ENGINEERING DESIGN REPORT
PORT GAMBLE BAY CLEANUP PROJECT

Prepared for

Pope Resources, LP/OPG Properties, LLC

Prepared by

Anchor QEA, LLC

720 Olive Way, Suite 1900

Seattle, Washington 98101

May 2015

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LIST OF ACRONYMS AND ABBREVIATIONS

µg	micrograms
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
BGID	below-grate inlet device
bgs	below ground surface
BMP	best management practice
CAP	Cleanup Action Plan
CD	Consent Decree
cm	centimeter
CoC	contaminant of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CQAP	Construction Quality Assurance Plan
CU	certification unit
cy	cubic yard
DGT	diffusive gradient thin sheet
DIN	dissolved inorganic nitrogen
DMMP	Dredged Material Management Program
DMMO	Dredged Material Management Office
DNR	Department of Natural Resources
DRET	dredging elutriate testing
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
EMNR	enhanced monitored natural recovery
H:V	horizontal to vertical
MAF	Model Airplane Field
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MHHW	mean higher high water
MHW	mean high water
MLLW	mean lower low water
MLW	mean low water

MNR	monitored natural recovery
MSL	mean sea level
MTCA	Model Toxics Control Act
MTL	mean tide level
NAD 83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
ng/kg	nanograms per kilogram
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Survey
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
OMMP	Operations, Maintenance, and Monitoring Plan
P&T	Pope & Talbot Inc.
PDI	pre-design investigation
ppt	parts per thousand
PQL	practical quantitation limits
PR/OPG	Pope Resources, LP/Olympic Property Group, LLC
PSP	paralytic shellfish poisoning
RCW	Revised Code of Washington
RD Work Plan	*Remedial Design and Adaptive Management Work Plan*
RI/FS	remedial investigation/feasibility study
SCO	sediment cleanup objective
SEPA	State Environmental Policy Act
Site	Port Gamble Bay
SMA	sediment management area
SMS	Sediment Management Standards
SPI	sediment profile imaging
SPT	standard penetration testing
SWPPP	stormwater pollution prevention plan
TCP	Traditional Cultural Property
TEQ	toxicity equivalency quotient
TESC	temporary erosion and sediment control
TVS	total volatile solids

USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
WAC	Washington Administrative Code

1 INTRODUCTION

This Engineering Design Report (EDR) describes the approach and criteria for the engineering design of sediment cleanup actions in Port Gamble Bay ("Site"), as set forth in the *Final Cleanup Action Plan* (CAP; Ecology 2013), and in accordance with the requirements of Consent Decree (CD) 13-2-02720-0 between the Washington State Department of Ecology (Ecology) and Pope Resources, LP/Olympic Property Group, LLC (PR/OPG), entered in December 2013. This EDR presents a narrative discussion of performance standards, the cleanup remedy design, and how the remedy meets professional engineering practices and regulatory requirements. Site cleanup actions described in this EDR will be performed by PR/OPG under Ecology oversight, consistent with CD requirements.

Cleanup of the Site is also being performed consistent with the requirements of the Model Toxics Control Act (MTCA), Chapter 70.105D in the Revised Code of Washington (RCW), as administered by Ecology under the MTCA Cleanup Regulation, Chapter 173-340 of the Washington Administrative Code (WAC). Cleanup actions also comply with the Sediment Management Standards (SMS) Chapter 173-204 WAC.

1.1 Site Location and Vicinity

Port Gamble Bay is located in Kitsap County and encompasses more than 2 square miles of subtidal and shallow intertidal habitat just south of the Strait of Juan de Fuca. Figure 1 presents the Site vicinity and location features, and Figure 2 presents the Site boundary and the location of sediment management areas (SMAs) 1 through 5 as defined in the CAP. Under Ecology's Toxics Cleanup Program Puget Sound Initiative, Port Gamble Bay is one of seven bays in Puget Sound identified for focused sediment cleanup. The bay and surrounding areas support diverse aquatic and upland habitats, as well as resources for fishing, shellfish harvesting, and many other aquatic uses. The area surrounding the bay remains largely rural in nature, though more than 100 acres of the basin are currently in commercial land use, largely in the Gamble Creek watershed. The Port Gamble S'Klallam Tribal Reservation is located adjacent to the east side of the bay. As neighbors to the bay, the Port Gamble S'Klallam Tribe uses the bay for shellfish harvesting, fishing, and other resources; other tribes in the area have similar uses for the bay.

1.2 Overview of Site Cleanup Requirements

The objectives of sediment cleanup actions at the Site, as detailed in the CAP, are summarized as follows:

- Eliminate, reduce, or otherwise control, to the extent practicable, risks to benthic organisms in localized areas of the Site through exposure to sediments or porewater containing deleterious wood waste breakdown products that exceed SMS sediment cleanup objective (SCO) biological criteria.
- Eliminate, reduce, or otherwise control, to the extent practicable, Site-wide human health risks from ingestion of seafood containing carcinogenic polycyclic aromatic hydrocarbons (cPAHs), as measured by the toxicity equivalency quotient (TEQ), that exceed natural background concentrations.
- Eliminate, reduce, or otherwise control, to the extent practicable, human health risks in localized areas of the Site from ingestion of seafood containing dioxin/furan TEQ and/or cadmium concentrations that exceed natural background concentrations.

The CAP describes specific Site cleanup requirements to be implemented under the CD. These actions include different cleanup activities in portions of individual SMAs (Figures 3 through 5), summarized as follows:

- Removal of creosote-treated piles and remnant and creosote-treated structures as practicable
- Intertidal sediment excavation (primarily during low tide conditions) and containment or beneficial reuse of these excavated materials in local uplands as appropriate
- Subtidal sediment dredging and containment or beneficial reuse in local uplands and/or disposal at a suitable Dredged Material Management Program (DMMP) open-water disposal site as appropriate
- Intertidal and subtidal capping using a protective layer of clean silt, sand, gravel, cobble, and/or armor materials, as appropriate for specific areas of the Site
- Placement of an enhanced monitored natural recovery (EMNR) layer of clean silt and/or sand, as appropriate for specific subtidal areas of the Site
- Long-term monitoring and maintenance to ensure the protectiveness of the remedy

Sediment that is unsuitable for upland containment or beneficial reuse in local uplands will be disposed at a permitted landfill or approved recycling facility.

Construction activities will be sequenced to maximize overall protectiveness, beginning with source controls (i.e., demolition and removal of creosote-treated materials) and followed closely in time by intertidal excavation and subtidal dredging. Capping and EMNR will be sequenced to occur shortly after removal actions are completed to maximize control of residuals and accelerate natural recovery processes, reducing the overall Site restoration timeframe. Construction and post-construction monitoring and institutional controls will be implemented to ensure the protectiveness of the remedy.

1.3 Report Organization

This EDR is organized following MTCA requirements, as detailed in WAC 173-340-400, and includes the following sections:

- Section 2 summarizes the background for Site cleanup actions and overall design requirements, data used in the design, and coordination with other potential actions in the Site area.
- Section 3 summarizes design criteria used in the engineering analysis of the cleanup remedy.
- Sections 4 through 9 provide detailed discussions of key design elements, including a summary of the anticipated construction sequencing approach at the Site and the most promising remediation technologies and best management practices (BMPs; Section 4); Site preparation and staging (Section 5); demolition, dredging, and capping in SMA-1 (Section 6); demolition, dredging, capping, and EMNR in SMA-2 (Section 7); EMNR in SMA-3 (Section 8); and demolition and monitored natural recovery (MNR) in the remaining SMAs (Section 9).
- Section 10 summarizes institutional controls that will be implemented as part of the cleanup project.
- Section 11 summarizes compliance monitoring to be performed during and after construction.
- Section 12 describes the anticipated implementation schedule for the cleanup project.
- Section 13 provides a list of references used to prepare this EDR.

The following appendices provide supporting technical evaluations for the EDR:

- Appendix A: Pre-Design Investigation Report (in development; not included in this draft)
- Appendix B: Chemical Isolation Cap Design
- Appendix C: Geotechnical Engineering Evaluation
- Appendix D: Coastal Engineering Evaluation and Propeller Wash Evaluation
- Appendix E: Construction Quality Assurance Plan (CQAP)
- Appendix F: Operations, Maintenance, and Monitoring Plan (OMMP)
- Appendix G: Construction Outreach Plan
- Appendix H: Vessel Management Plan
- Appendix I: Construction Specifications
- Appendix J: Construction Drawings
- Appendix K: Cost Estimate Details
- Appendix L: Archaeological Monitoring Plan and Inadvertent Discovery Plan
- Appendix M: Integrated Restoration and Cleanup Actions
- Appendix N: Shellfish Monitoring Plan

2 SITE AND DESIGN BACKGROUND

This section summarizes the background for Site cleanup actions and overall design requirements. The sources of data used in the design are described, as well as coordination with other potential actions in the Site area.

2.1 Site Background

In 1853, the corporate predecessor to Pope & Talbot Inc. (P&T) established one of the first sawmills on Puget Sound in Port Gamble, and continuously operated a forest products manufacturing facility ("Mill Site") up until 1995. Between 1853 and 1995, operations in Port Gamble included a succession of sawmill buildings, two chip loading facilities, a log transfer facility, and log rafting and storage areas. During the mill's operating period, logs were rafted and stored offshore. In the late 1920s, a chip barge loading facility was installed on the north end of the mill. During the mid-1970s, an additional chip barge loading facility (referred to as the alder mill) was constructed in the southeast portion of the mill.

In 1985, P&T transferred ownership of the uplands and adjacent tidelands portion of the mill to PR. P&T continued wood products manufacturing until 1995 under a lease with PR. Mill operations ceased in 1995, and the sawmill facility was dismantled and mostly removed in 1997. Since 1997, the uplands portion of the mill has been leased to a variety of parties for uses including log sorting and wood chipping, material handling activities, a marine laboratory, and parking.

P&T leased the 72-acre portion within and adjacent to SMA-4 from the Washington Department of Natural Resources (DNR) between 1974 and 2001 for log storage and transfer. The majority of log rafting ceased in 1995 when the mill closed. P&T removed piles from the former DNR lease area in 1996. Similarly, log rafting and associated log sort yard activities that began in 1970 at the former log transfer facility ceased after P&T removed the piles in 1996. Several historic landfills were located along the western shoreline, some of which received mill and municipal waste materials; these historic landfills were subsequently closed and remediated to MTCA standards.

In January 1997, Ecology conducted an initial investigation of the Mill Site, which consisted of sampling sediment in four catch basins. The results of that investigation indicated that concentrations of petroleum hydrocarbons and metals were present at levels above MTCA and SMS chemical criteria for these compounds. In April 1997, Clean Services Company, Inc. removed accumulated materials from 12 catch basins, four valve vaults, and four sumps.

In July 1998, Ecology notified P&T of the potential listing of the Mill Site on Ecology's Confirmed and Suspected Contaminated Site List. Subsequently, detailed environmental investigations were conducted by P&T and PR/OPG to characterize soil, groundwater, surface water, and sediment quality conditions. The site characterization identified the presence of hazardous substances in soil and groundwater in several uplands areas. The investigations also identified the presence of wood waste in nearshore sediments. Based on these data, Ecology added the Mill Site to the hazardous sites list in 2001.

Between 2002 and 2005, PR/OPG excavated approximately 26,310 tons of contaminated soils from the Mill Site, and in 2003, P&T dredged approximately 13,500 cubic yards (cy) of sediment containing wood waste from a 1.8-acre area. Excavated upland soils and the 2003 wood waste dredge material were disposed of at approved upland facilities. In 2004, follow-on surface sediment sampling and sediment profile imaging (SPI) were conducted by P&T to characterize post-dredge sediment quality conditions and to provide a baseline dataset for evaluation of anticipated future natural recovery. In 2006, P&T and Ecology performed additional sediment characterization including benthic infaunal abundance, sediment bioassays, and SPI across a gradient of wood waste levels.

In early 2007, DNR and Ecology dredged an additional 17,500 cy of wood waste from a 1-acre area adjacent to the 2003 dredging action and placed a 6-inch layer of clean sand over a portion of the newly dredged area. In cooperation with this agency-led project, P&T took over the day-to-day management of the dredged material once it was transferred to shore, and subsequently removed salt from the material, utilizing an on-site upland holding cell and freshwater washing system, to facilitate upland beneficial reuse of these materials. Unsuitable solid waste materials were segregated and disposed of at an approved off-site landfill facility. All soil segregation, disposal, treatment, and relocation tasks were completed in the spring of 2009, in accordance with Kitsap County Grading Permit 08-52323.

In November 2007, P&T filed for bankruptcy (Delaware Case No. 07-11738).

Initial remedial investigation/feasibility study (RI/FS) reports for portions of the Site including the Mill Site and Port Gamble Bay were completed, submitted, and released for public comment in February and March 2011. In response to public comments, in 2011, Ecology performed supplemental sediment and tissue sampling at the Site. This sampling included collection of additional sediment chemistry and sediment bioassay samples. During this time, the Port Gamble S'Klallam Tribe also collected sediment and tissue samples. In 2012, in response to public comment, the reports were revised and combined into a RI/FS that summarized investigation results and developed and evaluated remedial alternatives for the Site (Ecology 2012). The conclusions of the RI/FS formed the basis for the CAP, which Ecology developed in 2013 (Ecology 2013). The Site includes both in-water and upland portions; however, only the extent of the in-water portion of the Site has been characterized by Ecology. The CAP describes Ecology's selected cleanup action for the Site, consistent with MTCA and SMS requirements, and was incorporated as Exhibit A to the CD, which was entered in December 2013.

Under the terms of the CD, PR/OPG developed and Ecology approved the *Remedial Design and Adaptive Management Work Plan* (RD Work Plan; Anchor QEA 2014a), including amendments, addressing data gaps to support RD and permitting activities. Pre-design investigation (PDI) sampling and other Site investigations occurred from May to September 2014, and included the following activities:

- Surveys of Site physical conditions, including bathymetry (Attachment 1 of Appendix A).
- Porewater sampling and analysis, including diffusive gradient thin sheet (DGT) in situ passive sampling to characterize surface and shallow subsurface porewater hydrogen sulfide concentrations (Attachment 2 of Appendix A).
- Intertidal and subtidal sediment sampling including geoprobe and diver-deployed Mudmole™ coring, sediment physical and chemical analyses, DMMP

characterization, dredging elutriate testing (DRET), and surface sediment natural recovery sampling (chemical and bioassay analyses) (Attachment 3 of Appendix A).

- Eelgrass (*Zostera marina*) and habitat surveys in SMA-1 and SMA-2 (Attachment 4 of Appendix A).

The PDI sampling and analysis data supplemented the available RI/FS data to support the remedial designs described in this EDR.

2.2 Site Characteristics

This section describes Site characteristics relevant to the engineering design of Site cleanup actions, including the physical setting, shoreline conditions, geology, hydrogeology, surface water, navigational use, ecosystem, and cultural resources.

2.2.1 Physical Setting and Shoreline Conditions

The Mill Site is located in Township 27 North, Range 2 East, Section 5, at the foot of a steep bluff on a peninsula bounded by Hood Canal to the west (Figure 1). The shoreline at the Mill Site contains aging creosote-treated-pile-supported structures and derelict piles. Bank slopes are steep to vertical and are protected from erosion in most areas by large rock and concrete riprap (NewFields 2007) and by a wooden breakwater. Most of SMA-1 and SMA-2 are in net sediment depositional areas due to low tidal current activity. As a result, common subtidal sediment substrates include fine to medium sands with varying proportions of mixed silts and clays (Germano and Associates 2004; Anchor Environmental 2007). Deposits of subtidal wood waste are also present. Intertidal substrates of the Mill Site (shoreward of the 0 foot mean lower low water [MLLW] tideline) are dominated by large rock and concrete riprap, as well as a mixture of cobble, gravel, sand, and shell hash (NewFields 2007).

2.2.2 Geology

Detailed subsurface investigations performed at the Mill Site indicate that near-surface upland soils are primarily fill material consisting of gray, silty sand that ranges from very fine to coarse sub-rounded grains and contains varying amounts of wood and other debris. This material was placed at various times onto the historical sand spit to expand the upland area to accommodate mill operations. The fill material typically extends to a depth of 5 to 15 feet below ground surface (bgs) (Anchor Environmental and EPI 2008; Anchor QEA and EPI 2010; Anchor QEA 2014b; Attachment 3 of Appendix A). Underlying the fill unit is a 10- to 20-foot-thick layer of clean native sands, extending to elevations ranging between approximately 0 and -10 feet MLLW, which in turn is underlain by a regionally extensive glacial lake deposit, the Kitsap Formation, consisting of clay and silt.

Subtidal sediments in Port Gamble Bay range from silty sands (10% to 30% fines [clay and silt]) near the Mill Site, to more than 90% fines in the central bay (e.g., SMA-3). Sediment cores indicate a variable thickness of recently deposited sediments underlain by interbedded silts and sands, with localized wood waste deposits in parts of SMA-1 and SMA-2.

2.2.3 Hydrogeology

Hydrogeologic characteristics at the Mill Site and adjacent uplands were evaluated by Anchor QEA and EPI (2010), and are summarized as follows:

- An unconfined shallow aquifer is present within the upper fill unit and underlying clean native sands, recharged by local precipitation along with overland and shallow flow from the bluffs to the west. Groundwater in the shallow aquifer is generally encountered at approximately 5 to 10 feet bgs at the Mill Site.
- Slug test data indicate moderate but variable permeability of the shallow aquifer, characterized by hydraulic conductivity values ranging from 6.3×10^{-5} to 1.5×10^{-3} centimeters (cm) per second. Groundwater flow directions in the shallow aquifer are generally toward the northeast in the northern Mill Site and toward the east in the southern Mill Site. Groundwater flow from the surrounding bluffs, along with tidal fluctuations (see Section 2.2.4) influence groundwater flow patterns at the Mill Site.
- The shallow aquifer is tidally influenced and is subject to transient nearshore groundwater flow reversals during high tide events. Tidal reversals are most pronounced in the near-surface permeable soils of the fill and shallow aquifer, and dissipate rapidly with distance from the shoreline, which is common for unconfined aquifers. Nearshore flow reversals influence porewater dispersion and transport, as discussed in Appendix B.
- The regionally extensive Kitsap Formation separates near-surface aquifers from the regional Salmon Springs Aquifer, forming an effective aquitard beneath the Mill Site.

2.2.4 Surface Water Hydrology and Tidal Conditions

Port Gamble Bay has bottom elevations ranging from 0 to -65 feet MLLW, although more typical bottom elevations in the center of the bay range from -30 to -40 feet MLLW. The bay is oriented with its long axis directed generally north to south and is approximately 2.9 miles long and 0.9 mile wide at its maximum dimensions. Due to the long north/south fetch distance, wind-generated waves on the order of 1 to 3 feet occur during storms with recurrence intervals ranging from 50 to 100 years. Detailed wind/wave evaluations for the Site are provided in Appendix D.

Table 2-1 summarizes tidal datum elevations within Port Gamble Bay, based on the MLLW vertical datum.

Table 2-1
Tidal Datum Information – Port Gamble Bay

Reference Plane	Elevation in feet MLLW
Mean Higher High Water (MHHW)	10.2
Mean High Water (MHW)	9.3
Mean Tide Level (MTL)	6.0
Mean Sea Level (MSL)	6.0
Mean Low Water (MLW)	2.8
North American Vertical Datum of 1988 (NAVD88)	2.12
Mean Lower Low Water (MLLW)	0.0

Note:
Based on National Oceanic and Atmospheric Administration Station 9445016 at Foulweather Bluff, located 5.75 miles north of Port Gamble.

Tidal currents in Port Gamble Bay range from less than 0.5 foot per second near the Mill Site, to greater than 2 feet per second in the main tidal (and federal navigation) channel between Point Julia and the Mill Site (Parametrix 2002).

There are five year-round streams that discharge into Port Gamble Bay. Little Boston Creek is the nearest freshwater input and discharges to the bay's eastern shore. Other perennial streams include Gamble Creek at the head of the bay, Martha John Creek near South Gamble Marsh, Little Sluglum (Middle) Creek on the eastern shore, and Ladine DeCouteau Creek south of the Mill Site. South Gamble Marsh, on the southeastern shoreline of the bay, is a low-lying wetland fed by Miller Lake. A small lake, now filled, was located on the bluff west of the Teekalet spit during the early historical period (NWAA 2010).

Daily tidal exchange between Port Gamble Bay and Hood Canal (Table 2-1) results in a calculated average water residence time in the bay of approximately 4 to 6 days. Because of the pronounced sill in Hood Canal south of the Port Gamble Bay mouth, bottom waters in the southern and middle portions of Hood Canal with seasonally low dissolved oxygen concentrations do not exchange with Port Gamble Bay (Ecology 2012).

2.2.5 Navigational Uses

Existing navigational uses of the Site are primarily associated with tribal fishing and shellfish harvesting activities, recreational boaters and kayakers, industrial marine construction vessels using currently leased moorage space at the Mill Site, and U.S. Navy and Coast Guard vessels that occasionally access Port Gamble Bay via the federally authorized navigation channel. Measures to avoid or minimize potential navigation impacts associated with remedial construction activities are detailed in the Vessel Management Plan (Appendix H). Coordination with these navigational users during construction is described in the Construction Outreach Plan (Appendix G).

2.2.6 Ecosystem

The Site supports a variety of habitats, plants, and animals that occupy the shoreline and aquatic environment. Shorelines of SMA-1 and SMA-2 adjacent to the former sawmill facility are generally steep (commonly steeper than 2 horizontal to 1 vertical [2H:1V]) and armored, with riparian vegetation limited to within several feet of the shoreline adjacent to parking and paved areas. Existing shoreline vegetation in SMA-1 and SMA-2 is sparse, and includes the invasive species Scot's broom (*Cytisus scoparius)* and Himalayan blackberry (*Rubus armeniacus).* In contrast, shorelines in most of the rest of the Site are more natural and relatively sparsely developed, with overhanging coniferous and deciduous forests, including willow, alder, and maple. Subaquatic habitats throughout the Site contain abundant refugia.

Marine vegetation at the Site includes native and nonnative eelgrass (*Zostera marina and Z. japonica*), green algae including *Enteromorpha* spp. and sea lettuce (*Ulva fenestrata*), brown algae sugar wrack (*Laminaria saccharina*), and red algae (*Gracilaria* spp.) (NewFields 2007; Anchor Environmental 2007). A September 2014 eelgrass and habitat survey was performed to inform cleanup actions located in the intertidal and shallow subtidal areas of SMA-1 and SMA-2 and to comply with the State Environmental Policy Act (SEPA) Mitigated Determination of Nonsignificance. The eelgrass and habitat survey (Attachment 4 of Appendix A) identified four areas of eelgrass beds in prospective sediment cleanup areas at the Site. In SMA-1, eelgrass beds were found north of the existing dock and south of the rock jetty. In both cases, eelgrass beds comprised low to moderately dense patches or isolated plants between depths of approximately -6 and -12 feet MLLW. An eelgrass bed is also present along the southwestern portion of SMA-2, ranging from interconnected patches of moderately dense eelgrass in the middle of SMA-2 between elevations of approximately -2 and -14 feet MLLW to a continuous bed of highly dense eelgrass in the southern portion of SMA-2 between elevations of approximately -3 and -10 feet MLLW.

As described in more detail in Sections 6 and 7 of this EDR, the Site cleanup design includes a combination of offsets from excavation, dredging, and capping actions to avoid impacts to approximately 77,695 square feet (1.8 acres) of native eelgrass in SMA-1 and SMA-2. The avoided eelgrass beds are located in areas with relatively low concentrations of wood waste, hydrogen sulfide, and other hazardous substances. In total, an approximately 24,000-square-foot area (comprising approximately 16,300 turions) will be unavoidably impacted during excavation and dredging in SMA-1 and SMA-2. Areas of eelgrass that will be removed as a result of the proposed project overlie wood waste deposits with elevated concentrations of hydrogen sulfide and other hazardous substances; therefore, the ecological function of these eelgrass beds is impaired in the current baseline condition.

To mitigate for impacts to existing native eelgrass, the cleanup project will provide 24,000 square feet of eelgrass habitat within an on-site mitigation area located in the southern portion of SMA-2, with a total 1:1 replacement of area and turions (16,300 turions) accomplished through transplanting impacted turions prior to dredging, infilling of eelgrass transplants, and voluntary recruitment (or spreading) of adjacent eelgrass beds into the mitigation area. Details on eelgrass mitigation and monitoring are provided in the *Eelgrass Mitigation and Monitoring Plan* (Anchor QEA and ENVIRON 2015).

A substantial boulder-patch rocky reef community is present near the eastern boundary of SMA-2, at depths ranging from -8 to -20 feet MLLW. Coralline algae and other hard-substrate macroalgae species presently colonize this reef, providing habitat to a number of invertebrate and fish species (see Attachment 4 of Appendix A). As described in more detail in Section 7 of this EDR, the Site cleanup design includes an offset from capping actions in this area to avoid impacts to the reef community.

Port Gamble Bay is connected to Hood Canal, which provides habitat to many species including marine mammals, anadromous salmonid species (including federally protected species such as Puget Sound Chinook salmon [*Oncorhynchus tshawytscha*], Hood Canal summer chum salmon [*O. keta*], and bull trout [*Salvelinus confluentus*]), forage fish (sand lance, surf smelt, and herring), and shellfish such as subtidal geoduck (*Panopea abrupta*). Within and adjacent to Port Gamble Bay, surf smelt spawning occurs between October and March, sand lance spawning occurs between November and February, and herring spawning occurs between mid-January and mid-April (Penttila 2009). To minimize potential impacts to these resources, in-water work will be restricted to windows identified in the issued permits for this cleanup project.

2.2.7 Cultural Resources

There are documented cultural resources in the cleanup project area. A portion of the project will occur adjacent to and within the Port Gamble National Historic Landmark District, including the truck haul route leading to and along State Route 104. The overwater structures, piles, and debris that will be removed during the project do not contribute to the district, so no further actions are necessary to avoid or minimize impacts. The rock jetty that forms the northern boundary of SMA-1 was constructed in 1859, and has been determined by the U.S. Army Corps of Engineers (USACE) as eligible for listing in the National Register of Historic Places (NRHP) and as a contributing structure to the district. The jetty is not planned for removal during the project; however, piles that are embedded in the jetty will be removed as practicable.

There are eight archaeological sites, one log sorting facility, and two derelict vessels in the cleanup project area (see Appendix L). The derelict vessels and log sorting facility are not historic and do not require cultural resource consideration. Five of the archaeological sites (state site numbers 45KP274, 45KP275, 45KP276, 45KP277, and 45KP278) consist of historic and modern debris. They have been recommended as not NRHP-eligible. Two other historic-period sites, 45KP256 and 45KP257, have not been evaluated for NRHP-eligibility, but will not be affected by the cleanup project. The final archaeological site, 45KP252, is present beneath approximately 6 feet of fill at the Mill Site upland re-handling area. The cleanup project design described in this EDR does not include ground-disturbing work at site 45KP252, so no monitoring or other actions are necessary in this area.

Archaeological monitoring during construction will occur during ground-disturbing work (excavation, pile removal, and debris removal) within the boundaries of site 45KP275. Although the site is recommended to not be NRHP eligible, monitoring will ensure appropriate treatment of intact significant artifacts or deposits that were not encountered in the survey effort, if any exist. Based on additional coordination with tribes, monitoring will also occur during intertidal excavation and subtidal dredging within SMA-1 and SMA-2. While pre-design geoarchaeological investigations did not detect any precontact materials—or stable surfaces that have the potential to contain such materials in bank, intertidal, or subtidal cores advanced in SMA-1 and SMA-2—archaeological monitoring will be performed in these areas according to the protocols outlined in the *Archaeological Monitoring Plan* (see Appendix L). This monitoring will further ensure appropriate treatment of intact significant artifacts or deposits that were not encountered in the survey effort, if any exist. The *Archaeological Monitoring Plan and Inadvertent Discovery Plan* for the cleanup project are included as Appendix L.

Port Gamble Bay is a Traditional Cultural Property (TCP), significant for its association with ongoing tribal cultural practices. These revolve around shellfish and finfish harvesting, both subsistence and commercial, as well as associated ceremonial practices. The cleanup project design described in this EDR, including restricted in-water work windows (Section 3.5), dredging BMPs (Section 4.6), vessel management (Appendix H), shellfish monitoring (Appendix N) and other elements, has been developed to minimize potential impacts to tribal uses within the bay to the extent practicable.

2.3 Cleanup Standards

Cleanup standards consist of: 1) cleanup levels that are protective of human health and the environment; and 2) the point of compliance at which the cleanup levels must be met. Site-specific cleanup standards are presented in the CAP.

Ecological risk-based cleanup standards for sediments were based on SMS biological criteria, using the bioassay results presented in the RI/FS. The Site-specific bioassay cleanup standard identified by Ecology is the SCO criterion, which was used to delineate SMAs as described in Section 2.4.

Additional standards were developed based on the highest of human health risk-based concentrations, natural background levels, and practical quantitation limits (PQLs). Standards were developed for cPAH TEQ, dioxin/furan TEQ, and cadmium.

2.3.1 Sediment Cleanup Levels

Table 2-2 summarizes Site-specific sediment cleanup levels from the CAP.

Table 2-2
Sediment Cleanup Levels

Chemical of Concern	Site-Specific Cleanup Level
Toxicity due to wood waste breakdown products	SCO numeric biological standards described in WAC 172-204-320(3)
cPAH TEQ	16 µg/kg dry weight
Dioxin/furan TEQ	5 ng/kg dry weight
Cadmium	3 mg/kg dry weight

Notes:
µg/kg – micrograms per kilogram
ng/kg – nanograms per kilogram
mg/kg – milligrams per kilogram

2.4 Sediment Management Areas

This section summarizes SMAs in Port Gamble Bay that exceed Site-specific cleanup standards, as reflected in the most current RI/FS and PDI sampling and analysis data. Figures 3 through 5 depict these SMAs, which are summarized as follows:

- North Mill (SMA-1): An approximately 6-acre area located in the embayment north of the former Mill Site, the North Mill SMA has localized deposits of subtidal wood waste (primarily wood chips) located near the former chip loading area. SMA-1 was delineated based on bioassay results that exceed SCO biological criteria, as well as sediment surface cPAH TEQ and dioxin/furan TEQ concentrations that exceed Site-specific cleanup levels.
- South Mill (SMA-2): An approximately 20-acre area located immediately south and east of (adjacent to) the former Mill Site, SMA-2 also has localized deposits of subtidal wood waste (including sawdust, chips, and bark), particularly adjacent to the former alder mill chip loading area. SMA-2 was delineated based on bioassay results that exceed SCO biological criteria, as well as sediment surface cPAH TEQ and dioxin/furan TEQ concentrations that exceed Site-specific cleanup levels.
- Central Bay (SMA-3): During the RI/FS, an approximately 80-acre area located in the south-central portion of Port Gamble Bay exceeded SCO biological criteria, attributable at least in part to the presence of wood waste breakdown products in sediments. The four RI/FS stations that delineated the preliminary boundary of SMA-3 presented in the CAP were resampled in August 2014 to inform this EDR. The PDI bioassay data (Attachment 3 of Appendix A) revealed that one of the four stations (BW-19) no longer exceeded SCO biological criteria, reducing the size of SMA-3 to approximately 61 acres.
- Former Lease Area (SMA-4): During the RI/FS, an approximately 20-acre area located along the western shoreline of the south-central portion of Port Gamble Bay, including portions of the former DNR lease area, exceeded SCO biological criteria, attributable at least in part to the presence of wood waste breakdown products in sediments. The three RI/FS stations that delineated the preliminary boundary of SMA-4 presented in the CAP were resampled in August 2014 to inform this EDR. The PDI bioassay data (Attachment 3 of Appendix A) revealed that all three of these stations (BW-12, BW-18, and PGSS-29) no longer exceed SCO biological criteria,

eliminating the need to address this area as a separate SMA (i.e., the former SMA-4 area is incorporated into SMA-5; see below).

- cPAH Background Area (SMA-5): An approximately 600-acre area that encompasses all of the other SMAs, the boundary of SMA-5 was developed based on surface sediment cPAH TEQ concentrations exceeding Site-specific cleanup levels. It also includes an area of elevated dioxin/furan TEQ near SMA-3, as well as one station with elevated sediment cadmium concentrations.

2.5 Cleanup Action Overview

As described in the CAP and consistent with the supplemental data collected during the PDI (Appendix A), the major components of the Site cleanup remedy are as follows:

- To the extent practicable, creosote-treated piles will be removed as a source control measure for protection of human health and to facilitate access for subsequent dredging and capping. If creosote-treated piles cannot be practicably removed, they will be cut off below the final grade of the sediment surface. Areas of moderate to extensive pile removal, including within intertidal excavation and subtidal dredging areas, will be capped to ensure the long-term protectiveness of the remedy. Pile removal and/or cutting will be sequenced with removal of existing overwater structures adjacent to the former sawmill, as well as removal of the log transfer dock and creosote-treated piles from staging and rafting areas throughout the Site. Pile removal will be sequenced to occur prior to follow-on dredging or capping actions to maximize control of demolition residuals.
- Intertidal surface sediments in SMA-1 and SMA-2 that exceed Site-specific cleanup levels for cPAH TEQ and/or dioxin/furan TEQ will be excavated using upland-based equipment operating during low tide periods to a depth of 2 feet below the existing sediment surface, followed by placement of an engineered shoreline cap. Significant deposits of subsurface wood waste or contaminants that are encountered during construction will be removed as necessary to maintain chemical and structural integrity of the designed cap. Excavated material will be screened to remove debris and beneficially reused, placed in an upland containment area, or disposed at a permitted landfill or approved recycling facility as appropriate. Excavated shoreline armor rock in reusable condition will be stockpiled and reused to re-armor the

excavated shoreline where appropriate, based on location-specific coastal engineering designs.

- Subtidal sediment inshore of approximately -20 feet MLLW that exceeds SCO biological criteria and contains significant wood chip accumulations with total volatile solids (TVS) concentrations that exceed 15% will be dredged from SMA-1 and SMA-2 (see Figures 3 and 4). Subsequently, dredged areas will have sand placed to control dredging residuals. Dredged sediments will be beneficially reused, placed in an upland containment area, or disposed at a permitted landfill or approved recycling facility as appropriate. Subject to DMMP agency approval, up to approximately 10,000 cy of dredged material from SMA-1 may be screened to remove debris, and the screened sediments will be disposed at a DMMP open-water disposal facility. However, given current uncertainties in DMMP open-water disposal policies, the current design dredge cut elevations and volumes assume that dredged sediments will be beneficially reused, placed in an upland containment area, or disposed at a permitted landfill or approved recycling facility as appropriate.
- Subtidal sediments in SMA-2 offshore of approximately -20 feet MLLW that exceed SCO biological criteria and contain significant wood chip accumulations with TVS concentrations that exceed 15% will be contained below a 4-foot-thick cap (Figure 4). Beneficial reuse of clean navigational dredged material is the preferred source of the cap material, using materials that will support healthy benthic, shellfish, and forage fish communities, including geoduck. Clean sand generated from a local upland beneficial reuse source may also be used for the initial thickness of the SMA-2 cap.
- Subtidal sediment in SMA-1 that exceeds SCO biological criteria but contains moderate wood waste accumulations (TVS less than 15%) will be capped with an approximately 1-foot-thick cap (Figure 3). Beneficial reuse of clean navigational dredged material or clean sand generated from a local upland beneficial reuse source are the preferred sources of the cap material, using sediment that will support healthy benthic, shellfish, and forage fish communities.
- Approximately 6 inches of clean EMNR silt/sand materials will be placed over subtidal sediment in the remaining parts of SMA-2 and SMA-3 that exceed SCO biological criteria but contain moderate wood waste accumulations (TVS less than 15%; see Figures 3 to 5). To the extent practicable, the source of the sand will be clean navigational dredged material, which will enhance the rate of natural recovery,

reduce concentrations of wood waste breakdown products, and expedite restoration of a healthy benthic community.

- MNR is the selected remedy for SMA-5 (including the previously delineated SMA-4 and part of SMA-3; see Section 2.4). Surface sediment samples were collected in August 2014 as part of the PDI (Attachment 3 of Appendix A) to provide a baseline set of data to track natural recovery following completion of remedial construction. The OMMP (Appendix F) describes the long-term monitoring plan to document recovery of SMA-5 over time, and also outlines possible adaptive management actions based on the results of the OMMP sampling and analysis.

As described in more detail in Sections 6 and 7 of this EDR, the Site cleanup design also includes avoidance, minimization, and mitigation measures related to eelgrass impacts.

PR/OPG is currently in the permitting process for the development of a PR/OPG-owned and –operated local sand pit to obtain clean backfill materials for use at the Site. Other local upland sources, including commercial sources, may also be selected by the contractor provided that the contractor demonstrates that the proposed material meets chemical quality and gradation requirements presented in the Construction Specifications (Appendix I).

2.6 Existing Information Used for Design

The engineering design relies on existing information developed during the RI/FS and during the PDI. Available information used in development of this EDR is described in Sections 2.6.1 through 2.6.3.

2.6.1 Site Surveys

Several surveys performed throughout the Site were used to develop the project base map and support the remedial design efforts. Site surveys completed to date are summarized in Table 2-3.

Table 2-3
Site Surveys

Date	Description and Extent	Formats
Multiple dates/sources	Site-wide base map prepared by Ecology during the RI/FS	GIS
July 2012	Upland topography and base map[1]	AutoCAD, PDF
March 2014	Multi-beam bathymetry of Port Gamble Bay[2]	AutoCAD, PDF
October 2014	Multi-beam bathymetry in SMA-1 and SMA-2[3]	AutoCAD, PDF
September 2014	Eelgrass and habitat surveys[4]	PDF

Notes:
1 Upland topography and base map survey completed by Triad Associates.
2 Multi-beam bathymetry completed by Ecology.
3 Multi-beam bathymetry completed by eTrac Engineering, Inc.
4 Eelgrass and habitat surveys completed by ENVIRON Corporation (2014).

2.6.2 Existing Environmental Data Sources

Ten sampling investigations were performed at the Site between 2000 and 2011. Results of these studies are described and incorporated in the RI/FS and CAP. Both sediment and tissue samples have been collected throughout the Site, with additional focused sampling in SMA-1 and SMA-2. Site investigations have included surface sampling, sediment core collection, SPI, and physical, chemical, and biological analyses. Prior RI/FS sampling locations are shown in Figure 6.

2.6.3 Pre-Design Investigation Data

As described in Section 2.1, extensive additional data collection occurred as part of the PDI. The PDI results are presented in Appendix A and incorporated into this EDR, as described in more detail in later sections of this report.

2.7 Coordination with Other Actions in the Area

In addition to the cleanup activities described in this EDR, other potential actions may be implemented in the vicinity of the Site during or shortly following cleanup construction. This includes the final cleanup of the Mill Site uplands, likely including a final CAP and CD Amendment.

Other potential actions—which are currently at various planning stages, subject to separate and independent permitting, and not being conducted as part of the Site cleanup—are described in Appendix M.

3 ENGINEERING DESIGN CRITERIA

This section summarizes design criteria used in the engineering analysis of the cleanup remedy.

3.1 Project Datums

The horizontal datum that will be used is Washington State Plane North Zone, North American Datum of 1983 (NAD 83), measured in units of feet.

The vertical datum is National Ocean Survey (NOS) MLLW, and the nearest National Oceanic and Atmospheric Administration (NOAA) reference Station is No. 9445016, located 5.75 miles north of Port Gamble, Washington. Table 2-1 outlines the different water levels based on the NOAA Station No. 9445016 benchmarks. A local benchmark was referenced in developing the site-specific bathymetric and upland survey data as follows: U.S. Coast and Geodetic Survey disk stamped "BM NO.8 1966 B," located at N 317,163.38; E 1,211,002.15, with an elevation 15.24 feet NAVD88 (17.36 feet MLLW).

3.2 Chemical Isolation Design Criteria

Chemical isolation design criteria were developed to ensure that surface sediments—which overlie contaminated sediments or buried creosote-treated piles that may remain at the Site following remedial construction—are maintained below the Site-specific sediment cleanup levels summarized in Table 2-2. These design analyses were performed in accordance with U.S. Environmental Protection Agency (USEPA) and USACE *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al. 1998). As discussed in the CAP, for intertidal and shallow subtidal sediments, the point of compliance necessary to control contaminant exposure to humans and the environment is defined by the upper 24-inch biologically active zone. For deeper subtidal sediments in SMA-2, the point of compliance is defined by the 3-foot-thick biologically active zone to provide habitat for geoduck, which are an important natural resource in Port Gamble Bay.

The one-dimensional steady-state model of chemical transport within sediment caps developed by Lampert and Reible (2009; see also Reible 2012) was used for this design evaluation, consistent with current USEPA (2005) Superfund guidance. The Reible (2012) model makes the conservative assumption that the underlying sediment porewater concentration remains constant over time (i.e., infinite source), and has been used to support the evaluation and design of sediment caps at numerous Superfund and MTCA sediment cleanup sites. Details on the model structure and underlying theory and equations are provided by Lampert and Reible (2009) as well as in the USEPA/USACE capping guidance (Palermo et al. 1998; USEPA 2005). Additional details on the chemical isolation cap design are provided in Appendix B.

3.3 Geotechnical Design Criteria

The geotechnical design criteria were developed based on guidance from various technical references (Kramer 1996; Duncan and Wright 2005; NCHRP 2008; WSDOT 2011) and the American Society of Civil Engineers (ASCE 2010) 7-10 code. Appendix C describes the soil and sediment data utilized for development of geotechnical engineering soil properties for analyses, the methodologies employed, and the results and conclusions of the geotechnical engineering evaluations.

For non-structural remedial elements (e.g., earthen slopes and caps), seismic design criteria do not exist. Although specific seismic design criteria were not developed or applied to non-structural remedial elements, these elements were evaluated to better understand their expected performance during a seismic event. The seismic demand from the ASCE 7-10 design-level seismic event was assumed for this evaluation. This guideline reflects a similar stability demand as an earthquake with a 10% chance of exceedance in 50 years (i.e., the 475-year return interval earthquake), and is often used as a suitable seismic event to support remedial design evaluations in the Puget Sound region.

The other geotechnical design assumptions applied to the Site are as follows:

- Site characterization and soil properties such as unit weights, strength parameters, and gradations were based on soil borings, sediment cores, in situ geotechnical tests such as standard penetration testing (SPT), and other geotechnical investigation data available from previous investigation efforts completed at the Site.
- Slope angles were evaluated for dredged and capped areas based on static and dynamic conditions using factors of safety consistent with USACE (2003), Duncan and Wright

(2005), and Washington State Department of Transportation (WSDOT 2011) guidelines.
- Seismic deformation was evaluated to estimate the magnitude of permanent slope displacement under a design-level earthquake (see Appendix C for more detail).

3.4 Coastal Engineering Design Criteria

Coastal engineering design criteria include the following:

- Wave conditions at the Site were based on wind hind-casting for 20-, 50-, and 100-year recurrence interval events based on wind from the NOAA station WPOW1 in West Point, Washington. The wave hindcast was completed using predicted wind speeds from 45-degree (northeast), 105-degree (west southwest), and 165-degree (south southwest) directions, which represent the most important trajectories of wave attack at the Site. Nearshore wave heights for the 100-year recurrence interval were also evaluated using a wave transformation model to optimize armor rock size for that event. Additional details regarding the wave hindcast are in Appendix D.
- Stable sediment and armor sizes for shoreline areas impacted by waves were calculated using guidance in the USACE (2002) *Coastal Engineering Manual* (see Appendix D for more detail).
- Near-bed velocities due to vessel operations (propwash), and the stable aggregate sizes that will resist the given propwash, were developed using the methods presented in USEPA's *Appendix A: Armor Layer Design for the Guidance for In-Situ Subaqueous Capping of Contaminated Sediment* (Maynord 1998). The near-bed velocities were used to evaluate stable sediment and rock sizes. Specific vessel and operations criteria, as well as additional detail regarding propwash modeling, are in Appendix D.
- The impacts of predicted sea level rise for the years 2050 and 2100 on predicted wave heights and proposed stable rock sizes for remedial actions are also discussed in Appendix D.

3.5 In-water Work Window

In-water construction activities will be performed consistent with allowable work windows established in coordination with state and federal resource agencies and tribes. Final work windows will be specified in the issued permits for the project, based on the presence of several fish species of concern. Work windows were also established in coordination with tribes to minimize potential impacts to tribal shellfish and finfish harvesting.

The Washington State Department of Health issues advisory closures when any mussel sample equals or exceeds Food and Drug Administration regulatory levels (equal to or greater than 80 micrograms [µg] of paralytic shellfish poisoning [PSP] toxin per 100 g of shellfish tissue). An area is reopened when two successive samples, collected at least 7 days apart, fall below 80 µg/100 g of PSP toxin. While there is no recognized correlation between sediment resuspension (e.g., from dredging) and PSP outbreaks, intertidal excavation will occur during low tides ("in the dry") to the extent practicable and subtidal dredging activities for the project are proposed to occur between November 1 and January 14, as precautionary measures. PSP outbreaks have not been observed during winter months since 2006 (DOH 2013). In addition, the Port Gamble S'Klallam Tribe conducted sampling to evaluate seasonal patterns of geoduck closures in Port Gamble Bay due to PSP. There was one closure between August 20 and October 22, 2012. BMPs that represent a balance between minimizing the potential for PSP outbreaks while also facilitating Site cleanup include performing intertidal excavation "in the dry," limiting subtidal dredging activities to between November 1 and January 14, and conducting shellfish monitoring according to the *Shellfish Monitoring Plan* (Appendix N) during pile removal, intertidal excavation, and dredging activities and immediately following completion of cleanup construction actions at the Site.

Restricting dredging to the winter months will also minimize risks associated with potential nutrient releases and stimulation of algal blooms during dredging, as algal productivity during the colder winter months is typically not nutrient-limited (Paulson et al. 2007). DRET analyses conducted as part of the PDI (Attachment 3 of Appendix A) revealed that dredging would result in relatively marginal (roughly 40%) increases in dissolved inorganic nitrogen (DIN) concentrations in localized areas near the dredge (i.e., 390 micrograms per liter [µg/L] DIN measured in the DRET, compared to an average DIN concentration of 270 µg/L measured in adjacent waters of Hood Canal that circulate through Port Gamble Bay; Paulson et al. 2007). Since these marginal, localized increases in DIN concentrations would be rapidly diluted as a result of circulation in SMA-1 and SMA-2 (see Section 2.2.4), potential stimulation of algal blooms during the winter dredging months is very unlikely.

The proposed in-water work window for this project for demolition and removal of creosote-treated materials, along with follow-on intertidal excavation, intertidal and subtidal capping, and subtidal EMNR is July 16 to January 14. As outlined above, as a precautionary measure to minimize potential TCP impacts to shellfish and finfish harvesting to the extent practicable, subtidal dredging will be limited to between November 1 and January 14. In addition, intertidal work in SMA-5, including demolition activities, is limited to July 16 to October 14 for protection of surf smelt, sand lance, and herring.

4 SEQUENCING CONSIDERATIONS AND REMEDIATION TECHNOLOGIES

This section summarizes the anticipated overall construction sequencing approach at the Site, and reviews the most promising remediation technologies and BMPs that form the basis for the cleanup project design presented in this EDR.

4.1 Overall Project Sequencing

As discussed in Sections 1.2 and 2.5, cleanup construction activities will be sequenced to maximize overall protectiveness, beginning with source controls (i.e., demolition and removal of creosote-treated materials) and followed closely in time by intertidal excavation and subtidal dredging. Capping and EMNR will be sequenced to occur shortly after removal actions are completed to maximize control of residuals and accelerate natural recovery processes, reducing the overall Site restoration timeframe. Construction and post-construction monitoring and institutional controls will be implemented to verify and ensure the protectiveness of the remedy.

In June 2015, an initial pile removal pilot demonstration (see Section 4.2.3) will be conducted to define pile removal protocols, including the required level of effort for piles that break or cannot otherwise be easily removed using vibratory extraction methods. The selected contractor will be required to implement these protocols during the demolition phase of the work.

Work is anticipated to begin in July 2015 subject to obtaining permits. Based on conversations with experienced contractors, the work is expected to be completed within two in-water construction seasons.

Work in SMA-2 would generally be expected to occur from south to north due to the predominant movement of currents south of the Mill Site. In both SMA-1 and SMA-2, the preferred sequence is dredging before capping to minimize the potential for cap contamination from dredging residuals. The contractor may request that the wave attenuator in SMA-2 be demolished after intertidal work has been completed, which would minimize wave energy along the shoreline during excavation and capping.

A more detailed implementation schedule for the cleanup project is presented in Section 11.

4.2 Demolition and Creosote-treated Pile Removal

Creosote-treated piles will be removed from both intertidal and subtidal areas of the Site; this work will be sequenced to occur shortly before dredging or capping actions, if required within the pile area, to maximize control of pile removal residuals. Consistent with the CAP, piles will be removed using best efforts, equipment preferences, and BMPs identified in: 1) the statewide *Hydraulic Project Approval (HPA) - Creosote Piling and Structural Removal* (WDFW 2011); and 2) the DNR *Puget Sound Initiative – Derelict Creosote Piling Removal, BMPs for Pile Removal and Disposal* (DNR 2011), including additional efforts as described in this section to maximize the chance of success in removing short stub piles.

Removal of creosote-treated wood from Puget Sound has been a major focus of DNR over the last 10 years. The effort began in the northern Puget Sound region and has since expanded Sound-wide. As a result of these considerable demolition experiences and detailed evaluations of construction releases (see below), DNR has refined its creosote removal BMPs to improve the overall effectiveness and practicability of the removal program. The refined BMPs will be utilized for this cleanup project, as described below.

The most detailed evaluation of the effectiveness of creosote-treated pile removal BMPs was performed in 2010 by DNR during the removal or three large derelict docks and supporting creosote-treated piles from the former ASARCO smelter facility (Parametrix 2011a). The ASARCO docks covered an area of approximately 1.6 acre and were supported by approximately 2,300 visible creosote-treated piles, a similar scale as the existing Port Gamble wharf. Because of sediment contamination in the ASARCO site area, and also because the support piles provided geotechnical stability to the shoreline, DNR and USEPA made the decision to cut the supporting piles at or below the mudline. Nevertheless, the deteriorated condition of the piles resulted in many of the piles breaking between the water surface and the mudline during demolition. Pile stubs were cut using a sharp hydraulic shear that produced a clean cut and no detectable loss of wood fibers or cuttings.

Pre- versus post-demolition monitoring at the ASARCO site revealed a significant increase in surface sediment PAH concentrations adjacent to the demolition area, largely attributable to creosote released from broken piles. Sediments adjacent to the demolition area were subsequently covered with a 6-inch sand layer to control creosote residuals. DNR's detailed laboratory and field bioaccumulation studies performed concurrent with the ASARCO demolition project further demonstrated that substantial amounts of PAHs are released from freshly exposed (i.e., broken) creosote-treated surfaces of aged timber piles (Parametrix 2011b). Observed muscle tissue PAH concentration increases of greater than 10-fold resulting from the demolition actions were attributed to releases from freshly exposed surfaces of treated piles that broke during demolition.

The DNR evaluations underscore the importance of anticipating potential adverse impacts associated with creosote release when attempting to remove deteriorated piles, as aged piles may potentially break during removal and exacerbate PAH releases. Lessons learned from these studies, including minimizing the potential for breaking deteriorated creosote-treated piles to the extent practicable, have been incorporated into the cleanup project designs and BMPs described in this EDR, as discussed in more detail in Sections 4.2.1 through 4.2.3.

4.2.1 Creosote-treated Piles within Excavation/Dredging Areas

During development of this EDR, several experienced pile removal contractors performed a reconnaissance of the existing Port Gamble wharf area to evaluate demolition approaches and provide recommendations on removal designs and BMPs. Based on contractor input, most piles with more than 3 feet extending above the final excavation/dredge cut are anticipated to be successfully removed with vibratory extraction or similar equipment, although maximum success is attributed to piles that are 4 feet or longer. However, deteriorated piles and piles with less than 3 feet of extension above the mudline are anticipated to break during extraction attempts (this will be verified during an initial pilot demonstration; see Section 4.2.3 and Figure 7a). To maximize removal success, an excavation will be performed as necessary around each pile to expose at least the upper 3 feet above the existing mudline surface around all intertidal piles located within remediation areas. If a pile breaks during extraction, a second attempt is also likely to be unsuccessful—the break occurs at the weak point in the pile, and this area is typically too weak to allow subsequent reattachment of pile-removal equipment—and will lead to greater PAH releases to the Site, as discussed above. Thus, any piles that break during extraction will be cut 3 feet below the final constructed grade surface in intertidal remediation areas and 1 foot below the final constructed grade surface in subtidal areas. An amended cap type including organoclay will be placed over all cut piles within intertidal remediation areas prior to final cap material placement. The pile removal protocols are shown on Figure 7b.

4.2.2 Creosote-treated Piles outside of Excavation/Dredging Areas

To maximize removal success, excavation will be performed if necessary around each pile within intertidal areas to facilitate gripping at least 3 feet of the pile with the extraction equipment; extraction equipment will also be lowered to 1 foot below the current mudline as practicable for subtidal piles. Any piles that break during extraction will be cut approximately 2 feet below the existing mudline surface in intertidal non-remediation areas, and 1 foot below the existing mudline surface in subtidal areas. The pile removal protocols are shown on Figure 7b. Pile footprints located outside of the excavation and dredging areas will be covered with clean backfill material to manage pile removal residuals.

4.2.3 Initial Pile Removal Pilot Demonstration

Before initiating full-scale creosote-treated pile removal throughout the Site, PR/OPG will retain a contractor to conduct an initial pile removal pilot demonstration to evaluate and identify removal methods that are effective and practicable.

The initial pile removal demonstration will occur within two or three primary areas in representative intertidal high-density pile areas of the Site that consist of a range of existing pile conditions: one near the northern end of SMA-2 to the south of the current wharf and another north of the current wharf in SMA-1 (see Figure 10). An alternate intertidal high-density pile area is located on the jetty to allow for flexibility of contractor equipment access and conducting the demonstration work "in the dry." In two areas, the contractor will attempt to remove at least 20 representative piles (i.e., 40 piles total for both areas) with less than 3 feet extending above the current sediment surface. In SMA-1, the contractor will also attempt to remove at least ten piles with more than 3 feet extending above the current sediment surface. Pilot test work at both demonstration areas will be performed at low tide "in the dry."

Pilot test work will include an evaluation of the existing pile condition prior to any attempt to remove the pile by vibratory extraction or other extraction methods. The condition of each pile will be assessed by the Project Engineer, if appropriate, using a rating scale similar to that developed by the U.S. Navy (Naval Facilities Engineering Command 1995), which includes the following ratings from better to worse condition: No Defects, Minor Defects, Moderate Defects, Major Defects, and Severe Defects. The Project Engineer and contractor will use the pile condition assessment to determine if there is enough structurally sound pile present above the mudline in order to attempt removing the pile using vibratory extraction equipment. If the Project Engineer and contractor determine that enough structurally sound pile is present above the mudline, the contractor will proceed with the first vibratory extraction attempt.

If the Project Engineer and contractor determine that there is not enough structurally sound pile above the mudline or if the pile breaks during the first vibratory extraction attempt, the contractor will excavate, if necessary, to a depth of 2 feet below the existing mudline to allow sufficient grip between the contractor's extraction tool and the subsurface portion of the pile. The contractor will proceed with the second vibratory extraction attempt, or will switch to an alternate removal tool if appropriate.

If the pile cannot be practicably removed or breaks during the second extraction attempt, the contractor will excavate to a maximum depth of 4 feet below the existing mudline to expose the subsurface portion of the pile and a third attempt will be made to remove the pile. If the pile breaks a third time during the extraction process, the pile will be cut 3 feet below the final mudline. Following the pilot demonstration, piles that are cut will be capped with 6 inches of sand/organoclay and 6 inches of suitable cap material. The pilot demonstration flow chart is depicted on Figure 7a.

Immediately after the pilot test, the Project Engineer and contractor will review the pile removal protocol with Ecology. If necessary, a joint meeting between the Project Engineer, contractor, Ecology, Port Gamble S'Klallam Tribe, and Suquamish Tribe will be scheduled 3 working days after the meeting with Ecology.

4.3 Intertidal Sediment Excavation Methods

Conducting intertidal sediment and shoreline bank soil excavation during low tide will reduce the potential for release of impacted intertidal sediment and shoreline bank soils to the Site during construction. Intertidal sediment to be removed from the Site will be excavated using mechanical means during low tide conditions "in the dry," to the extent practicable. During the construction window, typical daytime low tides reach elevation 0 feet MLLW (although on some days this occurs for only a few minutes); during the winter, low tides tend to occur at night. Limiting intertidal excavation to dry periods will have the benefit of reducing construction-related releases, but will reduce efficiency and increase the duration of this element of the work.

Depending on weather, tides, scheduling, and contractor production, it may be necessary to conduct some relatively limited intertidal excavation below water. Intertidal excavation during shallow water conditions (e.g., to address weather, access, and/or schedule constraints) would be subject to consultation with and review by Ecology.

4.4 Subtidal Dredging Technology

Dredging of contaminated sediments is a common method of sediment remediation and was used during both the 2003 and 2007 interim actions at the Site when an aggregate total of approximately 31,000 cy of woody sediments were removed (see Section 2.1). Dredging can be performed using mechanical or hydraulic dredging equipment. Land-based excavation equipment can sometimes be used if the contaminated sediment is located within reach of the shore. This section provides a discussion of the dredging technology selection process for this cleanup project.

In-water dredging is less precise than land-based excavation because the work area is not visible, and due to the inherent precision limitations of the type of equipment used for in-water dredging. In addition, sediment resuspension and water column releases during construction, as well as post-dredge residuals following completion of construction, are inherent to both mechanical and hydraulic dredging and need to be planned for (USACE 2008a). Depending on site-specific conditions, dredging BMPs that can minimize sediment disturbance and turbidity include operational controls, barriers such as silt/turbidity curtains, specialized dredging equipment, and focused water quality monitoring. BMPs appropriate to dredging and disposal operations at the Site are discussed in Section 4.6. Final BMPs will be further defined in the Construction Specifications (Appendix I) and also may be defined in the project permits, which the contractor will be required to implement.

Both mechanical and hydraulic dredging projects result in post-dredge residuals (NRC 2007; Bridges et al. 2010). Empirical data from numerous sediment remediation projects indicate that residual contamination is more prevalent at dredging sites that contain significant debris (such as the buried logs, ropes, chains, wires, and other debris present in SMA-1 and SMA-2), resulting in 10% or more of the mass of sediments within the dredge prism returning to the sediment bed following either mechanical or hydraulic dredging operations (Patmont and Palermo 2007; Bridges et al. 2010).

Mechanical and hydraulic dredging equipment and operations, as well as a comparative evaluation of options to most effectively accomplish sediment removal at the Site, are summarized in Sections 4.4.1 through 4.4.3.

4.4.1 Mechanical Dredging

Common mechanical dredge equipment includes barge-mounted cranes (often referred to as clamshell dredges due to the standard use of a clamshell bucket), barge-mounted or land-based backhoe excavators, dippers, draglines, and bucket ladders to remove sediments and place them onto a barge or into a material scow. Barge-mounted cranes and backhoe excavators are the most common types of mechanical dredges in the Pacific Northwest. In shallower dredge depths, backhoe excavators outfitted with dredging buckets (often termed "instrumented backhoes") are also used in the Pacific Northwest.

Mechanical dredges are designed to remove sediment at or near the in situ density, though some amount of water is typically entrained within the dredge bucket as it closes and is lifted up through the water column. The quantity of water generated using mechanical dredging is less than that generated with hydraulic dredging, and mechanical dredges are also more effective at removing debris. Barge-mounted cranes can use different types of buckets or attachments to dredge or assist with debris removal or demolition activities. "Environmental" or closed buckets are sometimes used to help maintain water quality; however, regional and national experience has shown that environmental buckets are less effective than digging clamshell equipment when significant debris is present (Wang et al. 2002). Based on coordination with Ecology and the Port Gamble S'Klallam Tribe, a hydraulically closing Young or similar bucket will be used when significant debris is not present. Additional discussion on the use of environmental buckets is provided in Section 4.4.3.

A typical mechanical dredging sequence includes:

- Dredging sediment
- Placing dredged sediment in a haul barge, where passive dewatering occurs
- Transporting dredged sediment either to an open-water disposal site or to an upland offloading and staging area
- Dewatering sediment either directly on the haul barge or offloading sediment to a stockpile area for further dewatering (potentially including more active dewatering methods such as additives, filter or belt presses, or hydrocyclones, depending on site-specific sediment characteristics)
- Collecting and treating (if necessary) effluent from the stockpile (and haul barge) and discharging it to receiving waters or approved treatment works
- Loading the sediment into rail cars and/or trucks for upland transport
- Transporting contaminated sediment to an approved upland containment area or landfill facility by truck or rail

Mechanical dredging is feasible within open-water areas of the Site, and can also directly accomplish removal of debris.

4.4.2 Hydraulic Dredging

Hydraulic dredges are barge- or float-mounted and typically use centrifugal pumps to dredge sediment. The suction end is typically equipped with a mechanical or hydraulic device to loosen the sediment prior to drawing it into the dredge suction line. The most common types of hydraulic dredges are suction, rotating cutterhead, or horizontal auger. Upon removal from the sediment bed, hydraulically dredged material is typically transported via floating piping to a staging and processing area.

Sediment solids in hydraulically-dredged slurries typically average about 10% by weight and can vary considerably based on the thickness of the dredge cut and other factors; the balance (90% by weight) is entrained water from the hydraulic pumping. Hydraulically dredged sediment can be dewatered using either passive methods (e.g., dewatering basins or geotextile tubes) or active methods (e.g., filter presses), both of which would require a water treatment system to treat the decanted water prior to discharge. The extent of dewatering required is typically dictated by transportation and disposal facility requirements, and is influenced by the physical properties of the removed sediment and the amount of water entrained during the dredging process. On most hydraulic sediment remediation projects completed in the Pacific Northwest, sediment handling and processing methods are driven by the available upland space and final disposal site requirements. Hydraulic dredging has not been used in Puget Sound when the sediments are targeted for open-water disposal, and the DMMP is unlikely to approve its use in this application.

In general, hydraulic dredges cannot remove debris. Typical hydraulic pumps are on the order of 8 to 12 inches in diameter, with impellers that limit the size of particles that can pass through the dredge pipe. If hydraulic dredging were to be implemented at the Site, a mechanical debris sweep would be necessary to remove most of the debris prior to hydraulic dredging, given that significant amounts of logs and other debris are anticipated within both SMA-1 and SMA-2 (based on observations during the 2003 and 2007 dredging projects, as well as the results of geophysical surveys). Sediment resuspension, water column releases, and post-dredge residuals resulting from a debris sweep are similar to those resulting from mechanical dredging (NRC 2007). Any additional debris encountered during the hydraulic dredging process would need to be removed by mechanical means prior to resuming hydraulic operations, which can limit dredge production rates. Nevertheless, given these limitations, hydraulic dredging is technically feasible within open-water areas of the Site when used in combination with a pre-dredge debris sweep.

4.4.3 Comparison of Mechanical and Hydraulic Dredging

This section compares mechanical and hydraulic dredging methods for the removal of subtidal sediments at the Site. The comparative analysis was performed by evaluating environmental considerations (Section 4.4.3.1) and constructability considerations (Section 4.4.3.2) associated with the different dredging equipment.

4.4.3.1 Environmental Considerations

4.4.3.1.1 Sediment Resuspension and Water Quality

Many mechanical dredging operations require the use of BMPs to reduce resuspension in the water column, including controlling the rate of bucket movement through the water column and the use of environmental buckets that minimize the potential for dredged sediments to be redistributed back into the water column after removal. When BMPs are employed, sediment disturbance and turbidity can often be effectively managed with mechanical dredging operations. Water-tight barges have been used on sediment remediation projects in the Pacific Northwest to reduce turbidity and resuspension from water draining from the material barges. Water-tight barges require the treatment of entrained dredging process water utilizing settling tanks, pumps, and filtration systems (e.g., chitosan enhanced sand filtration) prior to discharging treated water to the work area. In this case, the use of water-tight barges and associated water treatment is an unnecessary water management design BMP, given the compliance with water quality monitoring criteria demonstrated in the 2007 interim action at the Site.

As discussed in Section 4.4.2, if hydraulic dredging were to be implemented at the Site, a mechanical debris sweep would be necessary to remove debris prior to hydraulic dredging, resulting in sediment resuspension and water column releases similar to those resulting from mechanical dredging. Sediment resuspension from follow-on operations using a hydraulic cutterhead or similar dredge will result from use of an agitating device to loosen the sediment, not all of which can be contained by the dredge (Hayes and Wu 2001). Thus, at sites where a debris sweep operation is not needed, sediment resuspension and water quality impacts are typically similar between hydraulic and mechanical dredges (Bridges et al. 2010). However, within SMA-1 and SMA-2 where a debris sweep operation would be necessary to facilitate follow-on hydraulic dredging, sediment resuspension and potential water quality and PSP impacts would be greater with hydraulic dredges when compared to mechanical dredges.

4.4.3.1.2 Dredge Residuals

Both mechanical and hydraulic dredging result in similar degrees of post-dredge residuals, particularly at dredging sites that contain significant amounts of debris. Residual management strategies, such as placement of post-dredge sand covers, are typically employed in conjunction with dredging activities for both mechanical and hydraulic equipment. A post-dredge residuals cover will be used for all dredge areas for this project.

4.4.3.1.3 Dewatering of Dredged Material

Mechanically dredged sediments placed on a scow barge can be unloaded by an excavator or crane onto a sediment processing area where debris and oversized material can be separated and the sediments allowed to passively dewater (via gravity) until they are ready for placement or off-site transportation. Passive dewatering and follow-on rehandling and truck transport was implemented successfully at the Site during both the 2003 and 2007 interim actions. If needed, amendments can be used to bind free water, further solidifying and stabilizing the dredged material to meet end-use or disposal requirements. Typical amendments include Portland cement, fly-ash, diatomaceous earth, or lime, and can be blended using a pugmill or excavators (which can be equipped with a mixing head attachment). The water that drains from the sediment during the passive dewatering step may require collection and treatment, though the volume of water to be treated from mechanical dredging is far less than that of a hydraulic dredge operation.

Hydraulic dredging involves pumping the sediment-water slurry from the dredge to the sediment processing area and generates relatively large quantities of water, which must be separated from the sediment and treated prior to discharge. Therefore, a dedicated water treatment system would be required. As discussed in Section 4.4.2, hydraulically dredged sediment can be dewatered using either passive methods (e.g., dewatering basins or geotextile tubes) or active mechanical methods. Several methods are available for mechanically dewatering hydraulically dredged sediment including desanding (e.g., screens, hydrocyclones), filter presses (e.g., belt or plate and frame), and geotextile tubes. As noted, debris would need to be removed mechanically prior to hydraulic dredging, and some additional oversized material (i.e., material that can be dredged but cannot be introduced into the filter presses) would need to be removed from the hydraulic slurry prior to dewatering.

4.4.3.1.4 Dredge Cut Thickness and Overdredging

The accuracy of mechanical dredging is operator-dependent, because the operator must be able to position each bucket cut immediately adjacent to the previous cut (after raising and lowering the bucket) and maintain a level dredge surface between each bucket removal. However, an experienced mechanical dredge operator equipped with the right equipment (including position tracking) can achieve similar overdredge tolerances to an experienced hydraulic dredge operator (about 4 to 6 inches). Special attachments (e.g., level cut or environmental buckets) can also be incorporated into the dredge design to further improve accuracy based on site-specific conditions.

Hydraulic dredge cutterheads or augers can be set to predetermined cut depths and are, therefore, capable of performing controlled passes at set elevations. This allows the hydraulic dredge to accurately dredge along the dredge prism with minimal overdredging (typically 4 to 6 inches). The size and type of agitation device can be designed specifically for anticipated dredging conditions. For instance, a small-diameter cutterhead could be selected where dredge cut thicknesses are small to maximize the solids content in the dredge slurry. Special attachments (e.g., disc-cutters and plain suction vacuum attachments) can also be used in some situations.

4.4.3.1.5 Final Disposal Requirements, Volumes, and Transport

Given the prospective dredge volumes at the Site and the limited dewatering requirements associated with open-water disposal, upland beneficial reuse or containment, and/or regional landfill disposal, and considering the successful implementation of the 2003 and 2007 interim actions, passive dewatering either on the scow barge or at an upland offloading facility (potentially supplemented with limited amounts of stabilizing amendments) would be effective for a mechanical dredging operation at the Site. Dewatered sediments could be transported to the beneficial reuse, upland containment, and/or disposal site using a combination of scow or bottom-dump barges, trucks, and trains.

The active dewatering methods typically used with hydraulic dredging (e.g., filter presses) often result in smaller disposal tonnage than passive dewatering methods because the solids content of the filter cake is higher (typically greater than 55% solids, by weight). However, hydraulic dredging would result in much more water to be treated than mechanical methods. Moreover, as noted, the DMMP is unlikely to approve hydraulic dredging for open-water disposal. Subject to DMMP approval, approximately 10,000 cy of sediment from SMA-1 may be suitable for disposal at a DMMP open-water disposal facility (see Section 6), which would further limit hydraulic dredging opportunities at the Site.

4.4.3.1.6 Noise

The noise generated during mechanical transport operations would be associated with the travel of material scow transport tugs at the Site, but the additional noise generated by these operations is typically minimal.

The noise generated from hydraulic dredging operations is typically slightly greater than mechanical dredging. Hydraulic dredging operations require the continuous operation of booster pumps throughout the duration of the work where longer pipelines are required. "Silenced" booster pumps produce less noise than comparably sized standard pumps and are regularly used in dredge projects near residential areas; however, the booster pumps would result in a continuous noise level at the pump locations during operations.

4.4.3.2 Constructability Considerations

4.4.3.2.1 Suitability for Site-Specific Conditions

For mechanical dredging, debris removal can be performed concurrently with dredging operations and would not require any additional equipment.

For hydraulic dredging at the Site, there is a high probability of encountering significant amounts of debris, primarily logs, ropes, chains, and wires, which could become entangled in a hydraulic dredge or choke a dredge pump or pipeline if not removed. Thus, mechanical removal of debris would need to be performed prior to, and possibly throughout, any hydraulic dredging operation.

4.4.3.2.2 Dredging Efficiency and Production

Dredging efficiency and production rates are affected by the presence of debris, material handling and off-site shipment constraints, and dewatering and water treatment capacity. Hydraulic dredging efficiency is particularly dependent on the presence of debris, and hydraulic dredging production rates must also accommodate dewatering and water treatment capacity. Considering the known presence of significant amounts of buried woody debris, bark, and logs in SMA-1 and SMA-2, overall hydraulic dredging efficiency and production rates would likely be lower than for mechanical dredging and could extend the duration of the dredging work.

Mechanical dredging requires non-working time (i.e., downtime) for switching between full and empty scows and moving equipment. Depending on the configuration (i.e., positioning using walking spuds or anchors) and the amount of debris encountered, hydraulic dredges may require similar amounts of downtime related to dealing with buried debris. Overall, dredging efficiency and production rates are likely to be higher for mechanical versus hydraulic dredging operations at the Site.

4.4.3.2.3 Dredged Material Transport

Transportation of mechanically dredged material typically involves scows (for upland disposal) or bottom-dump barges (for open-water disposal). Depending on the reach of the specific equipment, mechanical dredging operations may require shallow-draft scows and tugboats in order to transport material from the dredge area to the sediment offloading area. Shallow-draft scows are limited in the volume of dredged material that can be held; therefore, a larger number of scows could be necessary. This would likely lead to increased traffic and increased downtime while changing scows. Alternatively, by keeping scows in the deeper portion of the Site during dredging and performing preliminary navigation dredging at the unloading area prior to the remediation work, it may be possible to utilize larger scows, which would reduce the total amount of scows required and reduce downtime for scow handling.

Once the scows arrive at the offloading area, a mechanical or hydraulic offloader would remove sediment from the scows and load it into trucks to transport the sediment to the upland sediment processing area. This process is more labor- and equipment-intensive than hydraulic conveyance, but it provides greater independence from the dredging operation. Because mechanically dredged material is delivered via scows, the material would need to be rehandled as it is unloaded to a dewatering area.

Mechanically dredged sediment could also be transported hydraulically. Under this scenario, the mechanical dredge would place the sediment into a scow or hopper, where a slurry pump would introduce water to generate the slurry for transport directly to the sediment processing area for dewatering using filter presses or geotextile tubes. This additional water would be subject to similar treatment and processing options as discussed for the hydraulic dredging approach.

Dredged material could be transported between a hydraulic dredge and the upland sediment processing area using pipelines and booster bumps. This hydraulic conveyance technique requires few moving pieces of equipment, as well as reduced manpower during operations. However, if a problem such as a pipeline leak, clog, or mechanical failure of a booster pump occurs, production with the hydraulic dredge must be halted and the damage must be repaired. In addition, scows or barges would still be needed for transporting mechanically removed debris. As noted, hydraulic dredging is also not applicable for open-water DMMP disposal.

4.4.3.2.4 Uniformity/Accuracy of Post-dredge Surface

As noted, hydraulic dredging generally allows for a more uniform post-dredge surface than mechanical dredging, as a hydraulic dredge is capable of sweeping the bottom at a set elevation. A post-dredge surface from mechanical dredging could leave an array of “bite marks” from the bucket (depending on the skill of the operator), which could vary in elevation and temporarily create an undesirable surface.

4.4.3.2.5 Equipment Accessibility in Shallow Water Areas

A long-reach mechanical excavator may be able to conduct dredging of the nearshore areas while working from deeper water, depending on the reach distance of the excavator. This ability to position the mechanical dredge outside of the actual nearshore area would allow for more flexibility in dredging operations and potentially less of a need for "navigation" dredging to provide access for equipment. Mechanical dredging could also be conducted from the shoreline in some areas.

In order to access the areas nearest to shore, a small (likely 8-inch-diameter or less), shallow-draft hydraulic dredge would likely be required for hydraulic dredging operations. If water depths are less than the draft of the hydraulic dredge, the dredge may be required to work only during higher tide periods.

4.4.3.2.6 Equipment Requirements

The mechanical dredging option would require scows, tug boats, and support boats for transporting dredge material and relocating the dredge barge. In general, equipment traffic and the coordination of moving equipment within the Site are typically greater for mechanical operations than hydraulic operations, but given the anticipated dredge volumes and production rates at the Site, the number of daily scow movements required to transport dredged material is expected to be minimal.

Hydraulic dredging would consist of the hydraulic dredge, its conveyance line, and associated booster pumps. The conveyance pipeline for a small dredge is typically floating and may interfere with other marine traffic operating at the Site. To alleviate this potential conflict, appropriate navigational markings would be required, and sinking a portion of the pipeline may be necessary to provide access for navigation. Typically, the hydraulic dredging option requires few moving pieces of on-water equipment during operations, which makes coordination of equipment and workforce less complicated. However, an additional mechanical removal operation would be required to remove debris in advance of hydraulic dredging and would require scows, tug boats, and support boats similar to a mechanical dredging operation.

4.4.3.2.7 Availability of Contractors

In the Puget Sound area, there are more qualified contractors capable of performing the work and providing the necessary equipment for mechanical dredging operations than there are for hydraulic dredging operations. Mechanical dredging would provide a greater likelihood for conducting the work within the required schedule because the "bid pool" would be larger and there would be a lower risk of contractor unavailability.

The use of a small, shallow-draft dredge and conveyance pipeline required under the hydraulic dredging option could potentially limit the list of applicable contractors to those that are experienced in operating and maintaining these specialized pieces of equipment.

4.4.3.3 Summary

The comparative analysis of dredging methods is summarized in Table 4-1. Both hydraulic and mechanical dredging methods provide key advantages and disadvantages.

Table 4-1
Summary of Comparative Analysis of Dredging Technologies

Evaluation Item	Better Option (✓) Hydraulic Dredging	Better Option (✓) Mechanical Dredging
Environmental Considerations		
Sediment Resuspension and Water Quality		✓
Dredge Residuals	✓ (equivalent options)	✓ (equivalent options)
Dewatering of Dredged Material		✓
Dredge Cut Thickness and Overdredging	✓	
Final Disposal Requirements, Volumes, and Transport		✓
Noise		✓
Constructability Considerations		
Suitability Based on Expected Conditions (Material Type, Debris, and Dredgeability)		✓
Dredging Efficiency and Production (Time)		✓
Dredged Material Transport		✓
Uniformity/Accuracy of Post-dredge Surface	✓	
Equipment Accessibility in Shallow Water Areas		✓
Equipment Requirements [1]		✓
Availability of Contractors		✓

Note:
1 Equipment requirements for hydraulic dredging consider the need for a mechanical debris sweep

4.4.4 Dredging Equipment Selection

Based on the comparative evaluation of mechanical and hydraulic dredging summarized in Table 4-1, dredging at the Site will be performed using mechanical methods based on the following factors:

- Ability of mechanical dredging equipment to meet project requirements, including compliance with applicable water quality criteria and minimizing sediment resuspension and potential PSP impacts
- Presence of debris within the dredging areas (hydraulic dredging equipment is subject to fouling by such debris and thus would require a mechanical debris sweep)
- Mechanical dredging requires less intensive dewatering than hydraulic dredging

- Greater availability of equipment and expertise within the Pacific Northwest for mechanical dredging as opposed to hydraulic dredging
- Ability to use mechanical dredging equipment for other cleanup project activities (e.g., cap placement)

The selected contractor will determine the specific pieces of mechanical dredging equipment required to perform the Project work. It is assumed that the contractor will use dredge derricks, barges, and tugs. The contractor will be required to specify equipment choices and procedures in advance as part of the contractor pre-construction dredging work plan submittal.

4.5 General Construction Best Management Practices

A range of BMPs will be used during cleanup construction activities to minimize potential environmental impacts. These BMPs are summarized in the list below and Sections 4.6 through 4.8. Additional BMPs required by the project permits will also be implemented.

The following BMPs will be employed to prevent the potential for spillage of dredged material or spillage from construction equipment:

- Dredge vessel personnel will be trained in hazardous material handling and spill response and will be equipped with appropriate response tools, including absorbent oil booms. If a spill occurs, spill cleanup and containment efforts will begin immediately and will take precedence over normal work.
- The National Response Center (1-800-424-8802) and the Washington Emergency Management Division (1-800-258-5990 OR 1-800-OILS-911) will be notified immediately if a spill occurs.
- The dredging contractor will inspect fuel hoses, oil or fuel transfer valves, and fittings on a regular basis for drips or leaks in order to prevent spills into the surface water.
- Equipment will have properly functioning mufflers, engine-intake silencers, and engine closures according to federal standards.
- All barges handling dredged materials will have hay bales and/or filter fabric placed over the barge scuppers to filter suspended sediment from the barge effluent.

- When wet materials are transported, haul trucks or containers will be lined or otherwise sealed to prevent release of sediment or effluent during transport.
- The contractor will be required to retrieve any floating debris generated during construction using a skiff and a net. Debris will be disposed of at an appropriate upland facility.
- The contractor will prepare a spill prevention, control, and countermeasures plan and will have a spill kit on-site, as well as a marine spill response contractor available on an on-call basis. These precautions will minimize the potential for petroleum products or other deleterious materials to enter surface waters.

4.6 Excavation and Dredging BMPs

Excavation and dredging operations have well-established BMPs to minimize sediment disturbance and manage potential water quality impacts. Operational and engineering controls will be defined in the Construction Specifications (Appendix I) and the project permits, which the contractor will be required to implement.

4.6.1.1 Qualified Contractor

Bidding contractors will need to meet minimum qualifications that demonstrate experience with projects similar in scope and complexity. Specific requirements will be provided in the construction tender documents. Typically, the contractor will need to demonstrate experience with environmental dredging in the Pacific Northwest for similar projects within the last 5 to 7 years. In addition, the project superintendent will typically need to demonstrate similar experience. Contractors that cannot demonstrate experience may not be considered responsive to the bid.

4.6.1.2 Real-Time Positioning

The contractor will be required to use real-time positioning controls such as a differential global positioning system electronically displayed in the dredge operator's cabin to provide real-time positioning control for the dredge and dredge bucket. Controlling the position of the dredging equipment will minimize the potential for unintended excavation and associated water quality impacts.

4.6.1.3 Resuspension Barriers (Turbidity/Silt Curtains)

Temporary resuspension barriers, or turbidity/silt curtains, can be effective tools in minimizing or reducing potential turbidity impacts during dredging when implemented properly and where site conditions are compatible. However, temporary resuspension barriers may have limited effectiveness in reducing turbidity impacts if they are not adequately designed for site-specific conditions, not properly installed, and not properly maintained. They may also limit navigation and adversely impact dredging production rates if they need to be continuously repositioned to accommodate dredging vessels and barges. As discussed by Palermo et al. (USACE 2008a), it is critical to consider their potential benefits and limitations before requiring a contractor to implement a temporary resuspension barrier system.

The typical objective of using temporary resuspension barriers is to create a partial physical barrier around the dredge equipment to minimize the spread of suspended sediment that is generated during dredging operations. Temporary resuspension barriers are typically constructed of flexible, reinforced, thermoplastic material with flotation material in the upper hem and ballast material in the lower hem. The temporary resuspension barrier is placed in the water surrounding the dredge or disposal area, allowed to unfurl, and then anchored in place using anchor buoys. Temporary resuspension barriers are most effective on projects where they are not opened and closed to allow equipment access to the dredging or disposal area. Temporary resuspension barriers block or reduce the flow of water and suspended sediments, and therefore, are easily affected by tides and currents. Their effectiveness can be adversely impacted by high current velocities, moderate to large wave conditions, and typical tidal variations in Puget Sound. Temporary resuspension barriers are most effective if they can be deployed so that they extend from the water surface to the bottom or within a close distance (e.g., 2 feet) of the bottom, but this is seldom practical in Puget Sound due to tidal variation, water depth, and current velocities. When a temporary resuspension barrier does not fully extend from the water surface to the bottom, a gap will remain at the bottom where suspended sediment can be transported outside of the project dredging boundary. If the barrier is in contact with the bottom, the barrier itself can be a source of water quality impacts due to localized resuspension of sediments along the base of the curtain as it moves with tides, currents, and wind-generated waves.

Partial-length (e.g., silt/turbidity curtain depth of 10 to 15 feet) resuspension barriers will be identified in the Specifications as an additional BMP requirement to be used during intertidal excavation, intertidal pile removal, and dredging as practicable.

4.6.1.4 Environmental or Closed Buckets

For mechanical dredging, environmental or closed buckets consist of specially-constructed dredging buckets designed to try to reduce turbidity during dredging. In general, these buckets may help minimize the loss of sediment out of the bucket when used properly and when site conditions are compatible with their use. However, minimizing the loss of sediment out of the bucket does not necessarily result in lower turbidity. As discussed by Wang et al. (2002), closed buckets have not been proven to reduce suspended sediments in all site conditions. Debris encountered must be removed with the dredge bucket at the time of dredging. A standard clamshell bucket is expected to be more effective at removing debris or dense substrate; closed buckets (without digging teeth) are generally ineffective at removing debris. Closed buckets are typically lightweight in construction and typically not suitable for digging denser materials. Due to the presence of significant amounts debris in areas of SMA-1 and SMA-2, this BMP may have a more limited application.

As an additional BMP requirement, a hydraulically actuated fully enclosed bucket (Young or similar) will be required in the Specifications as the primary dredging technology when site conditions allow (i.e., in areas of minimal debris and where the depth of water supports the use of a hydraulic barge mounted excavator). If site conditions are not compatible, a standard clamshell bucket may be used.

4.6.1.5 Limits on Bucket Velocity

For mechanical dredging, reducing the velocity of the ascending loaded bucket through the water column reduces the potential for washing of sediment from the bucket. Pausing the ascending bucket at the waterline further reduces loss of sediment from the bucket. When the clamshell bucket hits the bottom, an impact wave of suspended sediment travels along the bottom away from the dredge bucket. Sediment resuspension also occurs when the bucket impacts the bottom surface. Sediment resuspension may be reduced by pausing the bucket at the sediment surface before closing the bucket and pausing the bucket at the waterline during the ascent, both of which increase cycle time but may reduce resuspension of sediment.

4.6.1.6 Eliminating Multiple Bites

When the clamshell bucket takes multiple bites before ascending to the surface, the bucket loses sediment as it is reopened for subsequent bites. Sediment is also released higher in the water column as the bucket is raised, opened, and lowered. The Specifications will prohibit taking multiple bites.

4.6.1.7 Minimizing Dredging During Peak Tidal Exchange Periods

Dredging during peak tidal exchange periods (i.e., an ebb tide) may increase downcurrent turbidity. The contractor may need to minimize working during these periods to minimize water quality impacts, depending on the results of water quality monitoring. However, considering the limited window available for subtidal dredging (November to January) and the volume of material to be removed, this BMP may not be practicable to implement regularly without significantly extending the overall construction project duration.

4.6.1.8 Eliminating Bottom Leveling

Dragging a bucket or beam to level the bottom of the dredge or excavation surface (to achieve the required dredge elevation) has the potential to resuspend sediment. The contractor will be prohibited from leveling the surface. Instead of leveling to remove high spots, the contractor will be required to make an additional dredging pass to remove any high spots that are identified during the post-dredge survey.

4.6.1.9 Eliminating Bucket Overloading

When the dredge or excavation bucket impacts soft sediment, there is the potential for the bucket to penetrate beyond the designed digging depth of the bucket. When this occurs, the bucket returns to the surface with excess material at the bucket surface, which could fall back into the water before being placed into the material barge. If bucket overloading is observed, the contractor will be required to control the rate of descent on the bucket to prevent excess penetration of the bucket into the mud.

4.6.1.10 Eliminating Barge Overloading

The contractor will be prohibited from overloading the material barge beyond the top of the side rails. When dredge material is stacked adjacent to and above the side rails, there is the potential for material to discharge over the rail. In addition, overloading or uneven loading of the barge can lead to barge listing and instability, which could result in loss of sediment back to the surface water.

4.6.1.11 Intertidal Geotextile Placement

If the contractor cannot complete intertidal excavation and confirm that required excavation elevations have been achieved "in the dry" prior to the next incoming tide, the contractor may be required to place and secure a temporary geotextile to minimize the potential for sediment resuspension during submerged conditions. The geotextile layer will be used as a temporary measure to minimize the potential for sediment resuspension during submerged conditions of the intertidal excavation. The geotextile would be removed at the start of the subsequent "dry" excavation period.

4.7 Material Transloading, Beneficial Reuse, Containment, and Disposal

Dredged material may be removed from the Site using several methods, depending on final permitting conditions. Dredged sediment may be transloaded in a number of ways, including:

- Transloading at one of the existing docks or a temporary offloading platform installed for the project
- Hydraulic or conveyor offloading from the material barge onto the Mill Site uplands or directly to a nearby placement site
- Shipment from the Site by barge, either for disposal at a DMMP open-water disposal site or for transloading at a permitted location with access to truck or rail facilities

BMPs for transloading at the Mill Site uplands or an off-site location include the following:

- Upland staging facilities installed for transloading of dredged sediment materials are intended only for temporary use during the project. After the project is completed, these temporary facilities will be removed unless otherwise approved by Ecology.

- Excess or waste materials will not be disposed of or abandoned waterward of mean higher high water (MHHW) or allowed to enter waters of the state.
- Erosion control measures for the upland sediment placement area will be defined in the Construction Specifications (Appendix I) and adhered to during construction activities. Unfiltered runoff from temporary upland stockpiles will not be allowed.
- Construction materials will not be stored where high tides, wave action, or upland runoff can cause materials to enter surface waters.
- When wet materials are transported, haul trucks or containers will be lined or otherwise sealed to prevent release of sediment or effluent during transport.

4.8 Cover, Cap, and Armor Material Placement

After remedial excavation and dredging is completed, the dredge plan includes placing either a clean sand residual management cover or an engineered cap, depending on the specific SMA-1 or SMA-2 location. Cap and EMNR material will also be placed in subtidal areas of SMA-1, SMA-2, and SMA-3. The Construction Specifications will identify acceptable placement methods and material specifications. The following acceptable low-energy placement methods, or a combination of these methods, will be used to minimize disturbance of the bottom sediments during material placement operations:

- Directly placing the sand at the mudline using a dredge rehandling bucket. The rehandling bucket would grab cover material from a haul barge and lower the material through the water column before opening slightly above the mudline.
- Placing the sand with a barge-mounted crane-operated clamshell or fixed-arm hydraulic excavator-operated clamshell slowly in a controlled fashion at the water surface. The clamshell placement method would involve taking a bite of sand from a material barge and slowly releasing the sand from the bucket at the water surface as the operator methodically moves the bucket in a sweeping motion from side to side, so that cover lift thickness is carefully controlled.
- Slowly opening the hopper of a bottom dump barge to place material in a controlled fashion, while moving the bottom dump barge across the placement area at a controlled rate, to avoid a large slug of capping or EMNR material being dropped in one area

- Placing gravel size aggregate or smaller using a land- or barge-based conveyor system (e.g., Telebelt system). Material would be loaded into a hopper for subsequent delivery to a conveyor boom with a horizontal reach extending over the placement area. The conveyor belt speed would be adjusted and would allow for accurate and steady placement of material in intertidal and subtidal areas.

5 SITE PREPARATION AND STAGING AREA DESIGN

As part of cleanup construction activities, the selected contractor will be required to bring the necessary barges, dredges, and other water-based specialized equipment to the Site. The equipment will be moored and repositioned within the Site as necessary to complete the work, at the locations shown in the *Vessel Management Plan* (Appendix H). The work will also require mobilization of land-based equipment including backhoes, shore-based cranes, loaders, and other equipment.

This section discusses the upland Site areas that may be used by the contractor to stage equipment and stockpile or transload demolition debris, dredged sediments, and capping/armor materials. The configuration and layout of upland staging areas will depend on the selected contractor's construction methods. Off-site transloading locations will be selected by the contractor depending on the final destination of materials that will require landfill disposal. Potential temporary staging, stockpiling, and transloading areas are shown in Figure 8a.

5.1 Mill Site Uplands Staging Areas

Portions of the Mill Site uplands will be made available to the contractor for use in staging equipment and materials for the cleanup project, for access to conduct shoreline work, and for temporary stockpiling and transloading cap materials and/or dredged sediments and debris for shipment (as necessary). Most of the approximately 18 acres of the Mill Site uplands will be available to the contractor during construction as shown in Figure 8a, with the exception of the northwestern portion of the Mill Site that currently houses the ENVIRON laboratory. The available area may be modified as necessary to coordinate construction activities with tenants or site users.

If practicable, the contractor may use existing dock structures (e.g., Pier 4 and Pier 5) for temporary access to barges and other water-based equipment, depending on availability and project phasing. If existing structures are utilized, demolition of these structures may occur late in the cleanup construction sequence after completion of most in-water cleanup construction activities. Temporary dock structures or floating platforms may be required by the contractor to access water-based equipment.

The final selection of temporary upland stockpile and transloading locations will depend on the final destination of demolition debris and dredged material. For example, if a significant quantity of material leaves the Site by truck, then a transload area will be constructed to efficiently handle those quantities. Additional transloading features may need to be constructed if a significant quantity of intertidal sediments leaves the Site by barge.

Where barge offloading and loading operations are conducted, spill containment measures will be required to ensure that all sediment and water from loading and offloading operations are fully contained and water generated from upland handling of dredge materials can be captured and managed.

Specific temporary stockpile configurations within the designated work areas will be at the discretion of the contractor. However, all temporary stockpile areas will be appropriately contained to prevent uncontrolled runoff from leaving the area. Methods for containing the stockpiles will be described in the construction work plan, which will be a required contractor submittal and will detail operations, including set up and breakdown, stormwater management, and maintenance and cleaning of upland work areas. An example containment scenario incorporates stacked ecology blocks, k-rails, or constructed berms, around the perimeter of the stockpile with an impervious geotextile fabric along the stockpile perimeter as shown in Figure 8b. The perimeter containment will be further subdivided into discrete stockpile areas, each with a capacity of approximately 1,500 cy of excavated or dredged material, for subsequent characterization as depicted in Figure 8b. Off-site locations may also be used by the contractor for sediment and debris offloading and staging.

The contractor will be responsible for site security at the upland staging areas. The contractor will also be responsible for daily housekeeping, and will need to maintain a spill kit on-site to control and contain any equipment leakage that could occur. The contractor will not be permitted to discharge solid or liquid waste from the staging area into the adjacent waterbody.

In summary, the following specific requirements will govern the operation of the upland staging area:

- The temporary staging and stockpiling area will be constructed in accordance with the Construction Drawings and Specifications and will include perimeter containment to prevent the release of unfiltered sediment from the temporary staging and stockpiling area.
- Debris stockpiles will need to be covered to protect them from the weather. The contractor will determine the means and methods for containment, subject to review and approval.
- The upland staging area will be isolated from surface water using standard erosion and sedimentation controls, such as filter fence barriers and/or lined ecology block walls or berms.
- Catch basins beneath stockpiles will be sealed.
- Other catch basins within the upland staging area but not directly beneath stockpiles will be protected with a below-grate inlet device (BGID) to collect sediment and debris from stormwater prior to discharge. The BGID will be inspected and maintained on a regular basis.
- The contractor will be required to maintain a clean upland staging area to prevent vehicles from tracking contaminated soil or sediment off-site.
- Trucks will be loaded within the established temporary staging and stockpiling areas so that stockpiled materials are contained within the area. Any spilled material will be immediately picked up and deposited in the appropriate stockpile area.
- The contractor will be required to provide a wheel/truck wash to ensure that no contaminated materials are tracked off-site onto public roads.
- Equipment will be fueled in a designated area that separates fueling operations and protects the environment from accidental spills during fueling.
- The contractor will maintain a spill kit on-site in the event a leak develops from their equipment. In the event of a spill, all other work will stop until the contractor has adequately cleaned the spill.

5.1.1 Stockpile Soil Management

Excavated and dredged materials will be segregated into approximate 1,500-cy stockpiles for ex situ sampling and contaminant of concern (CoC) analysis. The results of this testing will be used to verify that CoC concentrations meet suitability requirements, which will determine their ultimate disposition (e.g., beneficial re-use, upland containment, or off-site landfill disposal). Excavated or dredged materials that are determined to be unsuitable for upland containment or beneficial reuse in local uplands will be disposed at a permitted landfill or approved recycling facility.

Clean rock materials identified as suitable for replacement on the shoreline as armor material will be stockpiled separately and not subject to testing. Discrete stockpile areas will not be co-mingled until characterization of stockpiles has been completed. Ex situ sampling will consist of the following:

- One five-point composite sample will be collected and analyzed per each approximately 1,500-cy pile.
- The five discrete subsamples will be collected at approximately equidistant locations around the perimeter of each stockpile.
- Composite samples will be analyzed for CoCs including PAHs, dioxins/furans, and cadmium. Preliminary data results are expected to be available within 4 weeks of sample submittal to the laboratory.

Results of the ex situ sampling will be compared against suitability criteria for beneficial reuse in local uplands, upland containment, or permitted off-site landfill disposal or recycling facility, consistent with permitting requirements and other approvals.

5.1.2 Stockpile Water Management

5.1.2.1 Contaminant Transport

To ensure continued protection of underlying groundwater and adjacent nearshore sediments and surface waters following placement of dredged and excavated sediments/soils within the Mill Site uplands stockpile area, contaminant transport modeling was performed to calculate CoC concentrations in groundwater at equilibrium (i.e., conservatively assuming extensive contact time between soil and groundwater). The input assumptions and models used in this evaluation are more specifically described in Appendix B.

Partitioning of CoCs between sediments/soils and groundwater (anticipated to be present as an unsaturated phase within the Mill Site uplands stockpile area) is described by chemical-specific equilibrium partition coefficients (K_d), using the customary $K_d = f_{OC} * K_{OC}$ approach, where K_{OC} is the compound's organic carbon partition coefficient and f_{OC} is the organic carbon content of the placed sediment/soil material. For this analysis, PAH and dioxin/furan K_{OC}s were calculated based on the relative contributions of the individual PAH compounds and dioxin/furan congeners that contribute to measured TEQ concentrations, using validated sediment and soil sampling and analysis data collected at the Mill Site over the past 10 years. The contaminant transport model is described in detail in Appendix B.

Equilibrium groundwater CoC concentrations were calculated for prospective dredged and excavated soils/sediments, and are summarized in Table 5-1. Importantly, equilibrium groundwater cPAH TEQ, dioxin/furan TEQ, and naphthalene concentrations within or below prospective dredged and excavated sediments/soils at the Mill Site are all below conservative MTCA Method B criteria for drinking water use of such groundwater. The maximum concentration of cadmium in prospective dredged/excavated materials (1.2 mg/kg) is below the natural sediment background level of 3 mg/kg (Ecology 2013); therefore, cadmium is not a potential CoC for the Mill Site uplands stockpile area groundwater transport pathway.

Table 5-1
Summary of Predicted Equilibrium CoC Concentrations in Groundwater

Parameter	cPAH TEQ (µg/L)	Dioxin/Furan TEQ (pg/L)	Naphthalene (µg/L)
Groundwater Criteria [1]	**0.012**	**0.67**	**160**
Predicted Concentration Within or Below Prospective Dredged and Excavated Mill Site Sediments/Soils			
Subtidal Sediments	0.0024	0.0065	23
Intertidal Sediments	0.0094	0.097	14

Notes:
1 MTCA Method B groundwater cleanup levels for drinking water use

To further ensure that placement of dredged and excavated sediments/soils within the Mill Site uplands stockpile area is also protective of adjacent nearshore sediments, steady-state contaminant transport modeling was performed using the predicted equilibrium groundwater CoC concentrations summarized in Table 5-1. The results of this modeling evaluation, which are described in detail in Appendix B, reveal that such groundwater inputs would result in long-term cPAH TEQ concentrations in shoreline sediments (0 to 2 feet) of approximately 3 μg/kg, which is well below the 16 μg/kg site-specific sediment cleanup standard. Similarly, groundwater dioxin/furan inputs would result in long-term dioxin/furan TEQ concentrations in shoreline sediments of approximately 0.3 ng/kg, which is well below the 5 ng/kg site-specific sediment cleanup standard. Since both of these site-specific sediment cleanup standards are based on natural background concentrations, surface water quality standards for these CoCs will also be met (Ecology 2013). For naphthalene, the groundwater (drinking water-based) criterion is more restrictive than the surface water quality criterion/standard.

Based on these evaluations, placement of dredged and excavated sediments/soils within the Mill Site uplands would provide continued short and long-term protection of underlying groundwater and adjacent nearshore sediments at the Mill Site, consistent with remedial action objectives set forth in the CAP (Ecology 2013).

5.1.2.2 Stockpile Water Management

As discussed in Section 5.1.2.1, the infiltration of water from stockpiles into groundwater is protective of underlying groundwater and adjacent sediments and surface water, and accordingly, the primary water management tool for the stockpile area will be infiltration. As necessary, the contractor will demolish or perforate impermeable surfaces within the stockpile areas to allow for infiltration of interstitial water from sediments, as well as run-on from rainfall. Where infiltration alone cannot accommodate water from the stockpile area, excess water will be collected in one or more sumps. Sumps will provide a water sample collection point, and will be provided with an emergency overflow drain outlet to the adjacent surface waters. In the event that the emergency overflow is needed, a sample of the water from the sump will be collected and tested for temperature, dissolved oxygen, pH, and salinity prior to the use of the overflow. Test results will be compared to Marine Surface Water Quality standards for Excellent Quality in accordance with WAC 173-201A-612, Table 612, and water will be managed as described in Table 5-2. If discharge standards cannot be met, water will be stored in a temporary holding tank and treated to meet the standard prior to discharge.

Table 5-2
Decision Tree for Water Test Results

Analyte	Standard	Outcome
Temperature	> 60.8 F	Collect background temperature measurement in bay (T, measured in degrees Celsius). Measure incremental temperature increase at mixing zone boundary. If increase at mixing zone boundary exceeds 12/(T-2) as a result of discharge, cease discharge.
	≤ 60.8 F	Discharge allowed, provided other test results are in compliance.
Dissolved oxygen	≥ 6.0 mg/L	Discharge allowed, provided other test results are in compliance.
	< 6.0 mg/L	Collect background dissolved oxygen measurement. Measure dissolved oxygen at mixing zone boundary. If dissolved oxygen at mixing zone boundary is below standard or below background – 0.2 mg/L (whichever is lower) as a result of discharge, cease discharge.
pH	7.0 ≤ pH ≤ 8.5	Discharge allowed, provided other test results are in compliance.
	pH < 7.0 or pH > 8.5	Discharge not allowed.
Salinity	No standard	No trigger; monitored to assess potential soil placement offsite once salinity levels have dropped.

5.1.2.3 Stormwater Management

A National Pollutant Discharge Elimination System (NPDES) construction stormwater general permit has been obtained for upland construction activities at the Site. Stormwater will be managed according to permit conditions. The contractor will prepare a stormwater pollution prevention plan (SWPPP) that meets conditions of the permit and describes the BMPs that will be employed to minimize generated waters and ensure compliance with applicable water quality criteria and discharge requirements. The SWPPP will:

- Identify potential sources of pollution that may be reasonably expected to affect the quality of stormwater discharge from the work area
- Describe and ensure implementation of practices that will be used to reduce the pollutants in stormwater discharge from the work area
- Ensure compliance with terms of the State of Washington general permit for construction stormwater discharges as applicable
- Identify applicable BMPs for stormwater management

The contractor will not allow stormwater to directly discharge to the bay. The contractor will install and operate an appropriate system for management of construction water generated during the work, as discussed in Section 5.1.2.2. The contractor will use structural devices, such as hay bales, silt fences, and catch basin inserts, to filter or divert stormwater as needed.

5.2 Upland Containment Placement Area

If excavated or dredged material is unsuitable for beneficial reuse in local uplands, this sediment will be placed within a prospective containment area located within upland property owned by PR/OPG (Model Airplane Field [MAF]; see Figure 8a). The upland containment area may be located immediately adjacent to the MAF dredged sediment beneficial reuse area utilized in the 2007 interim action at the Site. While the MAF was selected for developing this EDR, alternate upland containment locations may be identified as project placement and containment details are finalized and subject to future land use determinations. The upland placement area will be constructed consistent with permitting and scheduling requirements and subject to Ecology approval. Construction activities will be performed using standard earth moving equipment. All activities will comply with the BMPs described in Sections 4.5 and 4.7.

5.2.1 Clearing, Grubbing, and Grading

Clearing, grubbing, and grading will be performed to provide appropriate subgrade for berm construction (if necessary), liner installation (if required), and receipt of excavated or dredged material.

The prepared subgrade will be firm and unyielding, and will be compacted to a level that permits the movement of construction equipment, liner deployment equipment, and other related traffic without causing rutting and/or deformation of the surface.

5.2.2 Berm Construction

A perimeter berm will be constructed, if necessary, to allow for a level surface of excavated and dredged material to be placed. The berm will be constructed consistent with applicable guidance documents. Additional engineering evaluations for any perimeter berms will be provided in a supplemental design deliverable. The equipment and methods for material placement activities will be described in the Construction Specifications and contractor work plan.

5.2.3 *Liner*

If a liner is required at the upland containment area, liner panels will be joined by seaming, welding, providing sufficient overlap, or other methods specified by the manufacturer. The liner will be anchored using an anchor trench or similar method specified by the manufacturer. The liner will be inspected prior to placement of dredged material. Alternate materials that meet the design requirements may be approved by the permitting authority.

5.3 Leachate and Stormwater Management

Within the first year following placement of excavated and dredged materials within temporary stockpiles, saline leachate is anticipated to be rinsed from the sediment by rainfall, and through application of additional water if necessary. Based on monitoring data collected during the 2007 interim action, leachate from rinsing is anticipated to have the following water quality characteristics:

- Temperature: 12 to 19 degrees Centigrade
- Salinity: 0.5 to 26 parts per thousand (ppt)
- Dissolved oxygen: 7 to 10 milligrams per liter (mg/L)
- pH: 7.4 to 7.7
- DIN: 0 to 20 µg/L

During the 2007 interim action, leachate from the dredged material stockpiles was discharged directly into what is now the SMA-2 area without treatment. After a period of 6 to 9 months following the 2007 dredging, salinity levels in the temporary stockpile leachate were low enough that offsite beneficial reuse of the dredged sediment was implemented.

During development of the upland containment facility, stormwater will be managed in accordance with the requirements of a forthcoming NPDES construction stormwater general permit. The handling, transport, and treatment (if necessary) of leachate generated by the upland containment facility will be managed in compliance with State Surface Water Quality standards and substantive or applicable permit requirements.

5.4 Haul Routes

Traffic impacts associated with cleanup project construction activities will be mitigated to the extent practicable. This will include limiting barge transport through Port Gamble Bay to the extent practicable, and where appropriate transporting construction materials to and from the Site using designated truck haul routes. Flaggers will be used if necessary to ensure traffic safety.

An estimated 5,000 to 6,000 truck round trips may be required between the Mill Site uplands through the Town Center of Port Gamble to transport dredged material to the upland containment area; however, if this material is beneficially re-used at the former Mill Site, trucking of excavated and dredged material through the Town Center would not be necessary. Delivery of clean aggregate materials would potentially require additional round trips (up to 13,000 to 14,000 additional truck and trailer trips), unless the movement of dredged material can be sequenced with the delivery of capping material to minimize empty truck trips. The actual number of trips needed will be dictated by the size of the trucks used, and whether additional capacity can be provided with dump truck trailers (also known as "pups"). Haul routes are shown in Figure 8a.

An alternative to the haul routes shown in Figure 8a would be to construct a road directly from the Mill Site upland to Route 104, thereby bypassing the Town Center of Port Gamble. However, this would require significant earthwork along the bluff at the south end of the Mill Site. Alternatively, a hydraulic pipe or conveyor system could potentially be used to transport material from the Site to the MAF, thereby minimizing hauling traffic in the area. While preliminary evaluations of these alternatives suggest that these options are unlikely to be practicable for the cleanup project, these options will continue to be considered as final designs for the cleanup project are developed. If such alternative designs are carried forward, they would be developed to prevent loss of material during the transport process.

5.5 Hours of Operation

The temporary stockpile and staging area is zoned "rural historic town waterfront." The majority of the uplands in the Town of Port Gamble are rural historic town commercial or residential. The areas around the bay are "rural wooded" or "rural residential" and the Port Gamble S'Klallam Tribe reservation is zoned as "tribal land." As such, additional noise limitations apply between the hours of 10 pm and 7 am. Construction activities are likely to occur between 7 am and 10 pm, 6 days per week, but could occur up to 24 hours per day, 7 days per week, to meet the required project schedule. Coordination has occurred with Ecology and the Port Gamble S'Klallam Tribe during project design, to plan for potential overnight work in order to meet schedule requirements.

5.6 Temporary Site Controls

Upland temporary facilities will be controlled by the contractor with respect to safety, noise, dust, security, and traffic. The construction site will be closed to the public at all times.

Temporary erosion and sediment control (TESC) BMPs will be employed to prevent pollution of air and water and control, respond to, and dispose of eroded sediment and turbid water during construction. TESC BMPs will be employed in all work areas, equipment and material storage areas, stockpiles, and haul areas.

5.7 Other Environmental Considerations

Other environmental considerations associated with upland staging and stockpiling activities include the following:

- Coordination with upland cleanup projects: Monitoring wells or other remediation or monitoring equipment that may be located within the upland work areas will either be protected or will be appropriately abandoned prior to implementation of the work. Methods for protection or abandonment will be reviewed and approved by Ecology prior to implementation.
- Control of fugitive dust: The contractor will control fugitive dust from the stockpile and staging areas using appropriate BMPs. The tracking of soil or dust off-site will be controlled.

Final permitting documents may require additional environmental considerations that will be included as part of the final design.

6 SMA-1 (MILL SITE NORTH) CLEANUP DESIGN

6.1 Pre-Design Investigation Data

PDI sampling activities were conducted to further delineate remedial action boundaries in SMA-1 (Appendix A). A summary of the results of the PDI sampling in SMA-1 is as follows (see Figure 9a):

- Surface and near-surface porewater sulfide concentrations at DGT sampling station B6a exhibited elevated sulfide levels. All other porewater sulfide DGT results in SMA-1 were relatively low or non-detect.
- Two cores (PG-PDI-16 and PG-PDI-17) were advanced and analyzed to bound the extent of wood waste in SMA-1. All sediment samples from both cores had TVS concentrations less than 15%.
- Five subtidal cores were advanced to further refine the vertical extent of wood waste in SMA-1. Sediment TVS concentrations below 15% were observed at the following elevations in each core:
  - PG-PDI-SC-01: approximately -20 feet MLLW
  - PG-PDI-SC-02: approximately -19.5 feet MLLW
  - PG-PDI-SC-03: approximately -14.5 feet MLLW
  - PG-PDI-SC-04: TVS did not exceed 15% at any elevation in this core
  - PG-PDI-SC-20: approximately -16.5 feet MLLW

6.2 Demolition and Disposal Design

6.2.1 Structure Removals and Demolition

Existing overwater structures will be removed during the demolition, concurrent with creosote-treated pile removal activities. Figure 10 shows a number of structures that will be removed prior to excavation, dredging, and capping in SMA-1. Overwater structures totaling an area of approximately 5,500 square feet in SMA-1 include the following structures composed of creosote-treated decking, creosote-treated piles, and support timbers:

- Log transfer dock
- Conveyor/pier

Creosote-treated timbers will be removed as part of demolition. In addition, as necessary to facilitate intertidal excavation and/or capping, shoreline debris (including concrete and asphalt rubble and rebar and other metal debris) will be removed as part of demolition.
A combination of upland and in-water demolition equipment is anticipated to be used for the removal of these structures.

6.2.2 Demolition Quantities

Creosote-treated piles, and the structures they support, will be removed as practicable based on the protocols established during the initial pile removal pilot demonstration as the first phase of cleanup work to be performed in SMA-1. The pile and structural removal area shown in Figure 10 contains an estimated 1,700 creosote-treated wood piles of variable length and diameter, most with less than 3 feet exposed above the current sediment surface (see Section 4.2). Pile counts were developed from bathymetric surveys, aerial photographs, visual observations and test pits, observations during prior dredging at the Site, and initial contractor discussions. An estimated 700 tons of creosote-treated piles and supported structures will be removed and disposed of off-site at a permitted landfill.

6.2.3 Demolition Debris Offload, Transport, and Disposal

Creosote-treated debris and demolition materials will be disposed in a permitted landfill or recycled in accordance with WAC 173-303-071(3)(g)(ii). Final transportation to the disposal or recycling facility may occur by barge, rail, or truck, depending on the selected facility and the transportation logistics selected by the contractor. Examples of permitted landfills that have historically managed creosote-treated debris include the Waste Management landfills in Wenatchee, Washington, and Arlington, Oregon; the Allied Waste facility located in Roosevelt, Washington; and the Cowlitz County facility located in Castle Rock, Washington. Other facilities may be utilized for material disposal or recycling, provided that they meet relevant permitting requirements.

Clean concrete debris generated during removal of concrete debris along the shoreline may either be crushed on-site and stockpiled for on-site reuse, or transported to appropriately permitted concrete recycling facilities.

The contractor will be required to transport creosote-treated debris from the Site to the landfill or recycling facility. The contractor will be responsible for providing an appropriate offload facility and the transportation logistics to move this debris from the demolition areas to the disposal site. This may include use of the staging areas as shown in Figure 8a, or alternative locations. The contractor will be required to barge or haul debris to the designated offload point. Transloading, staging, stockpiling, and dewatering methods will comply with the BMPs summarized in Sections 4.5 and 4.7. Transportation between the offload point and the final disposal or recycling site may include barge, truck, or rail transportation, or a combination thereof.

6.3 Excavation and Dredging Design

Intertidal excavation and subtidal dredging actions will be performed within SMA-1. Dredging activities will be performed using mechanical dredging equipment, and excavated/dredged sediment and debris will be handled at an on-site transload facility for upland beneficial reuse, containment, or disposal at a suitable DMMP open-water disposal site or upland permitted off-site landfill. This section describes the excavation and dredge prism design criteria used throughout SMA-1, and documents the basis for dredging equipment selection. Descriptions are then provided for excavation, dredging, and associated activities for SMA-1, including assumptions for residuals management, material staging, offloading, and upland containment design.

6.3.1 Intertidal Excavation Prism Design

The shoreline bank excavation in SMA-1 will occur over a total distance of approximately 1,330 linear feet, extending along the entire SMA-1 shoreline. The bank excavation extends from the top of the existing bank from approximately +13 feet MLLW at the highest point down to +0 feet MLLW. The lower elevation range was selected based on tidal variations and the reach length of typical long-reach excavators, considering that excavation in the dry is a key criterion for intertidal areas. The design excavation requires a minimum 2-foot cut below mudline to accommodate a post-excavation cap, resulting in the removal of approximately 2,500 cy of intertidal sediments over a footprint of approximately 0.8 acre.

Based on similar excavation projects in Puget Sound, the contractor is expected to be able to excavate approximately 150 cy per day in intertidal areas. Based on the volume of intertidal excavation in SMA-1, the duration of this task is expected to be approximately 17 days.

The design excavation will achieve final slopes of 3H:1V or flatter. Excavation will occur in intertidal areas during low tides to facilitate doing this work "in the dry". If the contractor cannot complete intertidal excavation and confirm that required excavation elevations have been achieved "in the dry" prior to the next incoming tide, the contractor will be required to place and secure a temporary geotextile to minimize the potential for sediment resuspension during submerged conditions. The geotextile layer will be used as a temporary measure to minimize the potential for sediment resuspension during submerged conditions of the intertidal excavation. The geotextile would be removed at the start of the subsequent "dry" excavation period.

There may be cost-effective opportunities for beneficial reuse of shoreline rock material generated during the cutback of the shoreline in SMA-1. Specifically, armor material that is free of concrete, bricks, plastic, or other unsuitable debris may be excavated, stockpiled, and reused as erosion protection in SMA-1 and SMA-2 provided that the size and durability of the rock is compatible with the requirements determined in the Appendix D hydrodynamic evaluation.

6.3.2 Subtidal Dredge Prism Design

Subtidal dredge prisms were designed based on the extent of sediments exceeding Site-specific cleanup levels, combining the RI/FS and PDI data. Other considerations used to develop the subtidal dredge prism designs included geotechnical evaluations of slope stability, locations, and characteristics of adjacent structures, and the typical precision and accuracy of dredging equipment that will be utilized to implement the work.

The horizontal extent of the dredge prism was designed based on surface and near-surface sediment sampling data as shown in Figures 9a through 9d. The vertical extent of the subtidal dredge prism was designed based on sediment coring data, supplemented with geophysical (sub-bottom profiling) data to assist in interpolation between core locations.

Consistent with the CAP, the bottom of the dredge prism was designed to correspond to elevations where sediment TVS concentrations are below 15%.

The SMA-1 neatline dredge plan is shown in Figures 9a through 9d and the Construction Drawings (Appendix J). The SMA-1 neatline dredge volume is approximately 12,500 cy, extending over a footprint of approximately 2.5 acres. The contractor will be provided with a payable overdredge allowance of 0.5 foot below the neatline elevation and a maximum overdredge allowance of 1 foot below the neatline elevation, resulting in an additional 2,000 to 4,000 cy of potential overdredge volume, for a total subtidal dredge volume of 14,500 to 16,500 cy.

Based on similar dredging projects in Puget Sound, the contractor will likely dredge on average 500 to 750 cy per day. Based on the volume of removal in SMA-1, the duration of subtidal dredging is expected to be 20 to 33 days.

The total amount of sediments removed from SMA-1 will be measured by computing the difference in volume between the bottom surface as shown by the soundings of the pre-dredge survey and the bottom surface as shown by the soundings of the post-dredge survey. This volume will be used to calculate the volume of sediment that was dredged by the contractor.

6.3.2.1 Unavoidable Impacts to Eelgrass

A narrow, moderate density eelgrass bed roughly in the middle of the SMA-1 subtidal dredge area cannot be practicably avoided and will be removed during the cleanup project. Sequencing remedial actions to begin in SMA-1 (see Section 4.1) will allow eelgrass turions within this area to be transplanted to colonize clean sediments placed several months earlier in SMA-2 (see Section 11). Eelgrass transplanted from SMA-1 to SMA-2 will be placed into the SMA-2 mitigation area at suitable elevations, between approximately -9 and -10 feet MLLW, and adjacent to areas where thriving eelgrass are documented (see Section 2.2.6).

6.3.3 Verification Monitoring and Certification

Water quality monitoring will be conducted to assess contractor compliance in meeting relevant standards to be issued in the project permits. In addition, progress surveys will verify that required dredge elevations have been met; in locations where required elevations have not been achieved, the contractor will be required to remove additional material. Certification units (CUs) will be used for assessing compliance with elevation targets and excavation/dredging thickness removal. CUs will be sized to reflect approximately 1 week of construction work. Subject to refinement during development of the contractor's work plans, CUs will be sized approximately as follows:

- For SMA-1 intertidal excavations, each CU will be approximately 17,500 square feet, for a total of two CUs in the SMA-1 intertidal area.
- For SMA-1 subtidal dredging, each CU will be approximately 27,500 square feet, for a total of four CUs in the SMA-1 subtidal area.

Additional details of verification sampling and certification are provided in the CQAP (Appendix E).

6.3.4 Management of Dredging Residuals

Residuals management cover material will be placed within the SMA-1 dredge area following completion of dredging activities to manage the unavoidable thin veneer of dredging residuals that is expected to remain at the sediment surface. The quantity and quality of dredge residuals varies depending on the dredge material properties, the presence of debris, and other factors (USACE 2008a, 2008b). The placement of a clean cover layer to manage dredging residuals accelerates the natural recovery process in the biologically active zone. This strategy was effectively demonstrated during the 2007 interim action in SMA-2 (Hart Crowser 2007).

Residuals cover material will be placed within dredge areas located in SMA-1 as shown in Figure 9a. An average 6-inch-thick layer of residuals cover material (clean sand) will be placed to manage anticipated dredge residuals generated by dredging activities.

6.3.5 Sediment Offload, Staging, Transport, Beneficial Reuse, and Disposal

Excavated and dredged sediment from SMA-1 that is suitable for beneficial reuse will remain on site. If not suitable for beneficial reuse, sediment will be transported and placed at the nearby upland containment area, an alternate containment location, or a permitted landfill as discussed in Section 5.2. Final transportation to the placement area may occur by truck or alternate method depending on the logistics selected by the contractor.

Sediment that is determined by the Dredged Material Management Office (DMMO) to be suitable for open-water disposal will be transported by barge and disposed of at a suitable open-water disposal site such as the Port Gardner or Elliott Bay non-dispersive DMMP disposal site after larger wood and debris greater than 2 feet in any dimension is removed. The current design dredge cut elevations and volumes assume no open water disposal.

Creosote-treated debris and other materials not suitable for beneficial reuse will be managed by upland disposal in a permitted landfill or approved recycling facility. Materials sent for permitted upland landfill disposal would be barged off-site to a permitted transloading location, likely in a metropolitan location with deep water barge berth access such as Everett, Seattle, Tacoma, or Olympia. The contractor's proposed transloading location will need to be permitted for such use, and will be subject to review and approval. The transloading location will be set up to offload materials from the project in a manner that prevents loss of materials to the water (such as spill plates), and will provide containment of materials prior to off-site shipping by truck and/or rail to the permitted landfill.

6.4 Engineered Cap Design

This section summarizes the design for engineered sediment caps to be constructed within intertidal and subtidal regions of SMA-1. Work to be performed in SMA-1 also includes removal of creosote-treated piles and structures, dredging, and shoreline modifications, as generally depicted in Figure 9a. The SMA-1 cap designs are summarized in Figure 9a and the Construction Drawings (Appendix J).

Cap design analyses were performed in accordance with USEPA and USACE *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al. 1998). The design thicknesses of the engineered caps were developed based on evaluations of contaminant mobility, bioturbation, erosion protection, future maintenance, construction tolerances, and geotechnical considerations. Sections 6.4.1 through 6.4.3 discuss basis of design criteria for intertidal and shallow subtidal caps in SMA-1.

6.4.1 Intertidal and Shallow Subtidal Capping

Following intertidal excavation, an engineered cap will be placed to control contaminant exposure to humans and the environment and to provide suitable habitat for benthic organisms and forage fish. Sections 6.4.1.1 through 6.4.1.4 summarize the intertidal engineered cap design.

6.4.1.1 Contaminant Mobility

The engineered cap design addresses contaminant mobility by developing a chemical isolation or attenuation layer that is typically placed directly above the contaminated sediment surface. Design of an effective chemical isolation layer includes consideration of the movement of contaminants driven by advection and molecular diffusion. The cap thickness was designed so that the engineered cap will effectively reduce the migration of contaminants into surface sediments and also physically isolate the contaminants from the benthic environment.

As discussed in more detail in Appendix B, the SMA-1 engineered caps have been designed to ensure that surface cap materials that overlie contaminated sediments and buried creosote-treated piles that may remain in intertidal and shallow subtidal areas of the Site (i.e., sediments and piles that cannot be practicably removed) are maintained below Site-specific sediment cleanup levels. Moreover, the cap designs were developed using upper-bound estimates of subsurface contaminant (especially cPAH) concentrations, including creosote-treated piles. For example, the upper-bound subsurface cPAH TEQ concentration assumed to remain in the former SMA-1 wharf areas (2,174 µg/kg) is approximately 25 times higher than the average cPAH TEQ concentration measured in sediments and bank soils (87 µg/kg; Appendix A), reflecting buried creosote-treated piles that may remain as a subsurface cPAH source. Thus, cap design specifications developed to be protective in areas with buried creosote-treated piles will also ensure protection in other intertidal and shallow subtidal areas of SMA-1 with lower subsurface contaminant concentrations.

The one-dimensional steady-state model of chemical transport within sediment caps developed by Lampert and Reible (2009; see also Reible 2012) was used for this design evaluation, consistent with current USEPA (2005) Superfund guidance. As discussed in Appendix B, the Reible (2012) model makes the conservative assumption that the underlying sediment porewater concentration remains constant over time (i.e., infinite source). The Reible (2012) model has been used to support the evaluation and design of sediment caps at numerous Superfund sediment cleanup sites throughout the United States and at MTCA sites in Washington.

The cap design evaluated herein consists of a mixture of sand, gravel, and cobble, similar to the existing sediment substrate present in the former wharf area and throughout much of the intertidal area of SMA-1. While these coarse sediment and armor materials have relatively little adsorptive capacity, they provide physical separation from underlying buried creosote-treated piles and associated sediments, limiting diffusive flux of chemicals by reducing the concentration gradient within the cap, improving cap effectiveness. The model was used to develop protective chemical isolation cap designs to maintain surface cPAH concentrations below the 16 μg/kg TEQ natural background sediment cleanup level at steady-state. To ensure the protectiveness of caps that are overlying buried creosote-treated piles that cannot be practicably removed, the cap design includes a layer containing an adsorptive amendment in the form of bulk sand blended with organoclay (50% by weight organoclay) that will underlie the sand, gravel, and cobble cap as described in Section 4.2.1. A detailed description of the cap modeling analysis is presented in Appendix B.

The cap design thickness was calculated to ensure that sorbed-phase cPAH TEQ concentrations within the bioturbation zone (vertical average over the upper 24 inches [61 cm] of the cap) would be maintained below the 16 μg/kg natural background sediment cleanup standard defined in the final CAP (Ecology 2013). The results of the modeling indicate that a cap thickness of 24 inches of mixed sand, gravel, and cobble materials, similar to the existing sediment substrate present in the former wharf area, would maintain surficial cPAH TEQ concentrations below 16 μg/kg TEQ under steady state conditions.

The SMA-1 remedy design includes placement of an approximately 1.5- to 2-foot-thick layer of clean sediment (predominantly sand and gravel materials with chemical concentrations below Site-specific cleanup standards) over approximately 3 acres of shallow subtidal sediments in SMA-1 with surface sediment toxicity exceeding SCO biological criteria but without significant underlying wood waste accumulations (TVS less than 15%). Porewater sampling performed in this area during the PDI (i.e., outside of the SMA-1 dredging area; Attachment 2 of Appendix A) confirmed that surface and shallow subsurface sediment porewater hydrogen sulfide concentrations (using DGT analyses) in this SMA-1 capping area are relatively low or non-detect. Thus, cap designs developed to address cPAH and erosion protection will also be protective of potential wood waste degradation exposures. The extent of the SMA-1 sediment cap is depicted in Figure 9a.

6.4.1.2 Avoidance of Eelgrass

As discussed in Attachment 4 of Appendix A, eelgrass and habitat surveys were performed in the prospective SMA-1 sediment cleanup areas. A relatively narrow eelgrass bed (*Zostera marina*) was observed in parts of SMA-1, typically as patchy beds (Figure 9a).

An eelgrass bed of low to moderately density was observed along the southern slope of the rock jetty, between depths of approximately -6 and -12 feet MLLW. The SMA-1 cap design avoids impacts to this developing eelgrass bed by offsetting cap placement at least 10 feet from the edge of the bed. This offset was developed to account for contractor accuracy with the type of equipment required for excavation and capping in the intertidal and shallow subtidal zone, and also to optimize overall cleanup outcomes of the project while maintaining existing native eelgrass beds to the extent practicable. This will result in approximately 5,960 square feet (0.14 acre) of avoided eelgrass impacts in SMA-1.

6.4.1.3 Biologically Active Zone

As discussed in the CAP (Ecology 2013), for intertidal and shallow subtidal sediments in SMA-1, the point of compliance is defined by the upper 24-inch (61-cm) biologically active zone. Bioturbation within the zone depth was incorporated into the chemical isolation cap design modeling (Appendix B).

6.4.1.4 Erosion Protection

In the aquatic environment, caps must be designed to withstand erosive forces generated by wave action and propeller wash, and must be thick enough to provide the required isolation of the material contained by the cap. Design criteria for erosion protection of engineered caps located along the SMA-1 shoreline were based on a combination of impacts from breaking waves on the upper portions of the slope (at and above -1.5 foot MLLW) and vessel operations (propwash) in deeper areas. Design wave conditions were based on the 100-year (based on wind data) recurrence interval storm events (see Appendix D). Design vessels for this area consist of a recreational vessel and a larger commercial cruise vessel (see Section 2.7). Based on the erosion protection evaluation, the D_{50} of the intertidal substrate is 1.2 inch for much of this area, with a larger D_{50} (9 inches) used in more exposed intertidal areas near the mouth of Port Gamble Bay (Figure 11). In subtidal areas, fine gravel (D_{50} of 0.5 inch) will be used on the surface of the cap to resist propwash.

6.4.2 Cap Construction and Tolerances

After dredging and slope cutbacks, the slopes will be capped to create stable sloping caps. Caps to be constructed in SMA-1 intertidal areas will typically be composed of two layers—a sand and gravel filter material, overlain by gravel or larger-sized armor—to isolate underlying contaminated sediments (and buried creosote-treated piles), and concurrently provide erosion protection primarily from wind/wave forces. The cap will consist of a thickness of sand and gravel filter material ranging from 6 to 14 inches and a thickness of armor material ranging from 4 to 18 inches. In higher wind/wave energy reaches of the shoreline, the cap will consist of a nominal 6 inches of habitat substrate material to fill the interstices of the larger armor rock.

The cap isolation design presented in Appendix B indicates that caps with a minimum thickness of 24 inches are needed to control contaminant mobility (in perpetuity). The cap armor design was based on a thickness that is typically 2 times the D_{50} particle size. Based on the armor sizes indicated in Appendix D, armor thicknesses on the order of 4 to 18 inches are required to resist erosion.

Construction tolerances also must be considered in developing design. Armor rock is a natural product, graded in various sizes, and using it to construct to an exact thickness is not practical. An additional tolerance of 6 inches of overplacement will be allowed to ensure that cap thickness requirements are met. Thus, the total cap thickness is expected to range from 2 to 2.5 feet thick in SMA-1 when construction tolerances are added (see Table 6-1).

Table 6-1
SMA-1 Intertidal and Subtidal Cap Design

Cap Type	Filter D_{50} Particle Size (inches)	Minimum Filter Layer Thickness (inches)	Armor D_{50} Particle Size (inches)	Minimum Armor Layer Thickness (inches)	Total Cap Thickness with Construction Tolerance (inches)
Type 1 Cap	0.2	12	1.25	6	24
Type 2 Cap[1]	0.2	6	9	18	30
Type 3 Cap	0.2	12	2.5	6	24
Subtidal Cap	Sand Cap	12	0.5	6	24

Notes:
1 An additional 6 inches of habitat substrate material will be placed over the Type 2 cap.

6.4.3 Cap Monitoring and Maintenance

The caps constructed in SMA-1 will be monitored over the long-term to verify their protectiveness. Monitoring will include periodic bathymetric surveys and comparison with design and as-built conditions. If bathymetric surveys reveal possible cap settlement and/or erosion of cap thickness to below cap design criteria, follow-on sampling would be performed to fully characterize cap conditions and determine appropriate contingency actions as needed. Details of long-term operation, monitoring, maintenance of the caps; contingency actions; and triggers are provided in the OMMP (Appendix F).

7 SMA-2 (MILL SITE SOUTH) CLEANUP DESIGN

7.1 Pre-Design Investigation Data

PDI sampling activities were conducted to further delineate remedial action boundaries in SMA-2 (Appendix A). A summary of the results of the PDI sampling in SMA-2 is as follows (see Figure 12a):

- Surface porewater sulfide concentrations at DGT sampling stations in SMA-2 were elevated in the vicinity of the chip loading structure and at one station each for the southern transects (E and F) at -15 and -10 feet MLLW, respectively. While several near-surface DGT stations contained elevated porewater sulfide concentrations, these areas are currently colonized with moderate- to high-density eelgrass beds (Attachment 4 of Appendix A). The DGT data and eelgrass surveys are discussed in more detail in Section 7.4.
- Two cores (PG-PDI-18 and PG-PDI-19) were advanced and analyzed to bound the extent of wood waste in SMA-2. Some subsurface sediment intervals at PG-PDI-18 contained TVS concentrations above 15%, while all sediment samples from PG-PDI-19 contained TVS concentrations less than 15%.
- Twelve subtidal cores were advanced to further refine the vertical extent of wood waste in SMA-2. Sediment TVS concentrations below 15% were observed at the following elevations in each core:
  - PG-PDI-SC-05: approximately -36.5 feet MLLW
  - PG-PDI-SC-21: approximately -35 feet MLLW
  - PG-PDI-SC-06: approximately -27.5 feet MLLW
  - PG-PDI-SC-07: approximately -21.5 feet MLLW
  - PG-PDI-SC-08: approximately -25 feet MLLW
  - PG-PDI-SC-09: TVS did not exceed 15% at any elevation in this core
  - PG-PDI-SC-10: TVS did not exceed 15% at any elevation in this core
  - PG-PDI-SC-11: approximately -10.5 feet MLLW
  - PG-PDI-SC-12: approximately -20 feet MLLW
  - PG-PDI-SC-13: TVS did not exceed 15% at any elevation in this core
  - PG-PDI-SC-14: approximately -21.5 feet MLLW
  - PG-PDI-SC-15: TVS did not exceed 15% at any elevation in this core

7.2 Demolition and Disposal Design

7.2.1 Over-water Structure Demolition

Existing overwater structures in SMA-2 will be removed during demolition, concurrent with creosote-treated pile removal activities (Figure 10); demolition may be phased to allow the use of Pier 4 and/or Pier 5 by the remediation contractor during the cleanup. Overwater structures totaling an area of approximately 45,000 square feet include:

- Eastern wharf (located between SMA-1 and SMA-2)
- Alder mill loading facility
- Pier 4
- Pier 5
- Timber breakwater

Creosote-treated timbers will be removed as part of demolition. In addition, as necessary to facilitate intertidal excavation and/or capping, shoreline debris (including concrete and asphalt rubble and rebar and other metal debris) will be removed as part of demolition.
A combination of upland and in-water demolition equipment is anticipated to be used for the removal of these structures.

7.2.2 Demolition Quantities

Creosote-treated piles, and the structures they support, will be removed as practicable (based on the protocols established during the initial pile removal pilot demonstration) as the first phase of cleanup work to be performed in SMA-2. The pile and structural removal area shown in Figure 10 contains an estimated 3,400 creosote-treated wood piles of variable length and diameter, many with less than 3 feet of exposure above the current sediment surface (see Section 4.2). Pile counts were developed from bathymetric surveys, aerial photographs, visual observations and test pits, observations during prior dredging at the Site, and initial contractor discussions. An estimated 1,700 tons of creosote-treated piles and supported structures will be removed and disposed of off-site at a permitted landfill or recycling facility.

7.2.3 Demolition Debris Offload, Transport, and Disposal

Offload, transload, and disposal design considerations are the same as those described for SMA-1 (see Section 6.2.3).

7.3 Excavation and Dredging Design

Intertidal excavation and subtidal dredging actions will be performed within SMA-2. Dredging activities will be performed using mechanical dredging equipment, and excavated/dredged sediment and debris will be handled at an on-site transload facility for upland beneficial reuse, containment, or disposal at a permitted off-site landfill. This section describes the excavation and dredge prism design criteria used throughout SMA-2, and documents the basis for dredging equipment selection. Descriptions are then provided for excavation, dredging, and associated activities for the SMA-2 area, including assumptions for residuals management, material staging, offloading, and upland containment design.

7.3.1 Dredge Cut Side Slopes

Dredge cut side slope stability was evaluated as described in Appendix C by identifying a critical cross section in SMA-2 and computing the factor of safety for the dredge cut slope under long-term static and pseudostatic (seismic) conditions. Based on this evaluation, it was determined that dredge cut side slopes of 3H:1V should be used to maintain an adequate factor of safety for long-term conditions.

For the seismic case, the factor of safety is less than 1.0 for a 3H:1V slope, which implies that some slope movement could occur as a result of a significant earthquake. Earthquake-induced slope deformations are estimated to be on the order of 6 inches for a 475-year earthquake (Appendix C). This is a common condition for shoreline slopes in Puget Sound due to potentially significant earthquake loads and typically unconsolidated (loose) saturated sediments along shorelines. The only reasonable mitigation options to entirely prevent earthquake-induced slope movement would be: 1) to reinforce the shoreline with a significant structure such as a bulkhead; or 2) to further flatten side slopes. Neither of these options is considered practicable; a shoreline bulkhead is not compatible with the intended habitat uses in Port Gamble Bay, and further flattening the slopes would either cause major upland land loss, or require more of the target dredged material to be left in place. Thus, the cleanup design presumes that any future earthquake-induced slope movement would be treated as a maintenance-triggering event, where post-earthquake inspection and slope regrading (if necessary) would be conducted.

7.3.2 Intertidal Excavation Prism Design

The shoreline bank excavation in SMA-2 will occur over a total distance of approximately 1,650 linear feet, extending along the entire SMA-2 shoreline. The bank excavation extends from the top of the existing bank from approximately +17 feet MLLW at the highest point down to +0 feet MLLW. The lower elevation range was selected based on tidal variations and the reach length of typical long-reach excavators, considering that excavation in the dry is a key design criterion for intertidal areas. The design excavation requires a 2-foot cut below mudline to accommodate a post-excavation cap, resulting in the removal of approximately 13,100 cy of intertidal sediments over a footprint of approximately 2.5 acres.

Based on similar excavation projects in Puget Sound, the contractor will likely excavate approximately 150 cy per day in intertidal areas. Based on the volume of intertidal excavation in SMA-2, the duration of this task is expected to be approximately 90 days.

The design excavation will achieve final slopes of 3H:1V or flatter. Excavation will occur in intertidal areas during low tides to facilitate doing this work "in the dry" from the land side. If the contractor cannot complete intertidal excavation and confirm that required excavation elevations have been achieved "in the dry" prior to the next incoming tide, the contractor will be required to place and secure a temporary geotextile to minimize the potential for sediment resuspension during submerged conditions. The geotextile layer will be used as a temporary measure to minimize the potential for sediment resuspension during submerged conditions of the intertidal excavation. The geotextile would be removed at the start of the subsequent "dry" excavation period.

There may be cost-effective opportunities for beneficial reuse of shoreline rock material generated during the cutback of the shoreline in SMA-2. Specifically, armor material that is free of concrete, bricks, plastic, or other unsuitable debris may be excavated, stockpiled, and reused as erosion protection in SMA-1 and SMA-2 provided that the size and durability of the rock is compatible with the requirements determined in the Appendix D hydrodynamic evaluation.

7.3.3 Subtidal Dredge Prism Design

Subtidal dredge prisms were designed based on the extent of sediments exceeding Site-specific cleanup levels, combining the RI/FS and PDI data. Other considerations used to develop the subtidal dredge prism designs included geotechnical evaluations of slope stability, locations, and characteristics of adjacent structures, and the typical precision and accuracy of dredging equipment that will be utilized to implement the work.

The horizontal extent of the dredge prism was designed based on surface and near-surface sediment sampling data as shown in Figures 11a through 11d. The vertical extent of the subtidal dredge prism was designed based on sediment coring data, supplemented with geophysical (sub-bottom profiling) data to assist in interpolation between core locations. Consistent with the CAP, the bottom of the dredge prism was designed to correspond to elevations where sediment TVS concentrations are below 15%.

The SMA-2 neatline dredge plan is shown in Figures 11a through 11d and the Construction Drawings (Appendix J). The SMA-2 neatline dredge volume is approximately 36,300 cy, extending over a footprint of approximately 3.4 acres. The contractor will be provided with a payable overdredge allowance of 0.5 foot below the neatline elevation and a maximum overdredge allowance of 1 foot below the neatline elevation, resulting in an additional 3,500 to 7,000 cy of potential overdredge volume, for a total subtidal dredge volume of 40,000 to 43,300 cy.

Based on similar dredging projects in Puget Sound, the contractor could be expected to dredge on average 500 to 750 cy per day. Based on the volume of removal in SMA-2, the duration of subtidal dredging is expected to be 53 to 87 days.

The total amount of sediments removed from SMA-2 will be measured by computing the difference in volume between the bottom surface as shown by the soundings of the pre-dredge survey and the bottom surface as shown by the soundings of the post-dredge survey.

This volume will be used to calculate the volume of sediment that was dredged by the contractor.

7.3.3.1 Avoidance, Minimization, and Mitigation of Eelgrass Impacts

As discussed in Attachment 4 of Appendix A, eelgrass and habitat surveys were performed in the SMA-2 sediment cleanup areas. A dense eelgrass bed was observed in the southern portion of SMA-2 between depths of approximately -3 and -10 feet MLLW. The project will avoid impacts to the majority of the high-density eelgrass bed in the southern portion of the Site (approximately 90% areal coverage). To avoid potential direct and indirect impacts to this area, a 10-foot offset from excavation will occur on the western edge of the high-density eelgrass bed, and a 15-foot offset from excavation and dredging will occur on the eastern edge of the high-density eelgrass bed (Figures 4 and 5). These offsets are determined based on contractor accuracy with the type of equipment required for excavation and dredging in the intertidal and shallow subtidal zone (10 feet) and deeper subtidal zone (15 feet), and also to optimize overall cleanup outcomes of the project while maintaining existing native eelgrass beds to the extent practicable.

An approximately 500-square-foot area of the high-density eelgrass bed will be unavoidably impacted by subtidal dredging. In addition, north of the highly dense eelgrass bed, eelgrass was found between depths of approximately -2 and -14 feet MLLW, occurring as moderately dense eelgrass. An approximately 19,500-square-foot area of the moderate density eelgrass bed will be unavoidably impacted by subtidal dredging. Eelgrass within the SMA-2 dredging area summarized above and the SMA-1 dredging area summarized in Section 6.3.2.1 will be transplanted to the SMA-2 mitigation area to achieve a minimum 1:1 ratio for direct eelgrass impacts as discussed in Section 2.2.6.

7.3.4 Verification Monitoring and Certification

Water quality monitoring will be conducted to assess contractor compliance in meeting relevant standards to be issued in the project permits. In addition, progress surveys will verify that required dredge elevations have been met; in locations where required elevations have not been achieved, the contractor will be required to remove additional material. CUs will be used for assessing compliance with elevation targets and excavation/dredging thickness removal. Subject to refinement during development of the contractor's work plans, CUs will be sized to reflect approximately 1 week of construction work. CUs will be sized approximately as follows:

- For SMA-2 intertidal excavations, each CU will be approximately 13,400 square feet, for a total of eight CUs in the SMA-2 intertidal area.
- For SMA-2 subtidal dredging, each CU will be approximately 16,500 square feet, for a total of nine CUs in the SMA-2 subtidal area.

Additional details of verification sampling and certification are provided in the CQAP (Appendix E).

7.3.5 Management of Dredging Residuals

Dredge residuals management considerations are the same as described for SMA-1 in Section 6.3.4. Residuals cover material will be placed within dredge areas located in SMA-2 as shown in Figure 12a. An average 6-inch-thick layer of residuals cover material (clean sand) will be placed to manage anticipated dredge residuals generated by dredging activities.

7.3.6 Sediment Offload, Staging, Transport, Beneficial Reuse, Containment, and Disposal

Excavated and dredged sediment from SMA-2 that is suitable for beneficial reuse will remain on site. If not suitable for beneficial reuse, sediment will be transported and placed at the nearby MAF upland containment area, an alternate containment location, or a permitted landfill as discussed in Section 5.2. Final transportation to the placement area may occur by truck or alternate method depending on the logistics selected by the contractor. Creosote-treated debris and other materials not suitable for beneficial re-use or upland containment at the MAF or alternate location will be managed by upland disposal in a permitted landfill or recycling facility (as described for SMA-1 in Section 6.3.5).

7.4 Engineered Cap Design

This section summarizes the basis of design for engineered sediment caps to be constructed within intertidal and subtidal regions of SMA-2. Work to be performed in SMA-2 also includes removal of creosote-treated piles and structures, dredging, and shoreline modifications, as generally depicted in Figure 12a. The SMA-2 cap designs are summarized in Figure 12a and the Construction Drawings (Appendix J).

Cap design analyses were performed in accordance with USEPA and USACE *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al. 1998). The design thicknesses of the engineered caps were developed based on evaluations of contaminant mobility, bioturbation, erosion protection, future maintenance, construction tolerances, and geotechnical considerations. Sections 7.4.1 through 7.4.6 discuss basis of design criteria for intertidal and shallow subtidal caps in SMA-2.

7.4.1 Intertidal and Shallow Subtidal Capping

Following intertidal excavation, an engineered cap will be placed to control contaminant exposure to humans and the environment and to provide suitable habitat for benthic organisms and forage fish. Sections 7.4.1.1 through 7.4.1.3 summarize the intertidal engineered cap design for SMA-2.

7.4.1.1 Contaminant Mobility

The intertidal and shallow subtidal caps designs developed for SMA-2 are equivalent to those described for SMA-1 (see Section 6.4.1), based on detailed contaminant mobility modeling presented in Appendix B. The results of the modeling indicate that a cap thickness of 24 inches of mixed sand, gravel, and cobble materials, similar to the existing sediment substrate present in the former wharf area, would maintain surficial cPAH TEQ concentrations below 16 μg/kg TEQ under steady state conditions. As described for SMA-1, to ensure the protectiveness of caps that are overlying buried creosote-treated piles that cannot be practicably removed the cap design includes a layer containing an adsorptive amendment in the form of bulk sand blended with organoclay (50% by weight organoclay) that will underlie the sand, gravel, and cobble cap.

7.4.1.2 Avoidance of Eelgrass

As discussed in Attachment 4 of Appendix A, eelgrass and habitat surveys were performed in the SMA-2 sediment cleanup areas. A highly dense eelgrass bed was observed in the southern portion of SMA-2 between depths of approximately +3 to -10 feet MLLW. The SMA-2 cap design avoids impacts to the highly dense eelgrass bed by offsetting cap placement at least 10 feet from the edge of the bed.

7.4.1.3 Biologically Active Zone

For intertidal and shallow subtidal sediments in SMA-2, the point of compliance is defined by the upper 24-inch (61-cm) biologically active zone. Bioturbation within this zone depth was incorporated into the chemical isolation cap design modeling (Appendix B).

7.4.2 Deeper Subtidal Capping

To the extent practicable, suitable SMA-2 capping material will be obtained by beneficially reusing clean sediment dredged from regional navigation dredging projects such as the Lower Snohomish River or other maintenance dredge sites that pass DMMO standards. Alternate sources of capping material include commercial quarries, as well as material that might be available from a PR/OPG-owned upland beneficial use site such as the PR/OPG-operated sand pit.

7.4.2.1 Contaminant Mobility

As discussed in the RD Work Plan (Anchor QEA 2104a), protective cap designs for SMA-2 were developed to ensure that surface and near-surface sediment porewater concentrations are maintained below protective levels considering groundwater upwelling, tidally induced transient porewater flow reversal, and geochemical processes in Port Gamble Bay. To support the cap design analysis, probes were advanced along transects in SMA-2 (and also in SMA-1) to characterize dissolved sulfide concentrations in the cap area. Probes were advanced along each transect at mudline elevations ranging from -5 to -30 feet MLLW. At each station, two depths were evaluated: approximately 0 to 6 inches and 2 to 2.5 feet below the mudline. The sampling probes consisted of passive in situ DGT gels, to obtain accurate tidal-average concentrations of dissolved sulfide. The porewater data are summarized in Attachment 2 of Appendix A.

The DGT data reveal that within significant wood waste deposits (TVS greater than 15%) present at mudline depths of less than approximately -20 feet MLLW, the combination of groundwater upwelling, tidally induced transient porewater flow reversals, and geochemical processes can lead to the accumulation of porewater sulfide concentrations that are potentially toxic to benthic organisms and thus pose a potential risk to aquatic life. Accordingly, significant wood waste deposits that occur within areas that have mudline elevations shallower than -20 feet MLLW will be dredged (see Section 7.3).

The DGT data also confirmed that porewater sulfide concentrations in wood waste deposits deeper than -20 feet MLLW were generally lower (highest reported values were 1.0, 1.4, and 2.0 mg/L), likely due to a combination of more limited groundwater upwelling and tidally induced transient porewater flow reversals, as well as greater geochemical processes that control sulfide mobility (e.g., iron precipitation reactions; Rickard and Morse 2005; Canfield 1989; Poulton et al. 2004; Morse et al. 1987). These empirical data reveal that mobility of sulfide in these deeper deposits is adequately controlled, and thus cap designs developed based on erosion protection criteria will also be protective of potential wood waste degradation exposures. The extent of the SMA-2 sediment caps is depicted in Figure 12a.

7.4.2.2 Biologically Active Zone

As discussed in the CAP, for deeper subtidal sediments in SMA-2, the point of compliance is defined by the 3-foot-thick biologically active zone to provide habitat for geoduck, which are an important natural resource in Port Gamble Bay.

7.4.3 Erosion Protection

The design of the erosion protection layer for engineered caps to be constructed along the SMA-2 shoreline was based on the combined impacts from breaking waves on the upper portions of the slope (at and above -1 foot MLLW) and vessel operations (propwash) in deeper areas. Design wave conditions were based on 100-year (based on wind data) recurrence interval storm events (see Appendix D1). Design vessels for this area include recreational boats (Appendix D2).

7.4.4 Geotechnical Evaluation of Caps on Slopes

The engineered caps to be constructed along the SMA-2 intertidal shoreline will follow cutback of the existing slope to provide a stable intertidal and subtidal cap. The geotechnical analysis for the SMA-2 intertidal and subtidal capping areas included a review of the following:

- Stability of the engineered caps placed on slopes
- Filter recommendations for the material underlying the riprap armor areas

A detailed discussion of these analyses is provided in Appendix C. Table 7-1 presents a summary of the results and geotechnical design recommendations for the engineered capping design in SMA-2.

Table 7-1
Geotechnical Evaluation of Engineered Caps

Analysis	Results	Design Conclusions
Slope Stability	The long-term Factor of Safety for slope stability is 1.7, which meets target criteria	Sand layer should be placed with in-water side slopes no steeper than 3H:1V; rock armor may be placed at steeper grades, up to 2H:1V
Seismic Performance	Permanent seismic slope displacements on the order of 6 inches were estimated for the capped in-water slopes	In the event of a major earthquake, caps will be inspected; if damage has occurred due to slope displacement, caps will be repaired

7.4.5 Cap Construction and Tolerances

After dredging and slope cutbacks, the slopes will be capped to create stable sloping caps. Caps to be constructed in SMA-2 intertidal areas will be composed of two-layers—a sand and gravel filter material, overlain by gravel or larger sized armor—to isolate underlying contaminated sediments (and buried creosote-treated piles), and concurrently provide erosion protection primarily from wind/wave forces. In higher wind/wave energy reaches of the shoreline, the cap will consist of 6-inch thickness of filter material overlain by an 18-inch thickness of armor rock material, which will be overlain with a nominal 6 inches of habitat substrate material to fill the interstices of the larger armor rock. Other areas of the shoreline less impacted by wind/wave action a shoreline cap will consist of a 13-inch thickness of filter material and a 5-inch thickness of armor material with a minimum D_{50} particle size of 2.5 inches. Intertidal cap armor D_{50} sizes are shown in Figure 11 for SMA-2.

The cap isolation design presented in Appendix B reveals that caps with a minimum thickness of 24 inches are needed to control contaminant mobility (in perpetuity). The cap armor design was based on a thickness that is typically 2 times the D_{50} particle size. Based on the armor sizes indicated in Appendix D, armor thicknesses on the order of 5 to 18 inches are required to resist erosion.

Construction tolerances also must be considered in cleanup design. Armor rock is a natural product, graded in various sizes, and using it to construct to an exact thickness is not practical. An additional tolerance of 6 inches of overplacement will be allowed to ensure that cap thickness requirements are met. Thus, the total cap thickness is expected to range from 2 to 2.5 feet thick in SMA-2 when construction tolerances are added (see Table 7-2).

Table 7-2
SMA-2 Intertidal and Subtidal Cap Design

Cap Type	Filter D_{50} Particle Size (inches)	Minimum Filter Layer Thickness (inches)	Armor D_{50} Particle Size (inches)	Minimum Armor Layer Thickness (inches)	Total Cap Thickness with Construction Tolerance (inches)
Type 2 Cap[1]	0.2	6	9	18	30
Type 3 Cap	0.2	12	2.5	6	24
Subtidal Cap	Sand Cap	48	NA	NA	54

Notes:
1 An additional 6 inches of habitat substrate material will be placed over the Type 2 cap.

7.4.6 Cap Monitoring and Maintenance

Cap monitoring and maintenance considerations for SMA-2 are similar to SMA-1 (see Section 6.4.3). Details of long-term operation, monitoring, and maintenance of the caps are provided in the OMMP (Appendix F).

7.5 Enhanced Monitored Natural Recovery

As discussed in the CAP, EMNR includes the placement of a thin cover layer of clean silt and/or sand to accelerate natural recovery. Consistent with recent Puget Sound projects, EMNR will include placement of an average 6-inch-thick layer of clean sediment over approximately 7 acres in SMA-2. To the extent practicable, suitable EMNR material will be obtained by beneficially reusing clean sediment dredged from regional navigation dredging projects. Alternate sources of EMNR material include commercial quarries, as well as material that might be available from an upland beneficial use site owned by PR/OPG, such as the PR/OPG-operated sand pit.

PR/OPG has been coordinating with USACE and the Port of Everett to obtain beneficial reuse maintenance dredged material from the Lower Snohomish River during USACE's 2015/2016 maintenance dredging event. The availability of material will be based in part on whether Jetty Island, the typical placement area, needs to be further enhanced with dredged material. Availability is also subject to ongoing discussions with USACE. In the event that sediment from the 2015/2016 maintenance dredging event cannot be used for the Port Gamble Bay cleanup project, opportunities to use material from the 2016/2017 Snohomish River maintenance dredging event will be explored.

Acceptable EMNR placement methods will include spreading from a bottom dump barge (where water depth allows access), or placement using mechanical methods from a material barge, with either a rehandling bucket, skip box, or similar equipment.

Following placement, monitoring will be performed to verify the protectiveness of the EMNR layer. Monitoring will include chemical and bioassay analyses of surface sediments. Details of long-term monitoring of the EMNR area are provided in the OMMP (Appendix F).

8 SMA-3 (CENTRAL BAY) CLEANUP DESIGN

8.1 Pre-Design Investigation Data

As discussed in Section 2.4, during the RI/FS, an approximate 80-acre area located in the south-central portion of Port Gamble Bay exceeded SCO biological criteria, attributable at least in part to the presence of wood waste breakdown products in sediments. As part of the PDI, the four RI/FS stations that delineated the preliminary boundary of SMA-3 presented in the CAP were resampled in August 2014 to inform this EDR. The PDI bioassay data (Attachment 3 of Appendix A) revealed that one of the four stations (BW-19) no longer exceeded SCO biological criteria, reducing the size of SMA-3 for the EMNR remedy to approximately 61 acres.

8.2 Enhanced Monitored Natural Recovery

EMNR material sources, placement methods, and monitoring in SMA-3 (see Figure 13) will be performed in a manner equivalent to that described for SMA-2 (Section 7.5).

9 SMA-4 AND SMA-5 CLEANUP DESIGN

9.1 Pre-Design Investigation Data

As discussed in Section 2.4, during the RI/FS, an approximately 20-acre area located along the western shoreline of the south-central portion of Port Gamble Bay, including portions of the former DNR lease area, exceeded SCO biological criteria, attributable at least in part to the presence of wood waste breakdown products in sediments. As part of the PDI, the three RI/FS stations that delineated the preliminary boundary of SMA-4 presented in the CAP were resampled in August 2014 to inform this EDR. The PDI bioassay data (Attachment 3 of Appendix A) revealed that all three of these stations (BW-12, BW-18, and PGSS-29) no longer exceeded SCO biological criteria, obviating the need for constructing an EMNR remedy in SMA-4.

9.2 Demolition and Disposal Design

Existing creosote-treated piles, dolphins, and structures associated with the former log transfer facility will be demolished. The existing structure is a timber pier and bulkhead measuring approximately 110 linear feet; comprises approximately 160 creosote-treated timbers, timber decking, and a bulkhead; and is shown in Figure 14. Timber piles under the structure and approximately 250 additional piles in the vicinity will be removed using vibratory extraction or cut below mudline using in-water equipment, following the protocols described in Section 4.2.

Soils immediately behind the wooden bulkhead on the west side of the structure will be partially excavated to expose potential existing tie-backs and reduce the load on the bulkhead prior to bulkhead removal. The bulkhead super-structure will be removed completely (as practicable) and if portions are not accessible, they will be cut off at 2 feet below the final mudline for that location. If tie rods exist they will be cut and the portions within the excavation will be removed. Soils removed from the Site will be transported to the Mill Site for temporary stockpiling and characterization, and ultimately placed within a beneficial reuse area or MAF upland containment area depending on soil suitability results (Section 5.2).

9.3 Offload, Transport, and Disposal

Engineering considerations for offloading, transport, and disposal of demolition materials and piles are the same as those described for SMA-1 (Section 6.2).

9.4 Monitoring

As discussed in Section 2.4, SMA-5 is an approximately 600-acre area that encompasses all of the other SMAs, including the originally delineated SMA-4 and that portion of SMA-3 that no longer requires EMNR. The boundary of SMA-5 was developed based on surface sediment cPAH TEQ concentrations exceeding natural background levels. It also includes an area of elevated dioxin/furan TEQ near SMA-3, along with one station at which cadmium exceeds natural background levels.

MNR is the selected remedy for SMA-5. As set forth in the Ecology-approved RD Work Plan, baseline surface sediment chemistry samples were collected and analyzed as part of the PDI (Attachment 3 of Appendix A). Monitoring will include chemical and bioassay analyses of surface sediments. Details of long-term monitoring of the MNR area are provided in the OMMP (Appendix F).

10 INSTITUTIONAL CONTROLS

Prior to completion of construction, an institutional control plan will be developed to ensure the long-term integrity of the engineered capping areas. The institutional control plan, which will be prepared under Ecology oversight, will describe restrictive covenants and other institutional controls (e.g., restricted anchorage areas) as may be needed to ensure the long-term integrity of engineered caps. Future in-water construction activities are also subject to additional project reviews under state and federal permitting authorities (e.g., USACE Section 10/404, Washington State Department of Fish and Wildlife Hydraulic Project Approval, Ecology 401 water quality certification, and Kitsap County permitting requirements). The remedial action described in this EDR anticipates long-term navigation uses and other marine-dependent activities at the Site. The institutional control plan will outline long-term uses and associated maintenance activities, as appropriate.

Restrictive covenants will be filed with Kitsap County upon completion of the active cleanup measures for engineered cap areas. On state-owned aquatic lands, the restrictive covenants will be recorded in DNR's index plates and property files used to track ownership and use activities and may include easements for constructed cap areas. These controls will remain in place indefinitely unless removal is approved by Ecology.

11 COMPLIANCE MONITORING

Monitoring and contingency response actions are an integral part of the cleanup. Compliance monitoring and contingency responses (as needed) will be implemented in accordance with WAC 173-340-410, Compliance Monitoring Requirements. PR/OPG will comply with detailed requirements in the CQAP (Appendix E) and OMMP (Appendix F). The objective of these plans is to confirm that cleanup standards have been achieved, and also to confirm the long-term effectiveness of cleanup actions at the Site. The plans detail the duration and frequency of monitoring, the trigger for contingency response actions, and the rationale for terminating monitoring. The three types of compliance monitoring to be conducted are as follows:

- Protection monitoring to confirm that human health and the environment are adequately protected during the construction period of the cleanup action
- Performance monitoring to confirm that the cleanup action has attained cleanup standards and other performance standards
- Confirmation monitoring to confirm the long-term effectiveness of the cleanup action once performance standards have been attained

Detailed monitoring requirements for the cleanup project are provided in Appendices E and F.

12 IMPLEMENTATION SCHEDULE

This section provides an overview of the anticipated implementation schedule for cleanup construction activities at the Site, including associated monitoring and institutional controls. The preliminary cleanup project construction schedule is presented in Figure 15.

The demolition, dredging, capping, and shoreline stabilization activities described in this EDR are anticipated to be completed within two construction seasons. The targeted start date for construction is during summer 2015, subject to final permitting approvals. Work will begin in SMA-1 or in SMA-2 (working from south to north) with demolition preceding excavation, and intertidal excavation occurring in the dry prior to subtidal dredging. Subtidal dredging will commence on or after November 1, 2015, followed by placement of clean residuals cover, EMNR, and in-water engineered caps. Construction activities will be conducted in a manner that achieves the following goals:

- Provides for a safe work environment
- Protects existing facilities from damage
- Maintains reasonable access and operation for users of the Bay
- Minimizes the potential for recontamination
- Accomplishes the work in a timely manner
- Accomplishes the in-water work during the allowable work windows established in the project permits
- Accomplishes the work in a cost-effective manner

The project work windows, as defined in the final project permits, will govern most in-water work activities. However, some work within the Site may be appropriately initiated prior to the opening of these in-water work windows. Likewise, some work activities may continue after closure of these in-water work windows. Activities that are not subject to in-water work restrictions may include some or all of the following examples:

- Preparation or removal of upland staging and stockpile areas
- Removal of nearshore structures located within project work areas
- Removal of nearshore vegetation, debris, or structures during in-the-dry tidal conditions, subject to applicable permit conditions

- Removal of overwater structures with appropriate BMPs to ensure that no materials enter Port Gamble Bay
- Upland excavations and backfill, including preparatory activities for the development of the upland containment area
- Upland staging or transportation and disposal of dredged materials, soil, debris, and other construction materials

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FIGURES