Final
Cleanup Action Plan
Westman Marine Cleanup Site
Blaine, Washington

Toxics Cleanup Program
Washington State Department of Ecology
Northwest Regional Office
15700 Dayton Avenue North
Shoreline, Washington

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LIST OF ABBREVIATIONS AND ACRONYMS

ARARs	applicable or relevant and appropriate requirements
CAP	cleanup action plan
CL	cleanup level
cm	centimeters
CMP	compliance monitoring plan
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSL	cleanup screening level
CSM	conceptual site model
DCA	disproportionate cost analysis
DNR	Washington Department of Natural Resources
Ecology	Washington State Department of Ecology
EMNR	enhanced monitored natural recovery
IHS	indicator hazardous substance
ft	foot/feet
FS	feasibility study
MNR	monitored natural recovery
MTCA	Model Toxics Control Act
NPDES	National Pollutant Discharge Elimination System
PBT	persistent bioaccumulative toxin
PCB	polychlorinated biphenyl
Port	Port of Bellingham
PQL	practical quantitation limit
PRDI	pre-remedial design investigation
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
SCO	sediment cleanup objective
SCU	sediment cleanup unit
Site	Westman Marine Cleanup Site
SL	screening level
SMA	sediment management area
SMS	Sediment Management Standards
SVOC	semivolatile organic compound
TBT	tributyltin
VOC	volatile organic compound
WAC	Washington Administrative Code
Westman Marine	Westman Marine Inc.

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1.0 INTRODUCTION AND SITE BACKGROUND

This final cleanup action plan (CAP) describes the cleanup action selected by the Washington State Department of Ecology (Ecology) for the Westman Marine Cleanup Site (Site) in Blaine, Washington (Figure 1). The CAP is based on findings of the remedial investigation/feasibility study (RI/FS; Landau 2020) conducted by the Port of Bellingham (Port) under an Agreed Order between Ecology and the Port. Site information includes the following:

Site Name:	Westman Marine
Site Location:	218 McMillan Avenue, Blaine, Washington
Facility Site Identification No.:	66519819
Agreed Order No.:	DE 9001
Effective Date of Order:	April 22, 2013
Parties to the Order:	Port of Bellingham, Washington Department of Natural Resources
Current Property Owner:	Port of Bellingham, Washington Department of Natural Resources

As specified in Washington Administrative Code (WAC) 173 340 380, this CAP:

- Provides a summary description of the Site, history, previous investigations, and current conditions (Section 1)
- Identifies Site cleanup standards (Section 2)
- Summarizes the cleanup alternatives and rationale for selecting the preferred remedy (Section 3)
- Provides implementation details for the preferred cleanup action (Section 4), including:
    - A conceptual summary of each element of the cleanup action
    - The schedule for implementation
    - Compatibility with future Site uses
    - Institutional controls (if necessary)
    - The types, levels, and amounts of hazardous substances that may remain on Site after the cleanup action is implemented, and the measures that will be used to prevent migration of, and contact with, those substances.

1.1 Site Location and Description

The Site is located in Blaine, Washington within Blaine Harbor (Figure 1). Blaine Harbor is at the north end of Drayton Harbor, in the northwest quarter of Section 1, Township 40 North, Range 1 West, Willamette Meridian. Westman Marine Inc. (Westman Marine) leased approximately 1.5 acres of upland Port property at 218 McMillan Avenue for use as a boatyard as well as other operators prior to Westman Marine (Figure 2). Westman Marine and other former tenants have conducted maintenance and repair of marine vessels at the Site, an activity generally referred to in this report as “boatyard activities." These boatyard activities resulted in the release of hazardous substances to Site media, including soil, groundwater, and marine sediment.

The Site boundary, as described in Agreed Order No. DE 9001 (Ecology 2013), is defined by the extent of contamination caused by the release of hazardous substances from Site activities and is not limited to lease area or property boundaries. This includes areas where hazardous substances have been deposited, stored, disposed of, placed, or otherwise have come to be located. The Site has been divided into an Upland Cleanup Unit and Sediment Cleanup Unit, which have different cleanup criteria under Washington State Model Toxics Control Act (MTCA) and Sediment Management Standards (SMS; Chapter 173-204 WAC) regulations. Apart from the vicinity map provided on Figure 1, the plan-view figures in this report are oriented to the northwest. Descriptions of direction in this report will reference project north.

The Site is being cleaned up under the authority of the MTCA, Chapter 70.105D of the Revised Code of Washington (RCW), and the MTCA Cleanup Regulation, Chapter 173-340 WAC.

1.2 Site History and Background

The history of Site development and operations presented in this section is a brief summary of the historical information presented in the RI/FS report (Landau 2020). The summary is based on a review of existing environmental reports related to previous Site investigations and a review of historical aerial photographs taken between 1949 and 2011.

Blaine Harbor was originally created in the late 1930s by dredging 2 acres of tideflats to create a small boat harbor. A road was constructed across the tideflats to access the harbor, and adjacent tidelands were filled to create uplands and provide shore support for the area. In the late 1940s, 4 additional acres were dredged, adjacent tidelands were filled, and a breakwater, bulkheads, floats, and ramps were constructed. The upland area created at the Site generally consists of dredge fill with timber bulkheads along the shoreline. An additional 15-acre area of tideflats was dredged and an extension of the breakwater was completed in the mid-1950s (TEC 2001). An aerial photograph from 1956 (Figure 3) shows the breakwater was extended farther east and improvements to upland facilities were made.

Business activity has historically been focused in the area along the western end of Blaine Harbor in the industrial area, which comprises the upland area shown on Figure 3. A portion of the southwestern end of the harbor includes state-owned lands that are managed by the Port under a Port Management Agreement with the Washington Department of Natural Resources (DNR). The Inner-Harbor Line (shown on Figure 2) defines the boundary between property owned by the Port (east of the Inner-Harbor Line), and property that is owned by the state and managed by the Port under the agreement with DNR (west of the Inner-Harbor Line).

The property at the Site has been leased by the Port to various commercial marine operations to support seafood processing, boatbuilding, and boatyard operations from approximately 1949 to present. Inadvertent releases of contamination occurred during boatbuilding or boatyard operations during this time. It is likely that the contamination, mostly concentrated in areas near the marine railway and sidetracks, was deposited during historical operations, prior to the implementation of the modern operational practices required by the National Pollutant Discharge Elimination System (NPDES), and State Waste Discharge General Permit for Stormwater and Wastewater Discharges Associated with Boatyards (General Boatyard Permit).

1.3 Current Site Conditions, Features, and Uses

The Port supports the local marine industry in multiple ways, including maintaining the critical boatyard capacity in Blaine to support the fishing fleet, which in-turn provides product to the local seafood processors. Figure 4 presents an aerial photograph depicting the general condition of the Site in 2019. The property is currently leased to On-Board Marine Services, which operates the boatyard under the General Boatyard Permit (WAG 030053).

As shown on the figure, the uplands of the Site are bounded on the south and east by surface waters of Blaine Harbor, and to the west and north by other uplands comprising commercial marine industrial properties owned by the Port and leased to various tenants.

1.3.1 Interim Action

In November 2013, a Port tenant, Boundary Fish, began construction activities for a new building in its lease area, located partially within the upland Site boundary. Prior to construction, surface soil samples were collected within the proposed new building footprint as part of a preliminary investigation, and results indicated that copper, mercury, and carcinogenic polycyclic aromatic hydrocarbons (cPAHs) were present in soil at concentrations greater than the Site soil screening levels (SLs). The contaminants were identified in fill in the immediate vicinity of the marine railway sidetracks.

In October 2013, two separate excavation events were conducted as an interim action to remove the identified contaminated soil. After each excavation event, compliance samples were collected to evaluate remaining conditions. In addition to collecting surface soil samples to guide removal efforts and document remaining conditions, several subsurface soil samples were collected using a direct-push boring rig to determine the extent of diesel-range petroleum hydrocarbon contamination surrounding a concrete structure discovered during the initial excavation.

Approximately 420 tons of soil was excavated from the area and temporarily stockpiled nearby on Port property. The soil stockpile was placed on top of plastic sheeting, covered, and secured with sandbags pending offsite disposal. In March 2014, the soil was transported off Site and disposed of at the Roosevelt Regional Landfill in Roosevelt, Washington, completing the interim action. Additional details of the effort were documented in the Interim Action Completion Report (Landau 2014).

1.4 Remedial Investigation and Results

The Port conducted the Site RI in 2013 and 2014, investigating for the presence of constituents of potential concern based on preliminary information from earlier studies and general historical information regarding property usage. The investigation analyzed samples of soil and groundwater for the following:

- Metals (arsenic, cadmium, chromium, copper, lead, mercury, and zinc)
- Semivolatile organic compounds (SVOCs, including naphthalenes and cPAHs)
- Polychlorinated biphenyls (PCBs)
- Organotins (tributyltin [TBT])
- Gasoline-range total petroleum hydrocarbons
- Diesel-range total petroleum hydrocarbons
- Motor oil-range total petroleum hydrocarbons
- Volatile organic compounds (VOCs).

The RI also analyzed sediments in the harbor for the following:

- Metals (arsenic, cadmium, chromium, copper, lead, mercury, silver, and zinc)
- SVOCs (including naphthalenes and cPAHs)
- Total PCBs
- Organotins (TBT)
- Persistent bioaccumulative toxins (PBTs; arsenic, lead, mercury, TBT, naphthalenes, PCBs, and cPAHs).

The contaminants exceeding the SLs established in the RI were carried forward in the RI/FS process, assuming they would need to be addressed through cleanup. These contaminants were subsequently referred to in the RI/FS report as indicator hazardous substances (IHSs). The identified IHSs that exceeded cleanup standards and their associated media are as follows:

- Soil
  - Arsenic, copper, mercury, PCBs, and cPAHs
- Sediment
  - Arsenic, copper, mercury, zinc, PCBs, cPAHs, and TBT.

Figure 5 presents the conceptual site model (CSM) , which describes the mechanisms for contaminant release, distribution, fate and transport, and potential exposure routes. Figures 6 and 7 present the areas where remedial efforts discussed in this CAP will be implemented. The RI determined that the CSM for contaminant release and subsequent distribution was primarily through historical boatyard maintenance operations, which resulted in contaminant release to the ground surface. Shallow soil along the railway sidetracks and throughout large portions of the Site's gravel surface is impacted. Contamination is also present along the marine railway, presumably due in part to historical maintenance activities at this location, and to stormwater runoff washing contaminated soil particles into the marine railway well, where it was later distributed to nearby sediment.

In the upland areas, IHSs are broadly distributed in shallow soil, as shown on Figure 6. The cPAHs, metals, and PCBs in the surface and shallow soil appear to be caused by historical releases from operations at the Site based on their distribution and the IHSs present. The cPAHs, and to a lesser degree arsenic, identified in deeper soil at concentrations exceeding the SLs, appear to be related to poor fill quality prior to boatyard operations. This conclusion is based on the association of contamination with the presence of wood debris in the fill and the lack of a viable migration pathway, based on the CSM, between the area of Site activities and the deeper soil contamination.

In the sediment areas, IHSs are present in marine sediment at concentrations that exceed the SLs (developed based on protection of benthic organisms) in the vicinity of the marine railway well and the travel lift area and extending south about 200 feet (ft) from the shoreline, as shown on Figure 7, defined as sediment management area 1 (SMA-1). Exceedance of the SLs protective of benthic organisms is limited to the immediate vicinity of the marine railway well and travel lift piers. The depth of sediment contamination in these areas is limited to approximately the upper 2.5 ft and does not extend deeper than surface sediment beyond about 100 ft from the shoreline for all IHSs except for PCBs; PCBs exceed the sediment cleanup objective (SCO) in subsurface sediment located approximately 200 ft out from the shoreline.

PCBs and cPAHs are present in marine surface sediment at concentrations above the SLs protective of human health and higher trophic-level species. PCB Aroclor concentrations generally decrease with distance from the marine railway until they are undetectable near the eastern and western harbor boundaries. The concentrations of cPAHs are highest near the marine railway and detected at various concentrations exceeding the SLs throughout the harbor. As described in the RI report, the cPAH distribution is interpreted to indicate that the harbor-wide cPAH concentrations are related to creosote-treated marine infrastructure and not Site releases.

The RI/FS identified two independent Site Units to evaluate cleanup alternatives: the Upland Site Unit and Marine Site Unit. Within the Marine Site Unit, two sediment management areas (SMA-1 and SMA-2) were identified where different remedial technologies may be applied. Alternatives were developed and evaluated for each Site Unit, and a preferred alternative was selected as described in Section 3. The Site Units identified in the RI/FS have been revised in this CAP to be referenced as the Upland Cleanup Unit and Sediment Cleanup Unit. This revised designation has been made primarily to support final definition of the sediment Site boundary based on the PBT results of future

Pre-Remedial Design Investigation (PRDI) activities. Additional PCB congener data will supplement limited existing RI data to address updated human health sediment cleanup levels, as described in Section 2.

2.0 CLEANUP STANDARDS

This section develops Site cleanup standards for IHSs detected in affected Site media (soil and sediment). No IHSs are identified for groundwater, so development of cleanup standards is not required for the medium. Cleanup standards consist of 1) numerical cleanup levels (CLs) defined by regulatory criteria that are adequately protective of human health and the environment, and 2) the points of compliance at which the CLs must be met.

2.1 Numerical Cleanup Levels

The following subsections summarize the development of Site CLs for media of concern at the Site. Table 1 provides a summary of CLs for soil and sediment.

2.1.1 Soil

The CLs for the IHSs identified in soil remain unchanged from the SLs developed during the RI/FS. The soil CLs are protective of human health using applicable risk assessment procedures specified in WAC 173-340-708, based on the reasonable maximum exposure at the Site. Although Site use is commercial and light industrial, soil CLs protective of human health were developed based on the requirements under WAC 173-340-740 for unrestricted land use, which represents a conservative basis for soil CLs given the reduced level of daily exposure associated with commercial and light industrial site use.

MTCA Method B soil CLs protective of direct human contact were determined in accordance with WAC 173-340-740(3) using Ecology's Cleanup Levels and Risk Calculations database (Ecology 2020).

The MTCA Method A soil CLs for unrestricted site use were used to address mercury because a MTCA Method B criterion is not available for that constituent. Some adjustments to CLs were made so that the values were no less than the practical quantitation limit or natural background metals concentrations in accordance with WAC 173-340-730(5)(c).

2.1.2 Sediment

The SMS (Chapter 173-204 WAC) provide a two-tiered approach for developing sediment CLs within an acceptable range of values. The lower limit of this range, the SCO, is the contaminant concentration that represents the goal for protection of human health and the environment. The upper limit of the acceptable range is the cleanup screening level (CSL), which is the maximum allowable concentration to be achieved in any cleanup action under the SMS. The CLs for marine sediment are typically set at the SCO, but could be increased to the CSL, at a maximum, if it is not technically possible to achieve and maintain the SCO and/or if meeting and maintaining the SCO would have a net adverse environmental impact on the aquatic environment. To establish CLs for PBTs, the regional/natural background values or the practical quantitation limits (PQLs) are often considered as their respective CLs.

The CLs for copper and zinc in sediment are established at the SCO (based on the protection of benthic organisms criteria). For those metals that are considered PBTs (i.e., arsenic, cadmium, lead, mercury, and TBT), the CLs are set at the SCO, which is the highest value of the comparison between the corresponding natural background values, PQLs, and the calculated risk-based concentrations (protective of human health and higher trophic-level species, based on Site exposure scenarios). Regional background metals concentrations are not available for the Site vicinity, so the CSLs are equal to the more conservative calculated risk-based SCO value. See Appendix A for the revised metals CL evaluations.

For other non-metal PBTs (i.e., PCBs and cPAHs), due to the broad distribution of PCBs and cPAHs at concentrations exceeding the SCOs (based on protection of human health), the RI/FS summarized an approach for establishing a proposed CL between the SCO and CSL based on the net adverse environmental impacts that would have been realized if dredging were to occur in such a large area. However, in re-evaluating the sediment CLs for this CAP (see Appendix A), the CLs for these two PBTs are also established at their respective SCOs. The CLs for IHSs in sediment are summarized in Table 1.

The SCOs may be re-evaluated in the future if regional background values are developed or during the periodic review (i.e., the post-cleanup confirmation monitoring) at the Site.

2.2 Points of Compliance

The point(s) of compliance under MTCA/SMS are the point or points at a site where the CLs must be attained to achieve cleanup standards. For the Upland Cleanup Unit, the point of compliance at which the CLs must be met is soil throughout the Site, in accordance with WAC 173-340-740(6).

In the Sediment Cleanup Unit, the point of compliance at which the CLs have been defined by Ecology is the predominantly biologically active zone (upper 12 centimeters [cm] of sediment; current or future). For sediment CLs developed for the protection of benthic organisms, compliance is based on a point-by-point comparison between sediment quality data and the associated CLs. For the sediment CLs developed for PBTs, compliance is assessed based on the surface weighted average concentration, in accordance with SMS and the Sediment Cleanup User’s Manual (SCUM) guidance (Ecology 2021), since human health and higher trophic-level species have area-wide exposure scenarios.

2.3 Applicable or Relevant and Appropriate Requirements

In accordance with MTCA, cleanup actions conducted under MTCA shall comply with applicable state and federal laws [WAC 173-340-710(1)]. MTCA defines applicable state and federal laws to include legally applicable requirements and those requirements that are relevant and appropriate. Collectively, these requirements are referred to as applicable or relevant and appropriate requirements (ARARs).

This section provides a brief overview of potential ARARs associated with Site cleanup. The MTCA cleanup regulations (Chapter 173-340 WAC) are considered the governing regulations under which Site cleanup will be conducted, and as such are not considered ARARs. The primary ARARs that may be applicable to the cleanup action include the following:

- Washington Chemical Contaminants and Water Quality Act and Washington Water Pollution Control Act and the following implementing regulation: Water Quality for Surface Waters (Chapter 173-201A WAC)
- Washington Chemical Contaminants and Water Quality Act implemented by the SMS (Chapter 173-204 WAC).
- Washington State Clean Water Act, with respect to water quality criteria for surface water (Blaine Harbor)
- Dredge and fill requirements under Code of Federal Regulations 320-330 implementing Section 404 of the Clean Water Act and Washington State Hydraulic Code Rules under Chapter 220-110 WAC
- Resource Conservation and Recovery Act (RCRA) and Subtitle C regulations, to the extent that hazardous wastes are discovered during the cleanup action
- Washington Hazardous Waste Management Act and Dangerous Waste Regulations, to the extent that dangerous wastes are discovered during the cleanup action
- Shoreline Management Act, with respect to construction activities during the cleanup action
- Endangered Species Act, due to the listing of Puget Sound Chinook salmon and the potential listing of coastal/Puget Sound bull trout
- Critical Areas Ordinance of the City of Blaine (Blaine Municipal Land Use Code Chapter 17.82 Critical Areas Management)
- Washington State Clean Air Act and air quality regulations (Chapter 173-400 WAC) for point source emissions
- Northwest Clean Air Agency Regulation 300 for point source emissions.
- In accordance with Washington State Executive Order 05-05 (WSOG 2005), the Section 106 Cultural Recourses Review Form must be completed for the project, and a site-specific Inadvertent Discovery Plan must be prepared to provide for proper monitoring for archaeological resources, and to respond appropriately if such resources are observed during construction.

The requirements of MTCA, the Water Quality Standards for Surface Waters, the SMS, and the Clean Water Act were considered in the development of Site cleanup standards. RCRA Subtitle C and Washington State Dangerous Waste Regulations are not expected to apply unless hazardous and/or dangerous wastes are discovered or generated during implementation of the cleanup action; these wastes are not known to be present at the Site.

In accordance with MTCA, the cleanup action will be exempt from the procedural requirements of Chapters 70.94, 70.95, 70.105, 77.55, 90.48, and 90.58 RCW, and of any laws requiring or authorizing local government permits or approvals. However, the substantive requirements of such permits or approvals (WAC 173-340-520) must be met.

3.0 SELECTION OF THE PREFERRED CLEANUP ACTION

The Site is determined to have two separate and distinct impacted areas that warrant designation and evaluation: the Upland Cleanup Unit and the Sediment Cleanup Unit (see Figures 6 and 7, respectively). The FS evaluated remedial alternatives, and a preferred alternative was selected by Ecology that achieves remedial action objectives (RAOs) for both Cleanup Units.

Three cleanup action alternatives were evaluated in the Site RI/FS for the Upland Cleanup Unit, and four alternatives for the Sediment Cleanup Unit (Landau 2020). This section discusses the cleanup action alternatives evaluated in the FS and provides an overview of the selection process. Ecology's selection of the preferred cleanup action was based on the procedures specified by MTCA including consideration of the RAOs, potentially applicable laws, meeting threshold requirements [WAC 173-340-360(2)], being permanent to the maximum extent practicable [WAC 173- 340-360(3)(f)], Site restoration timeframe [173-340-360(4)(b)], public concerns [WAC 173-340-515(4)(d)], and future land use. Additional discussion regarding the comparative evaluation of these considerations is presented in the RI/FS report (Landau 2020).

RAOs define the goals of the cleanup that must be achieved to adequately protect human health and the environment. RAOs must address all affected media, and a cleanup alternative must achieve all RAOs to be considered a viable cleanup action. RAOs can be either action-specific or media-specific.

The following action- and media-specific RAOs were identified for the Site:

- **RAO-1:** Prevent direct human contact with soil containing hazardous substances at concentrations exceeding the soil CLs
- **RAO-2:** Prevent releases of hazardous substances in upland soil and stormwater to surface water and marine sediment
- **RAO-3:** Prevent exposure of marine biota to sediment containing hazardous substances at concentrations that exceed cleanup standards protective of benthic organisms
- **RAO-4:** Prevent exposure of humans and higher trophic-level species to PBTs at concentrations that exceed cleanup standards protective of humans and higher trophic-level species.

3.1 Summary of Cleanup Action Alternatives

This section provides a summary of each alternative that was developed for the upland and sediment areas requiring cleanup. Section 4 provides additional details for the selected alternative. One element common to all remedial alternatives is the temporary removal of the marine railway system to allow for dredging. This generally requires removing the rails, rail ties, and support pilings to provide the necessary access to contaminated areas, thereby allowing implementation of the cleanup alternatives discussed below to meet RAO-1, RAO-3, and assist in meeting RAO-4. The marine industrial infrastructure will be reconstructed following contaminant removal efforts to preserve the functionality of ongoing boatyard operations.

3.1.1 Upland Cleanup Unit Remedial Alternatives Considered in the Feasibility Study

1. **Remedial Alternative U-1:** Extended near-surface excavation and offsite disposal of contaminated soil, and containment
    - Remove marine side rails and foundations
    - Excavation and offsite disposal of top 2 ft of soil within the areas of contamination
    - Install and maintain clean soil containment layer with stormwater management features
    - Institutional controls (restrictive covenants) and long-term operation and maintenance (assume 30 years).
2. **Remedial Alternative U-2:** Near-surface excavation and offsite disposal of contaminated soil, and containment
    - Remove marine side rails and foundations
    - Excavation and offsite disposal of top 1 ft of soil within the areas of contamination
    - Install and maintain asphalt containment layer with stormwater management features
    - Institutional controls (restrictive covenants) and long-term operation and maintenance (assume 30 years).
3. **Remedial Alternative U-3:** Site-wide removal of contaminated soil
    - Excavation of contaminated soils (entire Upland Cleanup Unit) and offsite disposal
    - Site restoration.

3.1.2 Sediment Cleanup Unit Remedial Alternatives Considered During the Feasibility Study

1. **Remedial Alternative M-1:** Sediment dredging and enhanced monitored natural recovery (EMNR) in SMA-1 and monitored natural recovery (MNR) in SMA-2
    - Replace existing bulkhead within dredging area
    - Temporarily remove the marine railway system and adjacent docks and replace after dredging
    - Remove contaminated sediment in SMA-1 (only where sufficient water depth is not available to support EMNR) and dispose of the removed materials at an upland offsite disposal facility
    - Implement EMNR in SMA-1, and MNR (as a contingency, if needed), in SMA-2 until cleanup standards are achieved.
2. **Remedial Alternative M-2:** Sediment dredging in SMA-1 and MNR in SMA-2
    - Replace existing bulkhead within dredging area
    - Temporarily remove the marine railway system and adjacent docks and replace after dredging

- Remove contaminated sediment from throughout SMA-1 and dispose of the removed materials at an upland offsite disposal facility
- Implement MNR as a contingency measure, if needed, in SMA-2 until cleanup standards are achieved.

3. **Remedial Alternative M-3:** Sediment dredging in SMA-1 and EMNR in SMA-2
    - Replace existing bulkhead within dredging area
    - Temporarily remove the marine railway system and adjacent docks and replace after dredging
    - Remove contaminated sediment from throughout SMA-1 and dispose of the removed materials at an upland offsite disposal facility
    - EMNR in SMA-2 (6 inches of sand to reduce area-weighted average PCB concentration to below the SCO)
    - Conduct compliance monitoring to confirm cleanup standards are achieved and maintained.
4. **Remedial Alternative M-4:** Harbor-wide contaminated sediment removal
    - Replace existing bulkhead within dredging area
    - Temporarily remove the marine railway system and adjacent docks and replace after dredging
    - Remove sediment throughout the harbor with concentrations of IHSs greater than SCOs and dispose of at a Subtitle D solid waste facility.

3.2 Rationale for Selecting the Preferred Cleanup Action

The cleanup alternatives listed above are developed and evaluated with respect to their ability to achieve compliance with MTCA cleanup requirements. The evaluation for selecting a cleanup action under MTCA requires developing a reasonable number of alternatives for cleanup, each meeting threshold criteria [WAC 173-340-360(2)(a)], including the ability to protect human health and the environment; comply with cleanup standards; comply with local, state, and federal laws (or ARARs); and provide for compliance monitoring. Compliance with these requirements under MTCA is presumed by definition to be protective of human health and the environment and in compliance with applicable local, state, and federal laws once cleanup standards have been met. The alternatives are further evaluated for their ability to satisfy these threshold criteria within a reasonable timeframe [WAC 173-340-360(2)(b)(ii) and WAC 173-340-360(4)] and achieve the RAOs identified for the Site.

MTCA provides for the costs and benefits associated with alternatives to be evaluated through a disproportionate cost analysis (DCA), which compares the relative environmental benefits of each alternative to the most permanent alternative. Costs are disproportionate to benefits if the incremental cost of the most permanent alternative exceeds the incremental degree of benefits achieved over the lower-cost alternative [WAC 173-340-360(3)(e)(i)]. An alternative that exhibits disproportionate costs is considered “impracticable,” and that alternative is eliminated from further consideration.

The six evaluation criteria for the DCA are:

- Protectiveness
- Permanence
- Long-term effectiveness
- Short-term risk management
- Implementability
- Considerations of public concerns.

Upland Cleanup Unit Alternative U-1 and Sediment Cleanup Unit Alternative M-2 are determined through the DCA process to be permanent to the maximum extent practicable and will achieve cleanup standards within a reasonable restoration timeframe. These two alternatives are combined as the preferred cleanup action for addressing contamination at the Site.

Figures 8 and 9 present the results of the DCA process for the upland and sediment cleanup alternatives, respectively. The rationale for the selection is summarized in this section and presented in detail in the RI/FS report (Landau 2020). The selected cleanup action complies with the provisions of WAC 173-340-360. It will be protective of human health and the environment; comply with cleanup standards and applicable local, state, and federal laws; provide for compliance monitoring; and establish restrictive covenants, if needed. Institutional controls will be implemented, as needed, to provide notification regarding the presence of residual contaminated soil.

4.0 CLEANUP ACTION PLAN

This section describes the cleanup plan for both the Upland and Sediment Cleanup Units that will be implemented to attain the cleanup standards described in Section 2. The primary cleanup objective is to eliminate, reduce, or otherwise control unacceptable risks to human health and the environment posed by hazardous substances in impacted media.

In the Upland Cleanup Unit, the objectives are to address hazardous substances in soil to prevent exposure to ecological or human receptors by direct contact, prevent transport of upland contaminated soil to the marine environment as a result of erosion, and reduce leaching of contaminants from soil to groundwater. Groundwater quality in the Upland Cleanup Unit has already been demonstrated to be adequately protected.

In the Sediment Cleanup Unit, the objective is to address hazardous substances in surface sediment associated with the following potential exposure routes:

- Aquatic organisms being exposed to hazardous substances in sediment within the biologically active zone (the upper 12 cm of sediment)
- Human exposure to hazardous substances in sediment by direct contact
- Human or other higher trophic-level species receptors from being exposed to PBTs by seafood ingestion or benthic invertebrate prey via ingestion.

4.1 Description of the Cleanup Action – Upland Cleanup Unit

In the Upland Cleanup Unit, the cleanup action will include demolishing and removing the upland component of the marine railway system (i.e., side rails and concrete foundations), excavating and disposing of the upper 2 ft of contaminated soil, capping the upland area with clean soil, and implementing institutional controls. The DCA process identified U-1 as the preferred remedy; however, because the weighted benefit scores with U-2 are very similar (within 5 percent) the engineering and remedial design process will re-evaluate targeted depth of soil removal and capping surface options, including incorporation of a clean soil cap versus a hard surface (i.e., asphalt/ concrete).

In the uplands, cleanup will include the excavation and offsite disposal of the upper 2 ft of soil. This will provide a significant amount of contaminant mass removal from the shallow depths where contamination was identified during the RI, and where future Site intrusive activities could potentially expose workers to contaminated soil and/or cause releases of hazardous substances to the environment. As noted above, if a hard capping surface is determined appropriate, the upper 1 ft of soil will be removed. The bottom of the excavation will be lined with a geotextile fabric, then backfilled with clean, granular soil to existing grades to contain the remaining contaminated soil in-place. The resulting ground surface will be sloped to provide for stormwater management, and institutional controls will be implemented so that future intrusive subsurface work at the Site would be conducted only in coordination with Ecology, to ensure the permanence of the remedy.

Based on the RI data, the excavated soil should be accepted for disposal at a permitted facility meeting Washington State requirements of Chapter 173-350 or -351 WAC, or complies with federal RCRA Subtitle D requirements. Approximately 2,000 cubic yards of soil would be excavated, removing hazardous substances from the upper 2 ft of soil across most of the Site. Deeper soil contamination is minimal in comparison to the surface soils that will be removed. The deeper soil would be contained in place by the environmental cap, bulkhead improvements to prevent lateral migration, and importantly, institutional controls to ensure long-term effectiveness of the capping system.

The demolition and removal of the marine railway system side rails will allow access to remove the adjacent contaminated soils and allow flexibility for the surface regrading to better direct and manage stormwater to achieve RAO-2. Depending on land-use considerations, the upland marine railway system (or other associated marine industrial infrastructure) may be replaced to preserve ongoing boatyard operations.

This cleanup approach in the uplands is anticipated to achieve both RAO-1 (prevent direct contact with contaminated soil) and RAO-2 (prevent releases of hazardous substances in upland soil and stormwater to surface water and marine sediment) through a combination of source control, containment, institutional controls, and stormwater management.

It is assumed that existing operations would continue on the clean capping surface created through the cleanup action and that the surface would be graded to manage stormwater. As part of this alternative, stormwater collection and control would be required and implemented because current and potential future Site uses involve activities that require an NPDES Boatyard General Permit, an industrial stormwater general permit, or an individual permit. These permits require the collection and analysis of stormwater samples, and the potential treatment of stormwater if applicable benchmark criteria are exceeded.

Institutional control would be in the form of an environmental covenant for the Site to prevent activities that could compromise the integrity of the cleanup or otherwise result in unacceptable risks to human health or the environment. The restricted activities would include those that could result in releases of hazardous substances or exposure of workers to contaminated soil.

4.2 Description of the Cleanup Action – Sediment Cleanup Unit

In the Sediment Cleanup Unit, two sediment management areas (SMA-1 and SMA-2) were identified where different cleanup actions will be implemented. The cleanup action in SMA-1 will include temporarily demolishing and removing the marine railway system, including removal of the steel rails, rail ties, concrete, and piles; temporarily removing and replacing the adjacent docks within the sediment dredging area; replacing the existing bulkhead within the sediment dredging area; and removing contaminated marine sediment by dredging. Depending on land-use considerations, the marine railway may be replaced with an alternative configuration (such as a travel lift and associated structures) to preserve ongoing boatyard operations. Completion of the PRDI will further refine the dredging footprint within SMA-1.

Sediment dredging within SMA-1 will remove contaminated sediment exceeding the SCO based on protection of benthic organisms. Dredging in SMA-1 is expected to achieve the sediment cleanup standards established for PBTs Site-wide (including SMA-2) based on reducing the harbor-wide area-weighted average of PBTs. The PRDI will include the collection of additional PBT data (PCB congeners and cPAHs) to evaluate harbor-wide area-weighted average concentrations and define the Site boundary. MNR in SMA-2 could be required as a contingent action (to be discussed further in the Compliance Monitoring Plan [CMP], see Section 4.5) after completing construction to attain cleanup standards throughout the Sediment Cleanup Unit. The primary components of the cleanup action to be conducted in the Sediment Cleanup Unit are shown on Figure 10.

Prior to dredging, environmental controls would be put into place as required by the project permits to protect the surrounding marine environment during the cleanup efforts. A silt curtain would be used to control turbidity and potential redistribution of contaminated sediment during construction, and limit impacts to surface water quality and sediment redistribution. Surface water quality monitoring would be conducted during the construction period to confirm compliance with applicable regulations. In addition, the removal of pilings and/or in-water structures will comply with DNR and US Environmental Protection Agency appropriate guidelines and procedures.

Bulkhead repairs will be necessary so that dredging can be accomplished near the uplands where contamination is highest, without undermining the integrity of the existing aged timber bulkhead. The existing marine railway system and adjacent docks will need to be temporarily removed to allow for unimpeded dredging. These physical preparations for dredging have the additional benefit of removing a significant amount of creosote-treated wood from the aquatic environment, which is a likely source of some of the cPAH contamination identified at the Site.

The existing bulkhead that separates the uplands from the marine portion of the Site is in poor condition and is exhibiting areas of localized failure. Additionally, design and as-built records of its construction are not available to provide a basis for engineering analysis of its stability under current or modified loading conditions. Based on visual inspection, the bulkhead would not be stable under dredging conditions if sediment is removed from near the toe of the bulkhead. As a result, either extensive shoring would be required to support the bulkhead during dredging, or the bulkhead would require replacement. Based on similarity in cost, it is assumed that the bulkhead would be replaced with a steel sheetpile bulkhead placed immediately in front of the existing bulkhead to allow for sediment dredging. The current condition of the bulkhead is allowing contaminated upland soil to erode from the bulkhead face and discharge to marine sediment. As a result of eliminating this erosion, the bulkhead replacement/reinforcement would also provide source control for the soil-to-sediment migration pathway. Replacement of the bulkhead would partially achieve RAO-2, RAO-3, and RAO-4.

After the marine railway system is removed and the bulkhead replaced, dredging of contaminated sediment would be conducted throughout SMA-1. This alternative assumes that mechanical dredging would be conducted throughout SMA-1 using a clamshell or environmental bucket or using a fixed-arm excavator operated over water from a barge and/or from the upland's shoreline. In a small portion of SMA-1 (east of the Upland Cleanup Unit), suction dredging using vacuum-excavation equipment operated from the uplands would be used to remove the thin veneer of contaminated intertidal sediment overlying the shoreline protection material in this area. Removing contaminated sediment from SMA-1 would achieve RAO-3, and partially achieve RAO-4.

4.2.1 Former Tide Grid

A secondary source of contamination from historical boatyard operations was associated with a former tide grid that was removed from service in 1992. Because the cleanup standards for PBTs in sediment are evaluated using area-weighted average concentrations, the cleanup may include additional dredging in the area of the former tide grid to further attain cleanup standards. The need for potential dredging will be established based on the results of the PRDI. The former tide grid is currently considered within SMA-2.

The tide grid was constructed between 1963 and 1965 and was used for hull scraping and other minor boat maintenance activities. The grid design allowed small boats to float onto the grid at high tide. At low tide, the boats rested on the grid allowing short-term boat maintenance to be performed.

The tide grid was replaced in 1988 and closed in 1992 in response to evolving water quality regulations. During the operation of the tide grid, releases of paint chips and dusts and potential spills or releases of other materials during boat maintenance may have occurred. Any such releases would have terminated in 1992 with the closure of the grid. The original grid structure was constructed with creosoted pilings. Leaching of creosote or abrasion of creosoted wood from the grid may have occurred prior to the grid's reconstruction. Creosoted wood was not used for construction of the replacement grid in 1988. During further investigations to be conducted as part of the design effort, additional sediment quality data will be collected in the area of the former tide grid to confirm the need for dredging or other appropriate cleanup action, if required.

4.2.2 Offsite Disposal of Dredged Sediment

It is assumed that dredged sediment would be dewatered on a small barge and the decanted water drained into the harbor. Appropriate procedures for management of decant water will be further established with the final remedial design. Final disposition of the dredged sediments will also be determined during the remedial design phase. It is not anticipated that the material would be considered for open-water disposal, but instead would likely be transported off Site for disposal at an upland regulatory facility.

During the remedial design process, additional sampling will be conducted in sediments around SMA-1 to update the planned dredged prism from the conceptual design presented on Figure 7. Figure 10 presents the planned dredged footprint as presented in the RI/FS report, and additionally predicts the potential expansion of the dredged area, if required, based on the results of the PRDI.

Based on anticipated slight expansions of the planned dredging footprint after completion of the PRDI, and the additional inclusion of sediment from the former tide grid area, the total quantity of contaminated sediment to be removed from the Site is likely to increase from the approximate 2,400 tons estimated during the RI/FS.

4.3 Hazardous Substances to Remain-In-Place

The extent of contamination was determined during the RI based on conservative interpretations of boring logs and Site analytical data. Based on the estimated areal extent and thickness of impacted soil, the cleanup will remove contaminated soil in the areas determined to be most impacted during the RI. Some underlying contamination will remain-in-place, to be contained by the clean surface soil cap, and restricted from lateral migration by improvements to the bulkheads. In the Sediment Cleanup Unit, the dredging is anticipated to meet cleanup standards following completion of the cleanup action.

4.4 Cleanup Action Implementation and Restoration Timeframe

The cleanup action described herein will be implemented by the Port, based on this CAP. Implementation will include remedial design, permitting, preparation of plans and specifications, construction (potentially in two phases), and post-construction monitoring and maintenance.

The remedial design activities will be initiated in late summer 2022 with the intent to facilitate engineering and design activities in late 2022 and 2023. Construction is anticipated in late 2023 through early 2024, based in part on permitting for the final design. Based on the estimated restoration timeframe and project schedule, it is estimated the Site will achieve compliance with cleanup standards following dredging in SMA-1. The engineering and design phase will include conducting the PRDI to collect the additional data required to prepare the engineering design report and detailed construction plans and specifications. The project permitting process will be initiated following development of the engineering design report.

It is anticipated that temporary removal of the marine railway system and adjacent docks and installation of the new bulkhead at the shoreline would be sequenced to occur in advance of the other cleanup activities. It is assumed that afterward, the remaining components of the cleanup could then be implemented concurrently or independently. Cleanup sequencing may be necessary to minimize disturbance to continued tenant operations.

4.5 Compliance Monitoring

MTCA and SMS require compliance monitoring for all cleanup actions, as described in WAC 173-340-410, and periodic reviews under WAC 173-340-420 to ensure the long-term integrity of the cleanup action. Long-term monitoring and maintenance will also be necessary to ensure the integrity of the Site cleanup after construction is complete. Both the monitoring and maintenance functions will be prescribed in a CMP, which will be developed during the remedial design process in coordination with and under the review of Ecology.

Compliance monitoring will include protection monitoring, performance monitoring, and confirmation monitoring. Protection monitoring is concerned with human and environmental impacts and will address topics such as safety requirements during construction. Performance monitoring will be conducted to demonstrate that the constructed remedy meets cleanup standards and will include the collection and analysis of samples to confirm soil quality at the final depth of excavation, and sediment quality at the newly-created sediment surface.

Confirmation monitoring will address the long-term effectiveness of the remedy in meeting cleanup standards. Specific procedures, analytical parameters, and sampling locations and frequency for the confirmation monitoring will be presented in the CMP. Similarly, the scope and timing of the inspection program, the institutional control provisions, and other aspects of long-term operations and maintenance monitoring will be established in the CMP.

Compliance monitoring would be conducted after dredging to confirm post-construction sediment quality. This would include collecting surface sediment samples throughout SMA-1 and the adjacent areas immediately outside the SMA-1 footprint (to evaluate recontamination potential), analyzing the sediment for IHSs, and comparing the results to the cleanup standards established for protection of benthic organisms at the Site. Bathymetric surveys would also be conducted both pre-and post-construction to confirm dredging volumes, that dredging design depths and lateral limits were achieved, and that the dredging residuals layer was properly placed (if applicable).

It is common for sediment resuspension during the dredging process to result in a thin veneer of contaminated sediment residuals that settles on the clean dredge surface. If compliance monitoring indicates that a residuals layer has formed on the dredge surface, a thin layer of clean soil/sediment would be placed across the newly exposed sediment surface after dredging to address this veneer of dredging residuals. It is anticipated that confirmation monitoring will include the collection of surface sediment samples throughout the sediment Site boundary for cPAH and PCB congener analysis.

4.6 Compatibility with Future Site Use and Institutional Controls

Implementation of the cleanup action will be coordinated with the long-term operations for the Site. Specific land-use plans for the Site and vicinity are currently being developed by the Port. The Port intends future Site use to be the same or similar to current Site use. Site use could involve the construction of a new marine fueling facility, development as part of a commercial boatyard, expansion of fish processing operations, or other marine-based commercial or light industrial activities. Regardless of its specific use, the use will remain consistent with current zoning and the existing master plan. The Port has no current plan for redevelopment or re-purposing the Site because of the continued need for a boatyard to support Blaine Harbor. The aquatic portion of the Site will remain in commercial and recreational maritime use, which will require maintaining, and possibly deepening channel depth to accommodate vessel drafts.

Institutional controls are included as a component of the remedy to ensure long-term protectiveness. As noted in WAC 173-340-440(4), institutional controls are required where contamination is left-in-place. These controls limit or prohibit activities that may interfere with or impair the integrity of a cleanup action, maintenance or monitoring, or any other activities necessary to maintain the remedy’s protection of human and environmental health. Institutional controls will include an environmental covenant (MTCA refers to this legal instrument as a “restrictive covenant”) to be filed with Whatcom County, to ensure the necessary restrictions are implemented and the integrity of the remedies is maintained. No aquatic use restrictions for state-owned lands that are part of the Site are anticipated.

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Data Source: Esri.

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LANDAU
ASSOCIATES

Westman Marine
Blaine Harbor
Blaine, Washington

Vicinity Map

Figure
1

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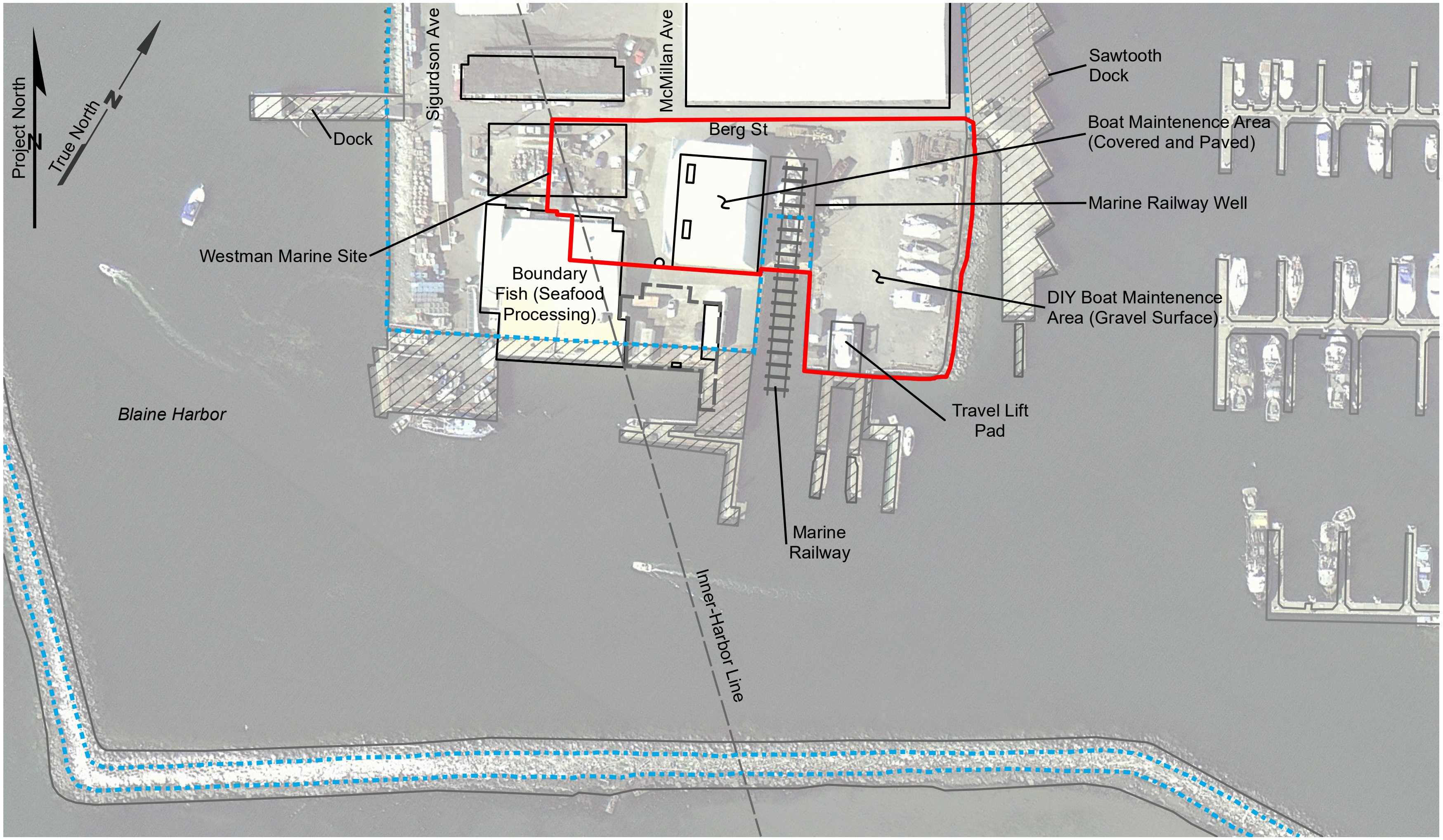

Legend

🟥 Westman Marine Upland Site Boundary

▨ Structure Over Water

— Existing Building Location

┅ MHHW = 9.5 ft

0 120 240

Scale in Feet

Data Sources: Wilson Engineering 2011; Port of Blaine 2011; Walker and Associates, Inc.; Google Earth Professional 2011

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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Westman Marine
Blaine Harbor
Blaine, Washington

Site Plan

Figure
2

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Westman Marine
Blaine Harbor
Blaine, Washington

Development of Blaine Harbor - Historical Aerial Photograph

Figure
3

Westman Marine
Blaine Harbor
Blaine, Washington

Current Conditions

Figure
4

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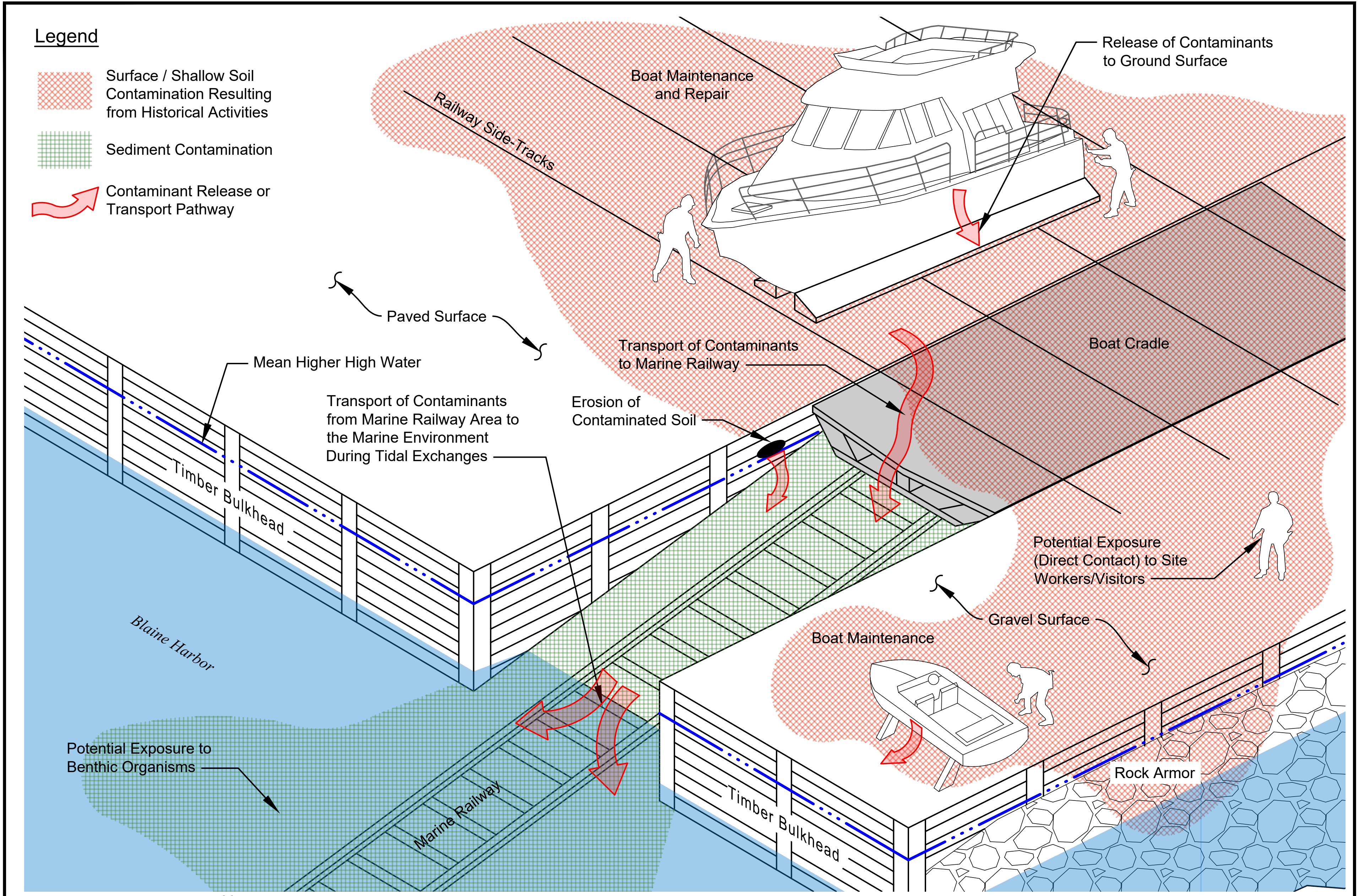

Note

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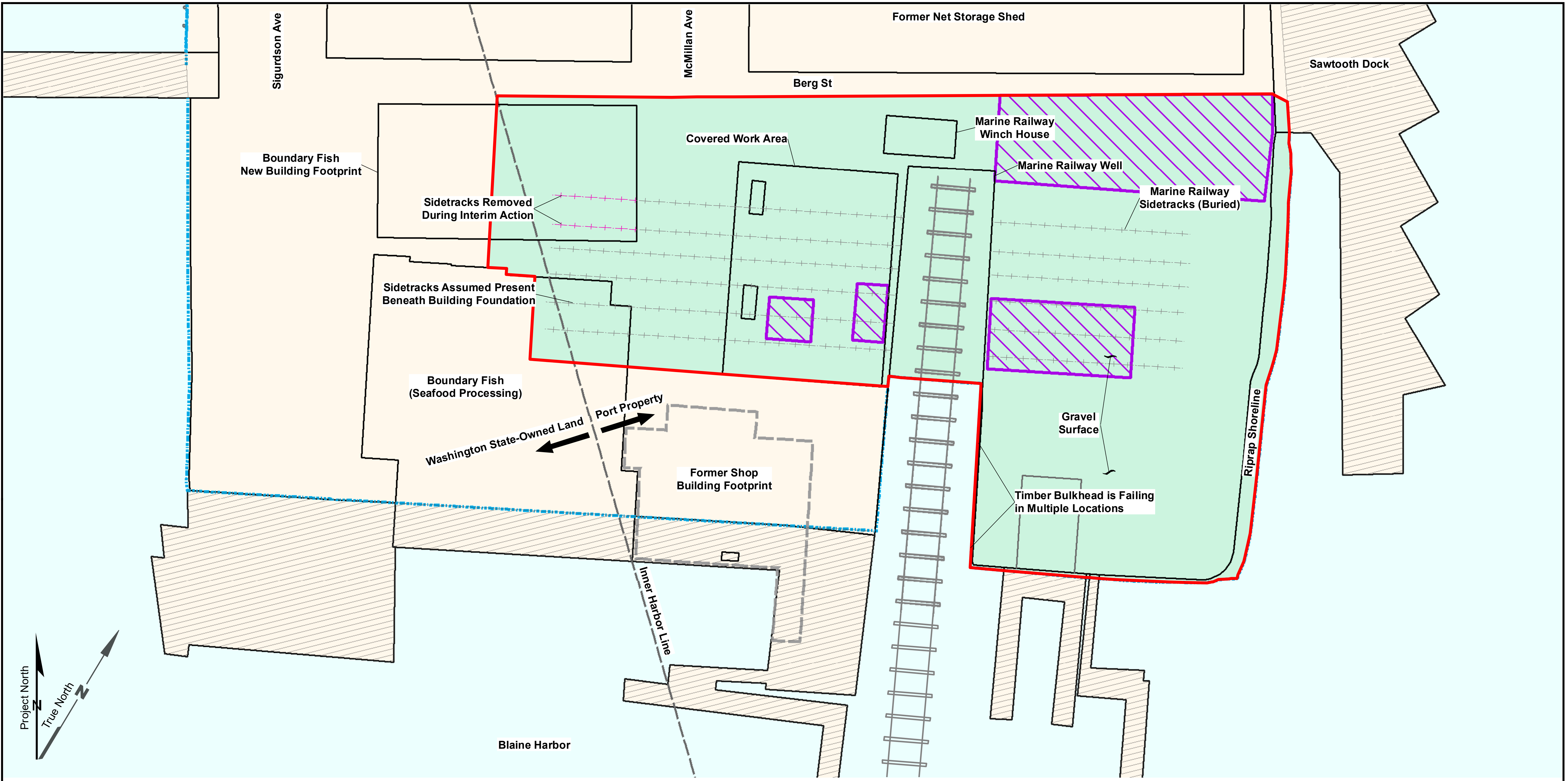
Westman Marine
Blaine Harbor
Blaine, Washington

Conceptual Site Model

Figure
5



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Legend

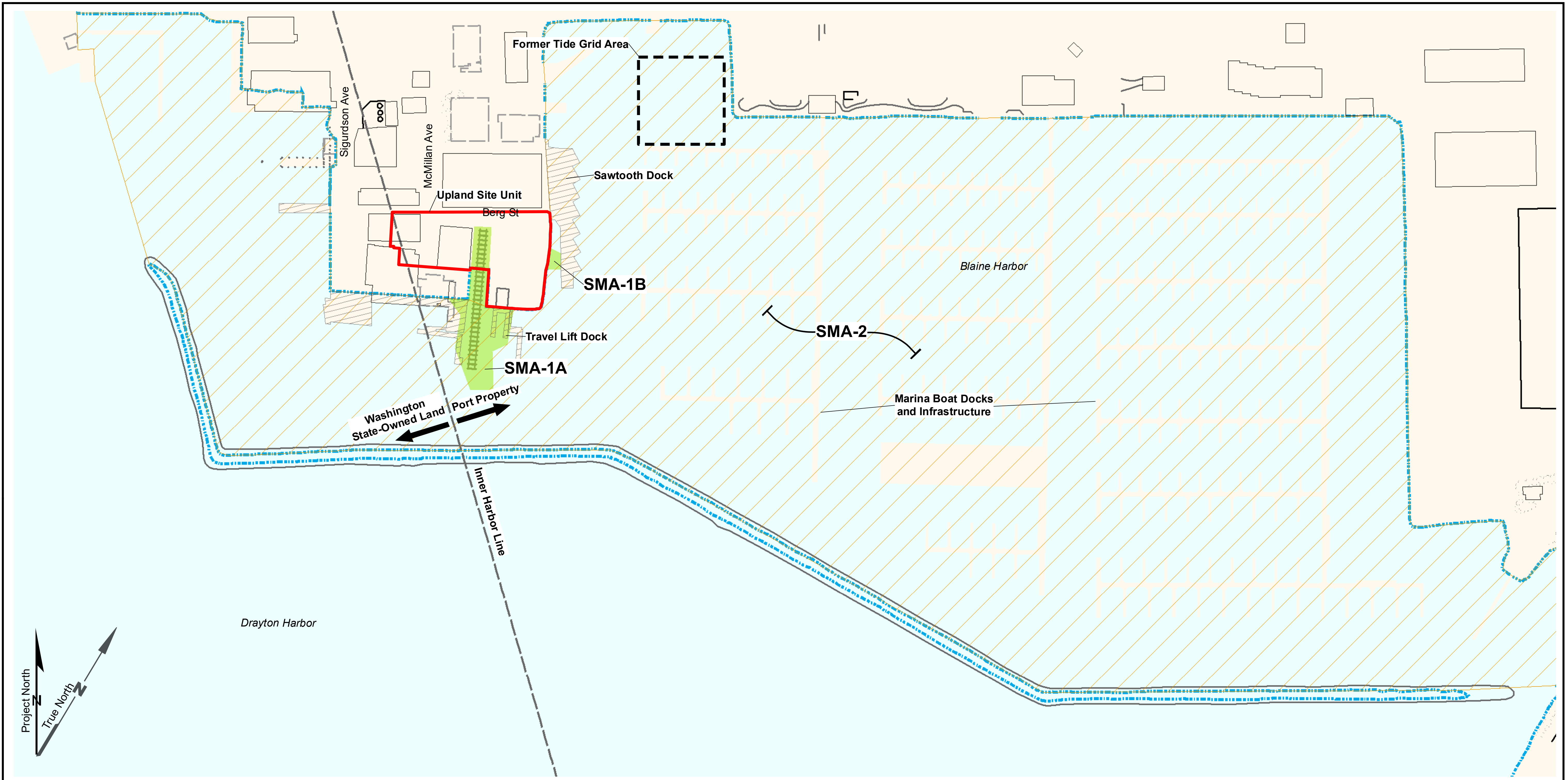
-+- Historical Track Location
🟥 Upland Cleanup Unit
▨ Structure Over Water
🟩 Surface and Shallow Soil Contamination
▭ Subsurface Soil Contamination

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Source: Wilson Engineering 2011, Port of Blaine 2011, Walker and Associates, Inc.

LANDAU ASSOCIATES

Westman Marine Blaine Harbor Blaine, Washington	**Upland Cleanup Unit**	Figure 6



Legend

🟥 Upland Cleanup Unit

🟩 Sediment Management Area (SMA)-1 (Includes SMA-1A and SMA-1B)

▨ Sediment Cleanup Unit

▨ Structure Over Water

— Rock Breakwater

-·-·- Mean Higher High Water

Notes

1. Sediment Cleanup Unit consists of SMA-1 and SMA-2.
2. SMA-2 = All of Blaine Harbor outside of SMA-1.
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 200 400

Scale in Feet

Source: Wilson Engineering 2011, Port of Blaine 2011, Walker and Associates, Inc.

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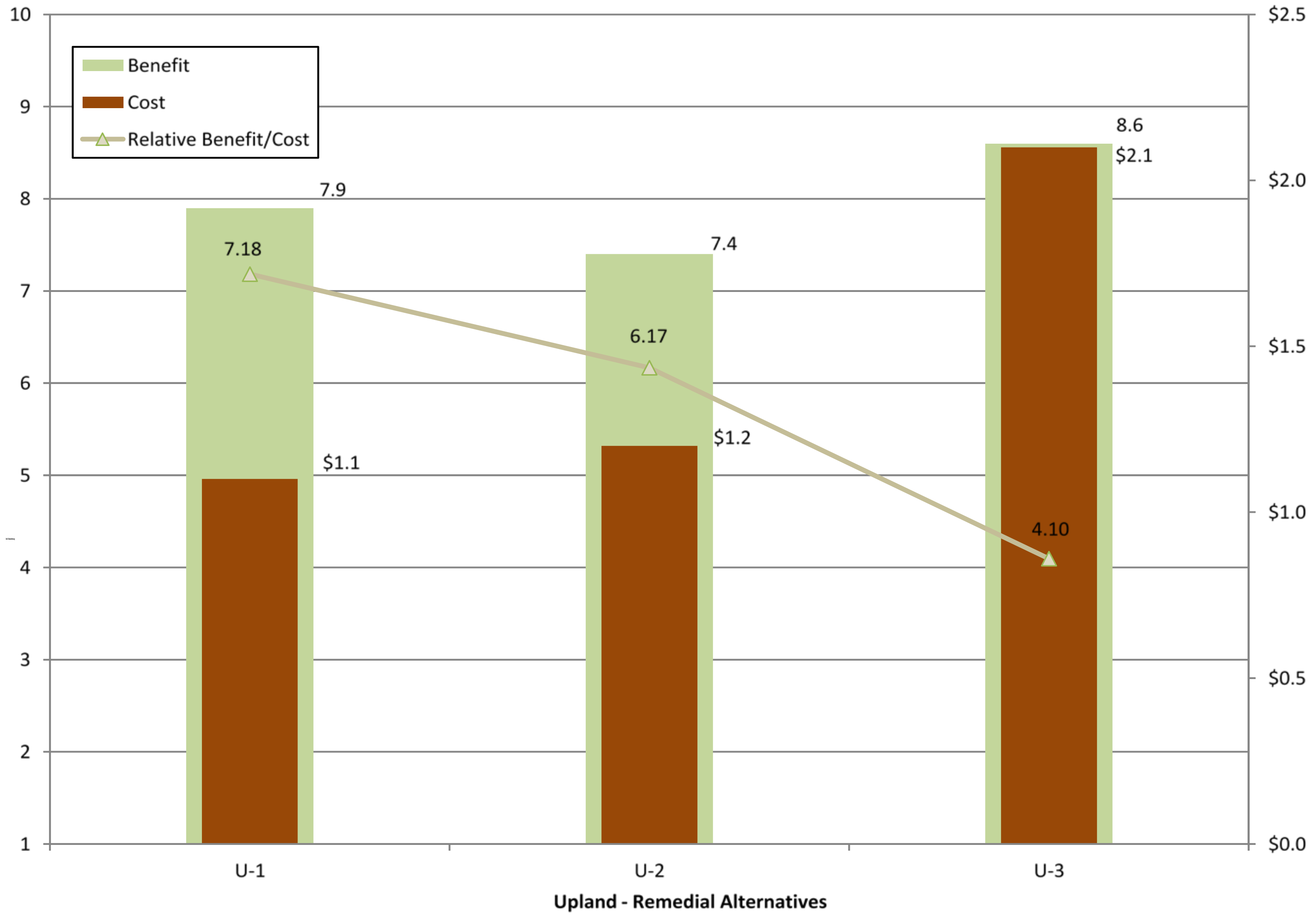
LANDAU ASSOCIATES

Westman Marine
Blaine Harbor
Blaine, Washington

Sediment Cleanup Unit

Figure
7

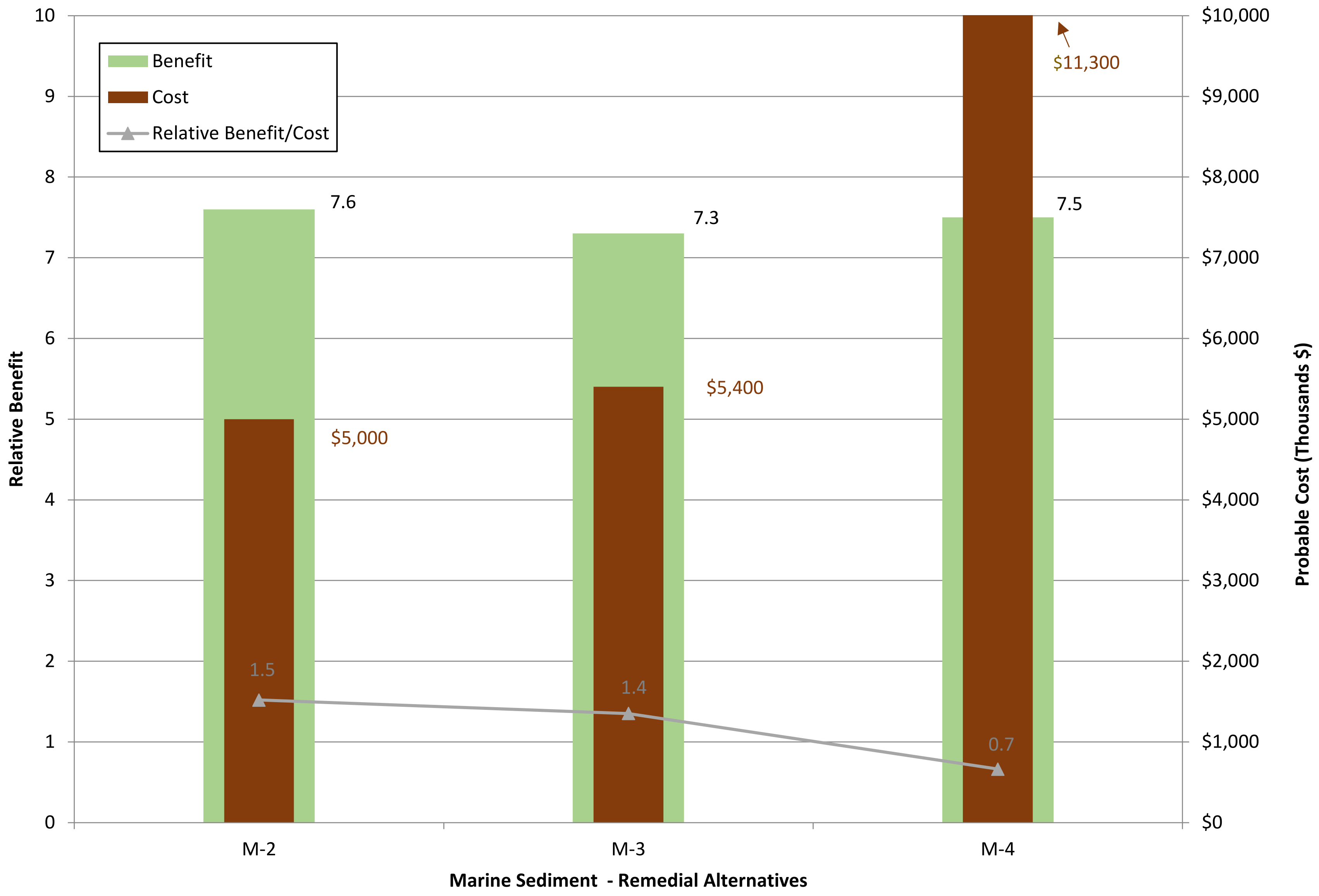


Landau Associates

Westman Marine
Blaine Harbor
Blaine, Washington

Upland Cleanup Unit
Disproportionate Cost Analysis

Figure
8



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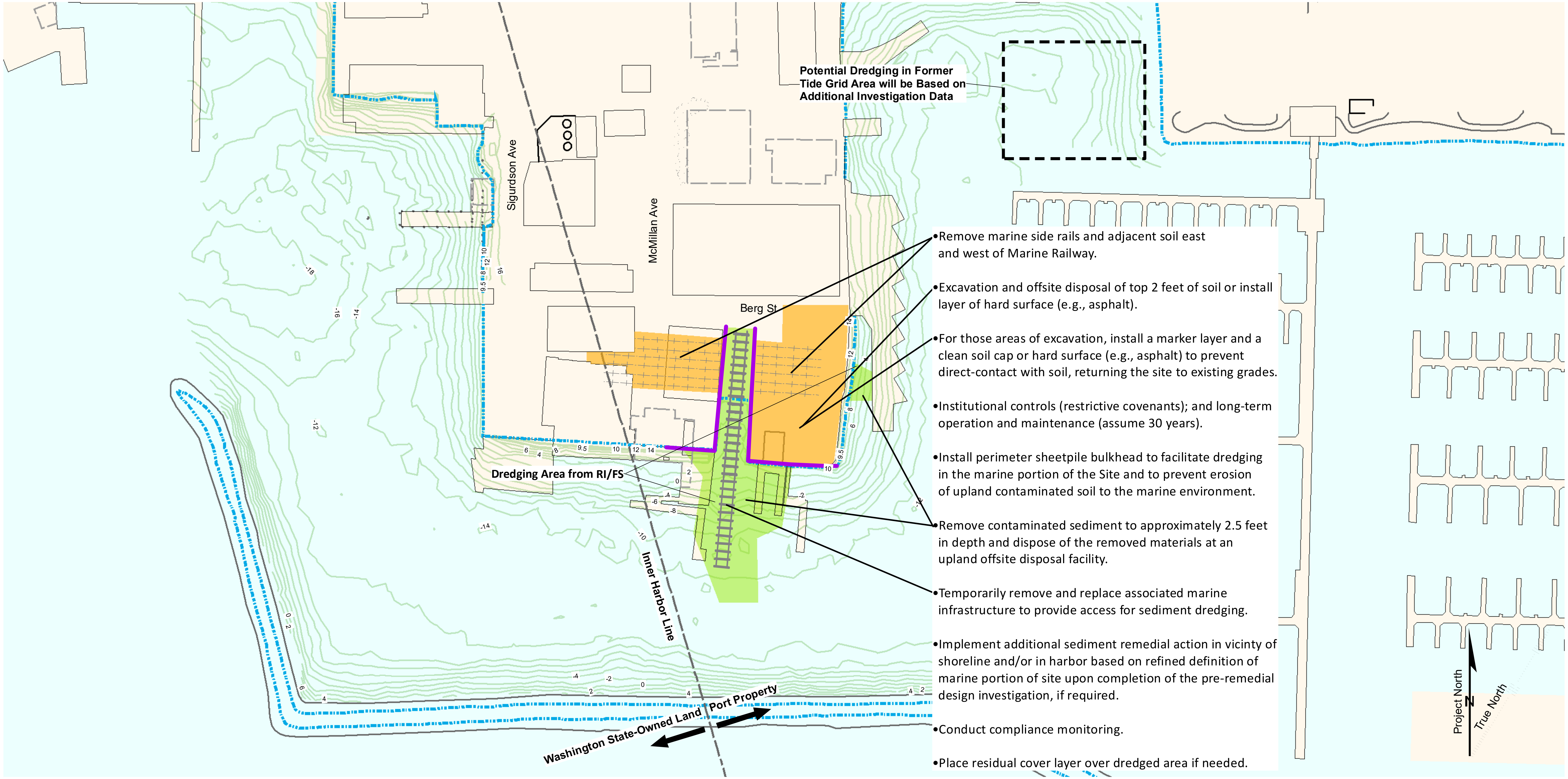
Westman Marine
Blaine Harbor
Blaine, Washington

Sediment Cleanup Unit
Disproportionate Cost Analysis

Figure
9



- Remove marine side rails and adjacent soil east and west of Marine Railway.
- Excavation and offsite disposal of top 2 feet of soil or install layer of hard surface (e.g., asphalt).
- For those areas of excavation, install a marker layer and a clean soil cap or hard surface (e.g., asphalt) to prevent direct-contact with soil, returning the site to existing grades.
- Institutional controls (restrictive covenants); and long-term operation and maintenance (assume 30 years).
- Install perimeter sheetpile bulkhead to facilitate dredging in the marine portion of the Site and to prevent erosion of upland contaminated soil to the marine environment.
- Remove contaminated sediment to approximately 2.5 feet in depth and dispose of the removed materials at an upland offsite disposal facility.
- Temporarily remove and replace associated marine infrastructure to provide access for sediment dredging.
- Implement additional sediment remedial action in vicinity of shoreline and/or in harbor based on refined definition of marine portion of site upon completion of the pre-remedial design investigation, if required.
- Conduct compliance monitoring.
- Place residual cover layer over dredged area if needed.

Legend

🟩 Dredge Area Presented in RI/FS (Extent to be Finalized Based on Additional Pre-Remedial Design Investigation)

🟧 Excavate to 2 ft Below Ground Surface and Install Soil Cap or Combination of Excavation and Soil Cap and Installation of Hard Surface (e.g., asphalt)

━ Sheet Pile Bulkhead

-·-· MHHW

Abbreviations

MHHW = Mean Higher High Water
RI/FS = Remedial Investigation/Feasibility Study

Notes

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Source: Wilson Engineering 2011, Port of Blaine 2011, Walker and Associates, Inc.

0 125 250
Scale in Feet

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Westman Marine
Blaine Harbor
Blaine, Washington

Cleanup Action Plan - Summary

Figure
10

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Table 1
Cleanup Levels for Affected Media
Westman Marine Site
Blaine, Washington

Indicator Hazardous Substance	Soil Cleanup Level (a)		Marine Sediment Cleanup Level (b, c)	
Arsenic	20	mg/kg	11	mg/kg
Cadmium	--	--	5.1	mg/kg
Copper	3,200	mg/kg	390	mg/kg
Lead	--	--	21	mg/kg
Mercury	2	mg/kg	0.41	mg/kg
Zinc	--	--	410	mg/kg
Polychlorinated Biphenyls (Dioxin-Like Congeners; TEQ)	--	--	0.7 (d)	ηg/kg
Polychlorinated Biphenyls (Total Aroclors)	160	µg/kg	--	--
Carcinogenic Polycyclic Aromatic Hydrocarbons (TEQ)	140	µg/kg	490 (e)	µg/kg
Tributyltin	--	--	167 (f)	µg/kg

Notes:

-- = Not applicable because constituent is not an Indicator Hazardous Substance for the medium.

(a) Cleanup level based on lowest soil criteria corrected for practical quantitation limit (PQL) and background.

(b) Cleanup level based on Sediment Management Standards (SMS; Chapter 173-204 WAC) and evaluation of risk-based criteria for chemicals considered persistent, bioaccumulative toxins. Cleanup levels address protection of human health and higher trophic-level species. Revised cleanup levels differ in some instances from those originally proposed in the RI/FS.

(c) Dry weight basis.

(d) Based on the PQL presented in Ecology's Sediment Cleanup User's Manual (Ecology 2021).

(e) Sediment cleanup level reflects early life stage risk-based calculations (Appendix A).

(f) Sediment cleanup level for bulk tributyltin based on Site-specific correlation established between porewater and bulk concentrations.

Abbreviations and Acronyms:

µg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
ηg/kg - nanograms per kilogram
PQL = practical quantitation limit
RI/FS = remedial investigation/feasibility study
TEQ = toxicity equivalence
WAC = Washington Administrative Code

APPENDIX A

Development of Sediment Risk-Based Cleanup Levels

Report
Development of Sediment Risk-Based Cleanup Levels
Westman Marine Site
Blaine, Washington

July 7, 2023

Issued By:

Washington State Department of Ecology
Toxics Cleanup Program
Northwest Regional Office
15700 Dayton Avenue North
Shoreline, WA 98133

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LIST OF ABBREVIATIONS AND ACRONYMS

ADAF	age-dependent adjustment factor
BAF	bioaccumulation factor
BSAF	biota-sediment accumulation factor
CAP	cleanup action plan
CL	cleanup level
CLARC	Ecology’s Cleanup Levels and Risk Calculations database
CPFo	oral cancer potency factor
CR	cancer risk
CSL	cleanup screening level
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CPF	cancer potency factor
DMMP	Dredged Material Management Program
Ecology	Washington State Department of Ecology
ELCR	excess lifetime cancer risk
ELS	early life stage
EPA	US Environmental Protection Agency
FS	feasibility study
g/day	grams per day
HQ	hazard quotient
IHS	indicator hazardous substance
km^2	square kilometers
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
ηg/kg	nanograms per kilogram
PBT	persistent bioaccumulative toxin
PCB	polychlorinated biphenyl
PQL	practical quantitation limit
RBC	risk-based concentration
RfD	reference dose
RfDo	oral reference dose
RI	remedial investigation
SCO	sediment cleanup objective
SCUM	Sediment Cleanup User’s Manual
Site	Westman Marine Site
SL	screening level
SMS	Sediment Management Standards

LIST OF ABBREVIATIONS AND ACRONYMS (CONTINUED)

SUF	site use factor
TBT	tributyltin
TCDD	tetrachlorodibenzodioxin
TEF	toxicity equivalency factor
TEQ	toxicity equivalence
USACE	US Army Corps of Engineers

1.0 INTRODUCTION

This document was prepared to accompany the Final Cleanup Action Plan (CAP) for the Westman Marine Site (Site) to present updated cleanup levels (CLs) for contaminated marine sediments. The CAP was prepared by the Washington State Department of Ecology (Ecology) in cooperation with the Port of Bellingham. The CAP presents a summary of the Site and Ecology's requirements for implementing the cleanup action in compliance with the Model Toxics Control Act, the Washington State Sediment Management Standards (SMS), and the Sediment Cleanup User's Manual (SCUM).

During the remedial investigation and feasibility study (RI/FS; Landau 2020), screening levels (SLs) were developed for various media to interpret the investigation data, and to determine where cleanup actions are necessary for the Site. Contamination detected during the RI in concentrations in excess of the SLs are established as indicator hazardous substances (IHSs). A subset (seven) of the IHSs in sediment are also considered persistent bioaccumulative toxins (PBTs) and require special considerations for developing SLs and CLs to address the risk to human health and higher trophic-level species. These PBTs include:

- Polychlorinated biphenyls (PCBs)
- Carcinogenic polycyclic aromatic hydrocarbons (cPAHs)
- Tributyltin (TBT)
- Metals (arsenic, cadmium, lead, and mercury).

This document provides a summary of the recalculated, updated values to support selection of final CLs for the CAP. Section 2 provides the basis and approach for developing sediment CLs, and Section 3 provides a summary of the selection of CLs for the Site.

2.0 DEVELOPING SEDIMENT CLEANUP LEVELS

The SMS have a two-tiered approach to setting sediment CLs for PBTs, described further in Ecology's SCUM (Ecology 2019b) guidance. This involves the development of a range of values relevant to establishing Site CLs, and selection of a single value from within the appropriate range. The range of values is bracketed by the sediment cleanup objective (SCO) at the lower end, and the cleanup screening level (CSL) at the upper end.

The **SCO** is established as the **highest** concentration from among the following three values:

1) ***Natural*** background concentrations,
2) The laboratory practical quantitation limit (PQL), or
3) Risk-based concentrations (RBCs) protective of the benthic organism community, upper trophic-level species, and human health using a risk tolerance of $1x10^{-6}$

The **CSL** is established as the **highest** concentration from among the following three values:

1) ***Regional*** background concentration,
2) The PQL, or
3) RBCs protective of the benthic organism community, upper trophic-level species, and human health using a risk tolerance of $1x10^{-5}$.

2.1 Background Concentrations and Practical Quantitation Limits

As listed above, the SCO and CSL values can consist of natural background, regional background, laboratory PQL, or calculated RBCs. This section summarizes considerations for using background or PQL concentrations. Section 2.2 provides additional considerations for developing RBCs.

In general terms, natural background concentrations are what is found in areas uninfluenced by localized human activities; regional background concentrations represent localized geographical background values (typically greater in concentration than natural background), and the PQL is effectively the lowest value that can reliably be quantified using the appropriately approved laboratory techniques.

Natural background is defined in the SMS rule [Washington Administrative Code (WAC) 173-204-505(11)]:

> *Natural background means the concentration of a hazardous substance consistently present in the environment that has not been influenced by localized human activities. For example, several metals and radionuclides naturally occur in the bedrock, sediment, and soil of Washington state due solely to the geologic processes that formed these materials, and the concentration of these hazardous substances would be considered natural background. Also, low concentrations of some particularly persistent organic compounds such as PCBs can be found in surficial soils and sediment throughout much of the state due to global distribution of*

> *these hazardous substances. These low concentrations would be considered natural background. Similarly, concentrations of various radionuclides that are present at low concentrations throughout the state due to global distribution of fallout from bomb testing and nuclear accidents would be considered natural background.*

Regional background is defined in the SMS rule in WAC 173-204-505(16):

> *Regional background means the concentration of a contaminant within a department-defined geographic area that is primarily attributable to diffuse sources, such as atmospheric deposition or stormwater, not attributable to a specific source or release.*

The ***PQL*** is generally defined as the lowest concentration that can be reliably measured within specified limits of precision, accuracy, representativeness, completeness, and comparability during routine laboratory operating conditions, using Ecology-approved methods. It is not considered practicable to accurately quantify concentrations in sediment below this level, and this typically represents the lowest and most-conservative value that can be established as a CL.

The SCUM guidance presents calculated Puget Sound natural background values using the BoldPlus dataset for arsenic, cadmium, lead, mercury, PCBs, and cPAHs (Ecology 2019b). Regional background concentrations are not available for the Site's vicinity. Natural background and PQL concentrations are provided in Table A-1.

2.2 Benthic Criteria

The SCUM guidance provides SCO and CSL values for protection of benthic species for the PBT metals under consideration. Although no promulgated SMS values are available for TBT, the US Army Corps of Engineers (USACE) Dredged Material Management Program (DMMP) evaluation criteria for open water disposal identifies a "no effects" TBT marine sediment porewater criterion of 0.05 micrograms per liter (µg/L) and a "potential adverse effects" marine sediment porewater criterion of 0.15 µg/L for open water disposal of dredged material. These DMMP criteria provide a reasonable basis for assessing the potential effects of TBT on marine biota.

Because significantly more bulk sediment TBT data are available than porewater TBT data, a correlation between bulk sediment and porewater TBT concentrations was developed in the RI to allow for a more comprehensive evaluation of the extent of TBT contamination based on bulk sediment TBT data. A linear regression analysis was performed for co-located porewater and bulk sediment TBT data. A strong correlation with an R^2 of 0.94 was obtained for the 15 available data points. Based on this linear regression, the Site-specific bulk sediment TBT SCO and CSL criteria protective of benthic organisms are 238 micrograms per kilogram (µg/kg) and 738 µg/kg, respectively. These values were developed with the review and concurrence of Ecology during the RI.

2.3 Risk-Based Concentrations

The RBCs for metals, PCBs, TBT, and cPAHs were developed to be protective of human health and higher-trophic level species based on the following considerations:

- Site exposure pathways
- Site exposure scenarios
- Acceptable health risk.

The following sections described parameter values used in the development of RBCs.

2.3.1 Exposure Pathways

Potential exposure pathways include consumption of seafood species impacted by Site contaminants through food-chain effects, and absorption through the skin or incidental ingestion of sediment during beach activities.

Although fishing within the harbor is not likely a common occurrence, some seafood species may include Blaine Harbor as a part of their home range, but then are caught outside of the harbor. As a result, human consumption of seafood is considered a reasonable exposure pathway and is considered further below.

The Site does not provide access for clamming, and since clams are relatively immobile, it is not expected that clams caught outside of the harbor would have been exposed to contaminants at the Site.

Beach play is not documented to occur at the Site and was not considered during the RI/FS. However, a boat ramp exists on the northeast side of Blaine Harbor, where both adults and children could potentially be exposed to sediment via direct contact and/or incidental ingestion during beach play. This updated assessment evaluates the potential exposure pathway as a conservatively protective approach and incorporates this activity as a reasonable exposure pathway for further consideration. As a result of this updated evaluation, the CLs identified in the CAP differ in some instances from those presented in the RI/FS report (Landau 2020).

2.3.2 Exposure Scenarios

Exposure scenarios include identifying the most highly exposed population and the appropriate parameters that describe their exposure. For the Site, the tribal subsistence fishing population was used as the most conservative assumption scenario, which is considered to occur through seafood consumption. Based on the exposure pathways described above, seafood consumption includes finfish (pelagic, benthic/demersal fish, and salmon) and crustaceans at 112 grams per day (g/day) and 81.9 g/day, respectively. These consumption rates are based on seafood consumption by adult members of the Tulalip Tribes (95th percentile) as provided in the Fish Consumption Rates Technical

Support Document (Ecology 2013). The average body weight of Tulalip tribal adults is 81.8 kg[1] (Toy et al. 1996). Ecology default values were used for the remaining exposure pathway scenario parameters. These parameters are provided in Tables A-2, A-4, and A-5.

The direct contact and incidental ingestion exposure pathways were evaluated through the beach play scenario in the intertidal area of the Site. RBCs protective of the direct contact and incidental ingestion scenarios were calculated for Site PBTs using Ecology's default equations (Ecology 2019b) and the parameters provided in Tables A-3 and A-4.

2.3.3 Acceptable Health Risk

Acceptable health risk due to potential exposure to individual PBTs is based on a number of Site- or chemical-specific factors, described below. These factors include the following:

2.3.3.1 Cancer Risk and/or Hazard Quotient

For carcinogens, the acceptable cancer risk (CR) is a unitless value that represents the risk that a contaminant concentration will result in cancer developing in a population for a specific exposure scenario. For both non-carcinogens and carcinogens (which may have a threshold toxicity in addition to their potential to cause cancer), the hazard quotient (HQ) is a unitless value that represents the threshold at which toxic effects will occur in a population.

Carcinogenic substance risks are calculated based on the likelihood of developing cancer, based on an exposure duration of 70 years, averaged over a 75-year lifetime. For individual carcinogenic substances, RBCs were developed for a CR within the range of 1 in 1 million ($1\text{x}10^{-6}$, the lower bound) to 1 in 100,000 ($1\text{x}10^{-5}$, the upper bound). The RBC-based SCOs for PBTs were developed for individual carcinogens using the lower-bound CR value ($1\text{x}10^{-6}$), and the upper-bound CR value ($1\text{x}10^{-5}$) was used to develop the RBC-based CSL.

2.3.3.2 Cancer Potency Factor and/or Reference Dose

Cancer potency is quantified with the oral cancer potency factor (CPFo), representing an upper-confidence limit on the increased CR over a lifetime of exposure. CPFo values for each Site PBT were taken from Ecology's Cleanup Levels and Risk Calculations (CLARC) database (Ecology 2020) and are provided in Table A-4.

Non-carcinogenic substance risks were calculated based on the concept of an HQ. Non-carcinogenic contaminants must reach a threshold concentration, known as the oral reference dose (RfDo), to have adverse health effects. The HQ is the ratio of a substance over a specified exposure period to the RfDo for that substance over the same exposure period. An HQ of 1 would indicate that the threshold for

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[1] Tulalip male average of 86 kilograms (kg; n=42); Tulalip female average of 76 kg (n=31).

adverse health effects has been reached; therefore, any ratio less than 1 would indicate that no deleterious effects would be expected.

Carcinogenic substances may also have a threshold toxicity in addition to causing cancer, and non-carcinogenic risks were also calculated for carcinogenic substances. CPFo and RfDo values for each contaminant, as applicable, were taken from Ecology's CLARC database (Ecology 2020).

2.3.3.3 Site Use Factor

An organism may spend only part of its life in the vicinity of contaminated sediment at a site. The site use factor (SUF) is meant to quantify the amount of time that an organism is potentially exposed to contaminated sediment. The marine portion of the Site, for the purposes of developing PBT SCO and CSL values, is conservatively assumed to be the entirety of Blaine Harbor (about 0.2 square kilometers [km^2]) for calculation of the SUF. Based on an assumed home range of 10 km^2 for finfish, the SUF was set to 0.02 or 2 percent. A smaller home range for mobile crustaceans (i.e., 2 km^2) is assumed to reflect the population that would spend any quantity of time in the vicinity of the marine portion of the Site, given the Site's access limitations. Therefore, the SUF for crustaceans was set at 0.1 or 10 percent.

2.3.3.4 Biota-Sediment Accumulation Factor

The PBTs considered in this evaluation bioaccumulate at variable rates. The bioaccumulation of contamination in organisms affected by marine sediment can be quantified as either a biota-sediment accumulation factor (BSAF) for non-polar organic contaminants or a bioaccumulation factor (BAF) for polar or metal contaminants. The BSAF is the lipid-normalized contaminant concentration in tissue divided by the organic carbon–normalized concentration in sediment. The BSAF is used for contaminants with generally high octanol/water partition coefficients (K_{ow}), which are hydrophobic and are preferentially distributed to lipids in organisms.

BSAF values for finfish were obtained from the US Environmental Protection Agency (EPA) Office of Research and Development BSAF database (EPA; accessed July 2020) and the USACE Environmental Research Development Center BSAF database (USACE; accessed July 2020). Mean BSAF values were calculated from listed BSAF values from whole body tissue samples, for the types of finfish species represented in each calculation. Finfish species used were the brown bullhead catfish (*Ictalurus nebulosus*), channel catfish (*I. punctatus*), common carp (*Cyprinus carpio*), and white sucker (*Catostomus commersoni*). BSAF values were screened for potential outliers with the ProUCL (EPA 2016) program and outliers were removed.

BSAF data for Pacific crab species native to the Blaine Harbor were not available from the EPA and USACE databases. BSAF values were available for other crustacean species, including crayfish and fiddler crabs; however, due to potential data quality issues and limited available data, these BSAF values were not applied to calculations for the Site. Crustacean species, like bottomfish, have enzymes that are capable of metabolizing polycyclic aromatic hydrocarbons (PAHs); however, the metabolism rate of crustaceans is less efficient than bottomfish (Stegeman and Lech 1991). Therefore, a safety factor of 5 was applied to the bottomfish BSAF to account for uncertainty in generating corresponding crab BSAF values for the Site (Ecology 2019a).

Only one BSAF value for TBT was identified from a review of the EPA and USACE databases for finfish and crustaceans. Therefore, BSAF values for mollusks were used to calculate a very conservative mean BSAF. Mollusks do not metabolize TBT well, and coupled with their high intake of sediment-based contaminants, they are the most sensitive organism to TBT concentrations in sediment (Lee 1996). The mean BSAF value for TBT in mollusks [10.0 grams tissue (lipid-normalized)/grams sediment (organic carbon-normalized)] was calculated from 16 values. One outlier was identified with the ProUCL software and removed.

BSAF values are provided in Table A-5.

2.3.3.5 Bioaccumulation Factor

The BAF is the concentration of contaminants in an organism divided by the concentration of contaminants in sediment. The BAF is used for polar contaminants and for metals where the BSAF is not appropriate. Since tissue samples were not collected at the Site, BAF values were established based on information from other sites in Puget Sound. Average arsenic, mercury, and cadmium BAF values for finfish and crustaceans were used from the report Preliminary Sediment Cleanup Objectives for Port Angeles Harbor, an investigation conducted by Newfields on behalf of Ecology (NewFields 2013); no BAF value was available for lead. BAF values are presented in Table A-5.

2.3.3.6 Fish/Shellfish Lipid Fraction

Lipid content in organisms is quantified with the fish/shellfish lipid fraction (SL_f). For calculations herein, the SL_f was assumed to be 0.03 based on the Ecology default value of 0.03 for both finfish and crustaceans (Ecology 2019b).

2.3.3.7 Fraction of Organic Carbon in Sediment

The bioavailability of contaminants in sediment can also be affected by the fraction of organic carbon in sediment (Sf_{oc}). For Site RBC calculations, the mean organic fraction (0.0156) for surface sediment at the Site was used.

2.3.4 Calculating Risk-Based Concentrations

The following paragraphs describe the development of RBCs for arsenic, cadmium, mercury, and TBT. An RBC was not developed for lead, as described below. Some PBTs, including mercury and TBT, pose a greater risk to higher trophic-level organisms than to humans. The second half of Ecology's default equation to identify a sediment RBC for higher trophic-level organisms is:

$$RBC = \left(\frac{1}{SUF \times BAF}\right)$$

For both mercury and TBT, the human health RBC was lower than the RBC for protection of higher trophic-level organisms, and the human health RBC was used as the more conservative value.

2.3.4.1 Standard Seafood Consumption Risk-Based Concentrations

Standard seafood consumption RBCs for arsenic, cadmium, mercury, and TBT as non-carcinogens were developed using the parameters discussed in Section 2.3 and Table A-2, along with Ecology's default equation:

$$RBC_{Noncancer} = \left\{\left(\frac{(HQ \times BW \times AT_{nc} \times RfDo)}{(FCR \times FDF \times EF \times ED\ )}\right) \times \left(\frac{S_{foc}}{SUF \times BAF}\right)\right\}$$

2.3.4.2 Standard Beach Play Risk-Based Concentrations

Standard carcinogenic and non-carcinogenic RBCs for the sediment ingestion/dermal contact exposure (i.e., beach play) pathway were calculated for TBT and metals using the parameters discussed in Section 2.3 and Table A-3, along with Ecology's default equations:

$$RBC_{Cancer} = \frac{ACR \times BW \times AT_{cr}}{EF \times ED \times [(IR \times AB \times CPF_o) + (SA \times AF \times ABS \times CPF_d)]}$$

$$RBC_{Noncancer} = \frac{HQ \times BW \times AT_{nc}}{EF \times ED \times \left[\left(\frac{1}{RfD_o} \times IR \times AB\right) + \left(\frac{1}{RfD_d} \times SA \times AF \times ABS\right)\right]}$$

A CPFo value was available for arsenic only through Ecology's CLARC database, so this was the only parameter for which the carcinogenic beach play equation was used.

The non-carcinogenic beach play equation was used for arsenic, cadmium, mercury, and TBT. An RfDo value for mercury was not available through Ecology's CLARC database; therefore, the RfDo for methylmercury, which is a more toxic form of mercury based on effects via oral ingestion, was used as a conservative approach. Neither EPA nor Ecology has published a CPFo or RfDo for lead; therefore, beach play RBCs were not calculated for lead.

2.3.5 Calculating RBCs for TEQ Factor-Modified PBTs

Each individual cPAH and PCB congener present at the Site varies in extent, cancer potency, and rate of bioaccumulation in aquatic organisms. To derive a single carcinogenic-human health RBC for these groups of compounds based on the individual potencies, uptake rates, and toxicity equivalency factors (TEFs), Ecology's default RBC seafood consumption equation (Ecology 2019b) was rearranged following the method described below. From this arrangement, Site-specific total excess lifetime cancer risks (ELCRs) through seafood consumption (both crustacean and finfish) for dioxin-like congeners PCB as a group ($ELCR_{PCB\ TEQ}$) and cPAHs as a group ($ELCR_{cPAH\ TEQ}$) were calculated. These Site-specific ELCRs, along with the target ELCR ($1x10^{-6}$), were used to generate a Site-specific dioxin-like PCB congener toxicity equivalence (TEQ) RBC and a standard Site-specific cPAH TEQ RBC, protective of human health.

In addition to generating the standard Site-specific dioxin-like PCB congeners and cPAH TEQ RBC for the Site, preliminary early life stage (ELS)-based RBCs were also generated for comparison to the standard RBCs to factor in the mutagenic effects (EPA 2005). EPA's guidance addresses mutagenicity by applying age-dependent adjustment factors (ADAFs) to modify the total dosage for each specific ELS age group. These ADAFs and corresponding exposure durations are presented in the table below.

Early Life Stage Age-Dependent Adjustment Factors and Exposure Durations

Age Group	Age-Dependent Adjustment Factor (ADAF; unitless)	Exposure Duration (years)
< 2 years	10	2
2 to <6 years	3	4
6 to <16 years	3	10
16 to 70 years	1	54

Source: EPA 2005.

To calculate the standard and ELS-based RBCs, first the expected tissue concentration ($C_{a,k}$) of ath individual dioxin-like PCB congener or cPAH in kth seafood type (finfish and crustaceans) was calculated using Equation 1, shown below.

Equation 1: $$C_{a,k} = SL_k \times BSAF_{a,k} \times CsedOC_a$$

By multiplying the fish/shellfish lipid fraction (Ecology default 0.03) by the uptake factor (BSAF for ath individual constituent in each kth seafood type), and by the average Site concentration of each constituent (carbon-normalized; $CsedOC_a$), the expected tissue concentration for each constituent was calculated.

Using the expected finfish and crustacean tissue concentrations of dioxin-like PCB congeners or cPAHs ($C_{a,k}$), the total chronic daily intake (CDI_a) of ath individual cPAH in the summed kth seafood types was calculated using Equation 2, shown below.

Equation 2: $$CDI_a = \sum_{k=1}^{m} \left(\frac{\boldsymbol{C_{a,k}} \times FCR_k \times EF \times ED \times FDF_k \times SUF}{AT_{cr} \times BW \times UCF} \right)$$

The parameters used in Equation 2 were set to the Ecology defaults, as shown in Table A-2.

Using the potential total daily uptake of each constituent through seafood consumption, the total excess lifetime cancer risk ($ELCR_a$) for each dioxin-like PCB congener or cPAH compound was calculated using Equation 3, shown below. Oral cancer potency factors ($CPFo_a$) for cPAHs were obtained from the CLARC database (Ecology 2020) and are based on the TEF that is a relative measure of benzo(a)pyrene, the most potent cPAH [$\text{CPFo}_{\text{benzo(a)pyrene}}$ = 1.0 (milligrams per kilogram [mg/kg]-d)-1]. Oral cancer potency factors ($CPFo_a$) for dioxin-like PCB congeners were obtained from the SCUM guidance (Ecology 2019b) and are based on the toxicity equivalency factor (TEF_a) that is a relative measure of 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD), the most potent dioxin congener [$\text{CPFo}_{\text{2,3,7,8-TCDD}}$ = 130,000 $(\text{mg/kg-d})^{-1}$]. CPFo data are shown in Table A-4.

Equation 3: $ELCR_a = CPFo_a \times \boldsymbol{CDI_a}$

For the ELS-based RBC calculations, Equation 3 was adapted to reflect application of EPA's ADAF across the age ranges, including the additional recommended adjustments upward in risk to account for the potential greater susceptibility of children from 0 to 2 and from 2 to 6 years of age compared to older children/teens and adults. The ELS-based ELCR_a was calculated using Equation 3.1, shown below.

Equation 3.1:

$$\begin{aligned} ELCR_{a(0-70)} &= CPFo_a \\ &\times \left(\left[\boldsymbol{CDI_{a(0-2)}} \times \frac{2}{6} \times 10\right] \right. \\ &\left. + \left[\boldsymbol{CDI_{a(2-6)}} \times \frac{4}{6} \times 3\right] \times \left[\boldsymbol{CDI_{a(6-16)}} \times 3\right] \times \left[\boldsymbol{CDI_{a(16-70)}} \times 1\right]\right) \end{aligned}$$

The standard and ELS-based Site-specific total ELCR for dioxin-like PCB congeners and cPAHs ($\text{ELCR}_{\text{PCB TEQ}}$ and $\text{ELCR}_{\text{cPAH TEQ}}$) were calculated by summing together their corresponding *a*th individual congener or cPAH ELCR_a, to the *g*th number of cPAHs, using Equation 4, shown below.

Equation 4: $ELCR_{cPAH\,TEQ} = \sum_{a=1}^{g} \boldsymbol{ELCR_a}$

The standard and ELS-based RBCs for dioxin-like PCB congeners and cPAHs in sediment ($\text{RBC}_{\text{PCB TEQ}}$ and $\text{RBC}_{\text{cPAH TEQ}}$) were based on the ratio of the sediment quality objective target excess lifetime cancer risk ($\text{ELCR}_\text{target}$ = $1\text{x}10^{-6}$) to the Site-specific ELCR ($\text{ELCR}_{\text{PCB TEQ}}$ or $\text{ELCR}_{\text{cPAH TEQ}}$) and to the sum of each constituent concentration multiplied by each individual TEF using Equation 5, shown below.

Equation 5: $RBC_{cPAH\,TEQ} = \frac{ELCR_{Target}}{\boldsymbol{ELCR_{cPAH\,TEQ}}} \times \sum_{a=1}^{g} (Csed_a \times TEF_a)$

RBCs for sediment exposure through ingestion/dermal contact exposure pathways were calculated using Equation 6, shown below. The parameters used in Equation 6 were set to the Ecology default assumptions, as shown in Table A-3.

Equation 6: $$RBC_{beach\ play} = \frac{CR \times BW \times AT_{cr}}{EF \times ED \times \left[\left(\frac{IR \times AB \times CPF_o}{UCF}\right) + \left(\frac{SA \times AF \times ABS \times CPF_d}{UCF}\right)\right]}$$

For the ELS-based calculations, Equation 6 was adapted to reflect application of EPA's ADAF across the age ranges, including the additional recommended adjustments upward in risk to account for the potential greater susceptibility of children from 0 to 2 and from 2 to 6 years of age compared to older children/teens and adults. The ELS-based RBC for the beach play exposure scenario was calculated using Equation 6.1, shown below.

Equation 6.1: $$RBC_{ELS-beach\ play} = \frac{CR \times AT_{cr}}{\left[\left(\frac{IRF_{child-adj} \times AB \times CPF_o}{UCF}\right) + \left(\frac{DF_{child-adj} \times ABS \times CPF_d}{UCF}\right)\right]}$$

Where: $$IRF_{child-adj} = \frac{IR_{0-2} \times ED_{0-2} \times EF_{0-2} \times ADAF_{0-2}}{BW_{0-2}} + \textit{(2-6yr, 6-16 yr, 16-70yr)}$$

$$DF_{child-adj} = \frac{SA_{0-2} \times AF_{0-2} \times ED_{0-2} \times EF_{0-2} \times ADAF_{0-2}}{BW_{0-2}} + \textit{(2-6yr, 6-16 yr, 16-70yr)}$$

3.0 ESTABLISHING SEDIMENT CLEANUP LEVELS FOR PERSISTENT BIOACCUMULATIVE TOXINS

For this Site, SCO and CSL values were developed in accordance with SMS, Ecology guidance, and as generally outlined by the approach and procedures described above. This section summarizes the process of establishing these values for each IHS, and presents the rationale for selecting the CL. In accordance with SMS, the CL is initially set at the SCO but may be adjusted upward as high as the CSL, based on Site-specific evaluation of technical feasibility and net adverse environmental impact.

During the RI/FS, it was suggested that the CL would be established at a value between the SCO and CSL for some constituents, based on consideration of the potential adverse impacts that could occur if dredging was necessary on a much larger scale. However, based on the updated calculations conducted for this update, the CL will be established at the SCO in all instances, maintaining a strongly protective remedy.

The Site marine sediment CLs were set at the lowest value of the SCOs compared across the relevant receptor groups (i.e., the benthic organism community, higher trophic-level species, or humans) for each Site-specific PBT, because the SCOs were determined to be technically feasible to achieve with a net positive impact to the environment. Table A-6 summarizes the results of this evaluation and the CLs to be adopted in the CAP.

The following subsections provide additional information regarding the CL development, including a summary of how the CLs have been updated from those developed during the RI/FS.

3.1 Polychlorinated Biphenyls

In the RI/FS report, SCO and CSL values were developed for both total PCBs and dioxin-like PCB congeners (PCB TEQ). The values for total PCBs were useful to determine the extent of contamination and develop cleanup remedies. However, compliance with the state cleanup standards will ultimately be assessed based on dioxin-like congeners, and as a result, SCO and CSL values for total PCBs were not updated herein. This evaluation included updating the RBC equations for PCB TEQ, using the parameters and considerations for early life stage exposure and beach play exposure noted in Section 2. As shown in Table A-6, the RBC values are both less than the PQL, and as a result the PQL is adopted as the SCO and the CSL. Thereby, the CL for PCB congeners is set at 0.7 nanograms per kilogram (ηg/kg).

3.2 Carcinogenic Polycyclic Aromatic Hydrocarbons

For cPAHs, more recent toxicological data became available after development of the SLs for the RI/FS report, prompting the need to update the CL calculations. Primarily, this consisted of the change in the cancer potency factor for benzo(a)pyrene from 7.3 $(mg/kg\text{-}day)^{-1}$ to 1 $(mg/kg\text{-}day)^{-1}$ (Table A-4). The equation input parameters were also updated to match the recent updates in Ecology's SCUM

(Ecology 2019b) guidance. Furthermore, additional consideration was given to evaluating the potential risks associated with beach play exposure scenarios and early-life stage exposures to be consistent with SCUM guidance.

The decreased cancer potency and increased exposure protection have competing effects on the RBC, but ultimately result in values greater than what was developed for the RI/FS. As shown in Table A-6, the RBC values are 490 micrograms per kilogram (µg/kg) for the SCO, and 1,028 µg/kg for the CSL. Because it is feasible to achieve the SCO without net negative environmental impact, the CL is set at the SCO, 490 µg/kg.

3.3 Tributyltin

During the RI/FS, Site-specific bulk TBT SCO and CSL values of 238 µg/kg and 738 µg/kg, respectively, were developed for the protection of benthic species. During this update, seafood consumption and beach play RBCs were calculated for protection of human health. The lowest RBC calculated for protection of human health for bulk TBT was 167 µg/kg. As a result, the lower and more conservative value of 167 µg/kg was selected as the SCO. The CSL was retained at 738 µg/kg, which is protective of benthic species.

No background or PQL values have been established for TBT, so the CL was set at 167 µg/kg, as shown in Table A-6.

3.4 Persistent Bioaccumulative Toxin Metals

The RBC calculated for arsenic was 0.43 mg/kg, protective of human health through beach play and based on an HQ of 1. This value is less than the SCO protective of the benthic community (57 mg/kg), so was established as the SCO for arsenic protective of human health. However, the arsenic natural background (11 mg/kg) is greater than both the RBC SCO value and the PQL (0.3 mg/kg); therefore, 11 mg/kg was established as the CL for arsenic.

The lowest RBC protective of human health for cadmium was 7 mg/kg. This is a higher value than the natural background concentration or the PQL (0.8 and 0.07 mg/kg, respectively) and it is therefore established as the SCO for cadmium protective of human health. Since no regional background concentration has been established for cadmium, the CSL protective of human health also corresponds to the RBC for cadmium as a non-carcinogen (7 mg/kg). However, these SCO and CSL values are higher than the SCO or CSL protective of the benthic community (5.1 and 6.7 mg/kg, respectively). Therefore, 5.1 mg/kg was selected as the final cadmium SCO, CSL, and CL.

The lowest RBC protective of human health for mercury was 0.5 mg/kg. This is a higher value than the natural background concentration or the PQL (0.2 and 0.02 mg/kg, respectively) and it is therefore established as the SCO for mercury protective of human health. Since no regional background concentration has been established for mercury, the CSL protective of human health also corresponds to the RBC for mercury as a non-carcinogen (0.5 mg/kg). However, these SCO and CSL values are higher than the SCO or CSL protective of the benthic community (0.41 and 0.59 mg/kg, respectively). Therefore, 0.41 mg/kg was selected as the final mercury SCO, CSL, and CL.

Since no RBC specific to the protection of human health and higher trophic-level species could be calculated for lead, the natural background concentration (21 mg/kg), which is higher than the PQL (0.1 mg/kg), was used as the CL for protection of human health. Because the SCO and CSL values for protection of benthic organisms are significantly greater that the values for protection of human health, the human health SCO of 21 mg/kg was established conservatively as the lead CL for marine sediment.

The CLs for PBT metals are presented in Table A-6.

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Table A-1
Background and Practical Quantitation Limit Concentrations
Westman Marine Site – Blaine, Washington

Parameter	Natural Background (a)	PQL (b)	Units
Polychlorinated biphenyls - TEQ (dioxin-like congeners)	0.2	0.7	ηg/kg
Carcinogenic polycyclic aromatic hydrocarbons - TEQ	21	9	µg/kg
Tributyltin	-	-	µg/kg
Arsenic	11	0.3	mg/kg
Cadmium	0.8	0.07	mg/kg
Lead	21	0.1	mg/kg
Mercury	0.2	0.02	mg/kg

Notes:

(a) From SCUM Table 10-1; calculated values (90/90 UTL) for marine sediment natural background from the data sets in Appendix I and Bold study (Ecology 2019b).

(b) From SCUM Table 11-1; programmatic sediment and tissue PQLs used to establish the PQL-based SCO and CSL (Ecology 2019b).

Abbreviations and Acronyms:

CSL = cleanup screening level
µg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
ηg/kg - nanograms per kilogram
PQL = practical quantitation limit
SCO = sediment cleanup objective
SCUM = Sediment Cleanup User's Manual (Ecology 2019b)
TEQ = toxicity equivalence
UTL = upper tolerance limit

Table A-2
Risk-Based Concentration – Seafood Consumption Calculation Parameters
Westman Marine Site – Blaine, Washington

Parameter	Symbol	Units	Value
Cancer Risk	CR	unitless	1.00E-06
Hazard Quotient	HQ	unitless	1
Body Weight	BW	kg	81.8 (a)
Averaging Time-Carcinogen	AT_{Cr}	days	27,375
Averaging Time-Non-Carcinogen	AT_{Nc}	days	27,375
Unit Conversion Factor	UCF	g/kg	1,000
Exposure Frequency	EF	days/yr	365
Exposure Duration	ED	years	70 (b)
Fish/Shellfish Consumption Rate (finfish)	FCR	g/day	112 (c)
Fish/Shellfish Consumption Rate (crustaceans)	FCR	g/day	81.9 (c)
Fish/Shellfish Diet Fraction	FDF	proportion	1
Fraction of Organic Carbon in Sediment	Sfoc	g/g	0.0156
Site Use Factor, Fish	SUF	proportion	0.02
Site Use Factor, Shellfish (crustaceans)	SUF	proportion	0.10
Fish/Shellfish Lipid Fraction	SL	g/g	0.03

Notes:

(a) Average body weight of Tulalip tribal adults (Toy et al. 1996).
(b) Early-life stage exposure durations applied as promulgated in EPA 2005.
(c) Tulalip Tribes consumption for pelagic and benthic/demersal fish and shellfish (Ecology 2013).

Abbreviations and Acronyms:

EPA = US Environmental Protection Agency
g/day = grams per day
g/g = grams per gram
g/kg = grams per kilogram
kg = kilogram
yr = year

Table A-3
Risk-Based Concentration – Beach Play Calculation Parameters
Westman Marine Site – Blaine, Washington

Parameter	Symbol	Units	Value
Averaging Time (ages 0-6)	AT	days	2,190
Averaging Time (ages 6-70)	AT	days	23,360
Averaging Time (ages 0-70)	AT	days	25,550
Body Weight (ages 0-6)	BW	kg	16
Body Weight (ages 6-70)	BW	kg	81.8
Body Weight (ages 0-70)	BW	kg	81.8
Cancer Risk	CR	unitless	1.00E-06
Dermal absorption fraction (organic hazardous substances)	ABS	unitless	0.1 (a)
Dermal absorption fraction (inorganic hazardous substances)	ABS	unitless	0.01 (b)
Dermal surface area (ages 0-6)	SA	cm^2	2,200
Dermal surface area (ages 6-70)	SA	cm^2	3,160
Dermal surface area (ages 0-70)	SA	cm^2	3,160
Exposure duration (ages 0-6)	ED	year	6
Exposure duration (ages 6-70)	ED	year	64
Exposure duration (ages 0-70)	ED	year	70 (c)
Exposure Frequency	EF	days/year	41
Gastrointestinal Absorption Fraction (organic hazardous substances)	GI	unitless	0.5 (a)
Gastrointestinal Absorption Fraction (inorganic hazardous substances)	GI	unitless	0.2 (b)
Gastrointestinal absorption fraction (soil)	AB1	unitless	1.0
Hazard Quotient	HQ	unitless	1.0
Ingestion rate (ages 0-6)	IR	mg/day	200
Ingestion rate (ages 6-70)	IR	mg/day	100
Ingestion rate (ages 0-70)	IR	mg/day	100
Sediment to skin adherence factor (ages 0-6)	AF	mg/cm^{2-}day	0.2
Sediment to skin adherence factor (ages 6-70)	AF	mg/cm^2-day	0.6
Sediment to skin adherence factor (ages 0-70)	AF	mg/cm^2-day	0.6

Notes:

(a) Organic hazardous substances include cPAHs, TBT, and PCBs.
(b) Inorganic hazardous substances include metals.
(c) Early-life stage exposure durations applied as promulgated in EPA 2005.

Abbreviations and Acronyms:

cm^2 = square centimeter
cPAHs = carcinogenic polycyclic aromatic hydrocarbons
kg = kilogram
mg/cm^2-day = milligram per square centimeter per day
mg/day = milligram per day
PCBs = polychlorinated biphenyls
TBT = tributyltin

Table A-4
Cancer Potency Factors and Toxicity Equivalency Factors
Westman Marine Site – Blaine, Washington

Carcinogenic Polycyclic Aromatic Hydrocarbons			
Chemical	**CAS**	**CPFo (mg/kg-day)$^{-1}$**	**TEF (unitless)**
Benz(a)anthracene	56-55-3	1.00E-01	1.00E-01
Benzo(a)pyrene	50-32-8	1.00E+00	1.00E+00
Fluoranthene (total)	205-99-2	1.00E-01	1.00E-01
Chrysene	218-01-9	1.00E-02	1.00E-02
Dibenz(a,h)anthracene	53-70-3	1.00E-01	1.00E-01
Indeno(1,2,3-cd)pyrene	193-39-5	1.00E-01	1.00E-01

Polychlorinated Biphenyls (Dioxin-Like Congeners)			
Chemical	**CAS**	**CPFo (mg/kg-day)$^{-1}$**	**TEF (unitless)**
PCB 77	32598-13-3	1.30E+01	1.00E-04
PCB 81	70362-50-4	3.90E+01	3.00E-04
PCB 105	32598-14-4	3.90E+00	3.00E-05
PCB 114	74472-37-0	3.90E+00	3.00E-05
PCB 118	31508-00-6	3.90E+00	3.00E-05
PCB 123	65510-44-3	3.90E+00	3.00E-05
PCB 126	57465-28-8	1.30E+04	1.00E-01
PCB 156	38380-08-4	3.90E+00	3.00E-05
PCB 157	69782-90-7	3.90E+00	3.00E-05
PCB 167	52663-72-6	3.90E+00	3.00E-05
PCB 169	32774-16-6	3.90E+03	3.00E-02
PCB 189	39635-31-9	3.90E+00	3.00E-05

Tributyltin and Metals			
Chemical	**CAS No.**	**CPFo (mg/kg-day)$^{-1}$**	**RfDo (mg/kg-day)**
Tributyltin	688-73-3	NA	3.00E-04
Arsenic	7440-38-2	1.50E+00	3.00E-04
Cadmium	7440-43-9a	NA	1.00E-03
Lead	7439-92-1	NA	NA
Mercury	7439-97-6	NA	1.00E-04

Abbreviations and Acronyms:

CAS = Chemical Abstracts Service
CPFo = cancer potency factor
NA = not available
PCB = polychlorinated biphenyl
RfDo = reference dose
TEF = toxicity equivalency factor
mg/kg-day = milligram per kilogram per day

Table A-5
Mean Biota Sediment Accumulation Factor Values
Westman Marine Site – Blaine, Washington

Carcinogenic Polycyclic Aromatic Hydrocarbons BSAFs			
Chemical	**CAS No.**	**Finfish**	**Crustaceans (a)**
Benz(a)anthracene	56-55-3	1.22E-03	6.11E-03
Benzo(a)pyrene	50-32-8	9.52E-04	4.76E-03
Total Fluoranthene	205-99-2	1.17E-03	5.84E-03
Chrysene	218-01-9	1.49E-03	7.46E-03
Dibenz(a,h)anthracene	53-70-3	1.29E-03	6.46E-03
Indeno(1,2,3-cd)pyrene	193-39-5	1.10E-03	5.49E-03

Polychlorinated Biphenyls (Dioxin-Like Congeners) BSAFs			
Chemical	**CAS No.**	**Finfish**	**Crustaceans (a)**
PCB 77	32598-13-3	3.72E-01	1.86E+00
PCB 81	70362-50-4	4.58E+00	2.29E+01
PCB 105	32598-14-4	1.25E+01	6.26E+01
PCB 114	74472-37-0	2.78E+00	1.39E+01
PCB 118	31508-00-6	6.26E+00	3.13E+01
PCB 123	65510-44-3	1.16E-01	5.79E-01
PCB 126	57465-28-8	7.18E-01	3.59E+00
PCB 156	38380-08-4	5.42E+00	2.71E+01
PCB 157	69782-90-7	1.42E+00	7.10E+00
PCB 167	52663-72-6	7.22E+00	3.61E+01
PCB 169	32774-16-6	4.32E-01	2.16E+00
PCB 189	39635-31-9	6.06E+00	3.03E+01

Tributyltin BSAF			
Chemical	**CAS No.**	**Finfish**	**Crustaceans**
Tributyltin	688-73-3	1.00E+01	1.00E+01
Metal BAFs (b)			
Chemical	**CAS No.**	**Finfish**	**Crustaceans**
Arsenic	7440-38-2	1.80E-01	4.88E+00
Cadmium	7440-43-9a	4.89E-02	1.57E+00
Lead	7439-92-1	NA	NA
Mercury	7439-97-6	1.61E+00	2.24E+00

Notes:

(a) Finfish BSAF data from USACE and EPA BSAF databases (EPA, USACE; both accessed July 2020). Crustaceans BSAF are five times the finfish BSAF (I&J Waterway Cleanup Action Plan, Ecology 2019a).

(b) From Newfields 2013.

Abbreviations and Acronyms:

BAF = bioaccumulation factor
BSAF = biota-sediment accumulation factor
CAS = Chemical Abstracts Service
EPA = US Environmental Protection Agency
NA = not available
PCB = polychlorinated biphenyl
USACE = US Army Corps of Engineers

Table A-6
Marine Sediment Cleanup Levels for Persistent Bioaccumulative Toxins
Westman Marine Site – Blaine, Washington

Parameter	Natural Background (a)	PQL (b)	Risk-Based SCO	Risk-Based CSL	Benthic SCO (c)	Benthic CSL (c)	Proposed Cleanup Level (d)	Units
Dioxin-like PCBs- TEQ	0.2	0.7	0.003	0.03	-	-	**0.7**	ηg/kg
cPAHs - TEQ	21	9	490	1028	-	-	**490**	µg/kg
Tributyltin (non-carcinogen)	-	-	167	738	238	738	**167**	µg/kg
Arsenic	11	0.3	0.43	0.43	57	93	**11**	mg/kg
Cadmium	0.8	0.07	5.1	5.1	5.1	6.7	**5.1**	mg/kg
Lead (e)	21	0.1	450	450	450	530	**21**	mg/kg
Mercury	0.2	0.02	0.5	0.5	0.41	0.59	**0.41**	mg/kg

Notes:

(a) From SCUM Table 10-1; calculated values (90/90 UTL) for marine sediment natural background from the data sets in Appendix I and Bold study (Ecology 2019b).

(b) From SCUM Table 11-1; programmatic sediment and tissue PQLs used to establish the PQL-based SCO and CSL (Ecology 2019b).

(c) From SCUM Table 8-1; marine and freshwater sediment chemical criteria for protection of the benthic community (Ecology 2019b).

(d) Proposed revised cleanup levels in some cases differ from those presented in the RI/FS (LAI 2020). The previously proposed cleanup levels in the RI/FS are as follows: cPAHs = 400 µg/kg, dioxin-like PCBs = 0.9 ng/kg, tributyltin = 238 µg/kg, cadmium = 0.8 mg/kg, mercury = 0.2 mg/kg.

(e) The more conservative natural background value for lead was chosen as the proposed cleanup level for the Site.

Abbreviations and Acronyms:

µg/kg = micrograms per kilogram
cPAHs = carcinogenic polycyclic aromatic hydrocarbons
CSL = cleanup screening level
Ecology = Washington State Department of Ecology
mg/kg = milligrams per kilogram
ηg/kg = nanograms per kilogram
PCBs = polychlorinated biphenyls
PQL = practical quantitation limit
RI/FS = remedial investigation/feasibility study
SCO = sediment cleanup objective
SCUM = Sediment Cleanup User's Manual (Ecology 2019b)
SMS = Sediment Management Standards
TEQ = toxicity equivalence
UTL = upper tolerance limit
WAC = Washington Administrative Code