APPENDIX A – SUPPLEMENTAL INFORMATION FOR SELECTION OF PRGS
EAST WATERWAY OPERABLE UNIT FEASIBILITY STUDY

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APPENDIX A TABLE OF CONTENTS

PART 1: COMPLIANCE WITH SEDIMENT MANAGEMENT STANDARDS

TABLE OF CONTENTS

List of Tables

List of Figures

1 INTRODUCTION

The Feasibility Study (FS) for the East Waterway (EW) Operable Unit (OU) has been developed under the regulatory framework of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Consistent with CERCLA requirements, the selected alternative must substantively comply with applicable or relevant and appropriate requirements (ARARs), which include portions of the Washington State Sediment Management Standards (SMS). The SMS are the Washington State standards for remediating sediments under the Model Toxics Control Act (MTCA). This appendix provides a brief description of the methods and procedures for establishing cleanup levels under the SMS, and also discusses how the EW alternatives developed under CERCLA can comply with SMS requirements.

This appendix is provided solely for the purpose of evaluation of the remedial action alternatives in the FS and presents a projection of how these alternatives may achieve compliance with those portions of the SMS that are anticipated to be ARARs based on assumptions about future conditions after remediation. Once the United States Environmental Protection Agency (EPA) selects ARARs for the EW OU as part of a Record of Decision (ROD), the mechanism of compliance with the selected portions of the SMS will be determined by EPA during or at the completion of the remedial action.

The preliminary remediation goals (PRGs) presented in Section 4 of the FS were developed to comply with portions of the SMS that are ARARs under CERCLA, including the determination of cleanup levels[1] under Washington Administrative Code (WAC) 173-204-560. The SMS cleanup level determination is performed by determining the sediment cleanup objectives (SCO; discussed in Section 2 of this appendix) and the cleanup screening levels (CSL; discussed in Section 3 of this appendix). The cleanup levels are initially set at the SCO. If the SCO is not technically possible to attain, or would result in net adverse environmental impacts, then the cleanup level can be adjusted up to the CSL.

[1] For the purposes of this appendix only, the SMS term "cleanup level" is considered analogous to the CERCLA term "PRG" used in the main text of the FS. This appendix sometimes uses the term "cleanup level" for consistency with the SMS. In other contexts, these terms may not have the same meaning.

For several contaminants of concern (COCs) in the FS, SCO-based PRGs have been established at their natural background concentration because risk-based SCO concentrations are lower than the natural background concentration. This is consistent with SMS. Although both SMS and CERCLA allow for a regional background-based value to be considered as well,[2] there is no EPA-approved regional background concentration determined for the EW area. In the absence of regional background values, cleanup levels (i.e., PRGs) for these COCs are based on the SCO in the EW FS. For some of these COCs, the modeling and associated analyses presented in this appendix indicated that the SCO is not technically possible to achieve. Empirical long-term monitoring data will allow for a more informed evaluation of technical possibility.

For the purpose of informing alternatives in the FS (Section 4.1.1), EPA requested that additional modeling of a "hypothetical maximum remediation scenario" be conducted to estimate the lowest concentration that could be achieved as a result of remedy implementation. This modeling was conducted to estimate post-construction concentrations and was not conducted for purposes of predicting the long-term outcome of any of the alternatives. The hypothetical maximum remediation scenario is based on a series of estimates using the best available data; however, these estimates are inherently uncertain. The modeling was based on FS-level evaluations and contains uncertainty insofar as detailed engineering design has not been conducted to inform the input parameters that affect the post-construction concentrations. While sensitivity and bounding analysis was completed for the long-term model predictions used in comparing FS alternatives, it was not conducted for the hypothetical maximum remediation scenario analysis. Nonetheless, the analysis provides information that could be used to evaluate whether it is technically possible to achieve natural background-based PRGs, and it provides additional information that EPA could consider for a potential future adjustment of cleanup levels under SMS or for a technical impracticability (TI) waiver under Section 121(d)(4)(C) of CERCLA, 42 U.S.C § 9621(d)(4)(C).

[2] The SMS term "regional background" is similar to the term "anthropogenic background" in EPA guidance (EPA 2002).

As described in Section 9 of the FS, model predictions indicate that long-term post-cleanup concentrations of total polychlorinated biphenyls (PCBs) and dioxins/furans will be higher than the natural background-based PRGs.[3] The modeling includes some assumptions for future source control for the EW and Lower Duwamish Waterway (LDW), but not for the upper Duwamish and Green Rivers, all of which contributes to uncertainty of predictions. While the analysis indicates that it will not likely be technically possible to achieve all natural background-based PRGs in the EW, the cleanup will still achieve the MTCA/SMS ARARs. This appendix discusses different mechanisms for SMS compliance.

Based on preliminary evaluations, the EW OU cleanup is expected to comply with MTCA/SMS for protectiveness of human health for direct contact (remedial action objective [RAO] 2), protection of the benthic community (RAO 3), and protection of higher trophic level organisms (RAO 4) by achieving the PRGs for these RAOs. Modeling of the hypothetical maximum remediation scenario at the completion of cleanup implementation and modeling of long-term site-wide concentrations following source control of LDW and EW lateral inputs both predict that surface sediments in the EW OU will not attain all natural background-based PRGs for protection of human health for seafood consumption (RAO 1). Long-term site-wide concentrations are driven primarily by the ongoing contribution of elevated concentrations from diffuse, nonpoint sources of contamination that contribute to regional background concentrations. However, achieving the MTCA/SMS ARARs may nonetheless occur in one of two ways:

- Post-remedy monitoring may demonstrate sediment concentrations lower than current model predictions, and PRGs identified in this FS may be attained for certain chemicals in a reasonable restoration timeframe. If necessary, the restoration timeframe needed to meet the PRGs could be extended by EPA, where consistent with CERCLA. In making such a determination, EPA may take into account the substantive criteria for a Sediment Recovery Zone (SRZ), as provided by the SMS at WAC 173-204-590(3) (see Section 5 of this appendix).

[3] Note that none of the alternatives is predicted to achieve the SCO for these chemicals; therefore, this appendix applies equally to any of the alternatives, if selected.

- Sediment cleanup levels (SCLs) may be adjusted upward if regional background levels are established for the geographic area of the EW (see Section 4 of this appendix). Considering that a regional background value has not yet been determined for the EW, such adjustments could occur in the ROD (before remediation) or subsequently as part of a ROD amendment or Explanation of Significant Differences (ESD) (during or after remediation). Consistent with the bullet above, the restoration timeframe needed to meet the SCLs could be extended by EPA where consistent with CERCLA requirements for a reasonable restoration timeframe.

In addition to these two potential MTCA/SMS ARARs compliance mechanisms, a final site remedy can be achieved under CERCLA if EPA determines that no additional practicable actions can be implemented under CERCLA to meet certain MTCA/SMS ARARs such that a TI waiver would be warranted for those ARARs under Section 121(d)(4)(C) of CERCLA, 42 U.S.C. § 9621(d)(4)(C).

Because it is not known whether, or to what extent, the SMS ARARs for total PCBs and dioxin/furans will be achieved in the long term, the selection of which of the two compliance mechanisms described above (either meeting the natural background PRG in a reasonable restoration timeframe, or upwardly adjusting the SCL to regional background and meeting it in a reasonable restoration timeframe), is not identified at this time.

The rest of this appendix provides additional detail regarding establishing SCO (Section 2) and CSL (Section 3) concentrations, potentially upwardly adjusting cleanup levels in the future (Section 4), and implementation of an SRZ (Section 5). Section 6 provides a summary of the methods that may be used to comply with the SMS ARAR.

2 SEDIMENT CLEANUP OBJECTIVES

The SMS outline procedures for establishing the lower bound for cleanup levels, called the SCO. Multiple exposure pathways, natural background concentrations, and practical quantitation limits (PQLs) are all considered when determining the SCO, as follows:

> *WAC 173-204-560 (3) Sediment cleanup objectives. The sediment cleanup objective for a contaminant shall be established as the highest of the following levels:*
>
> *(a) The lowest of the following risk-based levels:*
>
> *(i) The concentration of the contaminant based on protection of human health as specified in WAC 173-204-561(2);*
>
> *(ii) The concentration or level of biological effects of the contaminant based on benthic toxicity as specified in WAC 173-204-562 or 173-204-563, as applicable;*
>
> *(iii) The concentration or level of biological effects of the contaminant estimated to result in no adverse effects to higher trophic level species as specified in WAC 173-204-564; and*
>
> *(iv) Requirements in other applicable laws;*
>
> *(b) Natural background; and*
>
> *(c) Practical quantitation limit.*

As summarized in Tables 4-3 and 4-4 of the FS, RAOs were established under CERCLA for the FS to be consistent with WAC regulations:

- Risk-based threshold concentrations (RBTCs) associated with RAOs 1 and 2 were established to be consistent with WAC 173-204-560(3)(a)(i)
- RBTCs associated with RAO 3 were established to be consistent with WAC 173-204-560(3)(a)(ii)
- RBTCs associated with RAO 4 were established to be consistent with WAC 173-204-560(3)(a)(iii)
- Natural background concentrations were established to be consistent with WAC 173-204-505(11)
- PQLs were established to be consistent with WAC 173-204-505(14)

The Washington State Department of Ecology (Ecology) Sediment Cleanup User's Manual (SCUM) II (Ecology 2017) is not an ARAR under CERCLA, although portions of SCUM II may be evaluated as "to be considered" (TBC) criteria. As discussed in Section 4 of the main body of the FS, EPA has prescribed other methods for determining natural background concentrations for establishing PRGs in compliance with CERCLA (e.g., see FS Table 4-2). Solely for informational and comparison purposes, it is noted that in SCUM II, the SCO based on natural background for total PCBs is listed at 3.5 micrograms per kilogram (μg/kg) dry weight (dw) and the SCO based on the PQL for dioxins/furans is listed at 5 nanograms (ng) toxic equivalent (TEQ)/kg dw, because these are the highest of the three SCO levels for these compounds. The arsenic SCO is also established at natural background, but SCUM II defines the natural background concentration for arsenic to be 11 milligrams per kilogram (mg/kg), which would be achievable based on best-estimate FS model results. However, EPA does not consider these values to be ARARs.

3 CLEANUP SCREENING LEVELS

The SMS outline similar procedures for establishing the upper bound for cleanup levels, called the CSL:

> *WAC 173-204-560 (4) Cleanup screening levels. The cleanup screening level for a contaminant shall be established as the highest of the following levels:*
>
> *(a) The lowest of the following risk-based levels:*
>
> *(i) The concentration of the contaminant based on protection of human health as specified in WAC 173-204-561(3);*
>
> *(ii) The concentration or level of biological effects of the contaminant based on benthic toxicity as specified in WAC 173-204-562 or 173-204-563, as applicable;*
>
> *(iii) The concentration or level of biological effects of the contaminant estimated to result in no adverse effects to higher trophic level species as specified in WAC 173-204-564; and*
>
> *(iv) Requirements in other applicable laws;*
>
> *(b) Regional background as defined in subsection (5) of this section; and*
>
> *(c) Practical quantitation limit.*

RBTCs associated with the CSL (excess cancer risk of 10^{-5} or hazard quotient of 1) are presented in FS Table 3-13 and are well below the SCOs for total PCBs and dioxins/furans. The SMS define regional background as follows:

> *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 nonpoint sources, such as atmospheric deposition or storm water, not attributable to a specific source or release. See WAC 173-204-560(5) for the procedures and requirements for establishing regional background.*

The CSL for total PCBs and dioxins/furans may be based on regional background concentrations, once established. However, in the absence of regional background concentrations deemed by EPA to be suitable for use at the EW OU, and because the risk-based levels are below the CSL, the CSL has not been established for total PCBs or dioxin/furans.

In the future, Ecology may establish regional background for the LDW, but Ecology has not yet suggested how this may be applied to the EW. EPA may consider this approach and information once provided by Ecology.

4 ADJUSTMENT OF CLEANUP LEVELS

As discussed previously, because regional background concentrations have not been determined for the EW and the upper bound for the cleanup level (the CSL) has not been determined, the cleanup levels in the FS are set at the SCO for total PCBs and dioxins/furans. However, if regional background concentrations suitable for use at the EW OU are established, then, following the SMS, the cleanup levels may be adjusted upward by EPA based on the following site-specific factors:

> *WAC 173-204-560(2)(a)*
> *(ii) Upward adjustments. The sediment cleanup level may be adjusted upward from the sediment cleanup objective based on the following site-specific factors:*
>> *(A) Whether it is technically possible to achieve the sediment cleanup level at the applicable point of compliance within the site or sediment cleanup unit; and*
>> *(B) Whether meeting the sediment cleanup level will have a net adverse environmental impact on the aquatic environment, taking into account the short- and long-term positive effects on natural resources, habitat restoration, and habitat enhancement and the short- and long-term adverse impacts on natural resources and habitat caused by cleanup actions*

The following sections discuss the site-specific factors that could be considered by EPA to adjust the cleanup levels from the SCO.

4.1 Technical Possibility

The SMS defines "technical possibility" as follows:

> *WAC 173-204-505(23)*
> *"Technically possible" means capable of being designed, constructed and implemented in a reliable and effective manner, regardless of cost.*

Considerations for upward adjustments of cleanup levels based on technical possibility are provided in Ecology's SCUM II guidance document, which states that upward adjustments of cleanup levels under WAC 173-204-560(2)(a)(ii)(A) should be based on "whether it is technically possible to achieve *and maintain* the cleanup level at the applicable point of compliance." [emphasis added] Although SCUM II is not an ARAR, this provision of Ecology's guidance is similar to EPA's environmental criterion requiring long-term maintenance of remedial action alternatives.

This section first estimates the lowest technically possible concentrations that could be achieved in the EW immediately following construction for a hypothetical maximum remediation scenario (Section 4.1.1). The post-construction concentration modeling for the hypothetical maximum remediation scenario was based on FS-level evaluations using best available data, but contains uncertainty, as detailed engineering design has not been conducted to inform the input parameters that affect the post-construction concentrations, and no sensitivity or bounding analysis was completed. Additional design evaluations will be conducted in the future following the ROD.

This appendix also evaluates what is technically possible to maintain in the long term following construction (Section 4.1.2). Uncertainty also exists regarding long-term concentrations, including future conditions following source control, as described in FS Appendix J.

The combination of the hypothetical maximum remediation scenario evaluations and the evaluation of what is technically possible to maintain in the long term following construction may be used by EPA to evaluate technical possibility. This analysis is developed for FS purposes only.

4.1.1 Technical Possibility of Hypothetical Maximum Remediation Scenario

The EW is a highly urbanized, commercial waterway with actively used marine transportation infrastructure along most of the shoreline area that limits the remedial activities that can occur. For example, full removal of all contaminated sediment near structures is not possible without affecting structural stability. As a result, some amount of undisturbed contaminated sediment will in all likelihood remain near structures following remediation; however, measures to practicably reduce remaining contaminated sediment will be considered in the design phase.

This section describes an FS-level analysis on a hypothetical site-wide dredging scenario to estimate the lowest concentration that may be technically possible to achieve for total PCBs at the completion of construction. The scenario was developed assuming that all engineered infrastructure such as piers, engineered embankments, keyways, bridges, and the communication cable crossing would remain in place. Removing and reconstructing the infrastructure associated with the EW would require massive modifications (e.g., reconstructing the West Seattle Bridge, temporarily closing important Coast Guard and Port of Seattle terminals, etc.) that would result in excessive disturbance to essential public and private infrastructure. Moreover, this scenario assumed that remediation would be performed by dredging everywhere possible and included residuals management re-dredging passes where practicable to further lower concentrations. Dredging was assumed to be followed by residuals management cover (RMC) in most locations and was assumed to be followed by in situ treatment with activated carbon in under pier and keyway areas where RMC material could not be placed due to stability concerns and navigation depth requirements.

Note that this hypothetical scenario was created for the purposes of developing alternatives in support of the FS and does not itself represent an alternative in the FS; nor is it intended to provide definitive predictions regarding future concentrations in the EW. Also note that this analysis estimates concentrations at a single point in time (immediately after construction)—ignoring ongoing mixing, propwash, and incoming sedimentation during the construction period (Section 4.1.2). The scenario is based on estimates using best available data, but is subject to uncertainty, as detailed design evaluations have not been conducted.

To support this analysis, the EW was divided into six areas based on the physical constraints of each (Table 1, Figure 1). Spatially-weighted average concentrations (SWACs) immediately following construction were calculated using the box model inputs for each as summarized in the following paragraphs.

Area 1

The first area consists of most of the open-water areas of the waterway (114 acres) and has the fewest structural limitations affecting remediation. In these areas, the assumed remediation scenario was dredging the waterway to the deepest extent of contaminated sediment, followed by two residuals management re-dredging passes (average of 2 feet removal for each), followed by RMC placement. The resulting concentration immediately following construction in surface sediment (top 10 centimeters [cm]) was estimated to be 10 µg/kg dw for total PCBs for this area, based on the dredging residuals calculation methodology presented in FS Appendix B, Part 3A.

Area 2

The second area includes 15 acres of under pier sediments that have limited access and are present on top of slopes comprised of large riprap (see Figure 2). Remediation in these areas is challenging due to access limitations and the presence of hard riprap surfaces and rock interstices. These areas were assumed to be dredged by diver-assisted hydraulic dredging, followed by a thin placement of in situ treatment material to reduce bioavailability of the remaining sediment. The resulting post-construction concentration was estimated to be 290 µg/kg dw for total PCBs. This assumed that an average of 10 cm (3.9 inches) of sediments would remain in place following remediation due to the difficulty of full removal on riprap slopes and within rock interstices, followed by the mixing of 7.6 cm (3 inches) of in situ treatment material (see residuals calculations presented in FS Appendix B, Part 3A). In situ treatment material was also assumed to reduce the bioavailability of hydrophobic organic compounds such as PCBs by 70% (FS Section 5.3.5), resulting in an estimated effective bioavailable under pier average concentration estimated on a dry-weight basis of 153 µg/kg[4]. Note that in situ treatment is a less proven technology than the others presented in this evaluation and, therefore, in situ treatment is used only in areas where other, more-proven technologies are not feasible or unlikely to be effective, such as under the piers (see Section 7.2.7.1 and 7.8 of the FS). Reduction in bioavailability is approximated from available evidence from bench-scale studies and field demonstrations (FS Section 5.3.5) and is subject to uncertainty (Section 2.4 of FS Appendix J).

[4] Note the dry-weight concentration is intended to estimate bioavailability reduction to support calculation of a site-wide SWAC that considers the benefits of the application of in situ treatment material, but this concentration is not what would be measured on a dry-weight basis following construction.

Area 3

The third area includes 7 acres of keyways that are at the base of the under pier slopes (see Figures 1 and 2). These are rock structures keyed into the toe of the riprap slopes to maintain the stability of the slopes above. The tops of the keyways are situated at the navigation depth of approximately -51 feet mean lower low water, therefore limiting the amount of removal and the amount of clean fill placement that can be performed in these areas. Similar to the under pier areas, these areas were assumed to be dredged to the maximum extent possible without removing riprap, followed by a thin placement of in situ treatment material to reduce bioavailability. For this analysis, dredging was assumed to be performed by standard mechanical means. The resulting post-construction concentration was estimated to be 364 µg/kg dw for total PCBs based on an average of 10 cm (3.9 inches) of sediment remaining following dredging, with a 7.6-cm (3-inch) layer of clean in situ treatment material being placed following dredging. The effective bioavailable average concentration in keyways (using a 70% reduction in dry weight concentrations) was estimated to be 192 µg/kg. Note that the placement of in situ treatment material in keyways presented for this evaluation is hypothetical to support this evaluation; however, some keyway areas are already at the required navigation elevation and placement would not be possible in some areas due to navigation requirements. In addition, long-term effectiveness and stability of placement near active berthing areas is highly uncertain because of propeller wash (propwash) but was assumed to be stable for the purpose of this analysis.

Area 4

The fourth area includes 18 acres of structural slope and offset areas where dredge depths will be limited by the geotechnical stability of adjacent slopes (see Figures 1 and 2). In these areas, some contaminated sediment will be left behind; however, these elevation constraints are assumed to still allow the placement of a full RMC layer (i.e., average 9-inch-thick sand layer). The concentration immediately following completion of construction was estimated to be 35 µg/kg dw for total PCBs based on the dredging residuals methodology presented in Appendix B, Part 3A, of the FS.

Area 5

The fifth area includes 2.4 acres under the West Seattle Bridge and the bridge at the head of Slip 27 that have access restrictions (Figure 1). In these areas, removal is limited by geotechnical and structural considerations required to maintain stability of bridge columns. However, these areas are not limited in the amount of clean cover that could be placed following dredging. In addition, these areas experience little to no sediment disturbance from propwash. The resulting post-construction concentration was estimated to be 10 μg/kg dw for total PCBs through limited removal and RMC placement.

Area 6

The sixth area includes 1.8 acres under the three low bridges in the Sill Reach (Figure 1). These areas are characterized by extreme access limitations and widespread debris. Diver-assisted hydraulic dredging would be ineffective in these areas due to the presence of debris. Therefore, enhanced natural recovery (ENR) was assumed in these areas, with a post-construction concentration of 8 μg/kg dw, as a result of some dredging residuals depositing from adjacent areas consistent with the conceptual site model of sediment transport in the EW.

Considering all of these areas together, the site-wide SWAC immediately following construction was estimated to be 57 μg/kg dw for total PCBs, with an effective bioavailable concentration of 34 μg/kg. Recognizing this evaluation has uncertainties inherent to modeling, under this hypothetical maximum remediation scenario, the post-construction SWAC would not achieve the natural-background-based SCO for total PCBs. As discussed above, this hypothetical SWAC assumes that construction would be completed uniformly across the site, at a single point in time (e.g., instantaneously), therefore, this analysis does not consider the sediment mixing and exchange or ongoing sediment deposition that would occur over the timeframe required to conduct this cleanup. Moreover, this hypothetical scenario would have a construction timeframe of more than 15 years, during which time sediments would be mixing due to vessel propwash. Accordingly, the above site-wide post-construction SWAC represents an idealized condition that is not likely to be achieved during remedy implementation.

4.1.2 Maintenance in the Long Term

This section describes four considerations for whether it would be technically possible to maintain the natural-background based SCOs for total PCBs and dioxin/furan in the long term, considering the lowest technically possible achievable concentration estimated in Section 4.1.1. The four considerations are as follows:

1. Predicted increase in the SWAC following sediment mixing and exchange between under pier and open-water sediment
2. Predicted future average concentrations in particulate matter entering the EW
3. Measured concentrations present in surface sediment at remediated sites proximal to the EW
4. Measured surface sediment concentrations in Elliott Bay

The first line of evidence is the box model site-wide SWAC predictions. Following construction, box model predictions of the site-wide SWAC for each of the remediation alternatives except no action increase in the short-term (e.g., year 5 following construction) as a result of sediment mixing and exchange between open-water and under pier sediments (see FS Appendix J). The box model predicts that concentrations will then gradually reduce toward the net incoming sediment concentrations over time, which are estimated to be above natural background-based cleanup levels and lowest technically possible achievable concentration for total PCBs and dioxins/furans (see next line of evidence). As indicated in FS Appendix J, the box model is based on a series of estimates, which were developed for the purposes of comparing alternatives. The box model output was particularly sensitive to certain input parameters, including the incoming Green-Duwamish sediment concentrations, bioavailability reductions from activated carbon treatment, and net sedimentation rates, all of which are uncertain.

The second line of evidence is the estimated concentration of incoming sediments. Table 2 provides the estimated average sediment input concentrations for the EW based on incoming solids from both upstream (including Green River and LDW) and EW lateral inputs. These concentrations were calculated using a weighted average of chemical concentrations based on inputs entering the EW from the Green/Duwamish River, resuspended LDW bedded sediment, and lateral inputs from both the LDW and EW (see FS Table 5-5). Average input concentrations do not incorporate concentrations that may come from the EW bed, including the dredge residuals that will be present following construction, and sediments in unremediated areas. Average input concentrations were developed for the base case (best estimate), low bounding, and high bounding runs, adjusted to account for additional source control for lateral inputs (i.e., combined sewer overflow [CSO] and storm water inputs) managed by source control programs (e.g., National Pollutant Discharge Elimination System [NPDES]), which may have permit conditions modified in the future to reduce COC inputs to the EW. These estimates do not consider ongoing efforts to reduce sources of contamination to the upper Duwamish/Green River watershed. For total PCBs, the average input concentrations ranged from 8 to 85 μg/kg dw, and for dioxin/furans the average input concentrations ranged from 2 to 8 ng TEQ/kg dw. The base case (best estimates) values for both total PCBs (45 μg/kg dw) and dioxins/furans (6 ng TEQ/kg dw) are well above the SCO concentrations for total PCBs (2 μg/kg dw), and marginally above the SCO for dioxins/furans (2 ng TEQ/kg dw).

The third line of evidence is the post-remediation surface sediment concentrations of four cleanup sites in relatively close proximity to the EW, which were selected as representative of the post-remediation concentrations that could be expected to be achieved in the long term. Table 2 summarizes post-remediation monitoring data for Pier 53-54, Lockheed Shipyard, Todd Shipyards, and Duwamish Diagonal (through 2012), as well as the form of remediation (dredging, capping, or ENR) used at each site. The surface sediment data range from 5 to 10 years post-remediation and represent the surface sediment concentrations that can be expected following dredging, capping, or ENR, as well as the influence of ongoing sedimentation from diffuse urban inputs. Mean concentrations from the above four datasets suggest that post-remediation concentrations in the EW could range from approximately 32 to 133 μg/kg dw for total PCBs and be approximately 5 ng TEQ/kg dw for dioxin/furans (data from Duwamish/Diagonal cap only), depending on the dataset considered. These concentrations exceed the natural background levels for total PCBs and dioxins/furans. The resultant ranges of concentrations from all four of the datasets suggest that it is not technically possible to maintain the PRG for total PCBs (2 μg/kg dw) and may or may not be possible to maintain the PRG for dioxins/furans (2 ng TEQ/kg dw) in the long term in this region of Puget Sound, including the EW. It is important to note that ongoing and future source control efforts or sediment remediation in the surrounding area within the watersheds may decrease observed concentrations of depositing sediment. Furthermore, the sediment dynamics in the locations represented by these studies differ from those of the EW.

The fourth line of evidence is surface sediment concentrations from Elliott Bay. These data represent ambient concentrations in Elliott Bay, which provides an estimate of deposited sediment from diffuse urban inputs that may influence expected long-term concentrations. While the EW is adjacent to Elliott Bay, sediment load from Elliott Bay to the EW is assumed to be negligible compared to other sources (Windward and Anchor QEA 2014). Elliott Bay is a much larger waterbody than the EW and has many other sources along the shoreline that could contribute higher concentrations to sediment. As shown in Table 2, inner Elliott Bay[5] samples had a mean total PCBs concentration of 153 µg/kg dw (2007 data), and the mean dioxins/furans concentration was 20 ng TEQ/kg dw (2007 data). Concentrations are higher when 90th percentile values are considered (274 µg/kg dw for total PCBs based on 2007 data). In outer Elliott Bay, mean total PCBs concentrations range from 28 µg/kg dw (2007 data) to 32 µg/kg dw (1991 to 2004 data), and the mean dioxins/furans concentration was 2 ng TEQ/kg dw (2007 data) (see Table 2). Concentrations are higher when 90th percentile values are considered (e.g., 53 µg/kg dw for total PCBs based on 2007 data). Post-remediation concentrations of total PCBs and dioxins/furans in sediment in the EW may be higher than these values because of its closer proximity to diffuse urban inputs, which are more represented by data from inner Elliott Bay.

In summary, all the lines of evidence that inform an evaluation of the concentrations that can be achieved in the long term in the EW indicate that the PRG will not likely be achieved or maintained. For total PCBs, the average concentrations are well above the PRG of 2 µg/kg dw, and the range of achievable concentrations for all lines of evidence is 9 to 153 µg/kg dw. For dioxins/furans, the average concentrations are above the PRG of 2 ng TEQ/kg dw, and the range of achievable concentrations for all lines of evidence is 1.7 to 20 ng TEQ/kg dw. Regional background concentrations, if determined, may fall within these ranges.

4.2 Net Adverse Environmental Impact

The second factor in determining an upward adjustment of the SCO-based cleanup level is the determination of net adverse impact on the aquatic environment, which takes into

[5] Inner Elliott Bay samples are generally defined as samples east of a line from Terminal 91 directly south to West Seattle. Outer Elliott Bay includes the samples west of the line. See the depiction in Appendix J, Figure J-3, of the LDW FS (AECOM 2012).

account "the short- and long-term positive effects on natural resources, habitat restoration, and habitat enhancement and the short- and long-term adverse impacts on natural resources and habitat caused by cleanup actions" (WAC 173-204-560(2)(a)(ii)(B)). This discussion encompasses certain hypothetical scenarios and lines of evidence that could be used as part of a net environmental impacts analysis and is presented for comparison purposes only.

The SMS cleanup levels for total PCBs and dioxin/furans that are not adjusted significantly upward from the PRG could only be met and reliably maintained with additional dredging over larger areas and at greater depths, and repeated capping and re-dredging of the same areas as concentrations rise due to diffuse source inputs over time. This approach would result in very large adverse impacts on the aquatic environment (natural resources and habitat) from construction without producing any countervailing long-term environmental benefits from the additional cleanup measures (i.e., risk reduction). Repeated rounds of dredging and/or capping would result in major additional construction-related adverse impacts to the benthic community, due to disruption of the established biological active zone, and to fish tissue contaminant levels, due to releases of contaminated material during dredging, resulting in higher fish exposures. In addition, these adverse impacts would occur over a significantly longer period of time. Even with ongoing efforts of this type, evidence presented in Section 4.1 of this appendix suggests that the PRGs for total PCBs and dioxin/furans would still not be achieved. As such, the continued cleanup activities in an attempt to reach concentrations closer to the PRG would result in significant adverse impacts to the environment without commensurate benefits to the benthic community or reductions in tissue concentrations that would lower human health risks. Ultimately, the EW system will equilibrate to incoming sediment concentrations that are estimated to be higher than the PRG and similar to concentrations resulting from less disruptive cleanup activities associated with higher cleanup levels (e.g., CSL).

In comparison, the SMS cleanup levels based on the CSL for total PCBs and dioxin/furans (i.e., regional background, if established) would result in slightly smaller adverse impacts on the aquatic environment from construction because the cleanup technologies needed to meet the cleanup levels would be less intrusive to benthic communities in some areas (less dredging or capping), and the need for additional contingency actions would be greatly reduced or eliminated. A cleanup level at or close to a potential regional background concentration for total PCBs and dioxin/furans, if established, would reflect the concentrations of those contaminants in incoming sediment over the long term, thereby avoiding unnecessary adverse impacts on the aquatic environment from construction and ultimately resulting in similar or improved long-term environmental benefits from cleanup (i.e., risk-reduction). Therefore, sediment cleanup levels based on the PRG will result in net adverse impacts, which would likely not occur with cleanup levels that are adjusted upward to the CSL based on regional background.

4.3 Summary and Conclusion

Compliance with the SMS and CERCLA PRGs will likely involve the adjustment of cleanup levels upward from the SCO (PRG) to the CSL for total PCBs and dioxins/furans. This adjustment may occur in the future if the CSL (i.e., a regional background value applicable to the EW Superfund site) is established by EPA for these contaminants.

For FS purposes, a hypothetical maximum remediation scenario was analyzed to approximate lowest technically-possible concentrations for total PCBs that could be achieved following construction. While this analysis is subject to uncertainty, it indicated that approximately 57 µg/kg dw could be achieved (34 µg/kg when making adjustments for bioavailability) when considering limitations to remediating near structures to achieve very low total PCBs concentrations.

Multiple lines of evidence were evaluated to approximate values that could be achieved in the long term. For total PCBs, the average concentrations are above the PRG of 2 µg/kg dw, and the range of achievable concentrations for all lines of evidence is 9 to 153 µg/kg dw. For dioxins/furans, the average concentrations are above the PRG of 2 ng TEQ/kg dw, and the range of achievable concentrations for all lines of evidence is 1.7 to 20 ng TEQ/kg dw. As discussed in Section 4, under the SMS, the cleanup level may not be adjusted above the CSL (i.e., regional background values, if established by EPA).

Finally, a hypothetical possible scenario for considering the net adverse environmental impact for setting the cleanup level at the SCO was qualitatively discussed, indicating that the cleanup levels would likely need to be adjusted upward to the CSL, if established, to avoid environmental disturbances that result in no environmental benefit.

As noted above, this analysis was developed for FS purposes only; it contains assumptions about future conditions that are inherently uncertain. While CERCLA does not require that a technical possibility evaluation be conducted in the FS, it provides additional information that EPA could consider for a potential future adjustment of cleanup levels or TI waiver.

5 SEDIMENT RECOVERY ZONE

Under SMS, a restoration timeframe of longer than 10 years (i.e., cleanup levels not achieved within 10 years) would result in the designation of an SRZ (WAC 173-204-570(5)(b)). SMS define the SRZ as the following:

> *"Sediment recovery zone" means an area authorized by the department within a site or sediment cleanup unit where the department has determined the cleanup action cannot achieve the applicable sediment cleanup standards within ten years after completion of construction of the active components of the cleanup action.*

The SRZ is used to track a cleanup area that remains above cleanup levels and perform additional cleanup or source control actions as necessary. The requirements of the SRZ are listed in WAC 173-204-590(2) and are very similar to the CERCLA requirements for a selected remedy. EPA may consider the substantive criteria for an SRZ, WAC 173-204-590(3), when determining the reasonable restoration timeframe of the remedial action for the EW. The remaining portion of the discussion of SRZs under the SMS is presented for comparison purposes only.

The key components of the SRZ approach, if used, are the following:

- The SRZ could be designated side-wide for relevant human health risk drivers 10 years following construction.
- 5-year reviews and site-wide monitoring program could provide the periodic review process for adjusting, eliminating, or renewing the SRZ consistent with the SMS.
- The SRZ could be used in concert with active cleanup and source control measures for the selected alternative and would not replace cleanup actions. The contaminant concentrations within the SRZ will be as close as practicable to the cleanup level, based on the CERCLA comparison of alternatives under the nine criteria in the FS.

Post-construction site-wide monitoring data will be used to evaluate progress toward meeting the cleanup levels. This information could also be used to support establishment or evaluation of regional background concentrations and potential modification of the SRZ, if established by EPA, and closure of the EW OU.

If monitoring data shows cleanup standards cannot be met, the following options are available for Ecology to consider:

1. *If noncompliance is due to PLP sources not being controlled, additional source control may be necessary.*
2. *If noncompliance is due to contribution from other sources that are not under the responsibility or authority of the PLP, closure of the SRZ may be appropriate or adjustment of the cleanup level may be appropriate. For example:*
   a. *Ecology may consider whether the cleanup level should be adjusted upwards according to the process detailed in Chapter 7, Section 7.2.3. An example of when this may be appropriate is where the cleanup level was established below regional background, but Ecology has since established or approved regional background for the geographic area where the site is located. In this case, Ecology may determine that regional background represents the concentration in sediment that is technically possible to maintain, due to ongoing sources that are not under the authority or responsibility of the PLP. Therefore, Ecology could allow upwards adjustment of the sediment cleanup level to the CSL if regional background has been established as the CSL.*
   b. *If the cleanup levels are based on background (regional or natural), Ecology will consider whether background concentrations have increased, and the cleanup level should be adjusted upwards.*

(Ecology 2017, Section 14.2.6)

6 CONCLUSIONS

The PRGs in the EW FS have been developed under CERCLA to be consistent with the SMS (WAC 173-204-560). The selected alternative will meet the SMS ARAR over time in one of two ways: 1) by achieving the SCO in a reasonable restoration timeframe, as determined by EPA; or 2) by achieving the cleanup level in a reasonable restoration timeframe, as determined by EPA, after the establishment of a CSL and upward adjustment of the cleanup level. If cleanup levels are not achieved within a reasonable restoration timeframe, the SMS ARAR may be met through compliance with the substantive criteria of an SRZ (WAC 173-204-590(3)), potentially including determination by EPA of whether an extension of the restoration timeframe is appropriate.

Because it is not known whether, or to what extent, the SMS ARARs for various COCs will be achieved in the long term, or the timing of a potential regional background evaluation, the way in which the cleanup will comply with SMS (described above as meeting either the natural background PRG in a reasonable restoration timeframe, or by upwardly adjusting the cleanup level to regional background and meeting it in a reasonable restoration timeframe), is not selected at this time. The method used to comply with the SMS ARAR will depend primarily on the timing of regional background evaluations for the EW and measured remedial action performance following construction.

EPA may also issue a TI waiver at some point in the future if EPA determines that SMS-based cleanup levels cannot be practicably achieved within the EW.

7 REFERENCES

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TABLES

Table 1
Areas and Post-construction Concentrations for Maximum Possible Remediation Evaluation

	Area	Area (acres)	Remediation and Residuals Management Approach	Residuals PCBs Concentration (µg/kg dw)	Residuals Thickness (cm)	Resulting Post-construction Concentration	Notes
1	Open-water Areas Away from Offsets, Slopes, and Riprap	114	Two cleanup dredging passes and RMC	141	5.8	10	Residuals concentration and thickness based on residuals approach discussed in WPAM 1, but with two cleanup passes followed by RMC.
2	Underpier Areas	15	Diver-assisted hydraulic dredging followed by in situ treatment	510	10	290 µg/kg dw; 153 µg/kg effective bioavailable	Residuals concentration and thickness based on the Draft FS assumption for dredging down to riprap surface. Post-construction concentration based on volume-weighted average concentration under the pier (510 µg/kg), with a 70% reduction in bioavailability.
3	Keyways	7.0	Dredging to the extent practicable followed by in situ treatment[a]	640	10	364 µg/kg dw; 192 µg/kg effective bioavailable	Residuals concentration and thickness based on the Draft FS assumption for dredging down to riprap surface. Post-construction concentration based on the estimated site-wide average last-pass dredging concentration (760 µg/kg), with a 70% reduction in bioavailability.[a]
4	Structural Slope and Offset Areas	18	Dredging to the extent practicable with RMC	640	5.1	35	Residuals concentration, thickness, and post-construction concentration based on residuals approach discussed in WPAM 1.
5	Under the West Seattle Bridge and the Head of Slip 27 Bridge	2.4	Dredging to the extent practicable with RMC	640	10	10	Residuals concentration based on site-wide average concentration in the last dredging production pass (presented in WPAM 1). Residuals thickness incorporates offsets from bridge structures. Post-construction concentration is assumed to be 10 µg/kg based on minimal resuspension in the relatively quiescent conditions between the low bridges.
6	Under Low Bridges	1.8	Enhanced natural recovery (ENR) (dredging not possible due to access and debris)	640	1.0	8	Area is characterized by large debris and poor access. Dredging would be ineffective without bridge removal. Assume that ENR is used with a post-construction concentration based on a 1-cm residuals thickness from neighboring dredging.
Site-wide Area-weighted Average		157	Varies	262	Varies	57 µg/kg dw; 34 µg/kg effective bioavailable	Site-side SWAC based on the post-construction concentrations and areas above.

Notes:

a. The hypothetical placement of in situ treatment material in keyways is presented for this evaluation. However, some keyway areas are already at the required navigation elevation and placement types/thickness may be limited by the navigation requirements. In addition, long term effectiveness and stability of placement in active berthing areas is highly uncertain because of prop-wash. Reduction in bioavailability is approximated.

µg/kg - microgram per kilogram
cm - centimeter
dw - dry weight
FS - Feasibility Study
PCB - polychlorinated biphenyl
RMC - residuals management cover
SWAC - spatially-weighted average concentration
WPAM - Work Product Approval Meeting

Table 2
Technical Possibility Lines of Evidence

Location	Area Description	PCBs (µg/kg dw) Average (points)	PCBs (µg/kg dw) Median	PCBs (µg/kg dw) 90th Percentile	PCBs (µg/kg dw) n	Dioxin/Furan (ng TEQ/kg dw) Average (points)	Dioxin/Furan (ng TEQ/kg dw) Median	Dioxin/Furan (ng TEQ/kg dw) 90th Percentile	Dioxin/Furan (ng TEQ/kg dw) n	Notes	Citation
East Waterway Input Concentrations											
East Waterway	Weighted average input concentrations (base case)	45	n/a	n/a	n/a	6	n/a	n/a	n/a	From Table 5-5 of the East Waterway Feasibility Study. Methods described in Section 5.3.2 of the Feasibility Study. Based on future conditions.	n/a
	Weighted average input concentrations (low bounding)	9	n/a	n/a	n/a	2	n/a	n/a	n/a		
	Weighted average input concentrations (high bounding)	85	n/a	n/a	n/a	8	n/a	n/a	n/a		
Sediment Remediation Sites											
Pier 53-55, Elliott Bay	Post-remediation cap and ENR surface	32	15	68	7	n/a	n/a	n/a	n/a	Sampled in 2002, year 10 post-remediation (capping and ENR).	King County 2010
Lockheed, Shipyard No. 1, West Waterway	All open channel remediation areas (dredge with/without ENR)	133	102	202	5	n/a	n/a	n/a	n/a	Sampled in 2012, year 7 post-remediation (removal and removal with ENR). Beach samples excluded. Five samples from upper 10 cm.	Tetra Tech 2012
Todd Shipyards, West Waterway	All remediation areas (dredge with/without ENR, capping)	78	44	106	15	n/a	n/a	n/a	n/a	Sampled in 2010, 5 years post-remediation (mixture of open-water dredging, some dredging with ENR, and underpier and nearshore capping).	Floyd|Snider 2010
Duwamish Diagonal, Lower Duwamish Waterway	Caps A and B	54	55	90	8	5.1	5.1	6.6	3	Sampled in 2009, event year 6 post-remediation (capping).	AECOM 2012 (Feasibility Study report and database)
Elliott Bay Concentrations											
Elliott Bay	All of Elliott Bay from 2007 sampling	119	63	250	18	15	5.9	37	18	All Elliott Bay samples in the 0-10 cm interval collected in 2007. Both Outer Elliott Bay data and Inner Elliott Bay as defined by the report.	Ecology 2008
	Inner Elliott Bay only from 2007 sampling	153	184	274	13	20	6.5	73	13	13 samples from the 0-10 cm interval collected in 2007. Inner Elliott Bay as defined in the report.	
	Outer Elliott Bay only from 2007 sampling	28	17	53	5	1.7	1.6	2.9	5	Elliott Bay in the 0-10 cm interval collected in 2007. Outer Elliott Bay as defined in the report.	Ecology 2008
	Outer Elliott Bay only from 1991-2004 sampling events	38	17	82	28	n/a	n/a	n/a	n/a	Data from 1991 to 2004 from EIM database. Inner and Outer Elliott Bay as defined in the report.	AECOM 2012 (Feasibility Study Table J-1)

Notes:

µg/kg - microgram per kilogram
cm - centimeter
dw - dry weight
ENR - enhanced natural recovery
n/a - data not available or parameter not applicable
ng TEQ/kg - nanogram toxic equivalent per kilogram
PCB - polychlorinated biphenyl
Statistics were performed in Excel using standard equations.

References:

AECOM, 2012. Feasibility Study, Lower Duwamish Waterway, Seattle, Washington. Final Report. Prepared for Lower Duwamish Waterway Group. October 2012.
Ecology, 2008. Dioxins, Furans, and other Contaminants in Surface Sediment and English Sole Collected from Greater Elliott Bay (Seattle), Publication No. 08-03-017. June 2008.
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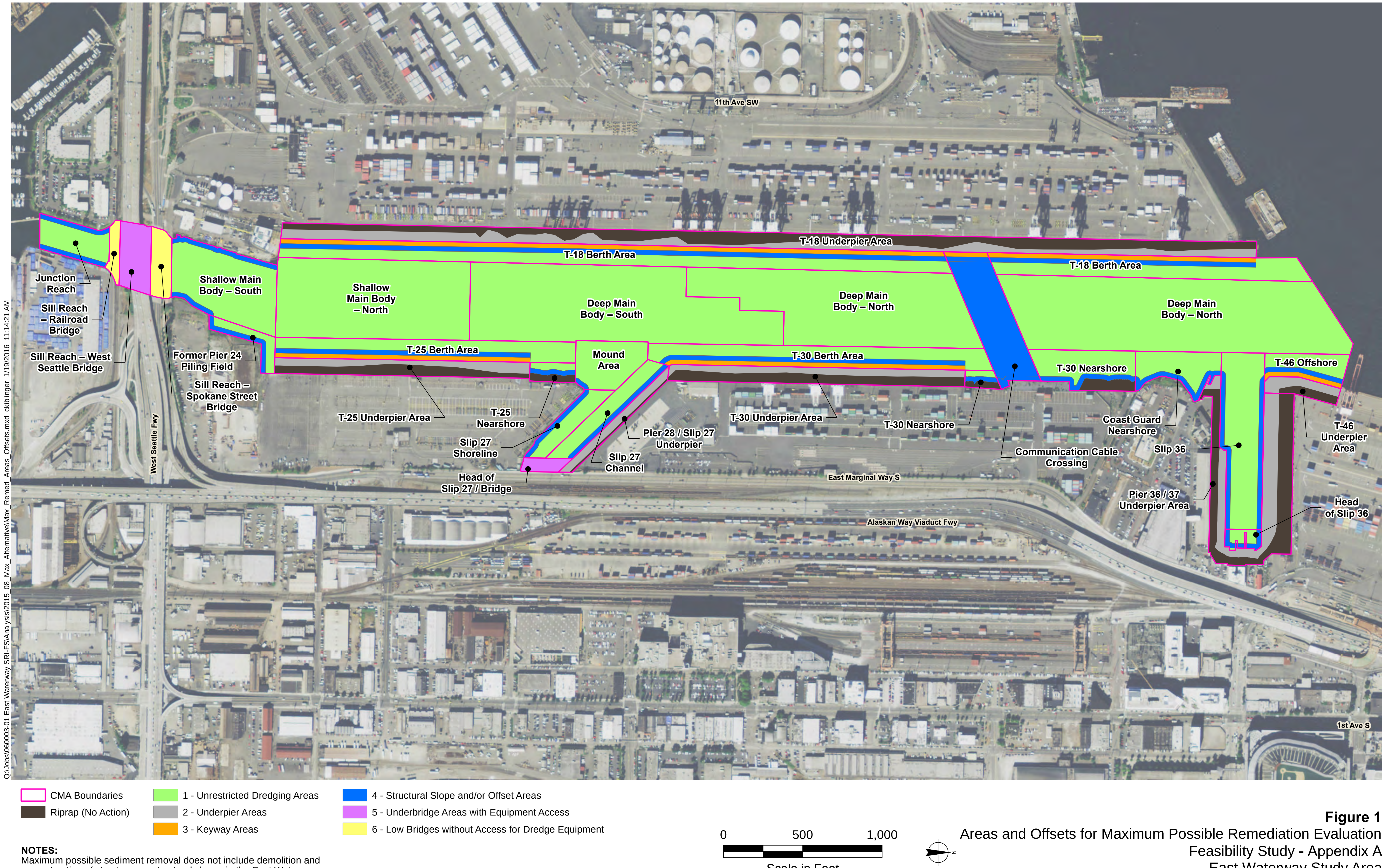
FIGURES



NOTES:
Maximum possible sediment removal does not include demolition and reconstruction of structures or structural slopes in the East Waterway.

Figure 1
Areas and Offsets for Maximum Possible Remediation Evaluation
Feasibility Study - Appendix A
East Waterway Study Area

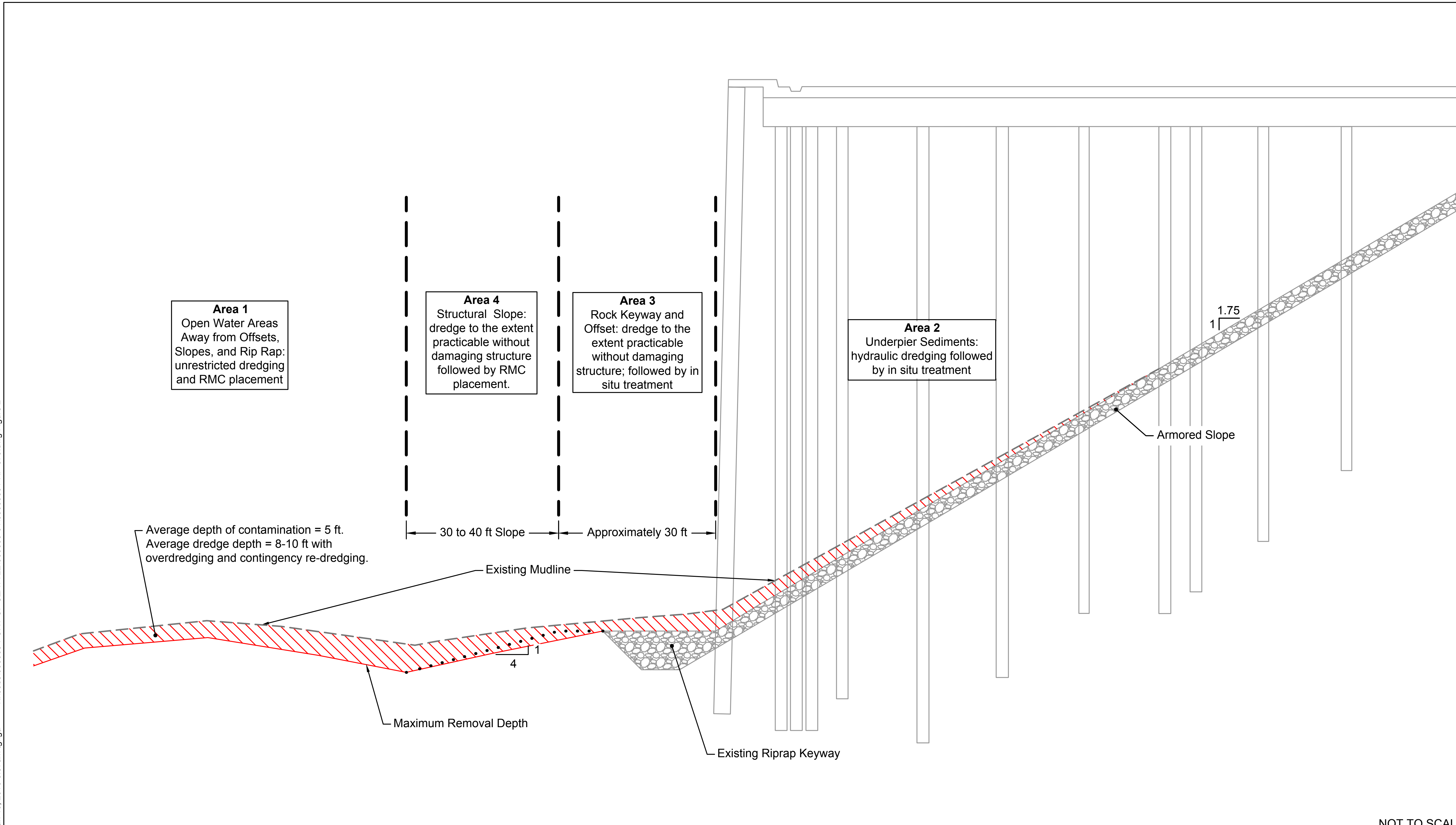


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Figure 2
Conceptual Cross Section Showing Maximum Possible Remediation for East Waterway Terminal with Keyway
Feasibility Study - Appendix A
East Waterway Study Area

PART 2: DEVELOPMENT OF SEDIMENT PRGS FOR PCBS IN FISH

Development of Sediment PRGs for PCBs in Fish

Total PCBs were identified in the Baseline Ecological Risk Assessment (ERA) for the East Waterway (EW) site as a contaminant of concern (COC) for English sole and brown rockfish because PCBs in tissues of both fish species exceeded the two lowest observed adverse effect level (LOAEL) toxicity reference values (TRVs) that were associated with adverse effects in fish. Total PCBs were also identified as a risk driver COC for fish based fish tissue concentrations exceeding the higher LOAEL TRV(Windward 2012).

Two LOAEL TRVs for fish were evaluated in the ERA for PCBs because of uncertainties associated with the lowest LOAEL TRV. Both TRVs are derived from Hugla and Thome (1999). The study examined the effects of PCB exposure on reproductive endpoints with fish dosed at two concentrations. During the first reproductive season there was no spawning at the high exposure, and no adverse effects were reported for the lower exposure level. One year following exposure, significant reductions in fecundity were reported at both exposure levels. The fecundity LOAEL associated with the lower dose is uncertain because fecundity as measured after the first two spawning seasons was not dose-responsive. Egg mortality was significantly higher than the control in the higher exposure level but at the lower dose, egg mortality was not significantly different from controls. The uncertainties in this study are detailed in the ERA uncertainty analysis (Section A.6.2.2.2). Uncertainties discussed include those associated with the statistical analysis for the fecundity endpoint and the fact that this endpoint was not dose responsive, uncertainties related to test conditions, and uncertainties in the estimate of the whole-body concentration associated with effects. Total PCBs in fish was the only COC that was evaluated based on two TRVs. In the EW Supplemental Remedial Investigation (SRI), the two TRVs were used to derive two tissue risk based threshold concentrations (RBTC) values from which two sediment RTBC values are derived.

A sediment PRG value for each fish species is needed to evaluate the effectiveness of proposed remediation strategies in the FS. This memo provides the basis for the development of a sediment PRG value for each fish receptor for total PCBs. As discussed in Section 4 of the FS, PRGs are developed based on an evaluation of RBTCs, background concentrations and practical quantitation limits. The analysis presented sediment RBTCs for fish that are above background concentrations for total PCBs and above practical quantitation limits (see Section 4 in the FS), and therefore, the RBTCs are used to set the sediment PRG for total PCBs for fish. Because of the uncertainties in the lower TRV (see ERA Sections A.6.2.2.2), the lower TRV was not used alone to develop the sediment PRG for fish. Instead, two approaches were evaluated for the development of the PRG value, both of which included the use of the lower TRV in combination with other TRVs. The first approach is based on the mean of the tissue

RBTC values from the EW SRI (Anchor and Windward 2013). The second approach is based on the calculation of the 5th percentile of the ERA effects dataset.

The first approach to deriving a sediment PRG for each fish receptor was to use the mean of the two tissue RBTC values (0.52 and 2.64 mg/kg ww) for PCBs in fish. This approach results in a tissue value of 1.6 mg/kg ww, which was then used to derive sediment values for both English sole and brown rockfish using the site-wide EW PCB food web model (FWM). This approach resulted in sediment values of 370 µg/kg dw for English sole and 250 µg/kg dw for brown rockfish.

The second approach was to calculate a percentile value of the TRV dataset for PCBs in fish tissue that was developed in the ERA (Windward 2012). The calculation of a low percentile value from a dataset of acceptable studies of effects is consistent with the approach used in developing ambient water quality criteria (Stephan et al. 1985) and other criteria developed for the protection of special-status species (e.g., Meador et al. 2002).

Thirteen studies with fish tissue LOAELs for the potential adverse effects of PCB mixtures on fish were reviewed in the ERA (Table 1). None of the studies used English sole or brown rockfish. Concentrations of PCBs in fish tissue were reported in 17 species (i.e., Atlantic croaker, Atlantic salmon, brook trout, channel catfish, coho salmon, common barbel, fathead minnow, goldfish, Chinook salmon, pinfish, rainbow trout, mummichog, sheepshead minnow, common minnow, and spot). Adverse effects included reduced body weight; reduced early life stage or fry growth and survival; and reduced fecundity, hatchability, and spawning success following exposure to PCBs.

Whole-body effect-level concentrations ranged over three orders of magnitude across the fish species included in the toxicological studies. Whole-body tissue LOAELs ranged from 0.520 mg/kg ww for reduced barbel fecundity (Hugla and Thome 1999) to 749 mg/kg ww for mortality of fathead minnows (van Wezel et al. 1995).

All LOAEL values were included in the derivation of the percentile value except the results of one study (Table 1). The LOAEL values from van Wezel et al. 1995 were excluded because of the lack of a control in the study design and large variability in the results.

Table 1. Fish whole-body tissue-residue TRVs for PCBs from the EW ERA

Chemical	Test Species	Tissue Analyzed	Whole-body NOAEL (mg/kg ww)	Whole-body LOAEL (mg/kg ww)	Effect	Source	Acceptable for derivation of 5th percentile LOAEL
Aroclor 1260	common barbel	whole body	na	0.520[a]	reduced fecundity	Hugla and Thome (1999)	Yes
Aroclor 1254	juvenile Chinook salmon	whole body	0.980	na	no effect on growth or survival	Powell et al. (2003)	LOAEL na
Aroclor 1260	common barbel	whole body	0.520[b]	2.64[a]	lack of spawning in first reproductive season; egg and larval mortality	Hugla and Thome (1999)	Yes
Aroclor 1254	rainbow trout (14 weeks)	whole body	8.0	na	no effect on growth or survival	Lieb et al. (1974)	LOAEL na
Aroclor 1254	sheepshead minnow (adult)	whole body	1.9	9.3	decreased fry survival in the first week after hatch	Hansen et al. (1974a)	Yes
Aroclor 1254	pinfish	whole body	na	14	reduced survival	Hansen et al. (1971)	Yes
Aroclor 1268	mummichog (adult)	whole body	15	na	no effect on fertilization, hatching, or larval survival	Matta et al. (2001)	LOAEL na
Clophen A50	common minnow	whole body	na	25	reduction in time to hatch, fry mortality	Bengtsson (1980)	Yes
Aroclor 1260	channel catfish	whole body	32	na	no effect on growth or survival	Mayer et al. (1977)	LOAEL na
Aroclor 1254	spot	whole body	27	46	reduced survival	Hansen et al. (1971)	Yes
Aroclor 1260	fathead minnow	whole body	na	50	reduced offspring body weight	DeFoe et al. (1978)	Yes
Aroclor 1254	brook trout embryos	whole body	31	71[c]	reduced fry growth	Mauck et al. (1978)	Yes
Aroclor 1016	sheepshead minnow	whole body	77	na	no effect on fertilization success, survival of embryos, or fry survival	Hansen et al. (1975)	LOAEL na
Aroclor 1016	pinfish	whole body	na	106	50% mortality	Hansen et al. (1974b)	Yes
Aroclor 1254: 1260 mixture	juvenile rainbow trout	whole body	120	na	no effect on survival	Mayer et al. (1985)	LOAEL na

Chemical	Test Species	Tissue Analyzed	Whole-body NOAEL (mg/kg ww)	Whole-body LOAEL (mg/kg ww)	Effect	Source	Acceptable for derivation of 5th percentile LOAEL
Aroclor 1254: 1260 mixture	juvenile rainbow trout	whole body	70	120	reduced growth	Mayer et al. (1985)	Yes
Aroclor 1254	brook trout embryos	whole body	71	125	reduced fry survival	Mauck et al. (1978)	Yes
Aroclor 1254	fathead minnow	whole body	na	196 (male)	reduced spawning	Nebeker et al. (1974)	Yes
Aroclor 1016	sheepshead minnow fry	whole body	77	200	reduced fry survival	Hansen et al. (1975)	Yes
Clophen A50	goldfish	whole body	na	250	lethal body burden	Hattula and Karlog (1972)	Yes
Aroclor 1242, 1254, or 1260	fathead minnow (6 months)	whole body	na	1.86 – 749	range of lethal body burdens (concentration associated with mortality of individuals)	van Wezel et al. (1995)	No

[a] Whole-body NOAELs and LOAELs were estimated using egg-to-adult conversion factors for studies that reported concentrations in eggs rather than whole-body tissue.

[b] Whole-body tissue residues were the weighted sum of 10 different tissues (i.e., blood, brain, muscle, skin, liver, gonads, adipose tissues, kidney, digestive tract, and skeleton) (Leroy 2007). Tissue concentrations were converted from dry weight to wet weight assuming 20% solids; all endpoints except first reproductive season spawning were evaluated 1 year after exposure.

[c] At the LOAEL, growth was significantly less than control at 48 days after hatching but not at 118 days after hatching. At NOAEL and LOAEL concentrations, study provides tissue concentrations only after 7 days and 118 days of exposure. LOAEL and NOAEL are tissue concentrations in fry at 118 days post hatch. Tissue concentrations at 7 days post-hatch associated with no effects (1.8 mg/kg ww) and low effects (3.2 mg/kg ww) were lower than the concentration at 118 days post-hatch.

ERA – Ecological Risk Assessment
EW – East Waterway
LOAEL – lowest-observed-adverse-effect level
na – not available
NOAEL – no-observed-adverse-effect level
PCB – polychlorinated biphenyl
TRV – toxicity reference value
ww – wet weight

The 5th percentile LOAEL value was calculated using fourteen whole-body LOAEL values from the ERA TRV dataset (Table 2). The 5th percentile of the LOAEL values is 1.9 mg/kg ww (Figure 1).

Table 2: LOAEL values used in calculation of 5th percentile LOAEL

Source	Whole-body LOAEL (mg/kg ww)
Hugla and Thome (1999)	0.520
Hugla and Thome (1999)	2.64
Hansen et al. (1974a)	9.3
Hansen et al. (1971)	14
Bengtsson (1980)	25
Hansen et al. (1971)	46
DeFoe et al. (1971)	50
Mauck et al. (1978)	71
Hansen et al. (1974b)	106
Mayer et al. (1985)	120
Mauck et al. (1978)	125
Nebeker et al. (1974)	196
Hansen et al. (1975)	200
Hattula and Karlog (1972)	250

LOAEL – lowest-observed-adverse-effect level
ww – wet weight

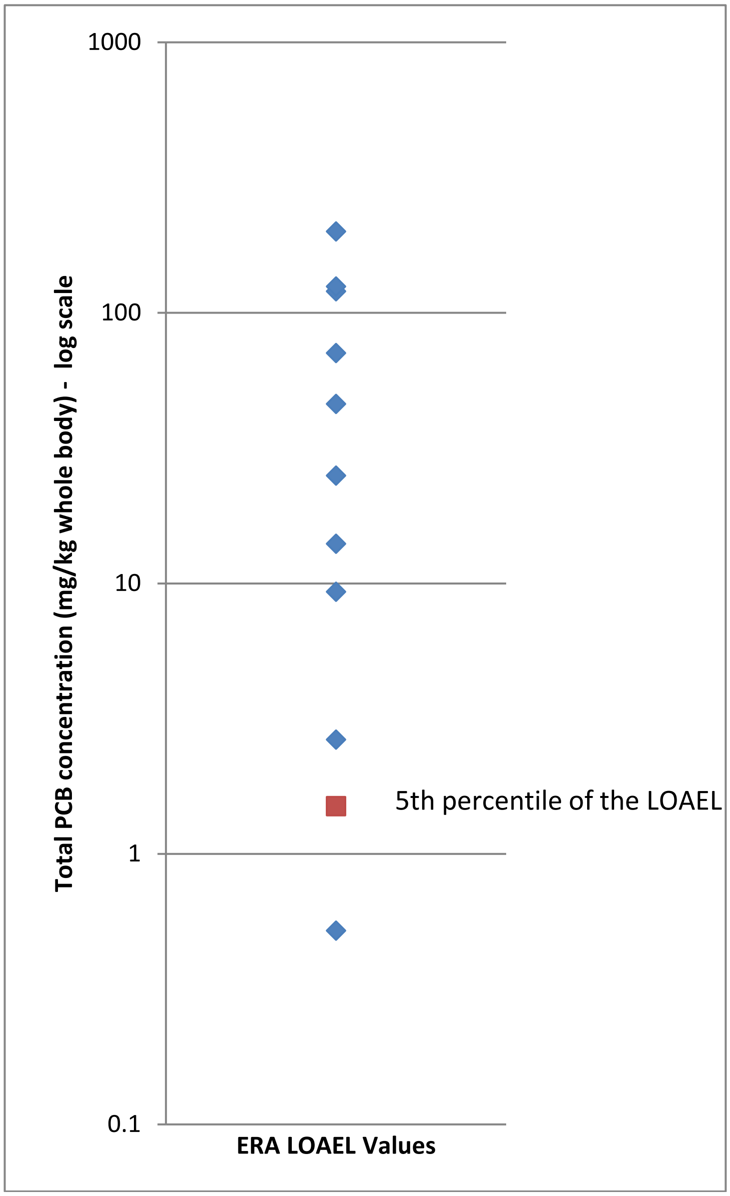

Figure 1: LOAEL TRV values and 5th percentile value

The tissue value of 1.9 mg/kg ww was then used to derive sediment values for both English sole and brown rockfish using the site-wide EW FWM for PCBs. This approach resulted in sediment values of 450 µg/kg dw for English sole and 280 µg/kg dw for brown rockfish.

The sediment values derived from the mean of the tissue RBTCs and the 5th percentile of the tissue TRV dataset are provided in Table 3. The values are within a factor of two of each other, which is within the bounds of food web model predictability (typically within a factor of 2 to 5). Because these values are subject to all the uncertainties associated with the food web model, the sediment values are not considered significantly different from one another. Based on this analysis and considering the uncertainties in the lowest LOAEL TRV, the sediment PRGs for fish are derived based on the sediment values calculated from the mean of the two tissue RBTCs. These values are above background sediment concentrations for PCBs (see Section 4 of the FS) as well as practical quantitation limits. Therefore, the sediment PRG for English sole is 370 µg/kg dw and the sediment PRG for brown rockfish is 250 µg/kg dw.

Table 3: Total PCBs Sediment PRG values for English sole and brown rockfish

Fish ROC	Sediment value(µg/kg dw) based on mean of tissue RBTCs	Sediment value (µg/kg dw) based on 5th percentile of TRV dataset	Selected Fish Sediment PRG
English Sole	370	450	**370**
brown rockfish	250	280	**250**

µg/kg dw – microgram per kilogram dry weight
PRG – preliminary remediation goal
RBTC – risk-based threshold concentration
ROC – receptor of concern
TRV – toxicity reference value

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