNERP ID#: **1003**
Full Restoration

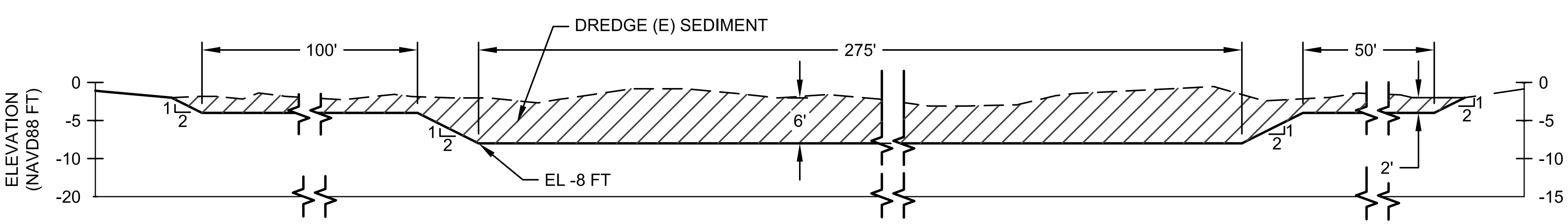
Figure 8-5



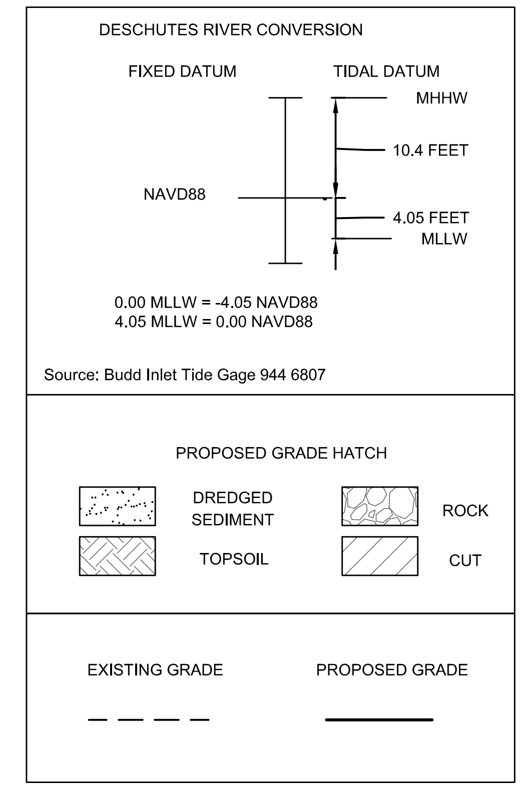
C MIDDLE BASIN - CENTRAL TYPICAL SECTION



D MIDDLE BASIN - SOUTHERN TYPICAL SECTION



E MIDDLE BASIN CHANNEL - DREDGING - TYPICAL SECTION



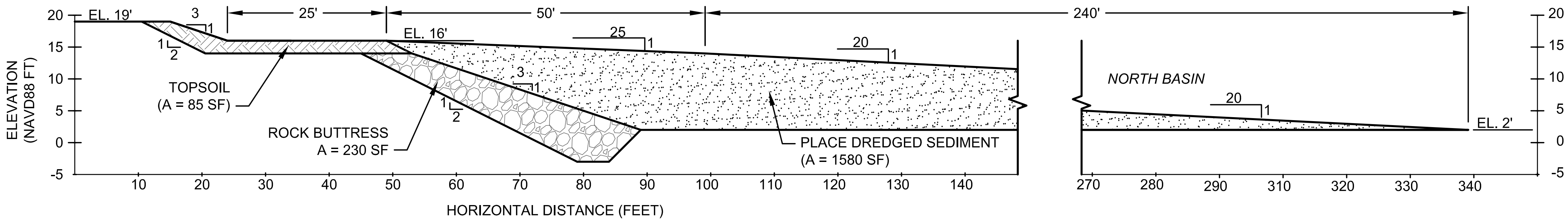
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA
Date: 3/2011

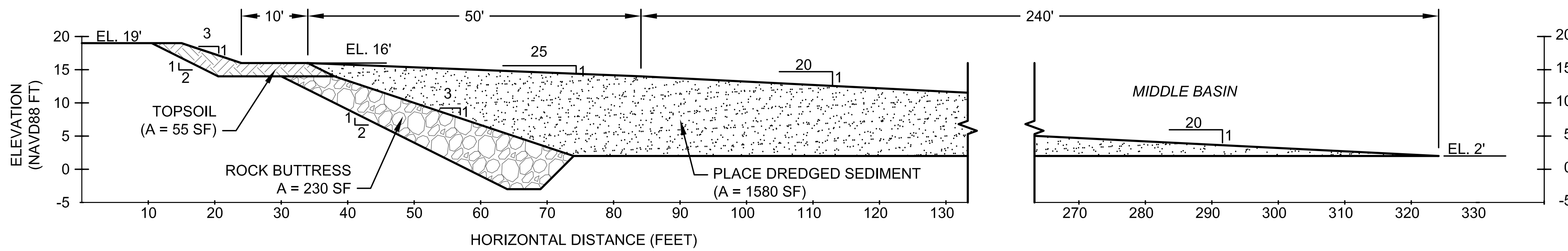
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Budd Inlet**
ACTION NAME: **Deschutes River Estuary Restoration**
PSNERP ID#: **1003**
Full Restoration

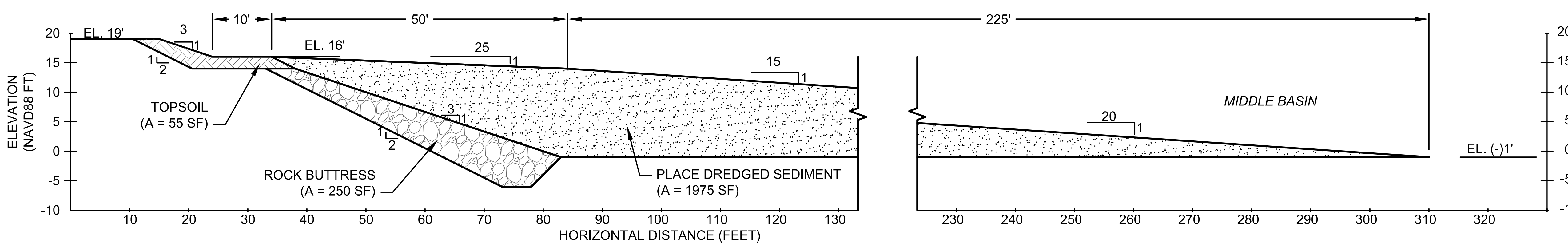
Figure 8-6



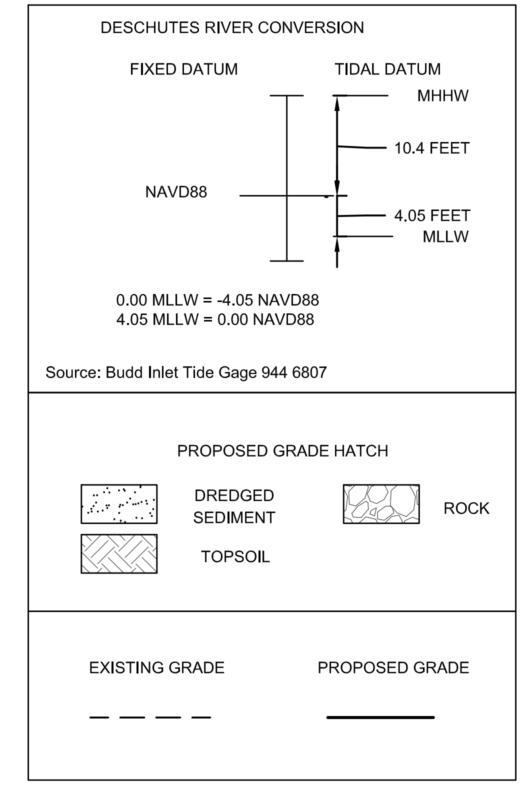
Ⓐ NORTH BASIN - TYPICAL SECTION



Ⓑ MIDDLE BASIN - NORTHERN TYPICAL SECTION



Ⓒ MIDDLE BASIN - CENTRAL TYPICAL SECTION



0 20
Scale in Feet

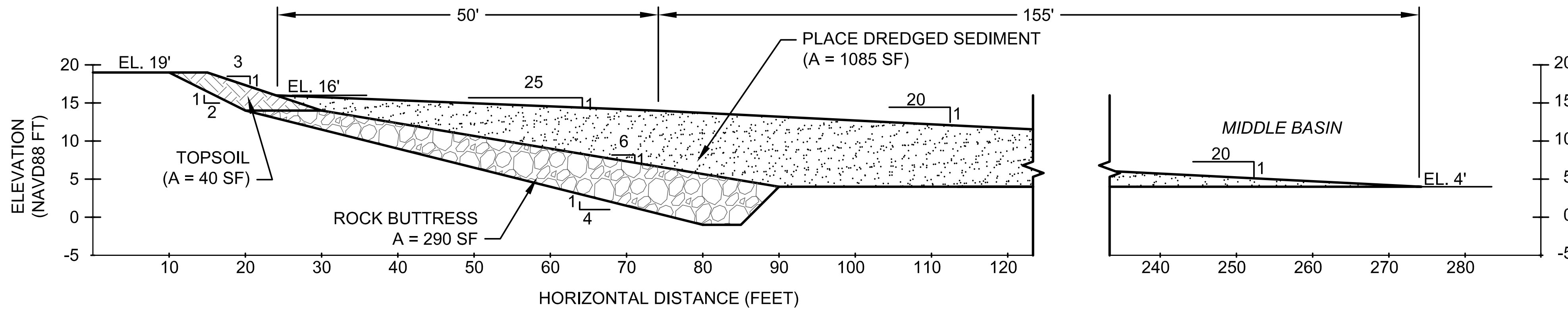
PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA
Date: 03/2011

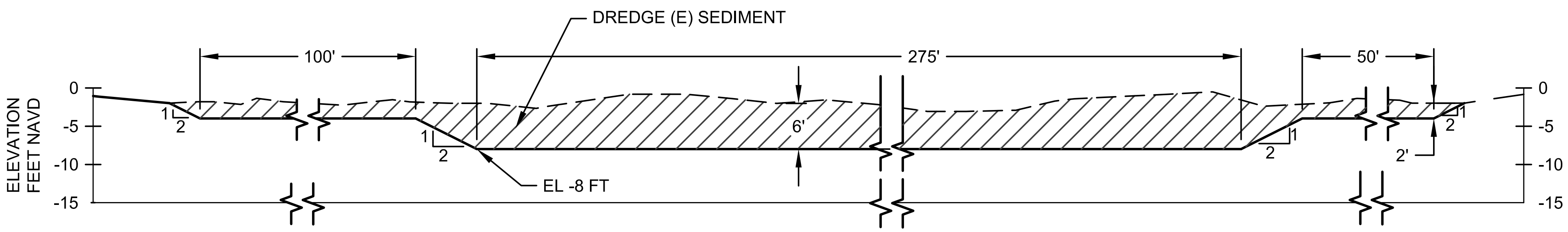
Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Budd Inlet**
ACTION NAME: **Deschutes River Estuary Restoration**
PSNERP ID#: **1003**
Partial Restoration

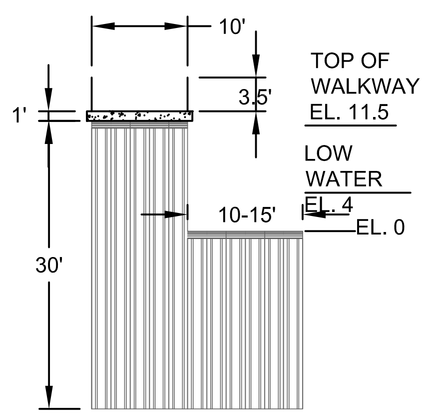
Figure 8-7



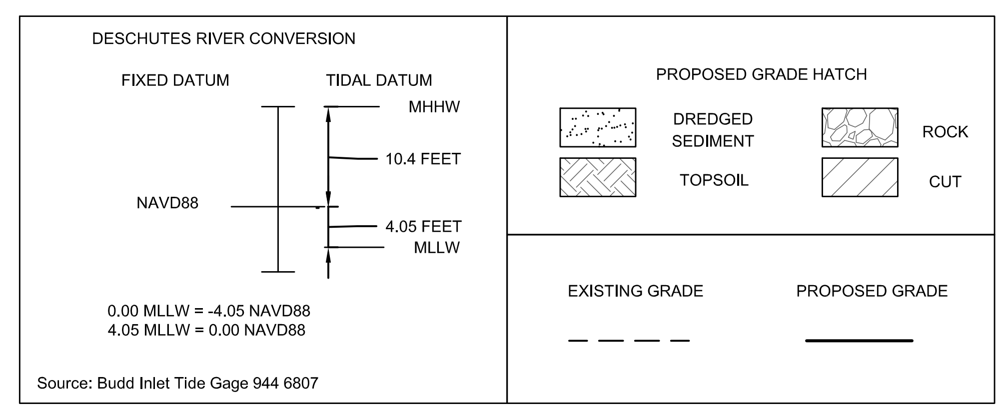
D MIDDLE BASIN - SOUTHERN TYPICAL SECTION

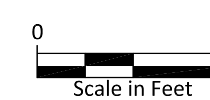


E MIDDLE BASIN CHANNEL - TYPICAL SECTION



F REFLECTING POOL BARRIER SECTION





PUGET SOUND NEARSHORE ECOSYSTEM RESTORATION PROJECT

Lead Contractor: ESA
Design Lead: ESA PWA
Date: 03/2011

Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) USACE Drawing File Number: D-1-1-64
WDFW Contract # 100-000204 (CAPS No. 10-1461)

Conceptual Design Section
SITE NAME: **Budd Inlet**
ACTION NAME: **Deschutes River Estuary Restoration**
PSNERP ID#: **1003**
Partial Restoration

Figure 8-8

Full Restoration Quantity Estimate

Action Name: Deschutes River Estuary Restoration
Action #: 1033
Date: February 2011
By: ESA PWA with KPFF

REMEDY: ***restore tidal dynamics to Deschutes Estuary by removal of the 5th Avenue dam***
Construction Period: 12 months

	Item	Unit of Measure	Material Name	Qty	Description of Item << provide detailed exlanation specific to this action; indicate section of design report where item is described>>		Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					Based on available mapping information		
	Required Project Lands	Acre		346	Total land required For action		
	Proponent / Partner-owned lands	Acre		346	Etimate of lands currently owned by Proponent (i.e., Public lands)		
	Lands To Be Acquired	Acre		0	Estimate land required to be acquired for action prior to implementation		
Material Sites					Not Used: See Earthwork - Imported Fill.		
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating		
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		0	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.		
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0	Up front cost for nontypical or remote locations. Assume 12% of other items		
	Site Access	LS		0	Use for special situations (e.g.. new bridge, new access roads) for the purposes of construction access. Include description.		
	Barge Access	Days		0	Access may be required for offsite transport of dredged sediment to Commencement Bay 200,000 + CY		
	Temporary Traffic Control (one of the following)						
	none	LS		0	Not Applicable to Action		
	signs	LS		1	Typical Construction Signage		
	flags / spotters	LS		1	Flags and spotters only during roadway transition connection		
	unique	LS		0	Not Applicable to Action		
	Temporary Roadway	SF		0	Not Applicable to Action		
	Control of Water	LS		1	Required for construction of new 5th Ave Dam. Components likely include coffer dam and bypass (96-inch)		8.3.4
Relocation Activities					Not Used: See Utilities, Structures		
Site Demolition Activities					Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.		
	Clearing and Grubbing (one or more of following)						
	Clear Vegetation - Local Disposal	AC		0	Not Applicable to Action		
	Clear /Grub Vegetation - Local Disposal	AC		0	Not Applicable to Action		
	Clear /Grub Vegetation - Offsite Disposal	AC		0	Not Applicable to Action		
	Clear, stockpile - large woody debris	CY		0	Not Applicable to Action		
	Hydraulic Structures - Culverts	LS		0	Not Applicable to Action		
	Hydraulic Structures - Large	LS		1	Dam removal - Remove earthen & concrete dam 5m deep x 25m wide		8.3.2
	Utilities	LF		1700	Reroute 1700' of sewer, water lines and 2 gas lines at 4th/5th Ave corridor		
	Buildings	LS or SF		0	Not Applicable to Action		
	Pavement	SF		95682	Removal of 74' Roadway (including sidewalks and shoulder) and Deschutes Pkwy		8.3.2
	Bulkheads	LF or SF		0	Not Applicable to Action		
	Demolition/Removal - Armor on Railroad Berm	LF, Ton or CY		0	Not Applicable to Action		
	Demolition / Removal - Railroad Berm	LF, SF or CY		0	Not Applicable to Action		
	Demolition / Removal - Bridge	SF		0	Not Applicable to Action		
	Removal - Misc. (e.g. angular rock from beach)	Ton		0	Not Applicable to Action		
	Demolition / Removal - in-water Piling	Number of Piles		0	Not Applicable to Action		
	Haul - Offsite Disposal of Demolition Debris	Miles		86	Commencement Bay (86 miles round trip)		8.3.3
Hazardous/Contaminated Waste Removal					These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.		
	Contaminated Earthwork	CY		54,000	Removal of contaminated dredged material. (~11% of total dredged material)		8.3.3
	Hazardous Earthwork	CY		0	Not Applicable to Action		
Construct Temporary Features					Use as needed for unusual temporary features not included elsewhere (see TESC below)		
EARTHWORK					Expand to include equipment, etc. to facilitate cost estimating.		
	Excavation	CY		0	Not Applicable to Action		
	Excavation - Upland	CY		44,000	Upland portion of 5th Ave dam		8.3.2
	Excavation - Lowland	CY		0	Not Applicable to Action		
	Dredging - Bucket - Land	CY		0	Not Applicable to Action		
	Dredging - Bucket - Marine	CY		0	Not Applicable to Action		
	Dredging - Hydraulic	CY		410,000	Middle Basin channel dredging and dredging at North Basin entrance		8.3.2
	Dredging - Hydraulic	CY		77,000	North Basing entrance dredging at dam		8.3.2
	Fine Grading	AC		0	Not Applicable to Action		
	Fill Placement - local borrow				This is additive to Earthwork -Excavation		
	Side cast	CY		0	Not Applicable to Action		
	Haul - uncontrolled placement	CY		383,000	Dredged sediment placement at western shore of North & Middle Basins		8.3.2
	Haul - uncontrolled placement	CY		50,000	Dredged sediment placement at Percival Cove		8.3.2
	Haul - uncontrolled placement	CY		98,000	Off-site disposal of surplus sediment (44,000 CY of upland excavation + 54,000 CY contaminated sediment)		8.3.2, 8.3.3
	Haul, place, compact	CY		0	Not Applicable to Action		
	Stockpile - uncontrolled placement	CY		0	Not Applicable to Action		
	Stockpile - controlled placement	CY		0	Not Applicable to Action		
	Conveyor placement from stockpile land/water	CY		0	Not Applicable to Action		
	Imported Fill						
	Select Fill	CY		0	Not Applicable to Action		
	Gravel Borrow, including haul	CY		0	WSDOT standard item		
	Sand / Gravel for Beach Nourishment	CY		0	special borrow and sorting required; identify material source		
	Cobble for Shore Nourishment	CY		0	special borrow and sorting required; identify material source		
	Embankment Compaction	CY		0	WSDOT standard item		
	Topsoil	CY		16,000	Topsoil placement at western shore of North & Middle Basins		8.3.2
RESTORATION Features							
	Channel Rehab / Creation	SF		0	Not Applicable to Action		
	Large Wood Placement	EA		0	Not Applicable to Action		
	Invasive Species Control	Acre		0	Not Applicable to Action		
	Physical Exclusion Devices	LF or EA		0	Not Applicable to Action		
	Other Restoration Features/ Activities	LS		1	Sediment curtains at Middle and North Basins during dredging and placement		
Structures		EA					
	Water Control Structures - Culverts with Gates	EA		0	Not Applicable to Action		
	Water Control Structures - Weirs	EA		0	Not Applicable to Action		
	Rock Slope Protection	CY		65,500	Rock Buttress (1-2 ft dia rock)		8.3.4
	Rock Slope Protection	LF		1,550	5th Ave, 4th Ave and Railroad bridge - scour protection		8.3.2
	Other - Bulkhead treatment	EA		25,000	Arc of Statehood surface treatment to protect against salt water (25,000 SF)		8.3.4
	Other - Stormwater outfalls	EA		1	Unknown number to be replaced or upgraded at Capitol Lake and Deschutes Parkway.		8.3.4
	Elevated Boat Ramp	SF		0	Not Applicable to Action		
	Fencing	SF		0	Not Applicable to Action		
Utilities							
	Water	LF		800	800' on new 5th ave bridge		n/a
	Gas	LF		1600	2 lines on new 5th ave bridge of 800'		n/a
	Electric	LF		0	Not Applicable to Action		
	Sewer	LF		800	800' on new 5th ave bridge		n/a
	Telecommunications	LF		0	Not Applicable to Action		
	Other	LF		0	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)		
Roadway / Railway							
	Roadway	SF		53650	Typical Roadway 74' wide, new section per City of Olympia		8.3.1
	Roadway - Switch (potential)	LS		0	Street lights, etc. (Temporary traffic control handled under Temporary Facilities)		
	Culvert (type)	LF		0	Provide specific culver size and type		
	Culvert - Jacking	LF		0	Through railway		
	Culvert - Horizontal Pile Driving	LF		0	Through railway		
	Bridge Deck	SF		33750	Precast Concrete Girder Bridge with 100' spans (450'x75')		8.3.1
	Bridge - Foundation Drilled Shafts	LF		375	(5) 75' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile cap		8.3.1
	Railway - Shoe fly	LF		0	Temporary alignment		
Permanent Access Features					KPFF expected to participate in these estimates		
	Roads	Level		1%	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access		
	Utility Access Routes	varies		0	Describe utility access feature, such as boardwalk or all-weather gravel road		
	Erosion Control Features	AC		2.2	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments		

Full Restoration Quantity Estimate

Action Name: Deschutes River Estuary Restoration
Action #: 1033
Date: February 2011
By: ESA PWA with KPFF

REMEDY: ***restore tidal dynamics to Deschutes Estuary by removal of the 5th Avenue dam***
Construction Period: 12 months

	Item	Unit of Measure	Material Name	Qty	Description of Item << provide detailed exlanation specific to this action; indicate section of design report where item is described>>		Indicate section of design report where item is described
Public Access or Recreation Features							
	Trails	SF		66,000	New Trails (10 ft width)		8.3.4
	Trails	SF		10,900	Improved trails (10 ft width)		8.3.4
	Bridges	SF		600	2 pedestrian bridges (12 ft by 25 ft)		8.3.5
	Kiosk	EA		0	Not Applicable to Action		
	Restrooms	EA		0	Not Applicable to Action		
	Interpretive Signs	EA		0	Not Applicable to Action		
	Parking Area	SF		0	Not Applicable to Action		
	Other	EA		0	Not Applicable to Action		
Vegetation & Erosion Control							
	Hydroseeding	AC		0	Not Applicable to Action		
	Planting	AC		17.5	Upland and wetland/marsh planting at western shore of North & Middle basins.		8.3.3
	Vegetation Maintenance	AC-YR		0	Not Applicable to Action		
	Erosion / sediment BMPs - Temp.	AC		2.2	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		n/a
	Erosion / sediment BMPs - Permanent	AC		0	Not Applicable to Action		
	Waterside controls - Temporary	EA, LF, LS		0	Not Applicable to Action		
Construction Management							
	Construction oversight	weeks		60	Assume 15 months for bridge and road. Quanity based on constructon duration/ # of construction seasons		n/a
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		0	% of construction cost		
	35% Design	LS		0	35% x 25% x Engineer's Estimate		
	65% design	LS		0	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		0	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		0	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies			0	Refer to design report for description of need		
	Cultural Studies			0	Refer to design report for description of need		
	HTWR Studies			0	Refer to design report for description of need		
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		250			
Operations & Maintenance					Unable to provide credible estimate at 10% design		

Partial Restoration Quantity Estimate

Action Name: Deschutes River Estuary Restoration
Action #: 1033
Date: February 2011
By: ESA PWA with KPFF

REMEDY: restore tidal dynamics to Deschutes Estuary by removal of the 5th Avenue dam
Construction Period: 12 months

	Item	Unit of Measure	Material Name	Qty	Description of Item	Indicate section of design report where item is described
ACQUISITION AND CONSERVATION					Based on available mapping information	
	Required Project Lands	Acre		346	Total land required For action	
	Proponent / Partner-owned lands	Acre		346	Etimate of lands currently owned by Proponent (i.e., Public lands)	
	Lands To Be Acquired	Acre		0	Estimate land required to be acquired for action prior to implementation	
Material Sites					Not Used: See Earthwork - Imported Fill.	
MOBILIZATION AND ACCESS for construction activities					Description required for each item to facilitate cost estimating	
	Mobilization - Typical (Equipment, Personnel, Planning, Financial)	LS		1	Up front costs such as bonding, planning and other staff time and financing. Typically, assume 8% to 10% of other items.	
	Mobilization - Remote (Equipment, Personnel, Planning, Financial)	LS		0		
	Site Access	LS		0		
	Barge Access	Days		0		
	Temporary Traffic Control (one of the following)					
	none	LS		0	Not Applicable to Action	
	signs	LS		1	Typical Construction Signage	
	flags / spotters	LS		1	Flags and spotters only during roadway transition connection	
	unique	LS		0	Not Applicable to Action	
	Temporary Roadway	SF		0	Not Applicable to Action	
	Control of Water	LS		1	Required for construction of new 5th Ave Dam. Components likely include coffer dam and bypass (96-inch)	8.3.4
Relocation Activities					Not Used: See Utilities, Structures	
Site Demolition Activities					Demolition and removal of structures (description required), temporary features and relocations, itemized separately); Clearing and grubbing of vegetation, and removal of minor debris (rocks, slabs) - description required.	
	Clearing and Grubbing (one or more of following)					
	Clear Vegetation - Local Disposal	AC		0	Not Applicable to Action	
	Clear /Grub Vegetation - Local Disposal	AC		0	Not Applicable to Action	
	Clear /Grub Vegetation - Offsite Disposal	AC		0	Not Applicable to Action	
	Clear, stockpile - large woody debris	CY		0	Not Applicable to Action	
	Hydraulic Structures - Culverts	LS		0	Not Applicable to Action	
	Hydraulic Structures - Large	LS		1	Dam removal - Remove earthen & concrete dam 5m deep x 25m wide	8.3.2
	Utilities	LF		1700	Reroute 1700' of sewer, water lines and 2 gas lines at 4th/5th Ave corridor	
	Buildings	LS or SF		0	Not Applicable to Action	
	Pavement	SF		95682	Removal of 74' Roadway (including sidewalks and shoulder) and Deschutes Pkwy	8.3.2
	Bulkheads	LF or SF		0	Not Applicable to Action	
	Demolition/Removal - Armor on Railroad Berm	LF, Ton or CY		0	Not Applicable to Action	
	Demolition / Removal - Railroad Berm	LF, SF or CY		0	Not Applicable to Action	
	Demolition / Removal - Bridge	SF		0	Not Applicable to Action	
	Removal - Misc. (e.g. angular rock from beach)	Ton		0	Not Applicable to Action	
	Demolition / Removal - in-water Piling	Number of Piles		0	Not Applicable to Action	
	Haul - Offsite Disposal of Demolition Debris	Miles		86	Commencement Bay (86 miles round trip)	8.3.3
Hazardous/Contaminated Waste Removal					These items for earthwork of quality not compatible with wetlands, requiring special handling and disposal. Describe basis for classification as contaminated or hazardous. State known or suspected contamination, describe known similar work.	
	Contaminated Earthwork	CY		54,000	Removal of contaminated dredged material. (~11% of total dredged material)	8.3.3
	Hazardous Earthwork	CY		0	Not Applicable to Action	
Construct Temporary Features					Use as needed for unusual temporary features not included elsewhere (see TESC below)	
EARTHWORK					Expand to include equipment, etc. to facilitate cost estimating.	
	Excavation	CY		0	Not Applicable to Action	
	Excavation - Upland	CY		44,000	Upland portion of 5th Ave dam	8.3.2
	Excavation - Lowland	CY		0	Not Applicable to Action	
	Dredging - Bucket - Land	CY		0	Not Applicable to Action	
	Dredging - Bucket - Marine	CY		0	Not Applicable to Action	
	Dredging - Hydraulic	CY		410,000	Middle Basin channel dredging and dredging at North Basin entrance	8.3.2
	Dredging - Hydraulic	CY		77,000	North Basing entrance dredging at dam	8.3.2
	Fine Grading	AC		0	Not Applicable to Action	
	Fill Placement - local borrow				This is additive to Earthwork -Excavation	
	Side cast	CY		0	Not Applicable to Action	
	Haul - uncontrolled placement	CY		383,000	Dredged sediment placement at western shore of North & Middle Basins	8.3.2
	Haul - uncontrolled placement	CY		50,000	Dredged sediment placement at Percival Cove	8.3.2
	Haul - uncontrolled placement	CY		98,000	Off-site disposal of surplus sediment (44,000 CY of upland excavation + 54,000 CY contaminated sediment)	8.3.2, 8.3.3
	Haul, place, compact	CY		0	Not Applicable to Action	
	Stockpile - uncontrolled placement	CY		0	Not Applicable to Action	
	Stockpile - controlled placement	CY		0	Not Applicable to Action	
	Conveyor placement from stockpile land/water	CY		0	Not Applicable to Action	
	Imported Fill					
	Select Fill	CY		0	Not Applicable to Action	
	Gravel Borrow, including haul	CY		0	WSDOT standard item	
	Sand / Gravel for Beach Nourishment	CY		0	special borrow and sorting required; identify material source	
	Cobble for Shore Nourishment	CY		0	special borrow and sorting required; identify material source	
	Embankment Compaction	CY		0	WSDOT standard item	
	Topsoil	CY		16,000	Topsoil placement at western shore of North & Middle Basins	8.3.2
RESTORATION Features						
	Channel Rehab / Creation	SF		0	Not Applicable to Action	
	Large Wood Placement	EA		0	Not Applicable to Action	
	Invasive Species Control	Acre		0	Not Applicable to Action	
	Physical Exclusion Devices	LF or EA		0	Not Applicable to Action	
	Other Restoration Features/ Activities	LS		1	Sediment curtains at Middle and North Basins during dredging and placement	
Structures		EA				
	Water Control Structures - Culverts with Gates	EA		0	Not Applicable to Action	
	Water Control Structures - Weirs	EA		0	Not Applicable to Action	
	Rock Slope Protection	CY		65,500	Rock Buttress (1-2 ft dia rock)	8.3.4
	Rock Slope Protection	LF		1,550	5th Ave, 4th Ave and Railroad bridge - scour protection	8.3.2
	Other - Bulkhead treatment	EA		25,000	Arc of Statehood surface treatment to protect against salt water	8.3.4
	Other - Stormwater outfalls	EA		1	Unknown number to be replaced or upgraded at Capitol Lake and Deschutes Parkway.	8.3.4
	Other - Tidal barrier in North Basin	SF		300,000	Sheet pile barrier to create pool adjacent to Arc of the Statehood	8.3.1
	Other - Tide gates	LS		8	Culverts for maintaining constant water level in reflecting pool	8.3.2
	Elevated Boat Ramp	SF		0	Not Applicable to Action	
	Fencing	SF		0	Not Applicable to Action	
Utilities						
	Water	LF		800	800' on new 5th ave bridge	n/a
	Gas	LF		1600	2 lines on new 5th ave bridge of 800'	n/a
	Electric	LF		0	Not Applicable to Action	
	Sewer	LF		800	800' on new 5th ave bridge	n/a
	Telecommunications	LF		0	Not Applicable to Action	
	Other	LF		0	Others = whatever is required (e.g.. power towers, petroleum, jet fuel, etc.)	
Roadway / Railway						
	Roadway	SF		53650	Typical Roadway 74' wide, new section per City of Olympia	8.3.1
	Roadway - Switch (potential)	LS		0	Street lights, etc. (Temporary traffic control handled under Temporary Facilities)	
	Culvert (type)	LF		0	Provide specific culver size and type	
	Culvert - Jacking	LF		0	Through railway	
	Culvert - Horizontal Pile Driving	LF		0	Through railway	
	Bridge Deck	SF		33750	Precast Concrete Girder Bridge with 100' spans (450'x75')	8.3.1
	Bridge - Foundation Drilled Shafts	LF		375	(5) 75' CIP Concrete pile caps with (2) 7' drilled shafts 100' embed at each pile cap	8.3.1
	Railway - Shoe fly	LF		0	Temporary alignment	
Permanent Access Features					KPFF expected to participate in these estimates	
	Roads	Level		1%	Level 1 direct access, Level 2 moderately difficult, Level 3 difficult access	
	Utility Access Routes	varies		0	Describe utility access feature, such as boardwalk or all-weather gravel road	
	Erosion Control Features	AC		2.2	Stabilized Construction Entrances, Sediment Ponds, Hydro Seed to Stabilize Roadway Embankments	

Partial Restoration Quantity Estimate

Action Name: Deschutes River Estuary Restoration
Action #: 1033
Date: February 2011
By: ESA PWA with KPFF

REMEDY: restore tidal dynamics to Deschutes Estuary by removal of the 5th Avenue dam
Construction Period: 12 months

	Item	Unit of Measure	Material Name	Qty	Description of Item		Indicate section of design report where item is described
Public Access or Recreation Features							
	Trails	SF		66,000	New Trails (10 ft width)		8.3.4
	Trails	SF		10,900	Improved trails (10 ft width)		8.3.4
	Bridges	SF		600	2 pedestrian bridges (12 ft by 25 ft)		8.3.5
	Kiosk	EA		0	Not Applicable to Action		
	Restrooms	EA		0	Not Applicable to Action		
	Interpretive Signs	EA		0	Not Applicable to Action		
	Parking Area	SF		0	Not Applicable to Action		
	Other	EA		0	Not Applicable to Action		
Vegetation & Erosion Control							
	Hydroseeding	AC		0	Not Applicable to Action		
	Planting	AC		17.5	Upland and wetland/marsh planting at western shore of North & Middle basins.		8.3.3
	Vegetation Maintenance	AC-YR		0	Not Applicable to Action		
	Erosion / sediment BMPs - Temp.	AC		2.2	BMPs for control of drainage - describe. Assume compliance with Construction General NPDES included		n/a
	Erosion / sediment BMPs - Permanent	AC		0	Not Applicable to Action		
	Waterside controls - Temporary	EA, LF, LS		0	Not Applicable to Action		
Construction Management							
	Construction oversight	weeks		60	Assume 15 months for bridge and road. Quanity based on constructon duration/ # of construction seasons		n/a
	Materials testing				Included in cost of material - no separate quantity		
Design and Detailed Site Investigations							
	Survey & Property, Utility Research	LS		0	% of construction cost		
	35% Design	LS		0	35% x 25% x Engineer's Estimate		
	65% design	LS		0	65% x 25% x Engineer's Estimate less the cost for 35% PS&E		
	90% design	LS		0	35% x 25% x Engineer's Estimate less the cost for 35% + 65%PS&E		
	100% design	LS		0	25% x Engineer's Estimate less previous costs		
	Geotechnical Studies			0	Refer to design report for description of need		
	Cultural Studies			0	Refer to design report for description of need		
	HTWR Studies			0	Refer to design report for description of need		
Project Agreement Activities					Unable to provide credible estimate at 10% design		
Site-Specific Adaptive Management Features & Activities					List if known		
Monitoring Activities					Assume 5 crew-days/year for each monitoring parameter in design report for 5 yrs		
	Monitoring (Type)	crew-days		250			
Operations & Maintenance					Unable to provide credible estimate at 10% design		