BASIS OF DESIGN REPORT
REVISION 0

REMEDIAL DESIGN SERVICES
SWAN ISLAND BASIN PROJECT AREA
CERCLA DOCKET NO. 10-2021-001

PORTLAND HARBOR SUPERFUND SITE
PORTLAND, MULTNOMAH COUNTY, OREGON

Prepared for:
Swan Island Basin Remedial Design Group

Prepared by:

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JUNE 2024

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BASIS OF DESIGN REPORT
SWAN ISLAND BASIN PROJECT AREA
PORTLAND HARBOR SUPERFUND SITE
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EXECUTIVE SUMMARY

This Basis of Design Report (BODR) presents the preferred remedial approach and the technical underpinnings for that concept for the Swan Island Basin (SIB) Project Area within the Portland Harbor Superfund Site (PHSS) in Portland, Multnomah County, Oregon. HydroGeoLogic, Inc. (HGL) performed the work on behalf of the SIB RD Group based on the requirements of the PHSS Record of Decision (ROD) (EPA, 2017) and the Administrative Settlement Agreement and Order on Consent (EPA, 2021a). The data used to inform this BODR were collected in accordance with the final Pre-Design Investigation (PDI) Work Plan (WP), which the U.S. Environmental Protection Agency (EPA) approved in May 2022 (HGL, 2022a). The data was reported in the PDI Evaluation Report (ER) that was submitted to EPA in April 2024 (HGL, 2024) and was conditionally approved in May 2024. The purpose of this BODR is to provide the basis of design for the preferred remedial approach to address contaminated sediments and riverbanks. The BODR also includes refining the conceptual site model (CSM) and the remedial technology assignments within the Sediment Management Area (SMA) and the SIB Project Area.

Swan Island Basin Project Area and Conceptual Site Model

The SIB Project Area is the active cleanup area between approximately river mile (RM) 8.1 and RM 9.2 on the northeast side of the Willamette River. A federal navigation channel, with an authorized depth of -40 feet (ft) Columbia River Datum, exists within the Willamette River and extends from the confluence of the Lower Willamette River with the Columbia River to RM 11.6. The U.S. Army Corps of Engineers maintains the navigation channel, which notably does not extend into SIB (Figure 2-1). The SIB Project Area is approximately 1.1 miles in length, 117 acres in size, and includes riverbanks from the top of the bank to the river.

The SIB Project Area is bounded by the uplands of Swan Island and Mocks Bottom to the southwest and northeast, respectively (Figure 2-1). Land uses within and adjacent to the SIB Project Area consist of light and heavy industrial uses and limited commercial uses. SIB is an active navigable industrial waterway, and the shoreline hosts many structures supporting light and heavy industrial activities.

The Portland Harbor reach of the Willamette River, including the SIB Project Area, has been redirected, straightened, filled, and deepened by dredging. Most of the riverbank has been filled, stabilized, and/or engineered for industrial-type operations with riprap, bulkheads, and overwater piers and docks (City of Portland, 2014).

The CSM from ROD Figures 2, 3, and 4 (EPA, 2017), the Sitewide CSM for the SIB Project Area, was refined by considering and applying the additional data and analysis presented in the PDI ER (HGL, 2024). Primary changes to the Sitewide CSM include improved characterization of physical processes, updates to the contaminants of concern (COC) transport and exposure pathways, consideration of site history and shaping of the waterway and landscape, and application of subsurface sediment data to update the 3-D extent of contaminated sediments. Additionally, the CSM was improved to align with key design considerations and to better support the recontamination potential analysis component of the Final Sufficiency Assessment Report (SAR). Determination of remedial technology assignments involves special considerations for work around structures. Therefore, the shoreline and overwater structures within the SIB Project Area structures were identified, inspected, and evaluated.

Next, future use activities and constraints as they pertain to development of the RD and Remedial Action (RA) were identified. These included:

- Current and expected future uses of shoreline and overwater structures;
- Definition and implications of different SIB Project Area regions (future maintenance dredging area, intermediate, shallow, and riverbank regions);
- Presence of debris on site;
- Construction access needs and existing utilities; and
- Community impact.

For the remedial technology assignment, decisions are made for places within the project area that are located within future maintenance dredging areas, as well as within intermediate, shallow, and riverbank regions. This includes consideration of the 23 current shoreline and on/overwater structures, 21 of which are currently in use, and the 33 active outfalls, including 5 larger diameter outfalls. The technology assignment of dredging and capping is also impacted by existing debris; bathymetric survey data was analyzed for the presence of debris. Evaluation results indicate that most (92.9 and 99.8 percent of the total debris count, and total volume evaluated, respectively) of the surface debris identified in the SIB Project Area is larger than 2 ft (60 centimeters). Construction access needs and utility location will be further assessed prior to start of RA activities. Since RA activities may generate both new jobs and limitations to operations of existing facilities, RD will consider community involvement and community impact.

Design Requirements and Performance Standards

Design requirements include remedial action objectives, applicable or relevant and appropriate requirements, and To Be Considered advisories, criteria, or guidance identified in the ROD. Design requirements as they apply to specific remedial technologies are considered along with the approach to developing performance standards in alignment with these requirements. Other considerations include specific requirements applicable to transport and disposal of contaminated materials as well as institutional controls (ICs). The Technology Application Decision Tree from the ROD was refined for the SIB Project Area to generate a SIB Remedial Technology Assignment Decision Tree.

Remedial Technology Considerations

The remedial technologies considered to address contaminated sediments in the SIB SMA include capping, dredging, dredging with capping, enhanced natural recovery (ENR), monitored natural recovery (MNR), and in situ treatment. Cap evaluation considerations concluded that amended alternatives with at least 4.33 inches (11 centimeters) of 5 percent granular activated carbon-amended sand would be protective of the most conservative SIB conditions (e.g., using 95^{th} percentile of the highest concentrations observed on site and the highest upwelling observed on site) for the duration of design life (100 years). An erosion protection layer will likely be needed at locations throughout the site to prevent scour of caps, especially within lanes of primary vessel traffic.

The dredging evaluation determined that SIB sediments are predominantly soft mud with a relatively low bulk density even at depth, indicating they may be readily dredged. Resuspension during dredging is likely to occur based on the predominantly silt-sized material, so best management practices (BMPs) will be implemented to mitigate residuals and re-release of contamination.

ENR would be the selected remedial technology within the SIB Project Area where surface and subsurface COC concentrations are above cleanup levels (CULs) but below remedial action level (RAL)/practical quantitation limit (PQL) thresholds. ENR would be more compatible with habitat impact minimization or restoration within near-shore shallow areas.

MNR is not considered to be effective within most of SIB due to quiescent conditions that limit water circulation and deposition of cleaner sediments that would drive natural recovery, except for limited riverbank portions that were originally assigned MNR in ROD Figure 28 and where PDI ER data indicate concentrations above CUL and below RAL/PQL. Potential MNR and ENR areas are currently being evaluated as part of the recontamination potential evaluation that will be reported in the Final SAR.

In situ treatment is the preferred methodology for situations where sediment removal or containment may be harmful to sensitive habitats or where permanent functional structures or steep slopes limit access or otherwise limit the feasibility of other remedial technologies. Specific locations for in situ treatment are not yet identified but will be applied to special consideration areas containing potential erosive banks or work around structures.

Preferred Remedial Approach

The preferred remedial approach synthesizes remedial technology assignments by applying the SIB Remedial Technology Assignment Decision Tree informed by the PDI dataset (HGL, 2024). The preferred remedial approach incorporates remedial technologies including capping and/or dredging, ENR, MNR, as well as additional considerations including backfilling to grade and potentially in situ treatment. Most of the SIB Project Area will be remediated with a combination of dredging and/or capping. The approach to determining specific areas for variations on this theme will consider depth of contamination, target maintenance dredging depths, and continuity of the finished riverbed surface to prevent formation of anoxic zones. Shoreline and overwater structures as well as steep riverbank slopes will require special considerations within defined zones around those features. These special considerations may involve area-specific evaluation of work around structures and geotechnical considerations. The preferred remedial approach identifies those zones, but the area-specific special considerations will be developed as a part of the Draft 50% RD. Remedial technology assignments for riverbanks will be developed in close coordination with the remedy for adjacent contaminated sediments. The remedial technology applied to sediments at the toe of riverbank slopes may be limited by the potential impacts of the remedy on geotechnical slope stability. Construction sequencing for remediation of riverbank soils and adjacent sediments will consider completing soil remediation before adjacent sediments to reduce the potential for recontamination of the sediments. That sequence of events would also provide an opportunity to apply slope modification and/or stabilization measures to address the risk of geotechnical slope instability.

The preferred remedial approach for the SIB Project Area assigns remedial technologies for all areas exceeding CUL thresholds based on data collected during PDI and subsequent refinement of the SMA for areas where RAL/PQL was exceeded vertically or horizontally. Special considerations are needed for erosive riverbanks and work around structures when assigning the appropriate remedial technology. The SIB Project Area compromises of the SMA (79 percent), riverbanks (10 percent), and areas outside of the SMA (11 percent).

The percentage breakdown of remedial technology assignments for the SMA is summarized as follows:

- Special considerations for work around structures constitute around 27 percent,
- Special considerations for potential erosive banks constitute around 0.85 percent,
- Dredging to RAL will address around 7.4 percent, and
- Dredging and/or capping will address around 65 percent of the SMA.

The percentage breakdown of remedial technologies for riverbanks is summarized as follows:

- Special considerations for work around structures constitute around 48 percent,
- Special considerations for potential erosive banks constitute around 39 percent,
- ENR/in situ treatment will address around 2.8 percent,
- MNR will address around 0.02 percent, and
- Bank stabilization, capping and/or dredging/excavation will address around 10 percent of the riverbanks.

The percentage breakdown of remedial technologies for areas within the SIB Project Area, but located outside the SMA, is summarized as follows:

- Special considerations for work around structures constitute around 59 percent,
- Special considerations for potential erosive banks constitute around 20 percent,
- ENR/in situ treatment will address around 18 percent,

- MNR will address around 2 percent, and
- Bank stabilization, capping, and/or dredging/excavation will address around 0.4 percent of the SIB Project Area outside of the SMA area.

Most areas in the SIB Project Area will be subject to ICs and applicable operations and maintenance (O&M) requirements. Special considerations will be made for work around structures and outfalls, erosive banks, and habitat impacts. Special consideration areas require further analysis. Analysis results, alongside area-specific remedial technology assignment, will be presented in the Draft 50% RD.

Remediation Implementability Assessment

The implementability assessment identifies and evaluates factors that will be important to consider for the timely, cost-effective, and successful completion of this RA. The assessment includes constructability considerations, structural and other impacts, and green remediation practices. Other impacts include business interruption, community impact and involvement, and potential conflicts with shoreline operators.

Constructability considerations that may exert a significant influence over the success of the project include technology assignments, construction activity, construction risks, and bidding and procurement. These considerations are evaluated in this BODR so they can be incorporated in the Draft 50% RD, as necessary.

The structural impacts evaluation considers construction impacts on existing shoreline and overwater structures that could result from implementing the RA. The impact evaluation looked at structure condition and functionality and geotechnical considerations, identified the construction risks and possible mitigation measures, and determined the potential risk to each structure. Nine structures were identified as having potentially high risk of impact by RA construction. Nine structures were identified as having potentially medium risk of impact by RA construction. Five structures were identified as having potentially low risk of impact by RA construction. All structures will require careful consideration during the preparation of the Draft 50% RD to consider how area-specific RD may result in construction impacts on each of these structures during or following RA. A structural evaluation to assess each structure's ability to accommodate remedy implementation during RA construction will be performed as part of the Draft 50% RD.

Other impacts from RA activities include business interruptions, conflicts with shoreline operators, and community impacts. Potential conflicts between marine traffic in SIB and construction equipment were compiled for each facility and the full range of potential locations where construction equipment may be located during RA. The largest conflict area is located between Berths 304 and 305 due to numerous vessels moving internally within the basin (not entering or exiting the basin). Most of the potential conflicts occur along the SIB Project Area centreline where vessel traffic is presently concentrated. Few vessel traffic conflicts are likely to occur at the head of SIB, in the shipyard area, or at the berths on the main river. Possible mitigation measures to minimize RA impacts on vessel traffic and facility operations were identified.

Potential business disruption impacts were examined to limit the impact of RA construction on waterfront business continuity. Potential community involvement and impacts of RA construction were also considered.

Some activities necessary to implement the remedy for the SIB Project Area may impose negative environmental impacts. Green remediation practices will be evaluated and incorporated into the RD, where practicable, to minimize such impacts. These practices will be documented in the Green Remediation Plan.

Flood Impact and Climate Change

The flood impact analysis evaluates the potential hydraulic effects of the remedy on flood water surface elevation and the spatial extent of notable floods. The evaluation of climate change considerations explores the potential effects of region-specific manifestations of climate change on elements of the remedy. The purpose of the flood impact analysis is to ensure that the remedy is designed in such a way to prevent increases in the frequency and extent of flooding that would otherwise result from the remedy's physical changes to the riverbed, riverbanks, shoreline, and overwater structures. The purpose of the climate change analysis is to incorporate anticipated future conditions into the development and evaluation of the RD to ensure the remedy will continue to function properly to protect human health and the environment under both present and future conditions.

The implications of climate change on various aspects of capping, recontamination, and flood impacts are multifaceted and warrant careful consideration. Climate change introduces a spectrum of challenges and uncertainties that intersect with environmental management strategies. In the context of capping, the evolving landscape due to climate change presents shifts in erosion protection requirements. Factors such as sea level rise, larger river flows, and increased outfall discharges all pose unique challenges, influencing water depths, velocities, and cap stability. Amidst uncertainties, addressing climate change implications demands a comprehensive approach to ensure the resilience and effectiveness of environmental protection measures.

EPA prepared a Climate Adaptation Implementation Plan that serves as EPA Region 10's response to Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad," and EPA Administrator's direction to update regional implementation plans as stated in the EPA Climate Adaptation Action Plan (EPA, 2022a). The EPA plan highlights regional vulnerabilities and identifies the strategies and priority actions to focus resources in areas of the greatest impact. Rising sea level may cause increases in shoreline erosion, groundwater elevations, salinity in groundwater, as well as changes in water chemistry at surface water near-shore cleanups. Significant regional vulnerabilities include increased precipitation frequency and intensity, flooding and fluctuating groundwater elevation levels, an increase in the frequency and severity of droughts throughout the region along with the potential for increased number and severity of wildfires, which can impact the porosity of surface soils modifying the groundwater flow and exposure pathways (EPA, 2022a). Evaluation of the design will be completed so that remedy functions properly under anticipated future conditions.

Habitat Impacts

Implementation of the remedy will involve in-water and near-shore work that will substantially modify the riverbanks and riverbed within the SIB Project Area. That work will include impacts to existing habitats, all of which are substantially degraded from natural conditions due to the extent of development and commercial activity. Remedial actions will strive to improve habitat conditions toward natural condition within the constraints and limits of the site. The habitat impact evaluation included in this BODR refers to the baseline habitat survey results published in the PDI ER and presents a qualitative discussion of the types of habitat impacts that would occur as a result of remedy implementation based on the preferred remedial approach. The discussion highlights a range of habitat impacts that would occur as a result of remedy implementation:

- **Edge Habitat** – impacts to riverbank edge habitat complexity and stability and active channel margin would occur during stabilization and remediation of riverbank soils.
- **Riparian Habitat** – impacts to riparian habitat conditions would occur due to stabilization and remediation of riverbank soils, land-based remediation of near-shore sediments, and work around shoreline and overwater structures.
- **Benthic Habitat** – impacts to benthic habitats in shallow water and deepwater zones would occur due to sediment dredging, cap installation, and installation of riverbed stabilization measures to prevent scour of caps.
- **Wetlands** – the history of landscape modification in Mocks Bottom and the uplands surrounding the SIB Project Area has eliminated functional wetlands from the project area. Therefore, remedy implementation would not result in impacts to wetlands.

The discussion of potential RA impacts to existing habitat is accompanied by identification and discussion of potential habitat enhancement opportunities within the SIB Project Area that could be developed to satisfy habitat mitigation requirements. The existing habitat conditions survey identified the lack of complex edge habitats. Habitat enhancement opportunities that would restore complex edge habitats exist primarily within undeveloped riverbank areas, shorelines, and shallow nearshore areas.

Monitoring and Maintenance

Monitoring will be required to evaluate both short-term and long-term remedy effectiveness. The RD will specify requirements for baseline monitoring, short-term monitoring, long-term monitoring, and O&M associated with the remedy. Baseline monitoring will be completed prior to RA to establish pre-construction baseline conditions for surface and subsurface sediment chemistry, riverbank soils, surface water, porewater, fish tissue, and air. Short-term monitoring will be conducted during construction and post construction to confirm that the remedial requirements and design specifications specified in the ROD have been achieved. Long-term monitoring will be used to monitor remedy performance and determine whether the remedy is functioning as intended to protect human health and the environment. Long-term monitoring will be conducted periodically in alignment with Five-Year Reviews until unlimited use and unlimited exposure for the whole PHSS is achieved. O&M will be required in perpetuity for caps, non-erodible riverbanks, in situ treatment, MNR, and ENR areas, and following ground motion triggers (seismic events) for post-event cap inspections, or any other events that may substantially impact remedy performance. The Draft 50% RD will include a project area monitoring plan and an O&M plan.

Conceptual Level Quantity and Cost Analysis

This BODR does not include a conceptual level cost estimate due to the preliminary nature of the preferred remedial approach and the uncertainties inherent to this early phase of design development. An RD cost estimate will first be published as part of the Draft 50% RD and updated in the Pre-Final 90% RD and Final 100% RD. The RD cost estimate will be developed using the Monte Carlo method, which runs a statistically significant number of simulations (typically at least 10,000). This method organizes the output of the simulations and presents them in graphics that illustrate the probability of different cost outcomes. This approach supports sensitivity analysis to transparently compare cost effects of unit cost variations, schedule risks, and cost risks.

Future Design Studies

Future design studies are anticipated to support the development of the Draft 50% RD, including the following:

- **Cap Evaluation Update** – Erosion protection requirements for caps will be refined to optimize placement locations and material quantities. Chemical isolation layer composition, including potential amendments, will be refined based on location-specific and COC-specific variations within the project area.
- **Dredging Evaluation Update**– The dredging evaluation in this BODR will be refined after more detailed RD information is available. Updates will include analysis and evaluation of transload facilities selected for the RA based on costs and feasibility.
- **Material Disposal Update** - Evaluation of the transload facilities, transport, and material staging and loading will be updated with each Draft 50% RD submittal based on continuing assessment of data. Additional updates will include analysis and evaluation of transload facilities selected for the RA based on costs and feasibility.
- **Constructability Updates** – The constructability considerations discussed in this BODR will be further evaluated at key milestones during each RD phase as project design details such as production rates and methodologies are further evaluated and developed. Constructability updates will arise from outreach to existing operations within the SIB Project Area to better delineate and characterize potential RA impacts to those operations during and following RA.
- **Green Remediation Plan** – This BODR includes a discussion of green remediation practices and how those could be incorporated into the remedy. As the RD advances and more detailed information is available, specific green remediation practices will be identified and incorporated into the RD where feasible and appropriate.
- **Flood Impact Evaluation** – Potential flood impacts will be evaluated using the EPA-approved Corrected Effective Model as a base tool, with site modifications and re-calibration as necessary to demonstrate any potential flooding caused by the proposed RA. This analysis may occur during Final 100% RD.

- **Climate Change Impacts** – Changes in physical conditions due to climate change can affect the cap alternatives, recontamination potential, and the potential for the project to cause flood impacts. The climate change evaluation will be performed in accordance with EPA design guidelines and coordinated with EPA. Effects of climate change will be quantified using numerical modeling tools.
- **Habitat Impact Evaluation** – This BODR includes a discussion of existing habitat conditions within the SIB Project Area and a qualitative discussion of the types of impacts that would occur due to RA implementation. The habitat impact evaluation will be refined as the RD advances by determining quantitative habitat impacts based on overlaying technology assignments on a map of existing habitat conditions.
- **Structural Analysis** – This study will evaluate chosen technology assignments for special consideration areas surrounding each structure to determine recommended remedy or slope mitigation approaches to facilitate RA implementation. Additional work may include detailed structural inspection and survey, and geotechnical analysis.
- **Porewater Study** – This study will determine porewater chemistry at locations with maximum porewater upwelling. Additional work will help obtain porewater concentrations during maximum porewater upwelling, and site-specific linear partition coefficients (using porewater chemistry and co-located sediment cores collected during PDI ER efforts). These results will be used in cap evaluation updates and to verify results from recontamination potential analysis. While all other future studies listed above will be completed as part of the Draft 50% RD, a porewater study will be completed as part of the treatability study.

Remedial Design Sequencing

This section presents an overview of the RD sequencing. After finalization and approval of this BODR, the schedule for subsequent RD deliverables will be confirmed or adjusted. The RD will start with the development of an RD WP followed by the submittal of the Draft 50% RD. The Draft 50% RD will progress in stages through the Pre-Final 90% and Final 100% RD package deliverables. Additional RD investigations may be pursued if data gaps, or additional analysis needs are identified during design between the submittal of the BODR and the Draft 50% RD. Any additional investigations would be coordinated with EPA and the RD design team to determine an appropriate schedule in support of the RD. The current project schedule plans for completion of the Final 100% RD in June 2026.

Summary

This BODR fulfills its stated purpose of introducing the preferred remedial approach and establishing the basis of design for the assigned remedial technology. The content of the BODR applies the data and analysis published in the PDI ER to establish the technical and factual underpinnings of the preferred remedial approach . To support those efforts, the PDI dataset was used to refine the boundaries of the SMA based on the 3-D extent of contaminated sediment. Additionally, this BODR includes a substantive refinement of the CSM to provide context for the design and support the process of refining the remedial technology assignments applied within the SIB Project Area.

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LIST OF ACRONYMS AND ABBREVIATIONS

3-D	three dimensional
cm	centimeter
CY	cubic yards
ft	feet/foot
g	peak ground acceleration
g/cm^3	grams per cubic centimeter
H:V	horizontal to vertical ratio
sq	square
ACA	Ash Creek Associates
ACM	active channel margin
AIDP	Archeological Inadvertent Discovery Plan
AIS	Automatic Information System
ARAR	applicable or relevant and appropriate requirements
ASAOC	Administrative Settlement Agreement and Order on Consent
ASCE	American Society of Civil Engineers
BEHP	bis(2-ethylhexyl)phthalate
bgs	below ground surface
BMP	best management practices
BODR	Basis of Design Report
CADD	computer-aided design and drafting
CEM	Corrected Effective Model
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CII	Construction Industry Institute
City	City of Portland
COC	contaminant of concern
CLE	contingency level seismic event
CQA	construction quality assurance
CRD	Columbia River Datum
CSM	conceptual site model
CUL	cleanup level
CWA	Clean Water Act
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DDx	DDD + DDE + DDT
DEA	David Evans and Associates, Inc.
DEQ	Oregon Department of Environmental Quality
DSL	Oregon Department of State Lands

ENR	enhanced natural recovery
EPA	U.S. Environmental Protection Agency
EPL	erosion protection layer
ER	Evaluation Report
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FMD	future maintenance dredge
FS	Feasibility Study
GAC	granular activated carbon
GHG	greenhouse gas
GIS	geographic information system
GPS	global positioning system
HEC-RAS	Hydrologic Engineering Center River Analysis System
HGL	HydroGeoLogic, Inc.
IC	institutional control
ITRC	Interstate Technology and Regulatory Council
LCA	Life Cycle Assessment
LDR	Land Disposal Restrictions
MC	Marine Consortium, Inc.
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MMSI	Maritime Mobile Service Identity
MNR	monitored natural recovery
MSU	Marine Safety Office and Group Portland
NAVD88	North American Vertical Datum of 1988
NCP	National Contingency Plan
NRWQC	National Recommended Water Quality Criteria
O&M	operation and maintenance
OAR	Oregon Administrative Rule
OHSRA	Oregon Hazardous Substance Remedial Action
ORS	Oregon Revised Statute
PAH	polynuclear aromatic hydrocarbon
PAMP	Project Area Monitoring Plan
PCB	polychlorinated biphenyl
PDI	Pre-Design Investigation
PeCDD	1,2,3,7,8-pentachlorodibenzo-p-dioxin

PGA	peak ground acceleration
PHSS	Portland Harbor Superfund Site
PIANC	World Association for Waterborne Transport Infrastructure
Port	Port of Portland
PQL	practical quantitation limit
PTW	principal threat waste
QCP	Quality Control Plan
RA	Remedial Action
RAL	remedial action level
RAO	remedial action objectives
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RDGC	Remedial Design Guidelines and Considerations
RI	Remedial Investigation
RM	river mile
ROD	Record of Decision
RPC	recontamination potential chemical
RSL	Regional Screening Level
SAR	Sufficiency Assessment Report
SCC	Shipyard Commerce Center
SDWA	Safe Drinking Water Act
SHPO	Oregon State Historic Preservation Office
SIB	Swan Island Basin
SMA	Sediment Management Area
SuperJTI	Superfund Job Training Initiative
TBC	to be considered
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TSCA	Toxic Substance Control Act
U.S.C.	United States Code
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
WP	Work Plan
WQS	Water Quality Standards

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BASIS OF DESIGN REPORT
SWAN ISLAND BASIN PROJECT AREA
PORTLAND HARBOR SUPERFUND SITE
PORTLAND, MULTNOMAH COUNTY, OREGON

1.0 INTRODUCTION

This Basis of Design Report (BODR) presents the Remedial Design (RD) approach and the technical underpinnings for that approach for the Swan Island Basin (SIB) Project Area within the Portland Harbor Superfund Site (PHSS) in Portland, Multnomah County, Oregon. HydroGeoLogic, Inc. (HGL) performed the work on behalf of the SIB RD Group based on the requirements of the PHSS Record of Decision (ROD) (EPA, 2017) and the Administrative Settlement Agreement and Order on Consent (ASAOC) (EPA, 2021a). The data used to inform this BODR were collected in accordance with the final Pre-Design Investigation (PDI) Work Plan (WP), which the U.S. Environmental Protection Agency (EPA) approved in May 2022 (HGL, 2022a). The data was reported in the PDI Evaluation Report (ER) submitted in April 2024, which EPA conditionally approved in May 2024 (HGL, 2024).

1.1. PURPOSE AND OBJECTIVES

The purpose of the BODR is to provide the basis of design for remedial technology assignment to address contaminated sediments and riverbanks within the SIB Project Area. The BODR will refine the Sediment Management Area (SMA), refine the conceptual site model (CSM), and refine the technology assignments to the SMA consistent with the Technology Application Decision Tree in Figure 28 of the ROD. The scope of the BODR (as required by the ASAOC) is as follows (EPA, 2021a):

- Summarize existing site conditions and site factors that affect technology assignments, including detailed reasonably anticipated future navigation and land use information and other data, as depicted in the Technology Application Decision Tree, and refine the CSM;
- Summarize design criteria applicable to the SIB Project Area as described in the *Remedial Design/Remedial Action Handbook*, (EPA, 1995) and consistent with Section 14.2.9 (Design Requirements) and Section 14.2.10 (Performance Standards) of the ROD (EPA, 2017);
- Describe the Technology Application Decision Tree analysis and identify a preferred remedial approach for the SIB Project Area consistent with the ROD;
- Present a conceptual design for the remedy based on the results of the Technology Application Decision Tree analysis and supporting data and analyses;
- Identify long-term monitoring and maintenance considerations for the SIB Project Area;
- Identify design studies for RD, if any, that may be needed to evaluate attainment of applicable remedial action objectives (RAOs) and address proposed remedial technology means and methods, and gather other information necessary for RD for the SIB Project Area; and

- Describe a sequencing plan, as well as an overall schedule, to complete the design studies, RD, and Remedial Action (RA) for the SIB Project Area.

An additional requirement is to summarize the results of the sufficiency assessment and to determine whether potential sources of recontamination have been adequately investigated and controlled or considered such that the RA can proceed. This recontamination potential evaluation will be completed in the Final Sufficiency Assessment Report (SAR).

1.2 REPORT ORGANIZATIONAL OVERVIEW

The report is organized into the following sections:

- Section 1 presents an introduction, including the objectives and scope of the BODR;
- Section 2 provides project area description and the refined CSM;
- Section 3 lists design requirements and performance standards and defines remedial technologies;
- Section 4 provides a summary of remedial technology considerations used to develop the preferred remedial approach;
- Section 5 presents the preferred remedial approach and assigned remedial technology;
- Section 6 assesses remediation implementability;
- Section 7 presents flood impact and climate change implications;
- Section 8 presents habitat impact evaluation;
- Section 9 presents monitoring and maintenance;
- Section 10 lists conceptual level quantity and cost analysis;
- Section 11 outlines future design studies;
- Section 12 lists future steps for RD sequencing; and
- Section 13 lists the references cited in the BODR.

Supporting remedial technology evaluations are provided in the following appendices:

- Appendix A presents the cap design evaluation, and
- Appendix B presents the dredging evaluation.

2.0 PROJECT AREA DESCRIPTION AND CONCEPTUAL SITE MODEL

This section presents the SIB Project Area description, a refined CSM used for refining remedial technology assignments, and future use activities and constraints relevant for the development of the RD.

2.1 SWAN ISLAND BASIN PROJECT AREA DESCRIPTION

2.1.1 Project Area

PHSS extends along 9.9 miles of the lower Willamette River in Portland, Oregon, from river mile (RM) 1.9 to RM 11.8. EPA listed PHSS on the National Priorities List in December 2000. The SIB Project Area is the active cleanup area between approximately RM 8.1 and RM 9.2 on the northeast side of the Willamette River (HGL, 2024). The SIB Project Area is approximately 1.1 miles in length, and 117 acres in size, and includes riverbanks from the top of the bank to mean high water (Figure 2-1). A federal navigation channel, with an authorized depth of -40 feet (ft) Columbia River Datum[1] (CRD), extends from the confluence of the Lower Willamette River with the Columbia River to RM 11.6. The U.S. Army Corps of Engineers (USACE) maintains the navigation channel. The navigation channel does not extend into SIB.

SIB is bounded by the uplands of Swan Island and Mocks Bottom to the southwest and northeast, respectively. Except for slopes along the riverbanks, the land surface within Swan Island and Mocks Bottom is generally flat, with elevations of about 30 to 40 ft National Geodetic Vertical Datum of 1929. Land uses within and adjacent to SIB Project Area consist of light and heavy industrial uses and commercial uses. Mixed residential/commercial and residential-only land uses are located outside but in proximity to the SIB.

2.1.2 Land Use and Ownership

The SIB is an active navigable industrial waterway, and the shoreline hosts many structures supporting light and heavy industrial activities (HGL, 2024). The waterway within the SIB Project Area currently supports commercial/industrial, recreational, and government vessel traffic related to the ongoing uses of the shoreline. Shoreline facilities support light and heavy industrial uses, vessel mooring, U.S. Coast Guard (USCG) operations, U.S. Navy operations, and public access (HGL, 2024). The 10 property owners in or adjacent to the SIB Project Area are as follows (Figure 2-1):

- Project Fleet Owner LLC/Shipyard Commerce Center (SCC)
- Port of Portland (Port)
- Freightliner
- Anchor Park, LLC

[1] 0 ft CRD = 5.28 ft North American Vertical Datum of 1988 (NAVD88). CRD is used as the nautical chart datum for the Lower Willamette River. CRD is a reference plane that the U.S. Army Corps of Engineers established in 1912 by observing low water elevations at various points along the Columbia and Willamette rivers (USACE, 1966). Consequently, CRD is not a fixed/level datum but slopes upward as one moves upstream. River users can obtain the depth on a chart and apply tide or river-level gauge readings, relative to CRD, to compute actual water depth. Low water values are used for navigation charting to provide conservative depth values in the event accurate tide data are not available to the river user.

- City of Portland (City)
- Swan Island Dock Company
- ATC Leasing Co.
- The Marine Consortium, Inc. (MC)/Republic Services
- United States of America/U.S. Navy and Marine Reserve Center
- United States of America/USCG Marine Safety Unit

Additionally, as indicated in the ROD (Section 7.1) and further specified in the communication with the State of Oregon (State), the State owns certain submerged lands (below mean low water mark) and submersible lands (ranging from ordinary high water to mean low water marks) underlying navigable and tidally influenced waters. Upland property owners may also own some submerged and submersible land. A map of Oregon-owned waterways shows general lines of State ownership within the SIB Project Area, including land on which the remedy will be implemented (Oregon Department of State Lands [DSL], 2024). Remedy implementation on State property will be conducted pursuant to all applicable regulations including Oregon Administrative Rule (OAR) 141-145-050 "*Special Conditions for a Soil or Sediment Cap.*"

2.1.3 Shoreline Activities

The waterway within the SIB Project Area supports commercial/industrial, recreational, and government vessel traffic related to the ongoing uses of the shoreline. Shoreline facilities support light and heavy industrial uses, vessel mooring, USCG operations, and public access (HGL, 2024).

2.1.4 Site Development History

The Portland area was first inhabited about 11,000 years ago by small, mobile groups who hunted and fished in the forest, prairies, wetlands and rivers. From these earliest inhabitants came Chinookan-speaking peoples, including the Chinook, Clackamas, Kathlamet, Multnomah, Tualatin Kalapuya, Molalla, and many other tribes and bands. These groups created communities and summer encampments along the Columbia and Willamette rivers and harvested and used the plentiful natural resources of the area for thousands of years. British and American fur companies entered the basin beginning in the 1810s. The Oregon Donation Land Act of 1850 offered free land to white settlers, who quickly laid claim to 2.5 million acres of land, including all of what is now Portland (Oregon Historical Society, 2014, 2023).

Since that time, the Portland Harbor reach of the Willamette River, including the SIB Project Area, has been redirected, straightened, filled, and deepened by dredging. Most of the riverbank has been filled, stabilized, and/or engineered for industrial or Port operations with riprap, bulkheads, and overwater piers and docks (City, 2014).

The fill history of the area surrounding SIB is illustrated in Figure 2-2. The history was generated based on a review of historical geodetic surveys, maps, and aerial photos from 1888 to 2023 (U.S. Coast and Geodetic Survey, 1888, 1909, 1951, 1955, 1960, and 1970; ACA, 2006; Vintage Portland, 2012; USACE, 1960 and 1979; EPA, 2016b; and Google Earth, 2024). As seen in Figure 2-3, SIB was historically part of the main channel of the Willamette River, and Swan Island was not connected to the shoreline area known as Mocks Bottom. The main river channel flowed east of the island adjacent to the marshy lowlands of Mocks Bottom, curving into the base of the high bluff, above which is Mocks Crest (HGL, 2024). As seen in Figure 2-3, the channel along Mocks Bottom had depths that ranged from 27 to 42 ft in the late 1800s/early 1900s. A natural bar repeatedly formed at the island, which required maintenance dredging from the 1870s through the 1920s to keep the ship channels open (Oregon Historical Society, 2014). Swan Island was a periodically flooded sand bar and marsh (ACA, 2006). On the south side of SIB, the current navigation channel was a low-elevation wetland complex with shallow, rocky channels. The channel depth on the northwest end of SIB ranged from 1 to 11 ft in 1888 and 2 to 11 ft in 1909 (Figure 2-3).

The Port purchased Swan Island in 1922 from Swan Island Real Estate Company. In 1923, the Port initiated a West Swan Island project to relocate the main navigation channel to the west side of the island (ACA, 2006). The Port subsequently received permission from Congress to permanently close the channel southeast of Swan Island and dredge a 35-ft by 1,155-ft channel on the west side of the island. River sediments dredged as part of the project were deposited on Swan Island to raise the surface elevation and construct a "causeway" connecting the island to the eastern shore of the river (ACA, 2006; Oregon Historical Society, 2014). Imagery from 1929 shows the beginning of the land development of Swan Island (Figure 2-3). Since the initial development of Swan Island and Mocks Bottom, additional placement of dredge fill has periodically occurred (HGL, 2024). The filling allowed industrial development of the island as Portland's first airport, which was completed and started operations in 1931 (Figure 2-4, Table 2-1) (ACA, 2006).

From 1909 to 1927, SIB experienced a 54 percent gain of land area (Table 2-1). However, this estimate is based on visible land mass and does not account for river stage at the time of the aerial photograph. From 1927 to 1929, there appears to be a 36 percent land area loss; however, the 1929 land area compared to the 1909 land area only shows a 2 percent loss with this difference likely due to projection distortions for the 1927 figure. From 1929 to 1932, SIB experienced a 10 percent land area loss. There was no land area change from 1932 to 1939, including undeveloped conditions of Mock Bottom (Figure 2-4, Table 2-1).

By 1940, the airport outgrew the island and was relocated to northeast Portland in 1941. In 1942, 250 acres of the northwest end of the island were leased to U.S. Maritime Commission contractor Kaiser Company Inc. for the construction and operation of the shipyard on Swan Island, and a parking lot and barracks at Mocks Bottom (ACA, 2006). In 1943, a pedestrian bridge connected the shipyard to the parking lot on Mocks Bottom. This pedestrian bridge was removed by 1951. Between 1942 and 1945, 147 T-2 tankers were built on Swan Island (Oregon Historical Society, 2014). In early 1945, the basin for drydock yfd69, which the Port and Vigor referred to as Drydock 1, was constructed. No shipways were removed to construct that basin. In 1947, the Maritime Commission transferred administrative functions of the facility to the War Assets Administration. Consolidated Builders was one of the War Assets Administration tenants, and they scrapped decommissioned troop landing ships at Swan Island between 1947 and 1949 (ACA, 2006). By 1946, North Basin Avenue was constructed, most of Swan Island was developed, and the Mocks Bottom area had been filled (DEQ, 2016).

In 1950, Swan Island became a public ship repair facility in Portland Harbor. The Port owned the ship repair yard. Private contractors performed actual ship repair activities for vessel owners and tenants who performed industrial operations in leased facilities. Around 1950, shipways 1, 2, and 3 (the northernmost shipways), were demolished to construct a new drydock basin. The remaining five shipways on the west end were demolished, covered with fill, or both. The Port constructed the ballast water treatment plant, Building 72, and the Willamette wharf and pier on the land over these former shipways (Figure 2-4). The total estimated fill needed to fill the shipways was 650,000 cubic yards (CY) (ACA, 2006). There was a minor (3 percent) increase in land area change from 1951 to 1960 (Table 2-1).

Over 13 million CY of dredged material was placed in the 1920s and 1930s to create commercial and industrial space from the former Mocks Bottom marshlands (Giesecke, 1920). Mocks Bottom clearing, filling, and development continued from 1951 to 1970. According to USACE records, between 1962 and 1973, Mocks Bottom was filled with over 5 million CY of material obtained in part from the deepening and widening of the river between RM 7.5 and the Broadway Bridge (Maul Foster and Alongi, Inc., 2002). During the 1964 flood, a portion of the reclaimed land was re-submerged and additional fill was needed (Vintage Portland, 2012). The area was developed for light industrial use in the 1960s through the 1990s (City, 2014).

In 1970, there was a dredge fill placement on the south side of the Swan Island "causeway," resulting in considerable expansion of the "causeway" and 13 percent land area gain from 1960 to 1970 (Figure 2-5, Table 2-1). The current configuration of dry docks at the north end of the island and berths along SIB and the Willamette River was largely completed by 1979. According to USACE, the upstream end of SIB was used for hydraulic pipeline disposal of material dredged from the main channel of the Willamette River and for bottom dumping of material barged from other Portland Harbor berthing areas. Periodic rehandling of the material from SIB to Mocks Bottom was done to restore the depth required for bottom dumping of sediment from split hull barges (USACE, 1979). By 1988, the progressive filling of the head of SIB continued, including the placement of approximately 900,000 CY of material in the northwestern portion of Mocks Bottom derived from the excavation of a new Swan Island drydock (USACE, 1979). Additional dredge material reportedly came from the shipyard berth maintenance dredging and maintenance dredging of the Willamette River (HGL, 2024).

The placement of dredged materials at the head of the basin was conducted in accordance with the 1973 Lower Willamette River Management Plan prepared by the Oregon Division of State Lands (Port, 1999). As a result of progressive filling at the head of SIB, the area saw a 21 percent gain in land area from 1970 to 1988 (Table 2-1). By 1994, the filling of the head of SIB was completed and formed the modern shoreline configuration and the southern bank of SIB (Figure 2-5). Additional buildings and the current public boat ramp were constructed by 1996 bringing the area to its current condition (DEQ, 2016). The area was fully developed by 2007 with industries related to truck manufacturing, shipping and transportation, marine salvage, and military uses that remain today (Section 2.6.2 and Figure 2-6).

As a result of historical activities that included extensive dredging and filling activities, SIB has changed substantially since 1888 (Figure 2-7). From 1888 to 2023, SIB experienced a 16 percent gain of land area (Table 2-1); these efforts also resulted in movements of the navigational channel from the east side of Swan Island to the west side of the island and turned the previous navigation channel into a lagoon. Moreover, industrialization and land development have completely altered the land of Swan Island and Mocks Bottom since 1888.

2.2 PHYSICAL SITE SETTING

2.2.1 Waterway and Riverbanks

SIB is a lagoon that is backwatered from the main Willamette River Channel. Currents within the interior of the SIB move slowly over the range of flow conditions in the river including flood events and daily tidal cycles. Daily tides may impact variation in surface elevations over 3 to 4 ft with a maximum range of approximately 6 ft as noted in Appendix I of PDI ER (HGL, 2024). The interior waterway is approximately 1 mile long and 650 ft wide. Typical water depths range from 20 to 35 ft with the shallowest depths in the interior of the lagoon and deepest areas located at the transition to the main river channel downstream of the end of the Swan Island peninsula (HGL, 2024).

The riverbanks within SIB are predominantly armored with riprap and/or protected from erosion by dense vegetation, bulkheads, or other shoreline structures. The SIB is roughly rectangular, and the entire shoreline was constructed by fill placement and other modifications that occurred over many decades. Much of the fill used to construct the shoreline and raise the surrounding landscape was derived from historical dredging activities. The shoreline at the head of the basin includes a sandy beach with sparse vegetation, and there are more vegetated and bare soil banks in a more natural condition along a larger portion of the Mocks Bottom shoreline than the Swan Island shoreline (HGL, 2024).

2.2.1.1 <u>Geology and Fill Material/Geotechnical Characteristics</u>

The Draft SAR presented an understanding of the geologic conditions at the SIB Project Area based on the PHSS ROD (EPA, 2017) and available environmental investigation reports for properties located on Swan Island and in Mocks Bottom. The data collected during the PDI geotechnical field investigation and laboratory testing program are consistent with the geologic setting described in the Draft SAR but provide a higher resolution, site-specific view of the subsurface conditions in the SIB Project Area. The site-specific geotechnical data collected during the PDI have enabled the refinement of the initial understanding and inform geotechnical decisions during RD and subsequent phases of the project.

All available geotechnical boring data and bathymetry survey data has been combined to identify the stratigraphy of SIB. Six sections were selected to represent the SIB Project Area – three transverse sections and three longitudinal sections (Figure 2-8). Transverse sections were selected to represent north, middle, and south basin sections, (Figures 2-9, 2-10, and 2-11, respectively) and three longitudinal sections were selected to represent mid-basin, North-East bank, and South-West banks of the site (Figures 2-12, 2-13, and 2-14, respectively). Banks were represented at -2 ft CRD, which is equal to +3.28 ft North American Vertical Datum of 1988 (NAVD88), a boundary between shallow and intermediate areas per ROD Figure 28 (EPA, 2017).

Four geologic unit layers were identified in SIB profiles. The first layer that was predominant near the surface was non-native material. Non-native material within SIB is primarily made of soft elastic silts with variable sand content. The thickness of non-native material was estimated based on the earliest available bathymetric data (collected from 1922 to 1938) and site-specific geotechnical and sediment core data collected during the PDI. Non-native material depth increases in the mid-basin from the north basin to the south basin (Figures 2-9 through 2-11), consistent with historical activities that occurred to fill the south end of the basin east of the “causeway” to Swan

Island and create what are now adjacent uplands. This trend is evident at the mid-basin cross-section, where non-native material thickness is near 40 ft towards the riverbank and up to 70 ft at the riverbank (Figure 2-12). The SMA boundary is depicted on the profiles in Figures 2-9 through 2-14. The SMA boundary is defined as at least one exceedance of the remedial action level (RAL)/practical quantitation limit (PQL). Although non-native material does not necessarily indicate a relationship to RAL/PQL exceedance, the depth of the RAL/PQL exceedance appears to coincide with the SMA boundary in longitudinal profiles (Figures 2-9 through 2-11), and mid-basin longitudinal cross section (Figure 2-12). Bank transverse sections (Figures 2-13 and 2-14) do not show an apparent consistent correlation between the SMA boundary and non-native fill as compared to other profiles. Clay, sand, and silt have been identified in the layers below the non-native material. Sand and silt are predominantly found in the basin section, whereas occasional layers of clay were located at riverbank portions of cross sections.

Riverbank stability on slopes steeper than 3H:1V (horizontal to vertical ratio) may be prone to static slope failure due to the variable nature of the upland and riverbank fill material. As a result, geotechnical slope considerations were further assessed in the dredging evaluation (Appendix B, Section 5) and with constructability considerations (Section 6.1).

2.2.1.1.1 Seismic Conditions

The SIB Project Area may be subject to strong earthquake-induced ground motions associated with the Cascadia Subduction Zone fault as well as active local crustal faults during the design life of the selected RA. Based on the potential for strong earthquake-induced ground motions at the SIB Project Area, and the presence of loose saturated soils within SIB, the potential for soil liquefaction and lateral spreading is present. As a result of this conclusion, liquefaction susceptibility analysis was included in the cap evaluation (Appendix A, Section 1.3.1.3) and remediation implementability assessment (Section 6.0) to evaluate seismic settlement. Seismic design parameters were based on the 2018 Conterminous U.S. National Seismic Hazard Map and a return period of 10 percent probability in 50 years. This liquefaction analysis included seismic parameters such as peak ground acceleration (PGA) of 0.234 g and moment magnitude of 9.08. The Draft 50% RD will discuss approaches to potential seismic events that may exceed these parameters.

2.2.1.2 Hydrology, Hydrodynamics and Sediment Transport

The Draft SAR presented an understanding of the hydrodynamics and sediment dynamics at SIB, as found relevant to contaminant transport for recontamination potential analysis. Hydrodynamics and sediment dynamics measurements subsequently collected during the PDI using SEDflume, Acoustic Doppler Current Profiler, and other field measurements have confirmed the initial understanding of these processes and allowed quantification of their influence on SIB sediment dynamics. Hydrodynamics and sediment dynamics measurements indicate the following findings:

- Soft fine-grained surface sediments indicate a quiescent, depositional environment in most of the SIB Project Area;
- Low river current speeds indicate that river flows are not likely to cause resuspension and erosion over most of the project area, even during flood events;

- Suspended sediments entering the project from the main river are well mixed and fine-grained, with low settling velocities. Most of the suspended sediments entering the project area are likely to leave prior to depositing on the riverbed; and
- Wind waves and boat wakes are small but likely govern sediment mobility in shallow water and near riverbanks. In these areas, storm waves will likely govern the erosion protection design.

Measurements have been used to calibrate hydrodynamics and sediment transport models, confirm the presence of sediment transport pathways, and will be used for future cap design.

Hydrologic/hydrodynamic conditions are an important factor in potential site recontamination and are a design criterion for RD. Regional hydrology is discussed because it affects site natural hydrodynamics and potential recontamination. Both natural and anthropogenic-based hydrodynamics are the focus of this section because they both drive sediment dynamics in the SIB.

2.2.1.3 Natural Hydrodynamics

Natural hydrodynamics that may affect sediment dynamics at SIB include (1) river currents and water level oscillations, (2) stormwater discharges (outfall jets, overland flows), and (3) wind-generated waves. While these processes can cause sediment mobilization and transport if they apply sufficient forces to the riverbed, the currents within SIB are consistently slow (too small to cause erosion of riverbed sediments) over the entire range of flow conditions including flood events in the main river. The fastest flow conditions that are capable of causing erosion occur close to outfalls and have a short duration. Throughout the interior of SIB, natural hydrodynamics produce current velocities that are too slow to mobilize sediment and are unlikely to cause site recontamination or mobilize capping materials.

2.2.1.3.1 Anthropogenic Hydrodynamics

Hydrodynamics induced by anthropogenic forces also may affect sediment movement within SIB. The quiescent nature of SIB results in these forces becoming a potentially meaningful contributor to sediment movement and an important consideration for RD. Anthropogenic forces potentially affecting hydrodynamics and sediment movement in the SIB Project Area include (1) propeller wash (prop wash), (2) vessel wakes, and (3) dry dock operations.

2.2.1.4 Recent/Ongoing Elevation Changes

Elevation change data is required to understand the recent/ongoing and future sedimentation and erosion within the SIB Project Area. This understanding is needed for recontamination analysis and RD. Multibeam hydrographic surveys from 2002 to 2022 were analyzed to discern elevation trends. Observed riverbed elevation changes in SIB are relatively small; therefore, a regression analysis was performed to develop more accurate annual rates of sedimentation and erosion. Surveys used for the analysis included:

- January 2002: Multibeam Hydrographic Survey for Integral Consulting Lower Willamette Group Portland Remedial Investigation (RI)/Feasibility Study (FS) (DEA, 2002).

- May 2003: Multibeam Hydrographic Survey for Integral Consulting Lower Willamette Group Portland RI/FS (DEA, 2003).
- March 2004: Multibeam Hydrographic Survey for Integral Consulting Lower Willamette Group Portland RI/FS (DEA, 2004).
- January 2009: Multibeam Hydrographic Survey for Integral Consulting Lower Willamette Group Portland RI/FS (DEA, 2009).
- April 2018: Multibeam Hydrographic Survey for Vigor Shipyard Facility in Portland (eTrac, 2018).
- June 2018: Multibeam Hydrographic Survey for Pre-RD Group (DEA, 2018).
- April 2022: eTrac for HGL as part of Swan Island Basin Remedial Design (HGL, 2024).

A consistency analysis was performed between the surveys, and it was determined that the 2002 through 2004 surveys contained a systematic shift relative to later surveys. Errors in elevation change calculations caused by positioning differences between surveys were negligible in most areas, but measurable on steeper slopes. David Evans and Associates (DEA) (2004) also performed elevation change analysis using these surveys and noted that *"(...)differences were detected along steep slopes that may be the result of minor positioning differences between surveys."* To produce more accurate elevation change trend data near riverbanks, a series of relatively static morphological features were identified and compared in all the surveys. Based on the elevation comparisons between surveys, the 2002 to 2004 surveys were shifted 5.7 ft towards 30 degrees True North, resulting in a more consistent set of surveys to be used for the regression analysis. Surveys from 2009 to 2022 were not modified.

The hydrographic surveys were overlaid and the area where overlap was obtained was gridded at 1-ft resolution. At least three surveys are used in the regression at any given location; therefore, areas where only two surveys provided coverage were not analyzed. At each 1-ft grid cell, a linear regression analysis of the elevations was performed, resulting in an annual average rate of change. The annual rates of change are shown on Figure 2-15, along with example regression plots at two points where sedimentation is observed. Reasonable trend correlations are observed in areas with ongoing sedimentation or erosion.

These sedimentation and erosion trend rates, combined with measured surface bulk density, provide an accurate estimate of average annual present and likely future mass loading to SIB. The recontamination potential evaluation presented in the Final SAR will include additional details on mass loading calculations, including assumptions made in areas lacking survey data.

2.2.1.5 Riverbank Erosional Stability

SIB riverbanks may be subjected to various forces (waves, boat wakes, overland sheet flow runoff, and stormwater discharges) potentially causing soil erosion, transport of riverbank soil into the river, and recontamination of SIB sediments. Elevation measurements (bathymetry and topography) and surveys performed during the PDI, combined with analysis of historical surveys, indicate the following findings:

- Observations indicate that modest erosion (inches per year) is occurring in riverbank areas, primarily where slope gradients exceed approximately 2H:1V, with the resulting sediment being deposited at the toe of the slope or in flatter areas. Erosion is occurring similarly on submerged slopes.

- Modest erosion on riverbanks is likely being caused by overland sheet flow, waves, and boat wakes, while erosion on submerged slopes is likely affected by wind waves, boat wakes, and outfall jets. The order of importance of each process in mobilizing and transporting sediment down-slope depends on elevation and location within the site, and sheet flow likely dominates transport above the river stage on unprotected banks. At lower elevations, waves dominate transport in areas with a larger fetch (distance for waves to grow) and vessel traffic.
- Surficial slope failures are evident in areas steeper than 2H:1V. No large-scale rotational failures have been observed.

Measurements and observations of riverbanks have been used to confirm the presence of riverbank sediment transport pathways, evaluate the potential for recontamination, and help develop remedial design for riverbanks.

2.2.2 Upland Properties

Upland areas around the SIB Project Area include 11 operating federal, Port, and private shoreline parcels with stormwater basins that discharge stormwater runoff to SIB. Upland areas around the SIB Project Area that discharge stormwater runoff to SIB include approximately 588 acres of mostly impervious area with primarily light industrial uses.

Stormwater discharges from these upland areas to SIB from 33 active outfalls, including 5 City outfall basins (M-1, M-2, M-3, S-1, and S-2) and 28 non-City outfalls (Figure 2-1). Non-City outfalls that discharge to SIB from the surrounding upland areas are located on federal (at USCG Marine Safety Unit facility), Port, and private shoreline parcels.

2.3 NATURE AND EXTENT OF CONTAMINATION

This section presents SIB Project Area contaminant characteristics, including the nature and extent of contamination for ROD contaminants of concern (COCs) for all relevant media. Relevant media includes stormwater, stormwater solids, surface and subsurface sediment, and riverbank soil. As discussed in the Draft SAR, the screening analysis of ROD COCs identified 14 chemicals as recontamination potential chemicals (RPCs) based on point-by-point and surface-weighted average concentration evaluations of surface sediment data compared to PHSS Cleanup Levels (CULs) (HGL, 2021). As will be further discussed in Section 2.4, RPCs were found in both stormwater outfalls and riverbank soils, suggesting a recontamination potential associated with those media and pathways.

2.3.1 Surface and Subsurface Sediment

The surface and subsurface sediment dataset provides information to refine the SMA by defining the lateral and vertical extent of contamination in relation to CULs, RALs/PQLs and principal threat waste (PTW) thresholds.

The results of the chemical characterization of surface and subsurface sediments in the PDI indicate that total polychlorinated biphenyls (PCBs) exceed the RAL in over 60 percent of samples and PTW threshold in over 40 percent of samples. Additionally, dioxins and furans (1,2,3,7,8-

pentachlorodibenzo-p-dioxin [PeCDD] and 2,3,7,8-tetrachlorodibenzo-p-dioxin [TCDD]) exceed the PQL in over 20 percent of samples (HGL, 2024). The depths to exceedances are bounded by 1, 2, or more samples at 125 of 168 locations (74 percent), whereas the depths to PTW threshold exceedances are bounded by 1, 2, or more samples at 141 of 168 locations (84 percent). RAL/PQL threshold exceedances are bounded by 2 or more consecutive 1-ft samples at 111 of 168 locations (66 percent). PTW threshold exceedances are bounded by 2 or more consecutive 1-ft samples at 127 of 168 locations (76 percent) (HGL, 2024).

The refined SMA for the SIB Project Area, defined by sediments exceeding RAL, PQL, or PTW thresholds (SMA thresholds), is approximately 107 acres within the ROD-defined Sediment Decision Unit boundary. The refined SMA extent is larger than previously depicted in the ROD (89.4 acres), primarily due to additional sediment data collected during the PDI and the inclusion of subsurface sediment data. The extent of surface sediment SMA threshold exceedances is 87.7 acres, which is slightly smaller than the ROD SMA. The depth of contamination is well constrained in most of the refined SMA extent with the exception of the central portion of the head of the basin. The estimated volume of sediment in the SMA extent is 1,431,000 CY and the estimated volume of sediment exceeding the SMA thresholds is 1,409,000 CY, which subtracts the sediment volume below RAL/PQL thresholds (22,000 CY). These represent sediment volumes and assume vertical slopes at the boundary of the refined horizontal SMA (HGL, 2024). The volume will be further refined in the Draft 50% RD.

2.3.2 Stormwater Outfalls

Stormwater and stormwater solids samples were collected during three storm events from City outfall basins (M-1, M-2, M-3, S-1, and S-2) and stormwater samples from six non-City outfalls. Stormwater and stormwater samples collected during PDI indicated that in addition to RPCs outlined in the Draft SAR, other ROD COCs detected included total polynuclear aromatic hydrocarbons (PAHs); organochlorine pesticides, such as aldrin and constituents of DDx (DDE [dichlorodiphenyldichloroethane] + DDD [dichlorodiphenyldichloroethylene] + DDT [dichlorodiphenyltrichloroethane]); metals such as cadmium, copper, lead, and zinc; bis(2-ethylhexyl)phthalate (BEHP); and tributyltin hydride. Stormwater discharges may be an important recontamination pathway in the refined CSM for the SIB Project Area. Recontamination potential is further discussed in Section 2.4. Results from recontamination potential analysis will be reported in the Final SAR.

2.3.3 Riverbank Soil

As described in Appendix M of the PDI ER (HGL, 2024) riverbank soil sampling results indicated that CUL exceedances were widespread and estimated to include 650,438 square (sq) ft of the riverbank's surface between 0 and 1 ft below ground surface (bgs) (100 percent); 476,799 sq ft from 1 to 2 ft bgs (100 percent); and 129,551 sq ft from 2 to 3 ft bgs (100 percent), based on data availability and the extent of sample coverage along the riverbank. RAL/PQL exceedances were less widespread than CUL exceedances and include an estimated 419,719 sq ft of the riverbank's surface between 0 and 1 ft bgs (65 percent), 152,576 sq ft from 1 to 2 ft bgs (32 percent), and 78,026 sq ft from 2 to 3 ft bgs (26.4 percent), based on data availability and extent of sample coverage along the riverbank. PTW threshold exceedances are less widespread than CUL and RAL exceedances and are estimated to include 131,186 sq ft of the riverbank's surface between 0 and 1 ft bgs (20 percent) and 12,874 sq ft between 1 and 2 ft bgs (2.7 percent), based on data availability. In the 2- to 3-ft interval, there were no PTW threshold exceedances in the 28 samples analyzed.

In addition to RPCs identified in the SAR, chemicals present in riverbank soils that exceeded thresholds included total PAHs, aldrin, DDT, arsenic, and mercury. The extent of riverbank contamination may also present an important recontamination pathway at SIB leading to a recontamination potential from PCBs, dioxins/furans, dieldrin, DDx, chlordane, arsenic, mercury, total petroleum hydrocarbons (diesel range), and BEHP. This also identifies a need to design a remedy considering not just RPCs, but all ROD COCs detected during the PDI due to recontamination potential. Riverbank stability on slopes steeper than 3H:1V (horizontal to vertical ratio) may be prone to static slope failure due to the variable nature of the upland and riverbank fill material.

Surface sediment and riverbank soil CUL, RAL/PQL and PTW threshold exceedances are presented in Figures 2-16, 2-17, and 2-18, respectively. Subsurface soil and riverbank soil CUL, RAL/PQL, and PTW threshold exceedances are presented in Figures 2-19, 2-20, and 2-21, respectively. These figures were used to develop the preferred remedial approach and assigned remedial technology presented in Section 5.

2.4 RECONTAMINATION POTENTIAL EVALUATION

This section evaluates the potential for recontamination of the sediments within SIB after remedy implementation. The evaluation considers potential recontamination associated with sources and pathways identified and evaluated in the Draft SAR. The Final SAR will include the results of the recontamination potential analysis for the SIB Project Area with a discussion of whether sources and pathways are controlled as part of a quantitative evaluation of the recontamination potential for upland and in-water pathways. Specifically, the recontamination potential evaluation in the Final SAR will focus on identifying and quantifying contaminant loading associated with upland and in-water pathways and assessing whether the cumulative effects of loading from multiple pathways could result in post-RA recontamination (i.e., contaminant loads associated with upland and in-water pathways, the fate of contaminants within the SIB Project Area, and magnitude of recontamination potential because of contaminant loading, transport, and accumulation within SIB sediments). The following identifies upland and in-water sources and pathways as they pertain to the refined CSM.

Contamination in the SIB reflects the historical industrial, marine, commercial, municipal, and defense practices for over 100 years in this active industrial, urban, and trade corridor. These activities have resulted in direct discharges from upland areas through stormwater and outfalls; releases and spills from operations occurring over the water; and indirect discharges through overland flow, bank erosion, and other non-point sources. In addition, contaminants from off-site sources have reached the site through the import and handling of dredged material, as well as surface water and sediment transport from upstream. The ongoing RD and future RA implementation will address and remediate contaminated sediments and riverbank soils within the SIB Project Area. EPA and the Oregon Department of Environmental Quality (DEQ) have worked to address and control upland sources of contamination.

2.4.1 Upland Pathways

Consistent with the RD scope of work included in the ASAOC (EPA, 2021a) and the Draft SAR (HGL, 2021), the sources of upland pathways are riverbank soil erosion; stormwater; shoreline and overwater activities; and groundwater. The PDI ER provides further information regarding the data collection and evaluation completed for upland pathways. The main findings as they pertain to the refined CSM are:

- **Riverbank Soil:** As noted in Section 2.3.3, ROD COCs were present in riverbank soils at levels exceeding RAL/PQL and PTW thresholds. Riverbank soils with ROD COCs have the potential to erode or be transported onto surface sediment in SIB via overland flow, wind, wave erosion, propeller wash, or riverbank erosion.
- **Stormwater:** As noted in Section 2.3.2, ROD COCs in stormwater and stormwater solids that disperse during storm events and settle in areas around the outfalls may impact surface sediment COC concentrations within SIB. This pathway will be further evaluated by modeling SIB Project Area stormwater discharges and the fate and transport of stormwater solids within SIB as part of the recontamination potential evaluation in the Final SAR.
- **Shoreline and Overwater Activities:** Shoreline and overwater structures include a mixture of pile-supported piers and wharves, cellular sheet pile wharves, floating docks, walkways, mooring dolphins, an air intake structure for a wind tunnel, a quay wall, a boat ramp, and floating drydocks (see Sections 2.6.1, 2.6.2, 6.2.1, and 6.3.2 for further details on shoreline and overwater structures). Shoreline and overwater activities include moorage, material transfer, repairs, washing, and/or fueling. No spills or releases from shoreline or overwater activities were reported from 2022 to 2023 (Property Owner Questionnaires, Appendix G of the PDI ER [HGL, 2024]).
- **Groundwater:** DEQ considers this pathway to be incomplete with low potential for recontamination in the SIB upland area and/or to have no upland contaminant sources (DEQ, 2016, 2021). In addition, EPA did not map groundwater plumes in the SIB Project Area, as seen in Figure 6 of the ROD Appendix I (EPA, 2017). HGL defers to DEQ and EPA conclusions that the groundwater pathway at upland sites has been sufficiently controlled and is not a recontamination pathway for the SIB Project Area. As a result, groundwater is not depicted in the refined CSM.

2.4.2 In-Water Sources and Pathways

The sources of in-water pathways for the SIB Project Area are upstream surface water, resuspension of sediment and riverbanks, porewater advection through contaminated sediment, and in-water structures.

Surface water at the SIB Project Area is mostly impacted by historical contamination, upstream surface water, and leaching or abrasion from existing submerged in-water structures. Historical contamination can be introduced into the overlaying water column via sediment bed processes (sediment resuspension, advection, diffusion and dispersion).

Since advection of groundwater through contaminated sediment (porewater upwelling) is a potential source of recontamination for the in-water pathway, porewater upwelling was quantified for SIB during the PDI. The highest recorded discharge was found to be 0.43 inches (1.1 centimeter [cm]) per day, measured at Station 10A during ebb tide (Appendix B of PDI ER [HGL, 2024]).

Surface water entering SIB from upstream may contain ROD COCs adsorbed to suspended solids moving via limited flow. ROD COCs may enter SIB in a dissolved phase from upstream surface water flowing into the basin and can have the potential to partition into underlying surface sediment, resulting in recontamination of surface sediment. Surface water entering SIB from the main river channel is limited, except possibly near the mouth of the basin where currents, especially during high-flow events, create a limited mixing zone between the fast-flowing main channel and the quiescent interior of SIB. Resuspension of bedded sediments in SIB has the potential to occur via natural processes (tidal fluctuation, waves, and flood events) and/or anthropogenic processes (scour impact from marine vessel propeller wash and maintenance dredging).

In-water submerged structures at SIB are used for vessel repair, construction, berthing vessels, dry-docking vessels, loading/offloading materials, and launching vessels. Other in-water structures include remnant pilings, dolphins, sheet piles, and similar structures. Abrasion, leaching, percolation, infiltration, and dissolution of ROD COCs on the surface of these submerged structures may result in recontamination of surface water and sediments within SIB. An additional, lesser-known impact of in-water discharges is historical contamination related to untreated sewage discharges.

2.4.3 Upcoming Steps

The data collected as part of the PDI are considered usable and sufficiently complete to perform a thorough recontamination evaluation. Preliminary results indicate that COCs are present in riverbank soils, stormwater, stormwater solids, and sediments transported into SIB from upstream. Non-zero contaminant loading via multiple transport pathways leaves open the possibility for post-RA recontamination, but the specific locations and degree of potential recontamination have not yet been determined. The quantitative results of the recontamination potential evaluation will be included in the Final SAR.

The work in progress includes a quantitative assessment of contaminant transport and fate within the SIB Project Area and a quantitative modeling analysis using SEDCAM to simulate the mixing of surface sediments and the resulting surface sediment concentrations as a function of time after RA implementation. That approach will provide a quantitative prediction of the locations and degree of post-remedy recontamination. If the analysis demonstrates that sources are not sufficiently controlled to prevent post-remedy recontamination, the results will be shared with EPA and DEQ with a referral to address uncontrolled sources located outside the SIB Project Area. If contaminated riverbank soils are highly erodible and/or shown to pose a recontamination risk, the RD will include measures to stabilize banks and/or remediate those soils. In accordance with ASAOC requirements, the Final SAR will include a recontamination potential evaluation and a conclusion as to whether potential sources of recontamination have been adequately investigated and controlled or considered such that the RA can proceed. The Final SAR is scheduled for delivery to EPA in the third quarter of 2024.

2.5 CONCEPTUAL SITE MODEL – SWAN ISLAND BASIN

EPA presented a Sitewide CSM for the entire PHSS in ROD Figures 3, 4, and 5. The CSM presented within this BODR provides an updated understanding of the CSM for the SIB Project Area based on the findings reported in the Draft SAR (HGL, 2021) and the PDI ER (HGL, 2024). Based on updated knowledge about the physical site setting (Section 2.2), the nature and extent of contamination (Section 2.3), and recontamination potential (Section 2.4), the refined CSM for RD presented in Figure 2-22 defines the present understanding of SIB Project Area-specific CSM elements that will be addressed in the RD. The CSM describes recontamination pathways, sources, release mechanisms, and affected media relevant for the SIB Project Area.

As described in Section 2.4, recontamination pathways most pertinent to the SIB Project Area include the following:

- Upland pathways:
  - Riverbank erosion;
  - Direct discharges, including stormwater2 and overland flow; and
  - Shoreline and overwater discharges.
- In-water pathways:
  - Upstream surface water;
  - Resuspension of bedded sediments;
  - Advection of groundwater through contaminated sediment (porewater upwelling); and
  - Leaching or abrasion from existing submerged in-water structures.

Environmental sources of contaminants relevant to the SIB Project Area include the following:

- Upland sources,
- In-water sources,
- Upstream surface water,
- Submerged structures,
- Overwater sources,
- Historical contamination, and
- Former sanitary sewer discharge points.

Environmental media relevant to the SIB Project Area include the following:

- Surface water,
- Sediment,

[2] The stormwater collection system was depicted to indicate the extent of stormwater runoff sources throughout the upland area.

- Riverbank soil,
- Stormwater and stormwater solids,
- Porewater, and
- Biota.

Release mechanisms relevant to the SIB Project Area include the following:

- Riverbank erosion,
- Discharges,
- Sediment bed processes,
- Propeller wash impact,
- Dispersion and flow,
- Wake and wave impact, and
- Abrasion or leaching from existing structures.

To refine the CSM, the following key findings from the PDI ER were incorporated:

- ROD COCs enter SIB primarily as direct stormwater discharges to outfalls and as runoff derived from the surrounding uplands;
- ROD COCs conveyed through stormwater outfalls show a need for a remedy protective of ROD COCs beyond RPCs identified in the Draft SAR;
- The predominance of discrete discharge points combined with the quiescent nature of SIB results in stormwater solids deposition predominantly within limited areas around each outfall;
- A fraction of the stormwater solids discharged via outfalls may be deposited over a broader area of SIB. That fraction is composed of fine-grained material that remains in suspension long enough to be transported further from the outfalls. The evaluation of recontamination potential focuses on those areas without neglecting contextually appropriate consideration of the entire SIB; and
- Exchange of water, sediment, and associated RPCs between the main river channel and SIB is limited to approximately 12 acres at the mouth of the basin where it transitions to the river channel.

Primary updates to the SIB Project Area CSM (Figure 2-22) include improved characterization of physical processes, updates to the COC transport and exposure pathways, consideration of site history and shaping of the waterway and landscape, and application of subsurface sediment data to update the 3-D extent of contaminated sediments. Additionally, the CSM was improved to align with key design considerations and to better support the recontamination potential evaluation component of the Final SAR.

2.6 FUTURE USE ACTIVITIES AND CONSTRAINTS

This section identifies additional considerations that are included in this BODR because they are relevant to the assignment of remedial technologies and the development of the RD. Future use activities and constraints include:

- Shoreline and overwater structures present on site;
- Current use and operation of these structures;
- Current operational navigation needs and future maintenance dredging areas for the SIB Project Area and their implications for remedial technology assignment;
- Definitions of intermediate, shallow, and riverbank regions, and their implications for remedial technology assignment;
- Presence of debris at the SIB Project Area that may impact dredging and capping technology assignment;
- Construction access that will be needed before RA commences;
- Locating existing utilities before the start of RA; and
- Community engagement and how they will impact both RD and RA.

2.6.1 Swan Island Basin Shoreline and Overwater Structures

There are 23 shoreline and/or overwater structures currently located in the SIB Project Area (Figure 6-2). These structures are described further in Section 6.2 and are listed below.

- USCG structures:
  - USCG Pier
  - USCG Floating Dock
- U.S. Navy Pier
- MC Pier
- Swan Island Dock Company Pier (Berth 311)
- City Swan Island Boat Ramp
- Freightliner Wind Tunnel
- Port structures:
  - Dredge Base
  - Berth 308
- Project Fleet Owner LLC/SCC:
  - Berth 302
  - Berth 303
  - Berth 304
  - Berth 305

- Berth 306
- Berth 307
- Pier A
- Pier C
- Quay Wall
- SCC Floating Docks
- East Pier
- West Pier
- Demo Pier
- Pier D

In addition to shoreline and/or overwater structures, there are 33 active outfalls, including 5 large-diameter City outfalls and 28 smaller non-City outfalls (HGL, 2024). The five large City outfalls are:

- Outfall S-1
- Outfall S-2
- Outfall M-1
- Outfall M-2
- Outfall M-3

2.6.2 Shoreline and Overwater Structures Use and Operations

Of the 23 structures located in the SIB Project Area, 21 are active and currently used, with the expectation that this use will not change in the future. Two structures (Berth 308 and the U.S. Navy Pier) are not in active use. The U.S. Navy has indicated that it is currently evaluating its pier for potential removal, although no timeline for this investigation or removal has been identified. The current owners/operators of shoreline and overwater structures are listed in Table 2-2. As discussed in Section 2.2.2, 28 active small diameter outfalls are located at federal (USCG Marine Safety Unit), Port, and private parcels[3] that discharge to the SIB Project Area from the surrounding upland areas (HGL, 2024). Further description of each structure, not including outfalls, is provided in Section 6.2.

2.6.3 Operational Navigation Needs/Future Maintenance Dredge Areas

Per ROD Section 14.2.1, "Future maintenance dredge (FMD) areas are those locations in the river that are periodically dredged to allow continued marine activity" (EPA, 2017). The remedy identified in the ROD included dredging sediments exceeding RAL concentrations to CULs and placing a residual layer as soon as practicable. If RAL concentrations cannot be achieved by

[3] There are 15 additional outfalls at the SCC that are inactive and discharge only if a precipitation event exceeds the design storm for the conveyance system.

dredging, sediment will be dredged to a specific depth that will allow the placement of cap or backfill material. If sediment concentrations exceed PTW/non-aqueous phase liquid thresholds, dredging will be completed to feasible limits of excavation and, if the PTW threshold is not reached, a significantly augmented or reactive cap will be placed. Maintenance dredge depth requests will be considered during design and implementation so that the final constructed elevation is below the maintained depth, including an overdredge allowance of the buffer zone. (EPA, 2017).

Navigational needs were mapped for SIB based on the navigation depths that are currently maintained based on previously requested navigable depths, as well as the navigable depth recently requested by the owners (green dashed line polygons in Figure 2-23). Recently requested navigation depths are based on responses received during owner/operator interviews conducted during the PDI (Appendix K of PDI ER [HGL, 2024]). Navigation depths currently maintained will be implemented at a minimum. Owner-requested navigation depths and associated cost impacts will be evaluated during the RD and presented in the Draft 50% RD. The polygons illustrated in Figure 2-23 currently constitute navigation areas balancing the previously requested and maintained depth and recently requested depths using experience and engineering judgment. Logical areas delineated around each dock provide reasonable near-dock maneuvering. For example, while a 30-ft navigation depth was requested by the owner/operator of Berth 311, navigable depths for the transit lane to Berth 311 have not been determined. The depth of the main navigation lane between the SCC and the MC Pier was set to -25 ft CRD so that vessels from the Port Dredge Base (depth of -25 ft CRD) would have consistent depth from dock to river. Slopes between navigation depth areas will be considered during RD to prevent the formation of anoxic zones. Additional area-specific determinations will be presented in the Draft 50% RD.

2.6.4 Intermediate, Shallow, and Riverbank Regions

ROD Figure 28 technology assignments were made for FMD, intermediate, shallow, and riverbank areas. FMD areas are defined in Section 2.6.3 above; intermediate, shallow, and riverbank regions are defined below.

2.6.4.1 <u>Intermediate Region</u>

The intermediate region in PHSS is a transition between the FMD area and riverbed elevation of approximately -2 ft CRD (+3.28 ft NAVD88). The selected remedy includes dredging contaminated PTW sediments to RAL or to a depth sufficient for the placement of augmented or reactive cap or backfill material. Where RALs are achieved, a residual layer consisting of sand (amended with activated carbon, as necessary) will be placed in accordance with ROD Section 14.2.9.2. EPA estimated in the ROD that the dredging depth to accommodate the cap will be 5 ft (EPA, 2017). During ongoing RD and RA implementation, the final elevation of capped and dredged areas will be considered so that the:

- Constructed remedy is appropriate for the post-construction use of each specific area; and
- Top of the cap or residual layer is no higher than the pre-design elevation except instances where design evaluation shows:
    - No adverse impacts to habitat and floodway (in accordance with Clean Water Act [CWA] Section 404); and/or
    - Mitigation of encroachments.

This consideration will help prevent the loss of submerged aquatic habitat, preserve slope stability, and negate adverse impacts on the floodway. The cap will be placed without dredging if needed to minimize disruption or improve habitat while maintaining remedy effectiveness.

If appropriate to protect sensitive species, a habitat layer will be incorporated into the constructed remedy (EPA, 2017).

2.6.4.2 Shallow Region

The shallow region is defined as shoreward of the riverbed elevation of approximately -2 ft CRD (+3.28 ft NAVD88, EPA, 2017). The boundary between shallow and riverbank regions is +13 ft NAVD88 (Figure 2-1; HGL, 2024). The selected remedy includes dredging contaminated sediment to remove PTW and achieve RAL levels, if feasible. If PTWs cannot be completely removed, a significantly augmented cap or reactive cap will be placed. Where PTW is not present but the depth of excavation to achieve RALs is greater than 5 ft, the area will be dredged to 5 ft, capped, and backfilled to grade (EPA, 2017). Like the intermediate region, the elevation of the top of the cap or residual layer (top of the habitat layer) will be no higher than the pre-design elevation to avoid loss of submerged aquatic habitat, preserve slope stability, and negate adverse impacts to the floodway. The same exception for the intermediate region applies to the shallow region. In the shallow region, a habitat layer such as beach mix may be used for the final layer of clean cover in residual management areas and capped areas to help maintain the natural habitat (EPA, 2021b).

2.6.4.3 Riverbank Region

Riverbanks are defined as areas from the top of the bank down to the shallow region of the river (mean low water at 7.28 ft NAVD88) that may be contaminated along the shoreline next to contaminated in-river shallow areas. Per ROD Section 6.6.6, *"remediation of contaminated riverbanks is included in the selected remedy where it is determined that it should be conducted in conjunction with the in-river actions and to protect the remedy"* (EPA, 2017). The remedy will include dredging/excavation to remove PTW to RALs up to 5 ft unless impractical, in which case it could be dredged and capped. Slopes will be backfilled to the original grade, or the slope will be further stabilized to prevent riverbank erosion. Engineered caps or vegetation with beach mix will be placed as the final cover based on area-specific designs, which will account for appropriate slope according to the programmatic or site-specific biological opinion. This will be defined in the Draft 50% RD (EPA, 2017).

2.6.5 Debris

This section evaluates the presence and conditions of existing surface debris in SIB. Oversized debris may impact dredging operations by slowing production, and damaging equipment, and may have to be removed prior to dredging. The presence of surface debris was determined by examination of bathymetric survey data for debris smaller than 2 ft (Figure 2-24), in a 2- to 5-ft range (Figure 2-25), and greater than 5 ft (Figure 2-26). This analysis supplements the debris analysis included in the Debris and Utility Identification and Survey Report (Appendix H of the PDI ER [HGL, 2024]). Surface debris refers to debris sitting on the riverbed that are visible in high-resolution bathymetric survey data.

Debris size and weight distribution analyses were performed using a code that identified surface-level debris in terms of location and size. Subsequent analysis estimated debris volume as well as the range of debris densities, both of which were used to compute the overall tonnage of debris. The results were further categorized by debris size. Debris size was used to guide the estimate of surface debris needing removal prior to dredging where it would be expected to be a hindrance to dredging efforts.

Surface debris was located and characterized using bathymetric data. The analysis code was validated through a desktop process using three test areas (ranging from approximately 31,500 to 86,500 sq ft) in the bathymetry data to evaluate debris count, length, and width. The debris was manually counted and compared with the code results. The analysis code reached an 80 percent accuracy level compared to the manually calculated debris parameters. The dimensions of the identified debris were close to hand-measured values, mostly within 2 ft (60 cm).

Debris density and tonnage were estimated assuming that the debris is composed of multiple material types including logs, rocks, and tires with varying densities. The estimate of overall density is highly dependent on the density of unclassified materials. Representative lower and upper bound densities were calculated and multiplied by debris volume to obtain weight bounds. The three test sites reviewed via desktop analysis were used to approximate the proportions of materials. Classifications were developed including pile, log, and unclassified items. The unclassified items were assumed to have a density in a range from wood- to rock-type material. The weight was based on approximate debris size and was estimated using minimum and maximum bulk density estimates with proportions obtained in the proxy zones and applied to all debris.

Debris was evaluated based on the ability of dredging equipment (environmental bucket) to remove the debris during dredging operations without hindering overall production rates (Appendix B, Section 4). As a result, the debris size was classified as smaller than 2 ft (60 cm), greater than 5 ft (150 cm), and debris in between these two sizes. The evaluation assumed that all materials apart from logs and/or piles were indistinguishable and had a density ranging from 0.9 to 2.46 grams per cubic cm (g/cm^3). Unclassified debris ranged from 0.9 to 2.7 g/cm^3 (Figure 2-27, below). Although limited amounts of steel, fiberglass, or other materials may be present, they are not anticipated to have a significant effect on total estimated material tonnages. Debris was grouped according to size. Total volume and weight bounds for all debris were estimated using mean densities ranging from 0.9 to 2.46 g/cm^3.

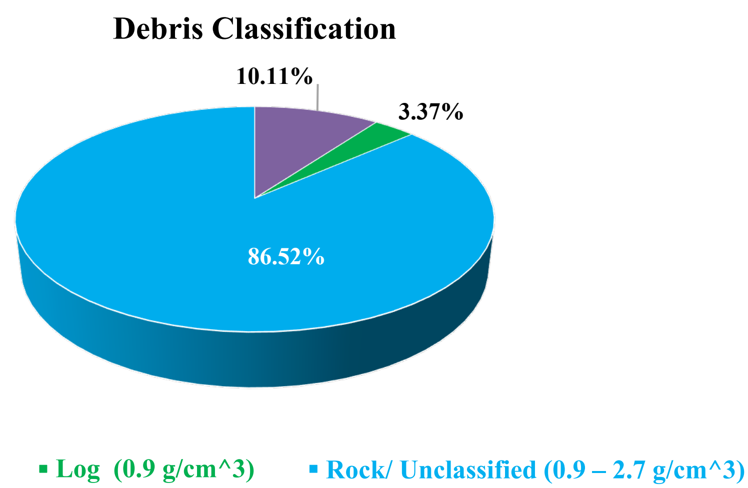

Figure 2-27. Debris Classification Based on Density and Occurrence of Debris Materials

Weight bounds were computed based on the assumed density range of unclassified materials. For 1,570 pieces of debris evaluated, the total volume was estimated to be approximately 1,632 CY (44,077 cubic ft, Table 2-3). The approximate weight bounds for the 1,570 evaluated pieces were from 1,240 to 3,390 tons. Debris that exceeded 2 ft (60 cm) represent approximately 92.9 and 99.8 percent of the total debris count, and total volume evaluated, respectively. Evaluation results indicate that most of the surface debris identified in the SIB Project Area is larger than 2 ft (60 cm). Surface debris smaller than 1 to 2 ft might be present but could not be identified due to the resolution of the bathymetry data.

Survey data used for the debris removal evaluation did not account for subsurface debris. Subsurface debris quantities in SIB are unknown, and any estimates of subsurface debris would be subject to high levels of uncertainty.

2.6.6 Construction Access

Six facility owners and operators indicated a willingness to allow upland construction access to the SIB Project Area through their property during RA construction. Access is subject to constraints including maintaining ongoing facility operations, relocation of existing infrastructure and stored materials, load restrictions, and sufficient notice and coordination. The remaining facility owners and operators indicated that their property was not suitable or available to allow upland construction access or were not responsive to the request. Responses from facility owners/operators are included in Appendix K of the PDI ER (HGL, 2024).

2.6.7 Existing Utilities

Requests will be sent to utility owners to obtain site data that will be aggregated to assemble the base data of the SIB Project Area utilities in a preliminary, unified map. Landowners will be queried via letter, followed by email, on existing utility locations on their property and this information will be incorporated into the unified map. Locations of utilities will be correlated between properties, any inconsistencies will be identified and resolved, and the unified map will be developed for review by the Port, City, and utility providers. This multi-phase approach will include multiple ongoing quality control checks to maximize the horizontal and vertical accuracy of utilities with the goal of minimizing the risk of damaging any utilities during RA.

2.6.7.1 Establish Location of Existing Utilities

Letters were developed in draft form to be sent to 10 landowners/lessees and Oregon DSL requesting information to develop a comprehensive map of existing utilities, with the intention of identifying the existing utilities that may be at risk of damage from dredging or riverbank excavation activities. The letters and the mailing process are undergoing internal review at this time, and a mailing date has not yet been determined. The following information will be requested from each landowner:

- A map or sketch of landowner property showing the approximate locations of all utilities and their depths and/or elevations.
- The names and contact information of the utility providers for the property.
- Any permits or easements obtained or granted for the installation or maintenance of the utilities on the property.

A similar letter will be sent to Century Link as an easement holder, requesting the following information to be provided by a given date:

- A map or sketch showing approximate locations of all underground utilities and their depths.
- A request to confirm the location and depth of cable shown in Exhibit A (enclosed).

Table 2-4 presents the landowners/lessees/easement holders who will be contacted and the current status of each utility information request.

Table 2-4. Utility Information Request Outreach Recipients

Property ID	Owner	Property Name	Status	
			Letter Sent	Reply Received
R673573	Swan Island Dock Co.	Berth 311, Swan Island Dock Company	No	N/A
R315704	Marine Consortium, Inc.	MIC (Fred Devine Diving & Salvage Co.)	No	N/A
R593920 R543777 R506872	Project Fleet Owner LLC	Berth 301-307 & DD	No	N/A
R543792	Port	B308	No	N/A
R315949	Freightliner	Freightliner/Wind Tunnel	No	N/A
Easement for Submarine Cable Line	Quest Corporation doing business as Century Link Q.C.	NE 1/4 Section 20, Township 1N, Range 1 E	No	N/A
R543792	Port	Historic Vessel Moorage; Between Berths 307 and 308	No	N/A
R315705	Port	Dredge Base	No	N/A
R592200	City of Portland Parks and Recreation Department	Swan Island Boat Ramp	No	N/A
R315695	USA; USCG	USCG Dock	No	N/A
R315697	USA; U.S. Navy	U.S. Navy Pier	No	N/A
R315711	Port of Portland	Land adjacent to Dredge Base	No	N/A
R315626	ATC Leasing Co.	Terminal 554	No	N/A
R315728	ATC Leasing Co.	Terminal 554	No	N/A
R238891	Anchor Park LLC	Land between Daimler and City of Portland	No	N/A
N/A	Oregon DSL	Submersible properties and submerged lands not owned by other entities	No	N/A

The goal is to send the request for information letters by the end of 2024 to have all information in hand by the submittal of the Draft 50% RD.

The information received will be managed as follows:

1) Collate all information received.
2) Transcribe all information into a 3-D computer-aided design and drafting (CADD) digital format to represent the true dimension, lateral location, and elevation of all utilities.
3) Conduct quality control checks, including the following:

a. Check horizontal and vertical alignment as well as dimensioning between utilities crossing between property boundaries;

b. Check horizontal and vertical alignment of all utilities compared to the digital map of the existing ground surface to confirm above-ground/below-ground alignment;

c. Check horizontal alignment of all utilities relative to published and/or surveyed locations of surface penetrations (power poles, sewer man covers, water hand-holes, utility boxes, etc.); and

d. Compare the utility location map to utility providers' GIS files of horizontal and vertical alignment to confirm connection points and alignment.

4) Route any discrepancies identified during the quality control checks to the appropriate party in an attempt to resolve that discrepancy. A survey may be performed to resolve the discrepancy to the satisfaction of the property owner and the RD team.

5) Prepare a Draft Utility Map in both digital 3-D CADD and hard copy full-size design drawings at a scale of approximately 1 inch = 20 ft. Any outstanding discrepancies will be flagged.

6) Share Draft Utility Map with all landowners, the Port, City, and utility providers for a review of overall consistency with known locations of utilities. The Draft Utility Map will be accompanied by a list of discrepancies and a request for input to resolve any outstanding issues.

7) Incorporate the collected review comments into a Draft Final Utility Map that will be produced in 3-D CADD and hard copy and shared for final review by key stakeholders.

8) Incorporate the collected review comments into a Final Utility Map that will be produced in 3-D CADD and hard copy and shared with key stakeholders.

The Final Utility Map is targeted for completion before the submittal of the Draft 50% RD, assuming the willingness of all parties to expeditiously participate in this process.

2.6.8 Community Impact and Involvement

The largest community impact as it pertains to the SIB Project Area will likely be public access to the boat launch or public beach and parking lot. Institutional Controls (ICs) will be implemented to limit the impact of RA construction on the community. ICs are further discussed Section 3.4.2. Although economic benefits from remedy implementation will not be substantial until the initiation of the RA, the RD will be developed to consider community involvement and community impact.

Community involvement will include engagement of dialogue and collaboration with community members during the RD development phase. Encouragement of early participation and meaningful input is believed to help develop an RD that has long-term effectiveness and considers community concerns. Community engagement will be informed by the historical context of equity, social justice, and environmental justice, as further discussed in the Community Impact Mitigations Plan (EPA, 2024b).[4] The closest residents are at 1,000 to 4,000 ft from the SIB Project Area, so impacts to residents are not currently considered as the distance exceeds 1,000 ft (EPA, 2024b). However,

[4] Environmental justice refers to fair treatment and meaningful engagements for people of all races, cultures and incomes regarding the development of environmental laws, regulations and policies.

construction and increased traffic may impact travel for community members. Additionally, there may be impacts from noise, light, odors, or air quality. These considerations will be further evaluated during the RD and presented in the Final 100% RD, if considered applicable.

Moreover, as noted in Section 5.3.1 of the Remedial Design Guidelines and Considerations (RDGC), best management practices (BMPs) and mitigation measures will be developed in the Draft 50% RD to address the following community impacts: "*Concerns about air quality, noise, odor, light, and other potential community impacts will be considered and minimized to the extent possible. Exceedances of health-based standards may result in additional controls being put in place so that construction impacts are mitigated to the extent practicable. EPA will provide contact information for community members to raise complaints or concerns during construction. Mitigation measures and BMPs shall be implemented to protect the community, workers, and the environment during construction of the remedial action.*" (EPA, 2021b).

Once RA is initiated, construction of the remedy may bring economic benefit to the community through job opportunities. These employment opportunities will also consider initiatives to benefit the community. Initiatives such as Superfund Job Training Initiative (SuperJTI) will be encouraged, including suggestions in the RD for RA contractors to discuss partnering with initiatives such as SuperJTI to fill their labor needs. This approach is expected to benefit area residents and cleanup contractors (EPA, 2024a). However, although the RA may create job opportunities and benefit the local economy, special care will be taken during RD to minimize RA impacts, to the extent possible, to the numerous existing businesses within SIB. The process to minimize impact on existing businesses will be informed by engaging owners, operators, and stakeholders as soon as possible during development of the Draft 50% RD.

3.0 DESIGN REQUIREMENTS AND PERFORMANCE STANDARDS

Design requirements from Section 14.2.9 of the ROD (EPA, 2017) applicable to the SIB Project Area are summarized in this section. Performance standards are developed to assess the effectiveness of the remedy through performance monitoring. As stated in Section 14.2.10 of the ROD: "*Performance standards related to the implementation of the Selected Remedy will be fully developed during the remedial design and will be based on environmental media (e.g. sediment, groundwater, surface water, etc.) and scientific criteria. The performance standards will be incorporated into all relevant remedial design documents. The standards will promote accountability and ensure that the remedy meets the RAOs, Site-specific ARARs [applicable or relevant and appropriate requirements], and cleanup levels*" (EPA, 2017).

3.1 RECORD OF DECISION REMEDIAL ACTION OBJECTIVES

RAOs are media-specific objectives or goals for RA established in the ROD to select a remedy protective of human health and the environment. RAOs were developed for COCs in the environmental media of interest, for exposure pathways, and for an acceptable COC range for each exposure route. The ROD identifies nine RAOs that define specific qualitative objectives to guide the development, implementation, and evaluation of the selected remedy. The RAOs listed below were summarized in ROD Section 9 (EPA, 2017) and RDGC Section 2.1 (EPA, 2021b). RAOs simultaneously address both current and future land and waterway uses since future land and waterway uses are not anticipated to change significantly from the current usage (EPA, 2017). RAOs 1 through 8 will be addressed by developing an RD for contaminated sediments and demonstrating that they are protective of human health and the environment by meeting COC CULs for appropriate media. RAO 9 will be achieved through riverbank cleanup and in conjunction with upland source control actions (EPA, 2021b).

3.1.1 Human Health RAOs

- RAO 1 – Sediment: Reduce cancer and non-cancer risks to people from incidental ingestion of and dermal contact with COCs in sediment and beaches to exposure levels that are acceptable for fishing, occupational, recreational, and ceremonial uses.
- RAO 2 – Biota: Reduce cancer and non-cancer risks to acceptable exposure levels (direct and indirect) for human consumption of COCs in fish and shellfish. Fish consumption advisories will still be in place until RAO 2 is achieved.
- RAO 3 – Surface Water: Reduce cancer and non-cancer risks to people from direct contact (ingestion, inhalation, and dermal contact) with COCs in surface water to exposure levels that are acceptable for fishing, occupational, recreational, and potential drinking water supply.
- RAO 4 – Groundwater: Reduce migration of COCs in groundwater to sediment and surface water during construction and source control action to such that levels are acceptable for human exposure.

3.1.2 Ecological RAOs

- RAO 5 – Sediment: Reduce risk to benthic organisms from ingestion and direct contact with COCs in sediment to acceptable exposure levels.
- RAO 6 – Biota (Predators): Reduce risks to ecological receptors that consume COCs in prey to acceptable exposure levels.
- RAO 7 – Surface Water: Reduce risks to ecological receptors from ingestion of and direct contact with COCs in surface water to acceptable exposure levels.
- RAO 8 – Groundwater: Reduce migration of COCs in groundwater plumes to sediment and surface water such that levels are acceptable in sediment and surface water for ecological exposure.

3.1.3 Human Health and Ecological RAOs

- RAO 9 – Riverbanks: Reduce migration of COCs in riverbank to sediment and surface water such that levels are acceptable in sediment and surface water for human health and ecological exposure.

3.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED

Applicable or relevant and appropriate requirements (ARARs) are requirements promulgated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). As discussed in Section 10.1 of the ROD, "*CERCLA § 121(d), 42 U.S.C. § 9621(d), further specifies that a remedial action must require a level or standard of control of the hazardous substances, pollutants, and contaminants, which at least attains ARARs under federal and state laws, unless a waiver can be justified pursuant to CERCLA § 121(d)(4), 42 U.S.C. §9621(d)(4)*" (EPA, 2017). ARARs associated with remedial technologies as indicated in ROD Section 10.1.1.10 include:

- Federal National Recommended Water Quality Criteria (NRWQC);
- Oregon Water Quality Standards (WQS);
- Safe Drinking Water Act (SDWA);
- Oregon Hazardous Substance Remedial Action (OHSRA);
- Solid and hazardous waste restrictions (Resource Conservation and Recovery Act [RCRA], Land Disposal Restrictions [LDRs], and Toxic Substances Control Act [TSCA]);
- Endangered Species Act (ESA);
- Section 404 of the CWA;
- Section 401 of the CWA;
- Section 10 of the Rivers and Harbors Act; and
- Federal Emergency Management Agency (FEMA).

As noted in Section 12.2 of the ROD, *"Section 121 (d) of CERCLA and NCP [National Contingency Plan] 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA Section 121(d)(4). Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than Federal requirements may be relevant and appropriate. Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other federal and state environmental statutes or provides a basis for invoking a waiver"* (EPA, 2017).

To be considered (TBC) items include: *"advisories, criteria, or guidance developed by the U.S. EPA, other federal agencies, or states that may be useful in developing CERCLA remedies"* (EPA, 2016a). TBCs used in this BODR included EPA Regional Screening Levels (RSLs) for tap water established at a 10^{-6} risk level (EPA, 2017).

Sections below discuss how some of the more pertinent ARARs and TBCs are applicable to water quality and waterway protection, cleanup standards, waste management, flood level evaluation, and cultural resources. Additionally, Section 10 of Rivers and Harbors Act, ESA, and FEMA floodplain regulations are discussed. ARARs and/or TBCs and the generalized criterion/requirements area are listed in Table 3-1, as summarized from the ROD Appendix II Tables 25a-c (EPA, 2017). The RD will consider all ARARs that are pertinent to the SIB Project Area. These ARARs, in addition to RAOs discussed in Section 3.1 and site-specific CULs, will be used to evaluate the implementation and the functionality of the designed remedy during monitoring efforts discussed in Section 9.

3.2.1 Water Quality and Waterway Protection

The following regulations regulate water quality, including, but not limited to:

- Section 404 of the CWA, which: *"establish[s] a program to regulate discharge of dredged or fill material into waters of the United States, including wetlands. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g., certain farming and forestry activities"* (EPA, 2024c).
- Section 401 of the CWA, which states that *"a federal agency may not issue a permit or license to conduct any activity that may result in any discharge into waters of the United States unless a Section 401 water quality certification is issued, or certification is waived. States and authorized tribes where the discharge would originate are generally*

responsible for issuing water quality certifications. In cases where a state or tribe does not have authority, EPA is responsible for issuing certification. 33 U.S.C. 1341. Some of the major federal licenses and permits subject to Section 401 include:

- *Clean Water Act Section 402 and 404 permits issued by EPA or the Corps,*
- *Federal Energy Regulatory Commission (FERC) licenses for hydropower facilities and natural gas pipelines, and*
- *Rivers and Harbors Act Section 9 and 10 permits"* (EPA, 2024d)

- SDWA, which is intended to: *"protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and requires many actions to protect drinking water and its sources—rivers, lakes, reservoirs, springs, and ground water wells. (SDWA does not regulate private wells which serve fewer than 25 individuals.) SDWA authorizes the United States Environmental Protection Agency (US EPA) to set national health-based standards for drinking water to protect against both naturally-occurring and man-made contaminants that may be found in drinking water. US EPA, states, and water systems then work together to make sure that these standards are met"* (EPA, 2024e). As stated in Section 10.1.10 of the ROD, SDWA authority was used to establish maximum contaminant limits (MCLs) and non-zero MCL goals (MCLGs), cleanup levels for surface water and groundwater discharging to the river, and action specific standards for minimizing discharges of contaminants during construction (EPA, 2017).
- RSLs for groundwater are TBCs that were used to establish acceptable risk levels for individual contaminants in groundwater and surface water where there were no MCLs or MCLGs to protect the human health from groundwater and surface water as potential drinking water use sources.
- Oregon Environmental Cleanup Laws, which set state standards for hazardous substance cleanup required.
  - Oregon Revised Statutes (ORS) 465.315(1)(a), which sets standards for degree of cleanup required for: *"any removal or remedial action performed under the provisions of ORS 465.200 (Definitions for ORS 465.200 to 465.545) to 465.545 (Suspension of dry cleaning fees) and 465.900 (Civil penalties for violation of removal or remedial actions) shall attain a degree of cleanup of the hazardous substance and control of further release of the hazardous substance that assures protection of present and future public health, safety and welfare and of the environment."*
  - ORS 468B.048, which sets *"standards of quality and purity for the waters of the state in accordance with the public policy set forth in ORS 468B.015 (Policy)."*
  - OAR 340-122-0040(2)(a) and (c), which lists RAs in the event of a release of hazardous substances and treatment required in the event of a release of a hazardous substance to groundwater or surface water constituting a hot spot of contamination.
  - OAR 340-122-0115(2) - (4), which defines acceptable risk levels for human exposure to individual and multiple carcinogens, as well as noncarcinogens.

- OAR 340-041, which details water quality standards for Oregon and includes the following:
  - OAR 340-041-0033, which details water quality standards for toxic substances and includes:
    - Aquatic Life Water Quality Criteria for Toxic Pollutants (OAR 340-041-8033 Table 30);
    - Aquatic Life Water Quality Guidance Values for Toxic Pollutants (OAR 340-041-8033 Table 31); and
    - Human Health Water Quality Criteria for Toxic Pollutants (OAR 340-041-9033 Table 40);
  - OAR 340-041-0340, including basin-specific criteria for Willamette basin to protect the designated beneficial uses and fish uses; and
  - OAR 340-041-0345, including basin-specific water quality standards for Willamette basin.

These water quality standards will be used in project-specific construction quality assurance (CQA)/quality control plans (QCPs) and CWA analysis. CWA analysis will be presented in the Draft 50% RD to detail RA implementation, minimize short-term and long-term impacts to water discharges.

3.2.2 Cleanup Standards

CULs were developed using risk-based CULs, ARARs-based CULs, human health, and ecological risk-based concentrations, and CULs based on site-specific background concentrations. Background concentrations are *"substances or locations that are not influenced by the releases from the site and are either naturally occurring or due to other anthropogenic sources" (EPA, 2016b).* As stated in ROD Section 9.1.3, *"The cleanup levels for RAOs 3 and 4 are based on the lower of the Federal NRWQC (organism +water) and Oregon WQSs (organism + water), MCLs, and non-zero MCLGs. EPA RSL values were only selected as cleanup levels when a value was not available based on NRWQCs, Oregon WQSs, or MCLs for a specific contaminant. Two RSL-based numbers were identified: manganese and MCPP (2-[4-chloro-2-methylphenoxy]propanoic acid). The cleanup levels for RAO 7 are based on the lower of the NRWQC (chronic aquatic life) and Oregon WQS (chronic aquatic life) only when risk-based values are not available or are greater than ARARs. ARARs-based numbers are used for TBT (tributyltin, RAO 7) and arsenic, chromium, and DDx (RAO 8)"* (EPA, 2017). CULs are listed in Errata #2 for PHSS ROD Table 17, alongside the basis of CULs for surface water, groundwater, riverbank soil/sediment, and fish/shellfish tissue (EPA 2020).

PTW is mobile and/or toxic source material containing hazardous substances. As stated in the PHSS FS, expectations regarding PTW were developed using the National Contingency Plan (NCP) [40 CFR §300.430(a)(1)(iii)(A) and (C)], which establishes the expectations regarding principal threats in developing appropriate remedial alternatives (EPA, 2016b). Moreover, the FS states: "*CERCLA [42 U.S.C. §9621], the NCP, and EPA guidance state an expectation that treatment [be used] to address the principal threats posed by a site, wherever practicable"* (EPA, 2016b). The PTW thresholds are based on a 10^{-3} risk level (highly toxic), except for not reliably contained PTW (chlorobenzene and naphthalene or the non-aqueous phase liquid PTW and may require treatment prior to disposal). PTW thresholds are listed in Table 21 of Appendix II of the PHSS ROD, and are updated in the ESD (EPA, 2017, 2019).

RALs are contaminant-specific sediment concentrations of focused COCs used to identify areas where active remedial technologies will be assigned to reduce risks more effectively than enhanced natural recovery (ENR) or monitored natural recovery (MNR) (EPA, 2017). EPA identifies dredging and capping as primary technologies for addressing sediments with RAL exceedances. The vertical and horizontal extent of RAL exceedances is referred to as the SMA footprint extent (Section 3.1, Appendices A and L of PDI ER [HGL, 2024]). RALs are listed in ROD Table 21. The EPA-prescribed PQL values are used in place of the RALs for TCDD and PeCDD (EPA, 2022b). Collectively, these thresholds are referred to as RAL/PQL and are listed in Errata #3 PHSS ROD Table 21 (EPA, 2022c).

The most updated RALs and PTWs are listed in Errata #3 PHSS ROD Table 21 (EPA, 2022c). Achieving RAOs relies on the ability to meet CULs. CULs are long-term contaminant concentrations that need to be achieved by the remedial alternatives to meet RAOs (EPA, 2017).

3.2.3 Waste Management

Dredged sediment and soil requirements for characterizing, treating, handling, and off-site disposal are listed in solid and hazardous waste regulations. These regulations will be used to characterize waste before disposal and determine appropriate landfill disposal. The regulations pertaining to waste management include RCRA, LDRs, TSCA, and OHSRA. These regulations are action-specific, as listed in Table 3-1, and are further discussed in ROD Section 15.2.3 (EPA, 2017).

3.2.4 Cultural Resources

To ensure compliance with the National Historic Preservation Act (16 U.S.C. 470 et seq., 36 CFR 800, 16 U.S.C. 469a-1) and State regulations (ORS 97.740-760, ORS 358.905, and ORS 390.235) an Archeological Inadvertent Discovery Plan (AIDP) was developed during the PDI to provide procedures in the event that archaeological sites, objects, or human remains are found during PDI activities within SIB. As stated in the AIDP "*The majority of the Swan Island Basin shoreline is indicated as having archeological probability areas of "moderate probability", with the northern portion of Swan Island rated as "low probability" and one <1 mi [mile] portion of the Mocks Bottom shoreline, northern end, rated as "high probability"* (HGL, 2022b). In addition, a professional archaeologist firm, Archaeological Investigations Northwest, Inc., retained by the SIB RD Group, has reviewed the Oregon State Historic Preservation Office's (SHPO's) database and found no listed findings for the SIB Project Area. (HGL, 2022b). Moreover, CSM site history included extensive landscape modification through fill placement, dredging, and shaping of Swan Island and the shoreline of the river channel (Section 2.1.4). Those past activities have a profound effect on reducing the possibility of finding cultural or archeological resources within the soils and sediments that will be disturbed during RA. The AIDP will be modified to include RA activities and will be followed in the event that inadvertent archeological discoveries are found during RA activities.

3.2.5 Section 10 of Rivers and Harbors Act

Section 10 of the Rivers and Harbors Act of 1899 requires that: *"The creation of any obstruction not affirmatively authorized by Congress, to the navigable capacity of any of the waters of the United States is prohibited; and it shall not be lawful to build or commence the building of any wharf, pier, dolphin, boom, weir, breakwater, bulkhead, jetty, or other structures in any port, roadstead, haven, harbor, canal, navigable river, or other water of the United States, outside established harbor lines"* (EPA, 2017). This work includes dredging, disposal of dredged material, filling, excavation, and other disturbances of soils/sediments. For the current SIB Project Area, the RA is not extending into the navigation channel and so it is not likely to obstruct navigable capacity of the Willamette River. However, areas where capping or dredging and capping is assigned as remedial technology in FMD areas will be designed to provide an overdredge allowance or buffer zone, in accordance with Section 3 of the RDGC (EPA, 2021b). A CQA/QCP will be presented in the Draft 50% RD to ensure compliance of RD with this and other necessary ARAR requirements and TBCs (Table 3-1).

3.2.6 Endangered Species Act

The ESA provides a framework to conserve and protect endangered and threatened species and their habitats both domestically and abroad. The lead federal agencies for implementing the ESA are National Marine Fisheries Services and the U.S. Fish and Wildlife Service. As stated in the ROD and Table 3-1, "*Coordination will occur with the National Marine Fisheries Service and US Fish and Wildlife Service regarding actions to be taken, their impacts on listed species, and measures that will be taken to reduce, minimize, or avoid such impacts so as not to jeopardize the continued existence or adversely modify critical habitat. If take cannot be avoided, take permission from the Services will be obtained. EPA evaluated effects to listed and threatened species and critical habitat from the proposed remedial action in a preliminary biological assessment. As further details are developed in remedial design, the biological assessment will be supplemented"* (EPA, 2017).

Per ROD, Section 10.1.1.0, "*The ESA, because threatened or endangered species migrate through and use the Site and the Site contains designated critical habitat for such species, requires reasonable and prudent measures to minimize adverse effects on the species and critical habitat from implementation of the remedy, including the time of year and duration in-river work can be conducted*" (EPA, 2017). Mitigation measures to reduce and minimize impact of RA on endangered and threatened species and their habitats will be discussed in a Habitat Impact Evaluation that will be presented in the Draft 50% RD. ESA Programmatic Biological Assessment will be used as appropriate. Habitat mitigation proposed to satisfy impacts under Section 404 of the CWA will be reviewed by EPA to determine compliance of impacts under ESA.

3.2.7 FEMA Floodplain Regulations

Per flood plain management regulations 44 CFR 60.3(d)(2) and (3) stated in ROD Section 10.1.1.10, *"Federal Emergency Management Agency (FEMA) floodplain regulations prohibit encroachments that would result in any increase in flood levels during occurrence of base flood discharge and require measures to reduce the risk of flood loss, minimize the impact of floods, and restore and preserve the natural and beneficial values of floodplains"* (EPA, 2017). Based on this requirement, flood impact engineering evaluation will be completed in the Draft 50% RD as indicated in Section 11.6 to evaluate flood-rise and encroachment impact of the assigned remedial technology (capping or other placement of material that may impact increased flood levels). Specifically, the remedy design will:

- Per 44 CFR 60.3(d)(2), carry the water of the base flood without increasing the water surface elevation for that flood more than 1 foot at any point; and
- Per 44 CFR 60.3(d)(3), use hydrologic and hydraulic analyses in accordance with standard engineering practices that the proposed encroachment will not result in any increase in flood levels within the community during the occurrence of the base flood discharge.

Floodplain management and protection of wetlands regulations (44 CFR 9) "*set[s] forth the policy, procedure and responsibilities to implement and enforce Executive Order 11988, Floodplain Management, and Executive Order 11990, Protection of Wetlands.*" Specifically per the ROD, it *"requires measures to reduce the risk of flood loss, minimize the impact of floods, and restore and preserve the natural and beneficial values of floodplains"* (EPA, 2017). As a result of this ARAR, impacts to the floodplain and flood storage will be assessed.

For areas where assigned remedial technology is cap, Executive Order 11988 amended by Executive Order 13690 will be considered "*to evaluate the potential effects of action that may be taken in a floodplain and to avoid, to the extent possible, long-term and short-term adverse effects associated with the occupancy and modification of floodplains, and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative. Executive Order 11990 directs that activities conducted by federal agencies avoid, to the extent possible, long-term and short-term adverse effects associated with the modification or destruction of wetlands and to avoid direct or indirect support of new construction in wetlands when there are practicable alternatives*" (EPA, 2017). Climate change effects will be considered in these modeling efforts. Substantive requirements of these ARARs will be met during RD and RA.

3.3 REMEDIAL TECHNOLOGY ASSIGNMENTS

The technology assignments for the selected remedy in the ROD (Figure 31d) for various SIB portions/units are the following remedial technologies:

- Dredge and/or cap in FMD area,
- In other areas:
    - Dredge,
    - Dredge with cap,
    - Cap,
    - ENR, and
    - MNR.

The current assignment of remedial technologies applied to each SIB portion/unit is conceptual in that additional analysis and interpretation is being conducted. This section currently includes the assignment of remedial technologies after further considering additional factors, such as additional technology that may be implemented (in situ treatment), disposal locations, construction duration, design life, and cost effectiveness. Assignment of remedial technologies is outlined in Section 5.0.

3.3.1 Capping

Capping is a remedial technology involving the placement of clean covering or isolating material to cover and separate subaqueous contaminated sediment from the water column to mitigate risks posed by contaminated sediments (ITRC, 2023). The material used in capping design may consist of layers of sand, sediments, and/or other materials. Capping creates a physical barrier between contaminated sediments and benthic organisms populating the top sediment layer, reduces contaminant fluxes due to organism-induced mixing (bioturbation), stabilizes contaminated sediments to prevent resuspension during high-flow conditions, and provides resistance to the transport processes that result in chemical release from the sediments (Lampert and Reible, 2009).

In situ capping refers to the placement of the cap at the contaminated site, while ex situ capping, which is not being considered at SIB Project Area, refers to the capping of contaminated sediment dredged and moved to a separate location (Randall and Chattopadhyay, 2013).

Sand or coarse media is often used as a cap layer, which facilitates in situ placement of the cap. Because contaminants are often associated with fine-grained particles, contaminated sediments often have high water content, low load-bearing capacity, and low shear strength, which is a concern for cap displacement or resuspensions that need to be addressed as part of this design (Reible, 2008). A reactive cap incorporates sorbent material (such as granular activated carbon [GAC]) within the capping material and relies on the sorptive properties of contaminants to slow down the contaminant migration through the cap by accumulation within the clean cap layer (Lampert and Reible, 2009).

3.3.2 Dredging and Excavation

Dredging is a remedial technology that involves the removal of sediment and debris from a water body. If the water has been removed or diverted, the technology is referred to as excavation. Dredging conducted for the purpose of remediating contaminated sediment is performed with subsequent treatment and/or disposal (EPA, 1995; Palermo et al., 2008; Reible, 2014). Components of environmental dredging are removing wood and other debris, removing sediment, staging, dewatering, treating water, transporting dredged material, treating dredged material, and disposing of liquids and solids. The following are objectives for sediment remediation dredging (Palermo et al., 2008):

- Dredging with sufficient accuracy such that contaminated sediment is removed and sediment RALs are met without excessive removal of clean sediment;
- Dredging the sediments in a reasonable timeline and a condition compatible with subsequent transport for treatment or disposal;
- Reducing and/or controlling resuspension of contaminated sediments, downstream transport of resuspended sediments, and release of contaminants of concern to water and air; and
- Dredging the sediments such that the generation of residuals is minimized and/or controlled.

Dredging is conducted using hydraulic or mechanical means. Hydraulic dredges use suction and hydraulic action to remove sediments. Hydraulic dredges have a rotating cutter head or a horizontal auger that suctions and/or scours bedded sediments and lifts sediment slurry through a pipe to a land-based sediment handling facility or a slurry discharge location. Clamshell buckets are typically used to remove large debris from the site prior to hydraulic dredging of sediment. Hydraulic dredging is applicable in areas with high sediment volumes and low levels of debris (Palermo et al, 2008; Reible, 2008; AECOM, 2012).

The advantage of hydraulic dredging is its effective removal with lower resuspension and recontamination/residual rate relative to mechanical dredging. Hydraulic dredging is more effective at achieving lateral and vertical cut control than mechanical dredging. Hydraulic dredging is also typically a viable option for location-specific circumstances where the total volume of water generated is small and controllable, such as using a diver-operated, hand-held, hydraulic dredge to remove materials under or around piers, pilings, or in other under-structure places where conventional dredging equipment is unable to reach. Using this technology can make an otherwise unreachable location easier to dredge. However, this is dependent on circumstances such as the diver's visibility, the overall safety of the diver, and the reduced production rate compared to the overall project volume requiring removal (Palermo et al, 2008; Reible, 2008; AECOM, 2012).

The disadvantage is that hydraulic dredging entrains a significant amount of additional water (approximately four to seven times the volume of dredged sediment), so a large dewatering and water treatment process area is needed which increases the energy used, adds complexity, and generates additional waste streams such as process water and expended treatment material (such as carbon used in filtration). Hydraulic dredging has high utility when used in conjunction with confined disposal facilities, which does not apply to SIB. A potential treatment facility would have to be located near the waterway with enough land space to accommodate retention basins, mechanical dewatering equipment, filtration (via sand and carbon), and transfer of dewatered material via trucks to an off-site landfill (Palermo et al, 2008; Reible, 2008; AECOM, 2012).

Mechanical dredges remove the sediment by excavation using a bucket. They have clamshells or environmental buckets that grab, rake, cut, and/or scour the sediment bed. Two major approaches to mechanical dredging are differentiated based on the method of bucket deployment. The first uses a wire attached to a crane or derrick barge to lower the bucket to the bed and retrieve sediment. The second uses a bucket deployed at the end of the arm of an excavator or backhoe and is sometimes referred to as an articulated fixed-arm dredge. A floating crane is mounted on a derrick barge and is used to control the bucket. The bucket is lowered into the sediment and upon retrieval to the surface via a cable, boom, or ladder, the bucket jaws are closed to retain the dredged material. Mechanical dredges are typically used in open-water areas due to the effective removal of consolidated sediments, debris, and other materials such as riprap with a relatively small operational footprint, as compared to hydraulic dredges (Palermo et al, 2008; Reible, 2008; AECOM, 2012).

Mechanical dredges are preferred in many situations because they produce dredged material with a high solids content (a low percentage of water entrained with the sediment as it is removed, with the water entrainment ratio of approximately two parts water to one part dredged sediment), and the ability to remove sediments containing debris. The material is partially dewatered on the haul barge to meet requirements for hauling and then can be transloaded, transported, and managed at permitted off-site facilities that are authorized to handle wet sediments for pretreatment, treatment, and final disposal. Mechanical dredges are effective for removal in areas with high debris and sediments with high sand or heavy clay content that require digging buckets. Mechanical dredging is also not depth-restricted in the SIB and is not affected by tidal exchange. Disadvantages include limited basin accessibility to a barge-operated dredge, as well as potentially higher resuspension and residual rates as compared to hydraulic dredging. It also has less vertical and horizontal operational control relative to hydraulic dredging (Palermo et al, 2008; Reible, 2008; AECOM, 2012).

Mechanical dredging is expected to be used at SIB due to the additional challenges to implementability associated with the infrastructure needs for hydraulic dredging in the Portland Harbor area as stated in the Portland Harbor FS (EPA, 2016a). However, since it is possible that contractor and/or technology availability may change by the time the Draft 50% RD is developed or at the time of the RA, the option of hydraulic dredging was kept in this evaluation, while details related to dredging efforts are focused on mechanical dredging.

As compared to dredging, excavation has advantages in that the removal operation can easily be overseen, and removal of contaminated sediment leaves lower residual contamination in place. Moreover, dewatering of excavation areas causes far fewer waterborne contaminants to be released. Lastly, much less attention needs to be given to potential debris and sediment characteristics. However, site preparation for excavation can be more costly and lengthy as compared to dredging due to the need for dewatering or water diversion. This process includes coffer dams, sheet pile walls, or other diversions/exclusion structures that need fabrication and installation. Excavation areas cause access challenges for earth-moving equipment, and excavation is generally limited to relatively shallow areas (EPA, 2024f).

The remediation aims to satisfy the ROD cleanup objectives, either through removal to meet cleanup goals (for dredging only) or by removing enough contaminated sediment to an elevation permitting the placement of a cap (for dredge and cap scenario) while not impacting structures or slopes and permitting the continued use of SIB. Evaluation of varying dredge depths will consider:

- Depth needed to dredge to cleanup goal based on contaminant concentrations,
- Need for additional dredging to place a cap of adequate thickness,
- FMD area elevations, and
- Navigable depth needs requested by the owners and operators within SIB.

As specified in RDGC Appendix C, Section 2.1: *"Dredging will occur as specified in ROD Section 14.2 followed by placement of a post-dredge residual management layer, backfill material, and/or engineered cap. Dredging will target removal of contaminated sediment exceeding the RAL and/or PTW thresholds specified in ROD Table 21 or to the feasible depth limit of the excavation technology, as approved by EPA. If RALs are not achieved or PTW is present below the feasible depth limit of the excavation technology, then a cap or backfill will be required instead of the residual management layer. and will be followed by placement of a post-dredge residual management layer, backfill material and/or engineered cap"* (EPA, 2021b).

3.3.3 Enhanced Natural Recovery

ENR involves the placement of a thin layer of sand cover outside of SMA areas to enhance or accelerate natural recovery processes to meet CULs within an acceptable timeframe (EPA, 2021b). ENR will likely include a thin layer placement (assumed in the ROD to be 12 inches [30 cm] of sand) and long-term monitoring. Per RDGC, Section 2.4, regarding the accelerations of natural recovery processes, "*the acceleration can occur through several processes, including increased dilution of contaminant concentrations in sediment from mixing, thereby decreasing the exposure* *of organisms to contaminants*" (EPA, 2021b). This technology assignment will be made on an area-specific basis outside of the SMA, and presented in the Draft 50% RD. The ROD states that ENR will be used at SIB outside of the SMA area to cost-effectively meet cleanup levels of sediments with lower contaminant concentrations within an acceptable time frame (EPA, 2017).

3.3.4 Monitored Natural Recovery

MNR relies on natural processes to destroy, contain, or reduce the bioavailability or toxicity of sediment contaminants. The processes operating in the sediment region to reduce contamination concentrations may be sedimentation or dispersion, biodegradation, and/or sorption and oxidation. From the ROD, it was anticipated that natural deposition of cleaner sediments would be the primary MNR mechanism (EPA, 2017).

3.3.5 In Situ Treatment

As discussed in ROD Section 10.1.1.2, in situ treatment includes the application of natural or mechanical mixing of amendment into sediments. In situ treatment may include solidification or stabilization, or sorption. For solidification or stabilization, chemicals or cements may be added to contaminated sediments to contain them into a solidified mass that reduces contaminant mobility and bioavailability. For in situ treatment via sorption, treatment amendments are placed on top of the or into the existing sediment to sorb COCs and help reduce the risk of harmful COC exposure of benthic communities, invertebrates, and other biota in the bioturbation zone. As compared to capping, where caps are placed as a distinct layer above the sediments (ITRC, 2014), in situ treatment is the preferred technology for situations where sediment removal or containment may be harmful to sensitive habitats. It can also be used in areas around permanent functional structures where access is limited and where slope stability presents challenges for the implementation of other technologies. These areas include contaminated sediment underneath and around pilings, docks, berthing and mooring dolphins, and other structures servicing active wharfs or shore-based facilities that will remain intact (RDGC Appendix C, Section 2.3; EPA, 2021b).

3.4 OTHER TECHNOLOGY ASSIGNMENT CONSIDERATIONS

The main additional considerations in assigning remedial technologies include disposal locations and ICs, as discussed in the following sections.

3.4.1 Disposal

The disposal location(s) will be dependent on waste characterization and compliance with ARARs. and TBCs (see Section 3.2.3) Since most of the dredged material is expected to be non-hazardous, landfills evaluated were all considered to be within a reasonable distance, including Roosevelt Regional Landfill, Chemical Waste Management of the Northwest, Wasco County Landfill, and Columbia Ridge Landfill. If the disposal locations listed above no longer have capacity at the time of the disposal or cannot accept the waste due to waste characterization results, alternative disposal locations will be identified.

3.4.2 Institutional Controls

ICs are non-engineering measures intended to affect human activities to prevent or reduce exposure to hazardous substances, often by limiting land or resource use (EPA, 2016a). ICs that may be implemented at SIB per the ROD (EPA, 2017) include:

- Fish advisories and education outreach,
- Waterway use restrictions or regulated navigation areas; and
- Land use/access restrictions.

ICs would be used in conjunction with other remedial technologies indicated above. A plan for implementing ICs that are SIB Project Area-specific and not PHSS-wide will be presented in the Draft 50% RD.

3.5 REMEDIAL TECHNOLOGY ASSIGNMENT DECISION TREE

The preferred remedial approach presented in Section 5.0 proposes technology assignments for the SIB Project Area consistent with the Technology Application Decision Tree as seen in ROD Figure 28 (EPA, 2017) and PDI results for the FMD areas (Section 2.6.3), riverbanks, shallow and intermediate regions (Section 2.6.4), and for areas around structures. During the development of the preferred remedial approach for the SIB Project Area, ROD Figure 28 was evaluated, and the following changes were indicated (Figure 3-1):

1) As compared to the ROD Figure 28, SIB is not in the navigation channel, and there is no required navigational depth; however, SIB does include FMD areas. The FMD area was used instead of the FMD/dredge area in Figure 3-1 to emphasize SIB-specific conditions. FMD areas, minimum depths and operational navigational needs are discussed in Section 2.6.3.
2) The RD team identified a potential need for remedy via dredging and capping of areas near structures that are functional and non-floating or movable (instead of just capping). An additional dashed line was added in Figure 3-1 to indicate this option in the decision-making process.

In addition to the changes indicated in Figure 3-1 that identify SIB-specific considerations included in the development of the preferred remedial approach, the Technology Application Decision Tree has some ambiguity in the remedial technology assignments selection (the same set of criteria is leading to cap, excavate and cap, or fill and cap). As a result, additional considerations were included in the preferred remedial approach. These considerations include geotechnical stability, structure condition considerations and their implications to remedy selection and work around structures, requested navigable depths, recontamination potential, potential business disruption, monitoring requirements, and cost implications of assigned remedial technology. Riverbank guidelines were further refined in the RDGC, Appendix D, Figure 4 (EPA, 2021b), which contains the *Decision Guide for Characterizing and Implementing Remedial Action for ROD Riverbanks*, discussed in Section 5.2.

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4.0 REMEDIAL TECHNOLOGY CONSIDERATIONS

The remedial technologies assigned for SIB include capping, dredging, dredging with capping, ENR, MNR, and in situ treatment. The key considerations applied to the evaluation, design, and assignment of each of these remedial technologies are described in the following subsections.

4.1 CAP DESIGN EVALUATION SUMMARY

The complete cap design evaluation is included as Appendix A. The following section presents a summary of the main conclusions. The following four cap alternatives were evaluated (Figure 4-1):

- Cap Alternative 1: 2 ft (60 cm) of unamended sand with overlying 2 ft (60 cm) erosion protection layer (EPL);
- Cap Alternative 2: 4.33 inches (11 cm) of GAC-amended sand with overlying 2 ft (60 cm) EPL;
- Cap Alternative 3: 3 ft (90 cm) of unamended sand; and
- Cap Alternative 4: 4.33 inches (11 cm) of GAC-amended sand with overlying 1 ft (30 cm) unamended sand.

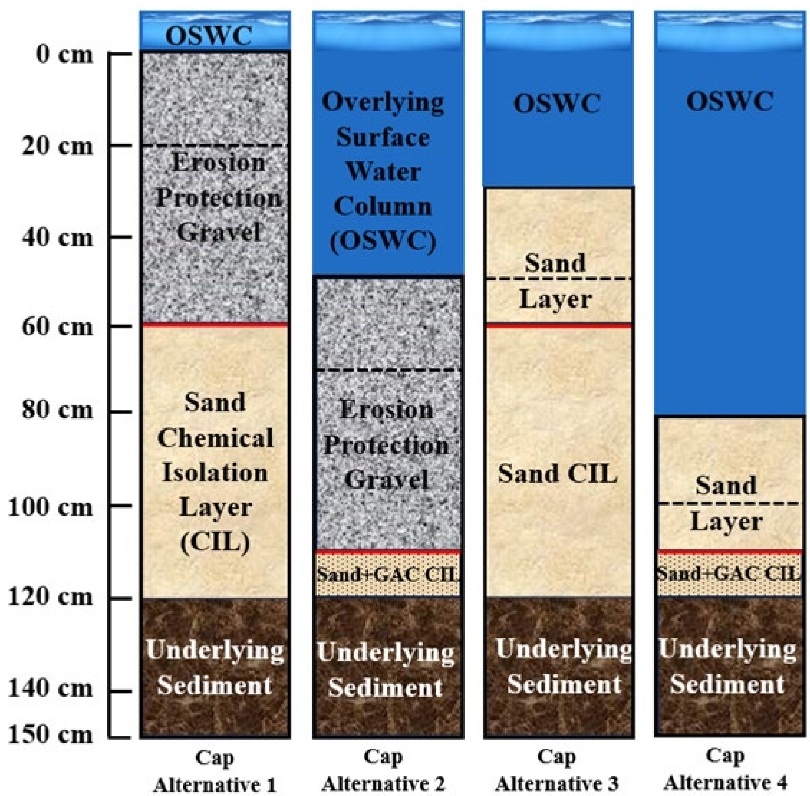


Figure 4-1. Depictions of Cap Alternatives 1 through 4[5]

[5] The red line represents the depth at which the cap performance was evaluated, also referred to as the cap performance point. The cap performance point was determined as the top of the isolation layer. The dashed line represents the presumed maximum depth of bioturbation (7.87 inches [20 cm]). Materials above and below the dashed line are the same. The layer thickness is in cm.

Cap evaluation considerations concluded that the amended alternatives with at least 4.33 inches (11 cm) of 5 percent GAC-amended sand would be protective of the most conservative SIB conditions (e.g., using 95th percentile of the highest concentrations and the highest upwelling velocity) for the duration of design life (100 years). However, area-specific parameters such as COCs exceeding RAL/PQL and PTW thresholds, and area-specific maximum porewater upwelling could impact specific cap composition and amendment may not be needed. Additionally, development of specific cap area placement in the Draft 50% RD could result in reduced cap thickness based on area-specific chemical concentrations and porewater upwelling input parameters.

With regard to the selection of the erosion protection layer (EPL) for a physically stable cap under flow conditions associated with a 100-year flood event, reasonably anticipated wind- and vessel-generated waves, and propeller scour (RDGC Appendix C Section 2.2; EPA, 2021b), medium to coarse gravel can be selected as EPL material. Selected EPL material can be placed in a single-layer approach (as compared to armor and bedding layer) directly above the chemical isolation layer containing medium or coarse sand. Caps with EPL will likely be used in the FMD, intermediate, and some shallow areas, but may also be used on SIB riverbanks, and under and around structures. Armor layer requirements are minimal except on steeper slopes and near outfalls.

Geotechnical considerations for cap design include the following:

- Cap designs all have a safety factor of at least 3 against bearing failure (based on near surface in situ sediment shear strengths);
- Predicted consolidation settlement of sediment material under anticipated cap loads and liquefaction-induced settlement magnitudes are variable across the basin;
- Detailed analysis is required during RD to assess the potential for differential settlement;
- Preliminary evaluation of grain size compatibility indicates the anticipated cap material types adequately limit the potential of vertical migration of both sediment and cap materials;
- Preliminary slope stability analysis indicates minimum required factors of safety are met for submerged cap slopes at gradients of up to 3H:1V (±22 degrees);
- Detailed analysis is required and will be completed in the Draft 50% RD to assess cap stability on emergent slopes basin wide; and
- Detailed analysis is required and will be completed in the Draft 50% RD for different locations around the basin, including cap placement around and under individual structures.

Additional considerations for determining cap composition and placement include cost effectiveness of the remedy between equally protective caps, areas of deposition or erosion, bed slope, physical sediment characteristics, contaminant mass flux, geotechnical stability for the area considered, proximity to outfalls, and functional structure stability. Selections that could address these considerations include the use of geotextiles and geogrids where geotechnical evaluation indicates the area analyzed may not have the strength to support a cap, and the use of a habitat layer to accommodate benthic communities and vegetation growth in habitat areas following the placement of the cap.

4.2 DREDGING EVALUATION SUMMARY

The complete dredging evaluation is included as Appendix B. The following list presents a summary of the main conclusions:

- Overall, dry bulk densities measured in the field are relatively low, indicating soft mud (even at depth) that can be readily dredged;
- Based on a mostly uniform grain-size distribution of near surface sediments, resuspension of material during dredging operations may occur due to the sediment top layer being composed of over 70 percent silt;
- BMPs that comply with regulations and requirements will be implemented to mitigate residuals and contamination release;
- Slopes in the SIB Project Area vary from 10H:1V to 1H:1V. The primary steep bed slopes are found in the vicinity of Dry Dock 3, the northern end of the riverbank from the U.S. Navy Pier to the MC Pier, and from Berth 302 to the Wind Tunnel;
- 1-ft (30-cm) overdredge of the targeted design dredge depth may be needed for construction equipment tolerances, although environmental dredging has been demonstrated to achieve tolerances of 6 inches in some instances;
- A daily (not SIB Project Area-specific) dredging production rate was estimated to be around 2,000 CY/day; and
- Most of previously observed surface debris in SIB may have to be removed before or during the dredging operations. Subsurface debris below the dredge design depth will remain.

Dredging areas were selected for SIB based on conclusions of the dredging evaluation (Appendix B). Data gaps remain for certain key considerations, such as subsurface debris locations or future structure repairs and maintenance. The available data have informed the details and criteria for the successful application of dredging technology to remediate sediments in the FMD areas, intermediate and shallow areas, and potentially in some areas around structures.

A continuously downstream sloping riverbed may be required from the head of SIB to the mouth to prevent the formation of anoxic zones, slopes along the edges of requested navigable depth polygons, and potential compromise between existing and owner-requested navigational depths.

4.3 DREDGING WITH CAPPING

In certain SIB areas, the technology assignment will include a combination of dredging followed by capping. These areas include sediment where RAL/PQL exceedance extends deeper than the limits of feasible sediment dredging to RAL, areas with physically stable buried contamination (e.g., greater than 1 ft), or where capping after partial dredging represents a more cost-effective solution. In these scenarios, dredging would be completed to allow for the placement of the cap and enough depth clearance that FMD or potential future flood rise will not interfere with the remedy. Capping in these locations will likely include a design with EPL to protect the physical integrity of the chemical isolation layer of the cap from erosive forces caused by heavy vessel traffic, currents, tides, and waves. An amendment (such as GAC discussed in Section 4.1 and Appendix A) will likely be used to minimize cap thickness and the need for overdredging so that remedy costs can be optimized. A cap would be placed within the final constructed elevation below the FMD depths.

4.4 ENHANCED NATURAL RECOVERY

As discussed in Section 3.3.3, ENR would likely include a thin layer placement and will require long-term monitoring. ENR would occur in areas with surface and subsurface concentrations below RAL/PQL unless these areas have recovered (have concentrations below CUL) naturally. ENR may be assigned within the SIB Project Area outside of the SMA and on riverbanks to meet CULs of sediment and soil with lower contaminant concentrations within an accepted time frame (EPA, 2017). The main consideration for areas where ENR would be implemented is the positive impact on habitat restoration and disruption to the benthic population (EPA, 2016a).

4.5 MONITORED NATURAL RECOVERY

As discussed in the ROD and FS, MNR is not considered to be effective within most of the SIB Project Area due to quiescent conditions limiting water circulation and deposition of cleaner sediment from further upstream (mouth of the basin) (EPA, 2016a, 2017). However, as seen in ROD Figure 31d with selected remedy technology assignments, there are portions of the riverbank where MNR would be applicable (EPA, 2017). As such, MNR would likely only be considered in areas indicated in ROD Figure 31d where all surface and subsurface contaminant concentrations were above CUL and below RAL/PQL (Figures 2-16, 2-17, 2-19, and 2-20). Potential MNR areas are currently being evaluated as a part of the recontamination potential evaluation and the determination will be revised once that evaluation is completed.

4.6 IN SITU TREATMENT

As discussed in Section 3.3.5, in situ treatment is the preferred technology for situations where sediment removal or containment may be harmful to sensitive habitats. It is also used around permanent functional structures where access is limited and where slope stability presents challenges for the implementation of other technologies. These areas include special considerations for work around structures or potentially erosive banks. Application of in situ will likely include AquaGate®+PAC or a similar product as discussed in ROD Section 14.2.9.3 (EPA, 2017) to reduce contaminant bioavailability in bioturbation layer without contaminant removal. In situ treatment may also be combined with ENR. In situ treatment is anticipated to be used in special consideration areas, including areas around structures and potentially erosive areas. Area-specific remedial technology assignments will be evaluated as needed in the RD and presented in the Draft 50% RD.

5.0 PREFERRED REMEDIAL APPROACH

This section presents the preferred remedial approach for the SIB Project Area as compared to ROD Figure 31d for the SIB Project Area (EPA, 2017). The preferred remedial approach refines technology assignments for the SIB SMA consistent with the Technology Application Decision Tree (ROD Figure 28 [EPA, 2017]), based on data collection and evaluation efforts completed during the PDI and previous sections of this BODR.

The preferred remedial approach areas within the SIB SMA are presented in Table 5-1 and Figure 5-1. The preferred remedial approach areas for riverbanks and areas outside of the SIB SMA are presented in Table 5-1 and Figure 5-2. Remedial technologies selected include capping and/or dredging, ENR, MNR, as well as additional considerations including backfilling to grade and potentially in situ treatment.

The general assignment includes:

- No further action at areas where either surface and/or subsurface concentrations were below CUL levels (Figures 2-16 and 2-19).
- Assignment of capping, dredging, or dredging with capping for areas with surface and/or subsurface RAL/PQL (Figures 2-17 and 2-20) and/or PTW threshold exceedances (Figures 2-18 and 2-21).
- Assignment of either ENR or MNR (for a limited portion of riverbank) in areas where COC concentrations were between CUL and RAL/PQL for at least one analyte and erosion potential was considered non-erosive, in accordance with ROD Figure 31d (EPA, 2017).

Consideration of the navigable depths requested by property owners/operators (Figure 2-23), were incorporated into the preferred remedial approach where reasonable and practical. Additional considerations will be included in the area-specific analysis to include transitions between navigable depths to avoid formation of anoxic zones. Special considerations were included in the preferred remedial approach and will be further defined on area-specific basis for erosive banks, work around structures, and potential revegetation areas. These considerations include additional technology assignment such as in situ treatment, and assignment of specialty caps, including components such as geotextile with reactive media such as activated carbon, to address challenges for areas requiring special consideration.

The preferred remedial approach synthesizes remedial technology assignments by applying the SIB Remedial Technology Application Decision Tree (Figure 3-1) and is informed by the PDI dataset (HGL, 2024), and the preliminary design analyses. The preferred remedial approach satisfies RD requirements published in the ROD and applies the guidance in the RDGC (EPA, 2021b). The following subsections present and discuss the preferred remedial approach for three areas:

- SMA,
- Riverbank and areas within the SIB Project Area that are outside of the SMA, and
- Work around shoreline structures and geotechnical consideration zones.

5.1 SEDIMENT MANAGEMENT AREA

The refined SMA horizontal extent for the SIB Project Area was presented in Contaminated Sediment 3-D extent (Appendix L of the PDI ER [HGL, 2024]). This area comprises the locations where sediment concentrations exceed RALs/PQLs and/or PTW thresholds in some areas. The SMA includes an FMD area as well as intermediate and shallow regions. The three remedial technology assignments for these locations are illustrated in Figure 5-1 and include dredging to RAL/PQL, dredging and capping, and capping only (placing a cap on a prepared surface close to the mud line elevation).

Areas where capping, dredging, or capping with dredging will occur will be presented on area-specific basis in the Draft 50% RD. Capping only is more likely to occur at more shallow areas with deep vertical contamination (such as the head of the basin); however, these remedial decisions will be finalized in the Draft 50% RD. In areas where capping is selected as a sole remedy or part of a dredging and capping remedy, there will be clearance of at least 1 ft between the top of the cap and the specified navigation depth as prescribed in the ROD (EPA, 2017).

The ratio of dredging and/or capping will vary and will be finalized in the Draft 50% RD on an area-specific basis following communications with the shoreline facility owners and operators to finalize navigable depths for SIB and resolution of additional considerations, including cost analysis, recontamination potential evaluation, and work around structures. Areas where the decision hinges on these considerations are indicated in Figure 5-1 as “dredging and/or capping.”

In areas within the SMA where COC concentrations exceeded CULs but were below RAL/PQL, ENR was assumed in accordance with ROD Figure 31d (EPA, 2017). Limited areas where CULs were not exceeded in surface or subsurface sediment samples are identified with black circles in grid cell C6 in Figure 5-1.

Design constraints within the SMA include working near and under shoreline structures or working near outfalls and riverbank slopes. Section 5.3 discusses the approach to developing the preferred remedial approach where remedial technology assignments will require consideration of interactions between the remedy and the shoreline structures, outfalls, and riverbank slopes.

5.2 RIVERBANKS AND AREAS OUTSIDE SEDIMENT MANAGEMENT AREA

The SIB Project Area includes riverbanks, which are defined in the ROD as extending to the top of bank (Figure 2-1). The ROD differentiates between situations where a contaminated riverbank poses a recontamination risk versus situations where remediation of contaminated riverbank soils must be addressed as part of the RD. Figure 2-17 illustrates the locations where riverbank soil concentrations exceeded RAL/PQL for the surficial samples (0 to 1 ft bgs). Riverbank soil contamination above RAL/PQL is widespread, but there are notable sections of the riverbank where COC concentrations are below RAL/PQL, but above CUL. For riverbanks with contaminant concentrations in soil/sediment greater than CULs but less than sitewide RALs/PQLs, the need for an action would proceed through a risk-based decision process, as outlined in the RDGC (EPA, 2021b). The ROD specifies addressing riverbanks based on the following COC concentration thresholds (Table 5-1):

- If COC concentrations are below CUL, the riverbank is not considered to pose a recontamination risk, and the riverbank does not require remediation ("no further action" scenario).
- If COC concentrations are above the CUL but below the RAL/PQL, the riverbank needs to be evaluated for human exposure, ecological risk, potential erodibility or recontamination risk and may require in situ treatment or ENR to arrest erosion and potential associated COC loading to post-remedy SIB sediments. Non-erodible areas of the riverbank with soil concentrations exceeding the CULs (but less than RALs/PQLs) must achieve the protectiveness goals of RAO 9 and be monitored to ensure the areas do not become erodible in the future. After evaluation, a non-erodible riverbank can be left undisturbed if a long-term monitoring program is implemented (EPA, 2019).
- If COC concentrations are above the RAL/PQL and/or PTW threshold, the RD must include remediation of the riverbank soil such as excavation/dredging, bank stabilization, potential backfilling to grade, and/or capping.

The RD approach to the riverbanks first delineates and differentiates these three situations. For non-erodible soils with COC concentrations above CULs but below RALs/PQLs, the RD will be evaluated for human exposure, ecological risk, erodibility and recontamination potential, and will address those areas as needed with bank stabilization measures, MNR and/or ENR. The RD approach to remediating contaminated riverbank soils above RAL/PQL combines measures that isolate contaminated soil in place using capping and stabilizing the new riverbank soil surface to arrest erosion. Riverbank soils exceeding PTW thresholds will be dredged/excavated to a specific depth and graded and backfilled using clean soil and a cap or isolation layer.

The other areas outside the SMA where surface sediment COC concentrations exceeded CULs are depicted on Figure 5-2. Since these areas are outside the SMA and do not exceed RAL/PQL, they will be further evaluated as a part of the recontamination potential and erodibility evaluation for areas with CUL exceedances. Areas that exceed CULs that are potentially erodible or have recontamination potential will be remediated using ENR or MNR.

Riverbanks and areas outside the SMA also have design constraints related to working near and under shoreline structures or near outfalls and riverbank slopes. Section 5.3 discusses the approach to developing the preferred remedial approach where remedial technology assignments will require consideration of interactions between the remedy and the shoreline structures, outfalls, and riverbank slopes. Additional work to be completed as part of the Draft 50% RD that will inform RD decisions for riverbanks and areas outside the SMA is the evaluation of revegetation and/or other surface treatments to assist with the erosion control and habitat considerations in accordance with ROD Sections 14.2.5 and 14.2.9.5 (EPA, 2017).

5.3 WORK AROUND STRUCTURES AND GEOTECHNICAL CONSIDERATIONS

Remediating contaminated sediments near and under shoreline and overwater structures, near outfalls, or near potentially erosive riverbanks requires special consideration of the interactions between the RA, the structures and geotechnical considerations, and erosive areas.

Implementing RA near and under structures introduces risk that the remedy could damage or destabilize the structure either by loading the riverbed with the additional weight of a cap or by affecting the integrity of pilings through dredging of contaminated sediments. In locations where contaminated sediments are present near and under shoreline structures, approaches to remediate those sediments may include:

- Coordinating with property owners/operators to complete temporary shoring and/or stabilization measures designed to prevent damage during remedy implementation;
- Completing the remedy incrementally, working in a sequence of smaller areas;
- Implementing in situ treatment, such as placement of a thin sand layer and powdered activated carbon or GAC to limit bioavailability of contaminants; and
- Coordinating with property owners/operators regarding structure demolition (with or without replacement).

Structures present a set of additional considerations for RD. Functionality and mobility of individual structures is discussed in Section 6.2. Implementing a remedy while working around structures can be costly and risky, especially if the condition of the structure is already deteriorated and more susceptible to the kind of damage that could result from RA implementation. The condition of each shoreline structure was studied and documented in the PDI ER (HGL, 2024), and a dialogue was initiated with each shoreline structure owner/operator through a questionnaire/interview process to gather information about each structure. The selection of remedial technologies to be applied near and under shoreline structures requires a structure-by-structure assessment of the relative cost of working around the structure in place.

The next step entails dialogue with individual structure owners/operators to understand facility planning efforts and timing to coincide with the construction sequence for remedy implementation. Remedy considerations could include options such as cap placement beneath or around a structure with the obligation for subsequent removal of the contamination at the end of the life of the structure or construction of sheet pile walls for support in the areas where dredging may need to occur. Individual determinations for each structure will be presented in the Draft 50% RD.

In parallel to constraints imposed by shoreline structures, the geotechnical stability of the outfalls and riverbank slopes located adjacent to the waterway must be considered when selecting remedial technologies that could affect slope stability. The stability of outfalls and riverbank slopes may be compromised by dredging at the toe of slope or by adding loads to the existing slopes through cap material placement. The analysis of existing slope stability conditions is in progress, after which the evaluation of potential RA impacts to slope stability will be completed. RD development to address contaminated sediments near riverbank slopes will consider the following approaches:

- Applying a thinner, lighter weight cap along portions of slopes that are sensitive to increased loading conditions;
- Completing the remedy incrementally, working in a sequence of smaller areas; and
- Stabilizing the slope through slope modification or temporary or permanent shoring, prior to remedy implementation adjacent to the slope.

Bank slope stabilization may include the following methods:

- Load distribution, including
- flattening slopes and

- slope buttressing;
- Slope protection, including
- vegetation,
- erosion control mats,
- soil confinement systems,
- riprap, and
- slope paving;
- Earth retaining systems, including
- bulkhead walls,
- gravity walls,
- cantilever retaining walls,
- toe walls,
- soil nail or ground anchor walls, and
- prefabricated modular walls.[6]

Technology assignments will be selected for contaminated sediments adjacent to riverbank slopes after the analysis of geotechnical slope stability is complete. Section 5.2 discusses stabilization and remediation of riverbanks as a component of the RD. Note that the construction sequence and required stabilization and/or remediation of contaminated riverbank soils presents the opportunity to apply one or more of the approaches listed above.

Similarly, outfalls will also have to be specially considered on a case-by-case basis. The RD approach may involve use of coarser material as a stable material size or armoring layer. Smaller outfalls may be removed in coordination with outfall owners to accommodate dredging and capping when necessary.

The RD technology assignments to remediate riverbank soils must be developed in the RD in close coordination with the remedy for adjacent contaminated sediments. As noted above, the remedial technology assigned to sediments at the toe of riverbank slopes may be limited by the potential impacts of the remedy on geotechnical slope stability. Consideration must be given to designing the construction sequence so that riverbank soil remediation occurs before the remediation of adjacent contaminated sediments. The order of events is necessary to reduce the potential for recontamination of sediments and provides an opportunity to incorporate slope modifications and stabilization measures into riverbank remedies to mitigate potential slope stability impacts and

[6] Definitions:

1. Bulkhead Wall - soil retaining wall also a barrier against forces of waves to prevent soil erosion.
2. Gravity Wall - concrete wall relying on its own weight to retain soil.
3. Cantilever Retaining Wall - soil retaining wall using materials to resist soil pressure using a steel or concrete member.
4. Toe Wall - low retaining wall typically at the bottom of an embankment.
5. Soil Nail or Ground Anchor Walls - soil retaining walls that use steel tendons or bars in the retained soil for strengthening.
6. Prefabricated Modular Wall - an assembly of precast concrete sections to retain soil.

other geotechnical considerations resulting from sediment remediation at the toe of riverbank slopes.

5.4 ASSIGNED REMEDIAL TECHNOLOGIES

Table 5-1 and Figures 5-1 and 5-2 present the preferred remedial approach for the SMA (Figure 5-1), as well as riverbanks and areas outside of the SIB SMA (Figure 5-2). Remedial technologies assigned in this preferred remedial approach are dredging, capping, dredging and capping, ENR, and MNR. Special considerations are needed for erosive banks and work around structures in selecting the appropriate remedial technology. These special considerations will be further discussed in the Draft 50% RD.

As compared to technology assignments for the SIB SMA depicted in ROD Figure 31d and based on additional data collected during the PDI and subsequent refinement of the SMA, this preferred remedial approach contains additional dredging and capping in some areas of the SIB SMA that were assigned ENR/MNR in the ROD. As seen in Table 5-1 and Figure 5-3 below, the following is a percentage breakdown of remedial technologies for the SMA, which comprises 79 percent of the whole SIB Project Area:

- Special considerations for work around structures constitute about 27 percent,
- Special considerations for potential erosive banks constitute about 0.85 percent,
- Dredging to RAL will address about 7.4 percent, and
- Dredging and/or capping will address about 65 percent.

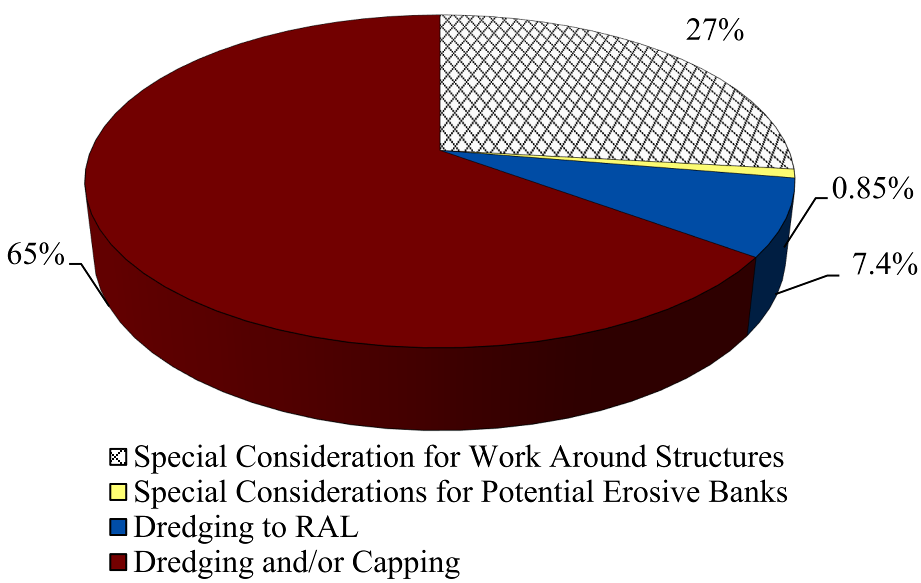


Figure 5-3. SMA Remedial Technology Assignment

As seen in Table 5-1 and Figure 5-4 below, the following is a percentage breakdown of remedial technologies for riverbanks, which comprises 10 percent of the whole SIB Project Area:

- Special considerations for work around structures constitute about 48 percent;
- Special considerations for potential erosive banks constitute about 39 percent;

- ENR/in situ treatment will address about 2.8 percent;
- MNR will address about 0.02 percent; and
- Bank stabilization, capping and/or dredging/excavation will address about 10 percent of the riverbanks.

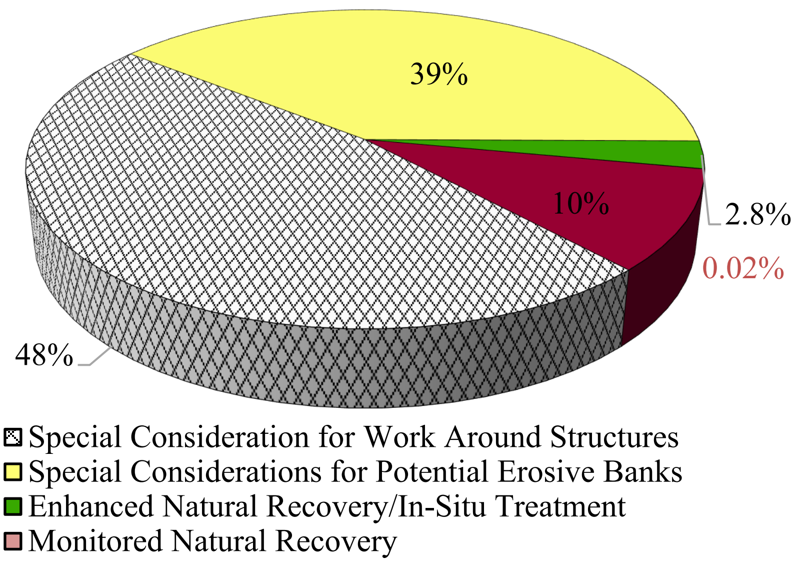


Figure 5-4. Remedial Technology Assignment - Riverbanks

As seen in Table 5-1 and Figure 5-5 below, the following is a percentage breakdown of remedial technologies for areas outside of SMA, but within SIB, which constitute 11 percent of the whole SIB Project Area:

- Special considerations for work around structures constitute about 59 percent,
- Special considerations for potential erosive banks constitute about 20 percent,
- ENR/in situ treatment will address about 18 percent,
- MNR will address about 2 percent, and
- Bank Stabilization, Capping, and/or Dredging/Excavation will address about 0.4 percent of the SIB Project Area outside of the SMA area.

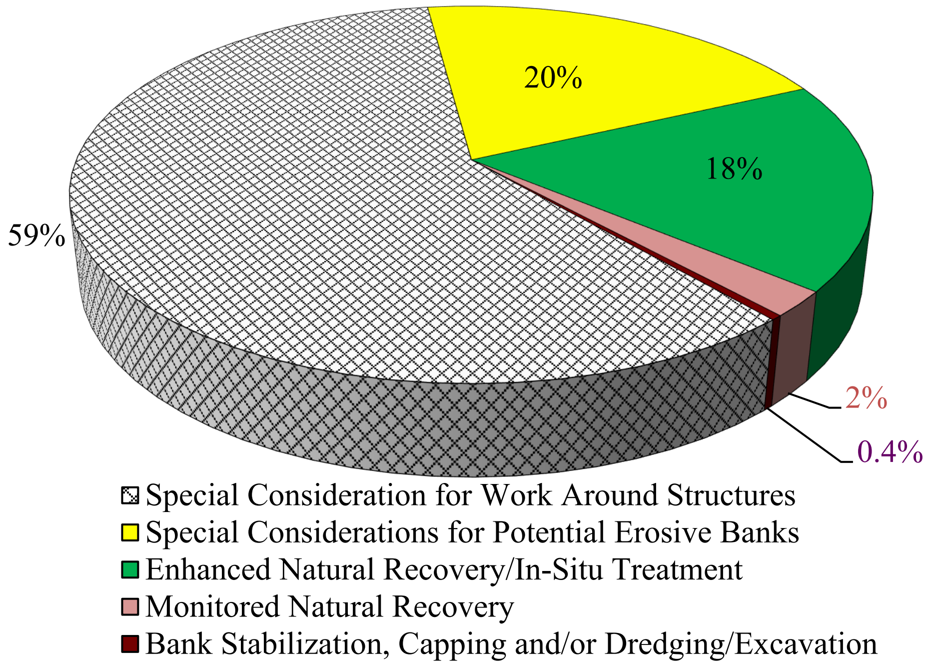


Figure 5-5. Remedial Technology Assignment – Outside of SMA Within SIB Project Area

As remedial technology is determined in the ongoing RD for areas with special considerations (work around structures and potential erosive banks), these assigned remedial technology percentage breakdowns will change. Moreover, a distinction will be made during area-specific RD between dredging, capping, dredging and capping, bank stabilization, and ENR/in situ treatment areas. Some areas in the SIB Project Area will be subject to ICs as described in Section 3.4.2 and applicable O&M requirements as discussed in Section 9.4. Additional considerations will be made for work around structures, outfalls erosive banks, and habitat considerations. The approach for developing conceptual level quantity and cost is discussed in Section 10.0. Specific determinations require additional analysis and will be presented in the Draft 50% RD.

6.0 REMEDIATION IMPLEMENTABILITY ASSESSMENT

The purpose of this implementability assessment is to identify and evaluate factors that will be important to consider for the timely, cost effective and successful conclusion of this remediation project. Implementability assessment factors identified and evaluated include:

- Constructability considerations (can the project be easily constructed);
- Structural impacts (remediation action construction impacts on existing shoreline and overwater structures);
- Other impacts (business interruption, conflicts with shoreline operators and community impacts); and
- Green remediation practices.

6.1 CONSTRUCTABILITY CONSIDERATIONS

This section considers the ease of construction of the assigned remedial technologies presented in Section 5.4. The Construction Industry Institute (CII) defines constructability as “the optimal use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives” (CII, 1986). The constructability considerations summarized are obstacles to be considered and, when feasible, addressed during RD to reduce or prevent errors, delays, cost overruns, and health and safety issues that may be incurred during the future RA construction phase. The SIB Project Area presents unique challenges that require special considerations for RD implementation, including the presence of larger structures, a more active waterway and berth use, steepness of riverbanks, and limited upland area access and security issues.

The purpose of this section is to provide an overview of primary constructability considerations that may exert a significant influence over the success of the project and need attention during the BODR phase so special considerations can be incorporated in the Draft 50% RD. In addition to these primary constructability considerations, additional considerations that may not necessarily be elements of design but should be understood and considered during the design will be discussed. This section provides a general overview of the different types of construction elements involved in the RA based on the preferred remedial approach presented in Section 5.0, and provides insight into the activities, constraints, and risks that must be addressed prior to RA implementation. Greater details regarding material volumes, construction plans and schedules, and material types (sources and handling) will be developed in the Draft 50% RD.

Construction activities on land and in water need careful consideration of access, impacts to current and ongoing activities, and the timing of when work can be completed safely and efficiently. For example, the timing of in-water construction activities presents an important limitation, as in-water work windows within the PHSS are relatively short (typically 4 months in summer, and 2 months in winter below -20 feet National Geodetic Vertical Datum of 1929. The logistical issues associated with in-water work timing exacerbate other factors that contribute to constructability challenges.

6.1.1 Technology Assignment Considerations

The following technology assignment constructability considerations will be made during development of the Draft 50% RD:

- Quantity and size of debris to be removed (surface debris, subsurface debris, remnant piles). Surface and subsurface debris as well as remnant piles will impact the ability to perform dredging and place capping effectively. The presence of debris (Section 2.6.5) and remnant piles left in place could hinder cap performance. Debris and remnant piles will be removed wherever possible.
- Dredging and capping around structures. Access limitations may pose challenges to traditional dredging methods and capping methods. Alternative remedial technology assignments, cap thicknesses, and placement verification methods may be required.
- Potential cable crossings or other utilities. These obstructions will be identified (Section 2.6.7), and adaptation of remedial technology in those areas will be required.
- Lease requirements. Owners/operators may have leases or licenses with DSL that may have requirements related to structure repair/removal upon lease renewal or termination. These leases and licenses, and other uses that do not require a lease or license, need to be well understood as they may impact RD, especially for work around structure areas and RA. Best efforts will be made during the RD to inquire and understand the lease, license, and other requirements as they pertain to structures and RD, including conferring with DSL, lessees, and other users.
- Impact of vessel traffic and facility operations. Existing vessel traffic (Section 6.3) will likely affect the timing and sequencing of RA. Coordination with stakeholders is critical (Sections 2.6.8 and 6.3.3).
- Impacts on existing structures. Additional action to prevent structural stability impacts when working around structures is likely to be required on a structure-specific basis.
- Bearing capacity, liquefaction susceptibility, settlement, and grain size compatibility of near surface sediments (Sections 3.1.2 to 3.1.5 of Appendix A). Placement of cap material on existing sediments requires evaluation of underlying material competence.
- Slope stability for capping materials and underlying sediment (Section 3.1.6 of Appendix A). Static and seismic geotechnical stability of submerged slopes and riverbanks requires site-specific analysis during RD. Stabilization methods may include slope adjustment, ground improvements, toe support, or other.
- Natural and anthropogenic hydrodynamic forces for erosion protection (Section 3.2 of Appendix A). Long-term stability of erosion protection above capping materials must consider a complete range of present and future forces under climate change conditions.
- Habitat considerations. Inclusion of beneficial surface treatment in certain elevation zones may affect stability of slopes and resistance to erosion, which will be analyzed during RD.

6.1.2 Construction Activity Considerations

This section provides an overview of the materials, equipment, and activity considerations that will likely be required to implement the RD at the SIB Project Area. Greater details of construction activities that are part of the preferred remedial approach are presented in other sections of this BODR and are listed here to provide an overview of constructability considerations associated with the activity.

6.1.2.1 Construction Materials

Additional details regarding the capping materials are provided in Appendix A and Section 5. In general, the RA will include the following materials:

- Chemical isolation layer for cap – sand and GAC;
- EPL for cap – gravel armor and/or articulating concrete mats;
- ENR – sand layer material;[7]
- Slope stabilization – structures, geotextile/geogrid products, riprap, bioengineering materials, materials for earth retaining systems and slope protection, or similar;
- Habitat – suitable sand/gravel/cobble materials, woody material, native planting or similar; and
- Sediment dewatering agents may be included and would be sourced based on costs and usability for the potential volume of wet sediment to be transported.

Plan(s) for obtaining construction and source materials and types will be determined once the RD is finalized.

A short work window places stress on available materials from vendors who will likely be supplying other remediation projects in the area that are being constructed within the same time period. The availability of capping materials is described here because it may influence the RD, and as such deserves consideration early in the RD process. Materials in high demand may include sand, GAC, gravel, and larger stone. To mitigate some of those risks, acquiring materials early and outside of potential seasonal price increases should be considered. This could include negotiating a preferred pricing structure or considering an early downpayment for securing minimum volumes of material.

There are typically long lead times for obtaining large volumes of materials for a project of this scope. Materials could be acquired directly from the supplier or suppliers, perhaps through a separate procurement process. The suppliers could potentially be charged with generating, storing, and maintaining materials for contractor use at appropriate times during construction. Stockpiling materials near SIB is not feasible due to the lack of available land for storage of such high volumes of material.

[7] Construction materials such as sand, GAC, and general fill will be tested for ROD Table 17 COCs. Only material without CUL exceedances will be used as a construction material.

6.1.2.2 Construction Equipment

This section summarizes the construction equipment that will be used to implement the RA based on the preferred remedial approach, including debris removal, dredging, capping, demolition, bank stabilization, rehabilitation or reconstruction of shoreline and overwater structures, and transloading of sediment. Similar equipment may be used for different activities; however, handling will vary depending on the materials involved (noncontaminated versus contaminated).

Constructability constraints to be considered for construction equipment are primarily related to the availability of specialized equipment, particularly for working under and near structures. Non-specialized equipment to support the RA is generally readily available. Additional constraints to be considered are associated with maneuverability of equipment in tight spaces, in particular where other non-RA activities are occurring. These constraints are discussed in more detail in Sections 6.2 and 6.3.

Although construction equipment selection will be a procurement consideration, rather than a design consideration, potential equipment issues will be considered in the Draft 50% RD. Table 6-1 presents a summary of equipment to be considered, separated by RA activity.

Table 6-1. Remedial Action Construction Equipment by Activity

Activity	Equipment
Dredging Removal of sediments and debris during dredging activities.	• Environmental bucket • Excavator or similar • Barges for dredged material and excess water • Environmental controls (turbidity/air curtains) • Survey vessels • Tugs for barge movements • Crew boat(s) for moving personnel to/from on water operations and inspection/maintenance of environmental controls
Capping or ENR Installation of cap or ENR components.	• Telescoping boom excavator or long-reach excavator • Environmental bucket • Specialized equipment for placing caps under structures (i.e., telebelt) • Material barges • Environmental controls (turbidity/air curtains) • Tugs for barge movements • Crew boat(s) for moving personnel to/from on water operations and inspection/maintenance of environmental controls
Riverbank Remediation, restoration, and/or bank stabilization.	• Environmental bucket for lower-elevation areas, or excavator • Backhoes • Barges • Dump trucks • Tugs for barge movements • Crew boat(s) for moving personnel to/from on water operations and inspection/maintenance of environmental controls

Table 6-1. Remedial Action Construction Equipment by Activity (continued)

Activity	Equipment
Contaminated Material Handling Appropriately documented and permitted removal and transport for disposal at a designated landfill.	• Environmental bucket • Excavator or similar • Barges for dredged material and excess water • Tugs for barge movements • Crew boat(s) for moving personnel to/from on water operations • Haul trucks
Work Around Structures Stabilization, relocation (of temporary structures), demolition, rehabilitation, and/or reconstruction where needed to implement RA.	• Cranes • Excavators • Backhoes • Barges • Dump trucks • Pile Driving Rigs • Tugs for barge movements • Crew boat(s) for moving personnel to/from on water operations and inspection/maintenance of environmental controls • Scissor Lifts • Scaffolding

6.1.2.3 Logistics and Constraints

This section describes the key logistical constraints imposed by SIB Project Area site conditions. The key logistical components and potential mitigation measures are as follows:

- The typical dredge plan footprint, discussed in Section 6.3, comprises a construction operations footprint/grid cell of 310 ft by 175 ft, which presents a constraint associated with the active waterway in which dredging will be occurring. Generally, mitigation measures for this constraint include:
  - Optimization for clearance of navigation lanes while allowing dredging and capping activities to proceed; and
  - Timing of construction to minimize construction traffic conflicts with in-water and shoreline operations (Section 6.3).
- There are marine traffic control constraints within SIB, as it is an active waterway, and also within the Federal Navigation Channel, outside the SIB. Generally, mitigation measures for addressing marine traffic control include:
  - Early and frequent coordination with shoreline owners/operators (Section 6.2);
  - Coordination with USCG and ensuring accurate and up to date information is provided for Notices to Mariners;
  - Management of conflicts with maneuverability of vessels (Section, 6.3); and
  - Coordination with Oregon DSL, as Oregon DSL manages the state-owned submerged and submersible lands within the SIB Project Area (Section 2.1.2), and has certain closure authorities that may be applicable.

sites are required to offload sediment from barges, perform additional drying of dredged sediments, and treat decanted water. This constraint has the significant potential to impact dredging production and ultimately, the overall duration of RA activities. Generally, mitigation measures for addressing transload site bottlenecks include:

- o Using several transload facilities or expanding existing transload facility processing capacity; and
- o Coordinating transload and disposal facilities' capacity relative to the multiple PHSS RAs occurring concurrently.

- There are 23 shoreline and overwater structures (21 actively in use), and 10 property owners/operators in the footprint where some RA activity will occur. Potential impacts and mitigation measures are described in Section 6.2. Additional constraints to be considered include in-water uses in areas where current owners/operators hold a DSL lease or license to use state-owned submerged or submersible land that does not require a lease or license from Oregon DSL, and uses of submerged or submersible land not owned by the State, each of which will require additional coordination.
- Existing utilities both in-water and within the riverbanks present a significant constraint for dredging/excavation activities. Potential impacts and mitigation measures are described in Section 2.6.7.
- In-water debris presents a significant constraint for dredging activities. Potential impacts and mitigation measures are described in Section 4.2 and Appendix B.

6.1.2.4 Dredging Productivity

This section describes dredging productivity. Total "active" construction time described here is based only on dredging throughput at this time, and hence likely represents an underestimate. Table 6-2 estimates the production rate of dredging activities that could be achieved based on the available working days in the work window (118 days) and a range of equipment plants (1 to 3 independent groups of working equipment),[8] assuming a nominal production rate of 2,000 CY/day for a typical equipment plant. Note, this does not represent proposed dredge volumes or production rates for implementing the RA.

Table 6-2. Estimated Dredging Production Rate

Equipment Plants	Production Rate (CY/day)	Working Days[1]	Total Dredged (CY)
1	2,000	118	236,000
2	4,000	118	472,000
3	6,000	118	708,000

Notes:
[1] Based on one full summer work window and would likely include work during the winter work window.

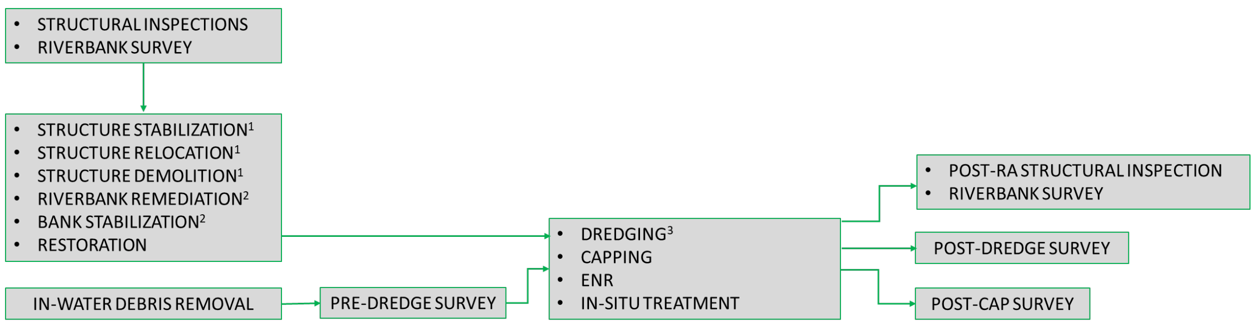
Total dredging volumes will be determined during RD. Overall dredging and disposal productivity may be constrained by the barge offloading process near landfill(s). Other productivity rates, such as capping and transload productivity, will be analyzed and presented in the Draft 50% RD.

[8] See Section 6.3.1.2 for further description of equipment.

6.1.2.5 Sequencing of Remedial Action

This section presents the interrelationships between RA activities in terms of constructability and considers any necessary marine structure demolition, stabilization/repair, or replacement.

Sequencing of active construction during RA will be completed based on available work windows and in phases that would minimize recontamination and maximize efficiency. From a constructability perspective, the key sequencing consideration is ensuring that the work is scheduled in a way that considers what activities must be done as predecessors to subsequent activities, what activities can be accomplished concurrently, and what activities must be done as successors to completed activities. Figure 6-1 presents an overview of RA activity dependencies that will be considered in terms of constructability sequencing.



1. If necessary.
2. Where required.
3. Beginning at head of basin working towards dredging extent in SIB Project Area.

Figure 6-1. RA Activity Dependencies

6.1.3 Construction Risks

The risks in construction caused by both internal and external sources can be summarized as equipment and materials risks, logistical risks, delay/cost risks, and environmental impact risks. All of these generalized risks would not only impact the costs of construction activities, but they could also impact the schedule and stakeholder relationships. The following subsections provide an outline to help identify and mitigate those risks for this project.

6.1.3.1 Risks Associated with Construction Equipment and Material Procurement

Risks associated with construction equipment and material procurement include equipment availability, timely material procurement, and loads on existing structures associated with the use of equipment for top-side work. Risks are discussed below.

6.1.3.1.1 Equipment Availability

Determination of overall equipment availability is a risk that will be addressed during the competitive bidding process and planning stages. Equipment availability will include coordination of equipment availability based on other PHSS areas. Additionally, a contractor industry survey will be completed to understand the local availability of equipment, including barges, dredging excavators, cranes, etc.

6.1.3.1.2 Timely Material Procurement

The risks associated with material procurement have been highlighted as a primary constructability consideration; however, material availability could be more limited during the construction windows for in-water activities. To mitigate material availability risks during high-demand periods, the following will be considered for the Draft 50% RD:

- Stockpile program with supplier(s),
- Regular communication with quarries and suppliers,
- Regular communication with other ongoing local projects, and
- Encouragement/involvement in supply chain enhancement.

6.1.3.1.3 Loads on Existing Structures

The loads on existing structures for top-side work could present additional risks. To identify and mitigate those risks, the following will be conducted:

- Assessment of structure load ratings for potential top-side work on structures and banks;
- Determination whether there is upland space availability for top-side work; and
- Assessment of potential upland modifications and site access for equipment movement, stockpiling, and staff.

6.1.3.2 Mitigating Risks Associated with Construction Logistics and Constraints

Multiple plans will be developed and implemented to monitor the RA in the field to evaluate if the work is being conducted safely and in accordance with the design plans. These plans will minimize risks during construction and facilitate prompt responses should certain risk triggers occur. Plans would be prepared as directed by the RA performing party by various entities including the construction management contractor and/or a program manager or individuals performing the element of the work the plan addresses under the direction of a management contractor. The plans are pre-construction submittals which will be reviewed and approved by EPA and other applicable state/local agencies in accordance with the EPA-approved RA schedule. Plans will include, but are not limited to, the following:

- RA WP
- Site Clearing and Management Plan
- Vessel Management Plan
- Health And Safety Plan
- Water Management Plan
- Structure Preservation and/or Demolition Plan
- Emergency Response Plan
- Stormwater Pollution Prevention Plan
- Dredging and Capping Plan
- Equipment and Personnel Decontamination Plan
- Spill Prevention, Control, and Countermeasure Plan
- Air Pollution and Odors Control Plan
- Construction QCP

- Water Quality Protection Plan
- Light Control Plan
- Temporary Facilities and Control Plan
- Erosion and Sediment Control Plan
- Noise Control Plan
- Instrumentation And Monitoring Plan
- Material Placement Plan
- Survey Control Plan

The following ICs are anticipated for the project to help mitigate construction activity risks:

- Signage,
- No anchoring,
- USCG registration, and
- Look-out boat for non-recreational vessels (small watercraft to intercept any vessel approaching the work zone).[9]

It is important to implement ICs so SIB is closed to recreational traffic during construction. This action would assist in the potential reduction of unplanned interactions, but it would also serve to mitigate potential recontamination from prop wash and damage to interim caps from anchoring.

6.1.3.3 Construction Schedule and Cost

The potential risks identified in Section 6.1.3.1 could severely impact the start or even the progress of the construction phase to such a degree that the work becomes significantly more costly and time consuming. Many of the risks associated with delays and cost overruns can be identified and mitigated during the pre-construction phase or even during RA implementation without having an impact that results in the cessation of the project.

Potential delays/cost overruns and possible mitigation measures include:

- Contractor access delays (legal challenges or operational issues)
  - Coordinate and establish a legal process for obtaining site access with owners/operators; and
  - Include temporary mooring/anchoring and access needs in the RD.
- Facility downtime (owners insist on operating)
  - Develop a sequence of work in coordination with operators;
  - Develop a sequence of work that minimizes the risk of recontamination of the cleaned area; and
  - Develop enumerated percentage of downtime to be allowed during specific conditions (weather events) to be included in the specification for bidding.

[9] Area will be closed to recreation.

- Delayed cleanup acceptance
    - Coordinate regular in-field and remote meetings with agencies and develop a cloud-based dashboard providing near real-time information for agencies to access to see how the project is progressing.
- Insurance claims
    - Present detailed insurance policy requirements to protect structure owners;
    - Use pre-construction structural survey to document pre-RA conditions and post-construction survey to document post-RA conditions; and
    - Develop Instrumentation Monitoring Plan as a pre-construction submittal.
- Delays triggered by monitoring results
    - Manage turbidity;
    - Monitor contractor performance against the established requirements of EPA's monitoring plan and implement corrective actions expediently; and
    - Timely reporting of monitoring results for acceptance by EPA.
- Delays triggered by potential rejection of material by disposal facilities upon arrival
    - Develop clear understanding of each site's requirements; and
    - Minimize characterization and analysis during construction by getting in situ sampling and analysis results approved.

6.1.3.4 Environmental Impacts Risks

Management and third-party monitoring of the RA will be critical to not only the schedule and project objectives, but also to identify and mitigate any environmental impacts. Construction controls and BMPs, including turbidity control, as well as sediment handling, transport, and disposal, will be developed for the Draft 50% RD. Construction controls and BMPs will specifically identify potential environmental impacts and mitigations to be employed to minimize the risk. Environmental impact risks and potential mitigation measures for each include the following:

- Downstream transport of contaminated sediment from SIB. Mitigations include:
    - Sequence construction activities to minimize recontamination;
    - Monitor for compliance with BMPs (bucket types, turbidity containment) while performing in-water work as well as during transport of hazardous materials for disposal;
    - Conduct monitoring of weather and river conditions, and forecasting of hydrodynamics, to assist in control of vessels and limiting releases;
    - Consider implementing time restrictions on when work can be done (barge loading/unloading at night);

  - Develop transportation safety plans that address barge stability, tug procedures, and response to spills;
  - Use sealed and/or covered barges to prevent contaminated sediment loss during transport; and
  - Conduct daily checks for and awareness of navigational risks on route to the barge off-load site.
- Uncontrolled releases at each material transfer point along the transportation, processing, and disposal. Mitigations include:
  - Comply with BMPs;
  - Use of sealed and/or covered barges and haul trucks that are lined; and
  - Implement daily inspections of all transport equipment and liners.
- Short-term impact posed to the environment. Mitigations include:
  - Monitor for compliance with federal, state, and local air quality regulations;
  - Monitor noise/light/air quality exceedances;
  - Monitor noise levels to ensure construction activities are being conducted in accordance with the plan; and
  - Monitor construction activities to ensure adherence to work hours/light pollution standards specified in the plan and, where impractical, implement BMPs established in the plan (using light shrouds/barriers).

6.1.4 Bidding and Procurement Considerations

The RA performing party or parties have not yet been identified for the SIB Project Area. Once they are identified, plans and specifications will be developed to conform with the RA performing party's or parties' standards. Specifications may need to be revised to reflect the preferred procurement approach used by the RA performing party or parties.

In seeking a competitive bid, the RA performing party or parties will consider numerous factors to determine the most advantageous balance of price, quality, experience, service, performance, schedule, and other elements to achieve the best value for a project. A short window for in-water construction work discussed in the previous section can limit how many competitive bids are received. Expertise and experience that are both available to work within short windows and located near the site are typically in high demand. Therefore, short construction windows can pose a potentially high risk to competitive bidding.

Important bidding and procurement considerations should be developed following RD, including whether to pursue an all-inclusive bid (in-water work, transportation and disposal, material purchases for capping) or whether multiple bids are advertised for distinct work items. When multiple bids are advertised, a construction management procurement should be made for a third-party quality assurance/quality control team. The RA performing party(ies) may have their own contractor selection criteria, including but not limited to experience, bonding, and insurance requirements. Initial scoping of candidates should include desktop identification, and meetings/discussions regarding interest, qualifications, experience, insurance and bonding ability, equipment, and potential subcontractors.

To qualify for a project and meet the short work window while incorporating the best experience and expertise, bidders may use a consortium approach. For example, a local contractor may perform dredging work under the management of an experienced out-of-state remediation contractor.

Typically, the RA performing party would assess the competitive bidding field during RD. It could form or engage a separate entity to coordinate individual bids. This entity could operate independently but in coordination with a construction management contractor and/or a program manager.

6.2 STRUCTURAL IMPACTS

This section summarizes potential RA construction impacts on existing shoreline and overwater structures based on the information collected on the shoreline and overwater structures, documented in the PDI ER (HGL, 2024), and the constraints associated with structures, in terms of ROD Figure 28. The first objective of this section is to determine structure functionality. The second objective of this section is to outline risks and potential impacts to the shoreline and overwater structures that could result from RA construction based on the remedial technologies described in the preferred remedial approach (Section 5.0), which will be further refined by specific areas in the Draft 50% RD.

Information presented herein will be used to refine remedial technology assignments to minimize the impacts of RA construction on the use of SIB Project Area facilities. Depending on the remedial technologies implemented at each structure, either additional riverbank stabilization measures will be implemented or strengthening of the existing structure will be designed to accommodate RA construction.

6.2.1 Shoreline And Overwater Structures

There are 23 shoreline and/or overwater structures currently located in the SIB Project Area (Figure 6-2). Two structures are not currently in use (U.S. Navy Pier and Berth 308). A summary of each structure, along with the owners/operators, operational status, and use is discussed in Sections 2.6.1, 2.6.2. and presented in Table 2-2. Information regarding the composition of each structure (timber, concrete), operational periods, and other details is presented in the Structure Condition Assessment Report (Appendix G of PDI ER [HGL, 2024]).

The following subsections discuss the constraints associated with the structures in terms of risk drivers of potential RA construction impacts on structures. These risks were evaluated by considering the age, current use, and condition of structures and remaining estimated service life as well as slope stability around each structure.

6.2.1.1 Structure Condition, Age, and Estimated Service Life

Additional details of shoreline and overwater structure conditions are provided in the Structure Condition Assessment Report (Appendix G of PDI ER [HGL, 2024]). The condition and age of the structures and estimated service life are summarized in Table 6-3.

Service life is defined as the length of time a structure is expected to remain in operation with inspection and maintenance but without rehabilitation or renewal work. The basis for service life estimation used information from two national standards and one international standard:

- Bridge Preservation Guide published by the U.S. Department of Transportation Federal Highway Administration (FHWA) (FHWA, 2018);
- American Society of Civil Engineer (ASCE) Manuals and Reports on Engineering Practice No. 130 (MOP 130) – Waterfront Facilities Inspection and Assessment (ASCE, 2015); and
- Life Cycle Management of Port Structures (Report No. 103) published by the World Association for Waterborne Transport Infrastructure (PIANC) (Colenbrander et. al, 2008).

Service life is highly dependent on materials used and the environmental conditions a structure is subjected to on a daily and seasonal basis throughout years of operation. The estimate of remaining service life is frequently based on the assessing engineer's experience and judgment. Service life estimation for SIB Project Area structures was established using the standards listed above to develop relationship curves between age and estimated service life without rehabilitation or renewal. The estimated remaining service life of each existing structure in the SIB Project Area is provided in Table 6-3. This estimated remaining service life assumes no rehabilitation or renewal of the structure; however, the service life of structures can often be extended to 50 years or greater by implementing rehabilitation measures and a regular inspection and maintenance program. The service life evaluation was completed on structures as they were during the shoreline and overwater structure inspections, reported in the Structure Condition Assessment Report (Appendix G of PDI ER [HGL, 2024]) and does not account for repairs or rehabilitation that may have been completed since that time or that may be completed prior to commencing RA construction.

The capacities of concrete, steel, and timber piling were computed both in their existing condition (as informed by the evaluation activities reported in the PDI ER [HGL, 2024]) for each structure as well as in their original condition (as informed by as-built documentation where available). In general, the existing condition of piling for each structure ranges from undamaged (100 percent capacity) to serious condition (10 percent of remaining capacity). Further evaluation of a structure's existing strength will be completed for the Draft 50% RD.

The age of the SIB shoreline and overwater structures is known for 21 structures, and ranges from 22 years old (Wind Tunnel) to 74 years old (Lagoon Wharf – Berths 302 to 305). The age of two structures is unknown. For structures with known age, 15 are greater than 50 years old, and 6 are less than 50 years old. Section 5.1.1 of the RDGC states that structures require review by the Oregon SHPO if they are at least 50 years old with no major alterations to key features (EPA, 2021b). Therefore, at least 15 structures in the SIB Project Area will require consultation with SHPO, if the RD includes the removal or modification of a structure.

6.2.1.2 Functional Structures Determination

RDGC Section 3.3, Technology Assignment Application Flexibility, defines functional structures as, *"those structures that are currently in operation or are being used to stabilize the riverbank and expected to have a service life of greater than 50 years"* (EPA, 2021b). Further, Section 14.2.9.2 of the ROD (EPA, 2017) states, *"Structures may be removed to access contaminated media unless it can be demonstrated that the structure is permanent (e.g., not floating or movable), functional (e.g., not beyond its design life and/or in disrepair) or needed for current or future property and waterway use."*

This functional structure assessment considered the following questions:

- Does, or is, the structure:
    - Used to stabilize the riverbank?
    - Permanent/immovable (not floating or movable)?
    - Functional (not beyond its design life and/or in disrepair)?
    - Needed for current or future property and waterway use?
    - Currently in operation?
    - Have a remaining service life greater than 50 years?

Answering 'Yes' to any of these questions means the Draft 50% RD must consider the presence of a structure where one exists. Each of the 23 structures evaluated in the SIB Project Area answers 'Yes' to one of the questions and thus are considered functional (EPA, 2017). As such, using the site-specific ROD Figure 28, as described in the preferred remedial approach (Section 5.0), if a structure is present, functional, and permanent, the remedial technology to be applied should be either capping or dredging and capping. Additional technologies applied will include ENR, MNR, and in situ treatment.

6.2.1.3 Geotechnical Considerations

Geotechnical considerations are included in the analysis of the existing shoreline and overwater structures to address how the RA construction may exacerbate the existing structure condition. The geotechnical engineering analysis to assess existing riverbank slope stability was evaluated by 2-D limit-equilibrium analysis. The analysis methodology included:

- Static analysis based on a minimum factor of safety of 1.5;
- Pseudo-static (non-liquefied) analysis based on a minimum factor of safety of 1.0;
- A comparison of 2-D limit-equilibrium analysis results against infinite slope chart solutions for general agreement; and
- Preliminary seismic analysis based on a contingency level earthquake (CLE) or return period of 10 percent in 50 years (475 years), sourced from the USGS 2018 Conterminous U.S. National Seismic Hazard Model (Rukstales and Petersen, 2019). A PGA of 0.234 g

and a horizontal seismic coefficient of 0.12 (0.5 x PGA) were used in this screening level analysis.[10]

The riverbank stability analysis indicated that minimum static factors of safety against deep-seated failure were typically below 1.5 and minimum seismic pseudo-static CLE factors of safety against deep-seated failure were typically below 1.0. The riverbank slope stability analysis concluded that riverbank slopes are in general marginally stable as currently configured (Figure 6-3). Additionally, if left as currently configured, riverbank slope failures should be anticipated during a CLE. Riverbank slopes will require careful consideration during the RD. Detailed geotechnical analyses to assess riverbank slope stability will be performed as part of the Draft 50% RD. Those detailed geotechnical analyses will be used to determine the need for and design of countermeasures or mitigation measures during RA implementation to address geotechnical hazards. Examples of such countermeasures are temporary shoring, temporary or permanent slope stabilization measures, limiting the size and shape of active work areas for technology assignments, and customizing technology assignment designs within geotechnically sensitive zones. Section 6.2.2.1 includes a discussion of additional countermeasures that could be applied during RA construction to mitigate geotechnical hazards.

6.2.2 Potential Remedial Action Construction Impacts

The following subsections discuss risks of potential RA construction impacts on the shoreline and overwater structures based on the general technology assignments outlined in the preferred remedial approach. Both the preferred remedial approach and the risk analysis will be further refined for the Draft 50% RD and will describe potential impacts on a structure-by-structure basis.

6.2.2.1 Remedial Action Construction Risks and Mitigation Measures

Remedial technology assignments, such as capping or dredging may present risks to structures as well as risks to the stability of riverbank slopes as compared to the existing (pre-remediation) conditions. To better understand the potential impact of RA construction on both slopes and structures, existing critical slope configurations, where the potential RA construction impact may be significant, were identified and engineering analyses were performed to assess the stability of existing riverbank slope configurations. Engineering analyses included static slope stability analysis and pseudo-static slope stability analysis (seismic), as described in Section 6.2.1.2.

The following summarizes the risks of potential RA construction impacts on shoreline and overwater structures (mitigation of these risks is presented below):

- Dredging: loss of sediment near and around piles resulting in loss of pile capacity and/or uneven soil loading on piles;
- Capping: vertical and lateral loading and down drag on piling, additional loading on slopes;
- ENR: similar to capping with sand layer and/or in situ mixing treatment will add loading or cause instability;

[10] Simplified seismic analysis studies were based on preliminary numbers as shown below in this bullet. A site-specific seismic analysis has not been performed for any specific structure or area within the project at this stage.

- Riverbank slope instability: slope failures due to dredge cuts; and
- Seismic considerations: few, if any, of the structures are likely to perform well during a large seismic event.

Each structure has been categorized from low risk to high risk (Table 6-4). The low-risk structures are ones where the slope and/or structure are likely able to support RA construction with minimal or no modifications. The high-risk structures are those that will not be able to withstand RA construction without modifications to the slope and/or structure. Medium-risk structures fall somewhere in between with required modifications to be determined during RD. Each structure is unique in structure type and location, and the appropriate remedial technology assignment will be determined in the Draft 50% RD.

The RD will evaluate short-term (during RA construction) and long-term (following RA construction) risks to structures that could result from RA implementation and identify measures that should be implemented to mitigate the risks. Mitigation measures to be further evaluated for the Draft 50% RD may include:

- Load reduction on the structure;
- Structural reinforcement or rehabilitation;
- Specialized construction techniques including hand work around structures and foundations, as well as sequenced dredging and capping;
- Ground improvements; and
- Slope Stabilization.

6.2.2.2 Potential Remedial Action Construction Impacts to Shoreline and Overwater Structures

The preferred remedial approach includes areas within the SMA (Figure 5-1) and riverbanks and areas outside of SMA (Figure 5-2). Remedial technology assignments that may be used include capping and/or dredging, ENR, and MNR, and other considerations including backfilling to grade and potential in situ treatment. The primary technologies assessed to complete the evaluation of RA construction impacts to shoreline and overwater structures were capping, dredging, and capping beneath and behind structures, and dredging or possible capping in front of the structures.

The following subsections present potential impacts on shoreline and overwater structures that could result from possible technology applications during the RA construction, both during and after (long-term) construction. The subsections are organized moving clockwise from the USCG facility (Figure 6-4). In each of the cross-section figures associated with the structures, river and riverbank elevations are indicated and the navigation depth is denoted by a green line. At each structure, the adjacent riverbank and foundation soils may be only marginally stable as currently configured. Removing material from the toe or surrounding area of existing slopes, or adding material along or above existing slopes may negatively impact the stability of both the slope and the associated structures. To screen for impacts to riverbank stability, imaginary lines with slopes of 2H:1V and 5H:1V are shown on each figure, starting from the top of the highest-level land area, projecting down into the water. These lines define risk zones and should not be confused with potential failure planes. The risk zones indicate boundaries between critical/caution and caution/low-risk dredge zones, where work in the critical zone will nearly always require slope reinforcement to protect existing facilities from damage, work in the caution zone may cause unstable conditions and should be carefully evaluated, and work in the low-risk zone can usually be performed without slope reinforcement (Palermo et al., 2008). Using the information presented in the following subsections, potential dredging in front of the riverward piles of structures and the stability of slopes to handle dredging operations would need to be evaluated. Additionally, any capping beneath a structure would need to be evaluated to ensure additional loads on the structure and slope are acceptable.

6.2.2.2.1 U.S. Coast Guard Pier

The USCG Pier is located on the Mocks Bottom side of SIB (Figure 6-4), where the mouth of the basin transitions to the interior. A cross-section of the USCG Pier is illustrated in Figure 6-5. The USCG Pier extends overwater and is currently in use as a fixed pier boat dock for small vessel deployment (Table 2-2). The structure was built in 1974 and is 50 years old. It currently has an estimated remaining service life of 30 to 40 years. The structure condition is fair (Table 6-3). The USCG Pier is positioned over a bank with slopes ranging from 2H:1V to nearly flat (Figure 6-5), indicating slopes in the caution zone. The slope under the USCG Pier is armored with rip rap. The potential impact of the RA construction on USCG Pier is considered medium because the existing slope falls within the caution zone. (Table 6-4). The impact to the structure by the chosen RA will need to be considered during design.

6.2.2.2.2 U.S. Coast Guard Dock

The USCG Dock is located on the Mocks Bottom side of SIB (Figure 6-4), adjacent to the USCG Pier, and extending overwater (Figure 6-4). A cross-section of the USCG Dock is illustrated in Figure 6-6. The USCG Dock is in use as a floating dock for small vessel deployment (Table 2-2). The structure was built in 1974 and is 50 years old. The estimated remaining service life is 30 to 40 years. The structure condition is fair (Table 6-3). The USCG Dock is positioned over a bank with slopes ranging from 2H:1V to nearly flat (Figure 6-6), indicating slopes in the caution zone and armored with rip rap. The potential impact of the RA construction on USCG Dock is low although it would be impacted by added loads on the structure (due to remedial technology assignment) (Table 6-4).

6.2.2.2.3 U.S. Navy Pier

The U.S. Navy Pier is located on the Mocks Bottom side of SIB and extends overwater (Figure 6-4). A cross-section of the U.S. Navy Pier is illustrated in Figure 6-7. The U.S. Navy Pier is not currently in use (Table 2-2) and the U.S. Navy has indicated that it is currently evaluating its pier for potential removal, although no timeline for this investigation or removal has been identified. The structure was built in 1973 and is 51 years old. The estimated remaining service life is 30 to 40 years. The structure condition is fair (Table 6-3). The U.S. Navy Pier is positioned over a bank with slopes ranging from 1.25H:1V to 6H:1V (Figure 6-7), indicating slopes ranging from a critical zone near the top of the bank, a low-risk zone near the toe of the bank, and a caution zone between these two areas. The bank slope is armored with rip rap. As reported in PDI ER, the U.S. Navy is investigating structural removal for U.S. Navy Pier, but has no timeline or funding at present (PDI ER, Appendix K, Table 3-2 [HGL, 2024]). If not removed, the potential impact of the RA construction on the U.S. Navy Pier is medium due to added loads on the structure (due to remedial technology applied) (Table 6-4).

6.2.2.2.4 The Marine Consortium, Inc. Pier

The MC Pier is located on the Mocks Bottom side of SIB and extends overwater (Figure 6-4). A cross-section of the MC Pier is illustrated in Figure 6-8. The MC Pier is in use as a fixed pier for small vessel emergency response deployment (Table 2-2). It is unknown when the structure was built, and the estimated remaining service life is 30 to 40 years. The structure condition is fair (Table 6-3). The MC Pier is positioned over the bank with slopes ranging from 1H:1V to 4H:1V (Figure 6-8). Slopes are in the caution zone. The bank slope is armored with rip rap. The potential impact of the RA construction on the MC Pier is medium (Table 6-4).

6.2.2.2.5 Dredge Base

The Dredge Base is located on the Mocks Bottom side of SIB and extends overwater (Figure 6-4). A cross-section of the Dredge Base is illustrated in Figure 6-9. The Dredge Base is in use as an access trestle for floating docks to support dredge operations (Table 2-2). It was built in 1970 and is 54 years old. The estimated remaining service life is 0 to 10 years. The structure has reportedly been recently repaired; however, a change in estimated service life and condition have not been confirmed with additional inspection, so the ratings in this BODR reflect information presented in Appendix G of PDI ER (HGL, 2024). The structure condition is serious (Table 6-3). The Dredge Base is positioned over the bank with slopes ranging from 1.5H:1V to 11.5H:1V (Figure 6-9), indicating slopes ranging from a critical zone adjacent to the top of the bank, a low-risk zone near the toe of the bank, and a caution zone between these two areas and at the top of the bank. The bank has a gradual slope with superficial failures and scarps forming. The potential impact of the RA construction on the Dredge Base is medium due to the shallower slope and minimal structure (Table 6-4).

6.2.2.2.6 Berth 311

Berth 311 is located on the Mocks Bottom side of SIB and extends overwater (Figure 6-4). A cross-section of Berth 311 is illustrated in Figure 6-10. Berth 311 is in use as a fixed pier for operations (Table 2-2). It was built in 1966 and is 58 years old. The estimated remaining service life is 0 to 10 years. The structure condition is serious (Table 6-3). Berth 311 is positioned over the bank with slopes ranging from 2.5H:1V to near flat (Figure 6-10), indicating slopes in the caution zone. The potential impact of the RA construction on Berth 311 is medium due to the possible dredging to navigation depth needed (Table 6-4).

6.2.2.2.7 Swan Island Boat Ramp

The Swan Island Boat Ramp is located at the head of the basin and extends overwater (Figure 6-4). A cross-section of the boat ramp is illustrated in Figure 6-11. The Swan Island Boat Ramp is currently in use as a public floating dock for recreational small craft (Table 2-2). It was built in 1987 and is 37 years old. The estimated remaining service life is 30 to 40 years. The structure condition is fair (Table 6-3). The Swan Island Boat Ramp is positioned over the bank with slopes ranging from 3.5H:1V to 8H:1V (Figure 6-11), indicating slopes ranging from a caution zone at the toe of the bank to a low-risk zone at the top of the bank. The potential impact of the RA construction on the Swan Island Basin Boat Ramp is low due to shallow slopes and minimal structures; however, the ramp may require reconstruction (Table 6-4).

6.2.2.2.8 Wind Tunnel

The Wind Tunnel is located on the Swan Island peninsula side of SIB, at the head of the basin, and extends overwater (Figure 6-4). A cross-section of the Wind Tunnel is illustrated in Figure 6-12. The Wind Tunnel is in use for aerodynamic testing of vehicles (Table 2-2). There are no in-water operations associated with the Wind Tunnel, but the structure requires unobstructed access to the basin for air intake. It was built in 2002 and is 22 years old. The estimated remaining service life is 45 to 50 years. The structure condition is satisfactory (Table 6-3). The Wind Tunnel is positioned over a slope ranging from 0.75H:1V to 3.5H:1V (Figure 6-12). Slopes are in the caution zone for this structure. The potential impact of the RA construction on the Wind Tunnel is medium due to the slope (Table 6-4).

6.2.2.2.9 Berth 308

Berth 308 is located on the Swan Island peninsula side of SIB and extends overwater (Figure 6-4). A cross-section of Berth 308 is illustrated in Figure 6-13. Berth 308 is not currently in use (Table 2-2). It was built in 1971 and is 53 years old. The estimated remaining service life is 15 to 25 years. The structure condition is poor (Table 6-3). Berth 308 is positioned over a slope of 1.5H:1V (Figure 6-13), indicating slopes in a critical zone. There is a longitudinal ground cracking at the top of the bank. The potential impact of the RA construction on Berth 308 is high due to the over-steepened slope (Table 6-4).

6.2.2.2.10 Berth 307

Berth 307 is located on the Swan Island peninsula side of SIB and extends overwater (Figure 6-4). A cross-section of Berth 307 is illustrated in Figure 6-14. Berth 307 is in use as a lay berth with limited daily operations (Table 2-2). It was built in 1971 and is 53 years old. The estimated remaining service life is 15 to 25 years. The structure condition is poor (Table 6-3). Berth 307 is positioned over a slope ranging from 1H:1V to 1.5H:1V (Figure 6-14), indicating slopes in a critical zone. There is cracking at the top of the bank. The potential impact of the RA construction on Berth 307 is high due to over-steepened slope (Table 6-4).

6.2.2.2.11 Berth 306

Berth 306 is located on the Swan Island peninsula side of SIB and extends overwater (Figure 6-4). A cross-section of Berth 306 is illustrated in Figure 6-15. Berth 306 is in use as a lay berth with limited daily operations (Table 2-2). It was built in 1971 and is 53 years old. The estimated remaining service life is 30 to 40 years. The structure condition is fair (Table 6-3). Berth 306 is positioned over a slope ranging from 1H:1V to 7H:1V (Figure 6-15), indicating slopes in a critical zone at the top of the bank and most of the bank slope, and a low-risk zone at the toe of the bank. The potential impact of the RA construction on Berth 306 is high due to over-steepened slope (Table 6-4).

6.2.2.2.12 Lagoon Wharf - Berths 302 through 305

Berths 302 through 305 are located on the Swan Island peninsula side of SIB and are positioned on the Lagoon Wharf (Figure 6-4). Figures 6-16, 6-17, 6-18, and 6-19 illustrate cross-sections of Berths 305, 304, 303, and 302, counting down due to structures in this chapter being represented in a clockwise location within SIB (Figure 6-4). The Lagoon Wharf is used as a fixed wharf along the riverbank to support portal cranes on rails (Table 2-2). Lagoon Wharf was built in 1950 and is 74 years old. The estimated remaining service life is 15 to 25 years. The structure condition is poor (Table 6-3). Berth 302 is positioned over slopes ranging from 0.5H:1V to 3H:1V (Figure 6-19), indicating slopes in the critical zone. Berth 303 is positioned over slopes ranging from 0.9H:1V to 3H:1V (Figure 6-18), indicating slopes on a verge between critical and caution zones at the top of the bank, the critical zone at the bank slope, and the caution zone at the toe of the bank. Berth 304 is positioned over slopes ranging from 0.5H:1V to 4.5H:1V (Figure 6-17), indicating slopes in the caution zone at the top of the bank, the critical zone at the bank slope, and the caution zone at the toe of the bank. Berth 305 is positioned over slopes ranging from 0.7H:1V to 3H:1V (Figure 6-16), indicating slopes in the caution zone at the top of the bank and the critical zone for the remainder of the bank slope and at the toe of the bank. The potential impact of the RA construction on the Lagoon Wharf is high due to over-steepened slopes (Table 6-4).

6.2.2.2.13 Pier A

Pier A is located at the tip of the Swan Island peninsula at the transition of the interior of SIB to the mouth of the basin (Figure 6-4). A cross-section of Pier A is illustrated in Figure 6-20. Pier A is in use as Berth 301 with daily operations (Table 2-2). Pier A was built in 1962 and is 62 years old. The estimated remaining service life is 0 to 10 years. The structure condition is serious (Table 6-3). Pier A is positioned adjacent to slopes of 3.5H:1V (Figure 6-20), indicating work in the caution zone. The potential impact of the RA construction on Pier A is high due to the age of the structure, known deteriorations, and stability concerns (Table 6-4).

6.2.2.2.14 Pier C

Pier C is located at the tip of Swan Island peninsula and extends out into the mouth of the basin (Figure 6-4). A cross-section of Pier C is illustrated in Figures 6-20 and 6-21. Pier C is in use as a fixed pier for Berths 309 and 310 (Table 2-2). Pier C was built in 1962 and is 62 years old. The estimated remaining service life is 30 to 40 years. The structure condition is fair (Table 6-3). Pier C includes a vertical bulkhead where it connects to Swan Island and covers riverbed slopes ranging from 5H:1V to nearly flat (Figures 6-20 and 6-21). There are areas of the riverbed that are in the critical zone near the bulkhead, in the caution zone further along the structure, and in the low risk zone. The potential impact of the RA construction on Pier C is low due to deep piling and the redundant nature of the structure (Table 6-4).

6.2.2.2.15 Quay Wall

Quay Wall Dry Docks 3 and 5 are located at the tip of Swan Island peninsula (Figure 6-4). Figures 6-22 and 6-23 illustrate cross sections of Dry Docks 5 and 3, respectively (represented in clockwise direction). Figure 6-20 illustrates the position of Dry Docks 3 and 5 as compared to Piers A and C. The Quay Wall is in use as a cellular cofferdam (Table 2-2). The Quay Wall was built in 1962 and is 62 years old. The estimated remaining service life is 0 to 10 years. The structure condition is serious (Table 6-3). The cellular sheet pile of Dry Dock 5 is adjacent to the slope ranging from 2H:1V to 4.5H:1V (Figure 6-22), indicating slopes in the critical to caution zone range. The cellular sheet pile of Dry Dock 3 is adjacent to the slope ranging from 2H:1V to 16H:1V (Figure 6-23), indicating slopes in the caution to low-risk zone range. The potential impact of the RA construction on the Quay Wall is high due to the age of the structure, known deterioration, and stability concerns (Table 6-4).

6.2.2.2.16 Shipyard Commerce Center Floating Dock

SCC Floating Docks 1 and 2 are located overwater at the tip of the Swan Island peninsula (Figure 6-4). Cross-sections of SCC Floating Docks 1 and 2 are illustrated in Figures 6-24 and 6-25, respectively. SCC Floating Docks are in use as floating docks for small craft used for operations (Table 2-2). It is unknown when the floating docks were built, so their age is also unknown. The estimated remaining service life is 35 to 50 years. The structure condition is satisfactory (Table 6-3). The SCC Floating Dock 1 is positioned over a slope ranging from 3.5H:1V to 10H:1V (Figure 6-24), indicating slope values in caution and low-risk zones. The SCC Floating Dock 2 is positioned over a slope ranging from 4H:1V to 15.5H:1V (Figure 6-25), indicating slopes in caution and low-risk zones. The steeper slopes shown in these figures at the inland end are vertical bulkhead walls not associated with the floating docks. The potential impact of the RA construction on the SCC Floating Dock is low due to its shallow slope and minimal structure (Table 6-4).

6.2.2.2.17 East Pier

East Pier is located at the tip of the Swan Island peninsula and extends overwater (Figure 6-4). A cross-section of the East Pier is illustrated in Figure 6-26. The East Pier is in use as a fixed pier and gangway for pedestrian access to the Vigorous Dry Dock (Table 2-2). The East Pier was built in 1979 and is currently 45 years old. The estimated remaining service life is 30 to 40 years. The structure condition is fair (Table 6-3). The East Pier is positioned over a slope ranging from 1.5H:1V to 10H:1V (Figure 6-26), indicating slopes in the caution zone. The potential impact of the RA construction on the East Pier is medium due to the shallow slope and minimal structure (Table 6-4).

6.2.2.2.18 West Pier

West Pier is located at the tip of the Swan Island peninsula and extends overwater (Figure 6-4). A cross-section of the West Pier is illustrated in Figure 6-27. The West Pier is in use as a fixed pier and hinged bridge for pedestrian access to the Vigorous Dry Dock (Table 2-2). The West Pier was built in 1979 and is currently 45 years old. The estimated remaining service life is 15 to 25 years. The structure condition is poor (Table 6-3). The West Pier is positioned over the slope ranging from 1.5H:1V to 10H:1V (Figure 6-27), indicating slopes ranging from critical at the top of the slope, caution at the slope, and low-risk zone at the toe of the slope. The potential impact of the RA construction on the West Pier is medium due to the shallow slope and minimal structure (Table 6-4).

6.2.2.2.19 Demo Pier

Demo Pier is located at the tip of the Swan Island peninsula and extends overwater (Figure 6-4). A cross-section of Demo Pier is illustrated in Figure 6-28. The Demo Pier is in use as a fixed pier for daily operations (Table 2-2). The Demo Pier was built in 1986 and is currently 38 years old. The estimated remaining service life is 30 to 40 years. The structure condition is fair (Table 6-3). The Demo Pier is positioned over slopes ranging from 1.5H:1V to 7.5H:1V (Figure 6-28), indicating slopes ranging from critical at the top of the slope, caution at the slope, and low-risk zone at the toe of the slope. The potential impact of the RA construction on the Demo Pier is medium due to the shallow slope and minimal structure (Table 6-4).

6.2.2.2.20 Pier D

Pier D is located at the tip of the Swan Island peninsula and extends overwater (Figure 6-4). No cross-section is available for Pier D. Pier D is used as Berth 312 (Table 2-2). Pier D was built in 1979 and is currently 45 years old. The estimated remaining service life is 50 years. The structure condition is fair (Table 6-3). A cross-section of Pier D is not available and therefore, slopes and the potential impact of the RA construction on Pier D are unknown. However, due to deep piling and redundant nature of structure, Pier D was identified as potentially having low risk of impact by RA construction (Table 6-4).

6.2.3 Structure Risk Impact Summary

The riverbank slope stability analysis concluded that riverbank slopes are in general marginally stable as currently configured. A summary of the potential RA construction impact risks is listed below and detailed in Table 6-4.

- Nine structures were identified as potentially having high risk of impact by RA construction:
  - Lagoon Wharf – Berths 302–305
  - Berth 306
  - Berth 307
  - Berth 308
  - Pier A
  - Quay Wall
- Nine structures were identified as potentially having medium risk of impact by RA construction:
  - USCG Pier
  - U.S. Navy Pier
  - MC Pier
  - Dredge Base
  - Berth 311

    - Wind Tunnel
    - East Pier
    - West Pier
    - Demo Pier
- Five structures were identified as potentially having low risk of impact by RA construction:
    - USCG Dock
    - The Swan Island Boat Ramp
    - Pier C
    - SCC Floating Dock
    - Pier D

All structures will require careful consideration during the preparation of the Draft 50% RD to consider how area-specific RD may result in impacts on each of these structures during or following RA construction. Additional structural analyses to assess selected structure's ability to accommodate implementation of the remedy during RA construction may be performed as part of RD.

6.3 OTHER IMPACTS

This section discusses other impacts from RA activities, including business interruptions, conflicts with shoreline operators, and community impacts.

6.3.1 Business Operation Interruptions

The objective of this section is to provide an assessment of the potential impacts of RA activities on operations of existing facilities within SIB and potential mitigation measures of those impacts. This assessment will help determine the implementability of remedial technologies in the SIB Project Area. Information from this assessment will be used in the future refinement of capping and dredging sequencing and phasing for the Draft 50% RD.

Based on owner/operator interviews, it is anticipated that all structures except for the U.S. Navy Pier will be used in the future. The U.S. Navy Pier may be removed as noted in Section 6.2.2.2.3. It is recommended that early engagement with owners is warranted to clearly define potential user (or owner/operator) requirements as they pertain to structures, facility future uses, and their interaction with RA activities. This engagement is important due to long timelines for permitting and construction of structural modifications (if required). In developing construction schedules for dredging and capping, significant additional construction time must be considered for work under and around structures, given that productions rates are likely to be lower than in open water locations.

The impact on waterfront business continuity must be considered when assessing constructability. It is not practical to curtail maritime traffic for extended periods during the construction phase, which would constrain local commercial and industrial operations.

The waterfront area of SIB hosts several active businesses and, in alignment with job creation opportunities, maintaining the operation of existing businesses with their current workforce is critical. Engagement and coordination efforts with the waterfront business community should occur prior to the finalization of the RD and commencement of construction activities. Early steps to initiate engagement and coordination efforts include an initial group meeting with all businesses, establishing a sequence/timeframe for individual meetings, and developing a plan for communication lines during the RA.

6.3.1.1 Assessment Inputs and Methodology

This section describes the data inputs and methodology for the assessment, including analysis of owner-operator responses, characterization of the construction equipment footprint, and analysis of vessel traffic that could potentially conflict with construction equipment. This analysis focuses on and emphasizes the potential conflicts between vessel traffic and the in-water remedy construction (dredging and capping). The remedy construction will also include riverbank stabilization, remediation of riverbank soils, and remediation near and under shoreline and overwater structures. Those remedial activities may pose substantial temporary impacts to facility operations activities that occur on the structures and on the riverbanks. At this early phase of design development, there is not sufficient design detail for those remedy elements to support identifying and assessing specific construction impacts on those operational activities. This BODR acknowledges that such impacts are likely and establishes the need to characterize and to the degree feasible, incorporate mitigation for those impacts as the design development progresses.

6.3.1.1.1 Owner/Operator Data

Information from the owner/operator surveys (Appendix K of the PDI ER [HGL, 2024]) was analyzed to determine existing facilities with marine operations that could be impacted by RA activities (Figure 6-29). Specific information analyzed included waterway operations, schedules, and vessel types, maneuverability, and frequency data for each facility. The information included in this assessment is summarized in Section 6.3.2.

6.3.1.1.2 Construction Equipment

The anticipated construction equipment used in the assessment was based on the capping and dredging evaluation (Sections 4.1 and 4.2, respectively). The assessment focused on mechanical dredging; however, the assessment may be updated in the future to include hydraulic dredging as more information becomes available. The assessment used the following equipment-based assumptions to conceptualize the construction sequencing (see Figure 6-30):

- A construction operations footprint/grid cell of 310 ft by 175 ft would be needed to accommodate the mechanical dredge, material and water barges, and tug. A conservative equipment layout was used for the vessel conflict assessment. During construction a smaller footprint may be feasible;

- Rigid and/or flexible turbidity barriers or a different piece of equipment may be required, which could change the operations footprint/grid cell; and
- RA activities would progress until dredging/capping is complete, with the dredging rate of approximately 2,500 to 3,000 CY/day. Based on recent dredging records, 2,500 to 3,000 CY/day represents a reasonable estimate for open water production rates where the vessel traffic conflict analysis is most relevant. The overall production rate and production rates in confined areas will be lower, as discussed in Section 4.2; and
- RA activities in each construction grid cell would require approximately 5 days to complete. Dredging depths and rates were assumed to be constant sitewide in the analysis, but are likely to vary depending on dredging and capping strategies developed during RD.

Construction duration at each berth has not been determined since duration will depend on final dredging depths, capping, and any structure protection work that will be developed in the Draft 50% RD.

6.3.1.1.3 Vessel Traffic Analysis

Automatic Information System (AIS) data were used to assess the location and frequency of potential conflicts. AIS is a navigation safety device that transmits and monitors vessel location and characteristics. Each data transmission via AIS is called a "ping." Information collected using AIS data includes:

- Static information on ship characteristics, including unique nine-digit vessel identifier (Maritime Mobile Service Identity [MMSI]), International Maritime Organization ship number, ship name, call sign, ship type, and ship dimensions;
- Dynamic information on ship movements, including latitude and longitude of ship position, navigation status, speed over ground course for each data submission over ground (direction the boat is traveling over the bottom), and navigation and position data. AIS "ping" speed is defined as the difference in GPS locations between two subsequent "pings" divided by the time interval between "pings"; and
- Specific travel-related information, including destination, estimated time of arrival, vessel draught or draft data (vertical distance between the waterline and the bottom of the hull, also known as keel).

Assessment of the collected data (Figure 6-31) included the following:

- Analysis of approximately 3 months (February 21 to May 27, 2022) of vessel locations, speed, and draft data;
- Extrapolation of approximately 3-month AIS vessel dataset to 1 year;[11] and

[11] Estimating annual transit numbers based on the shorter dataset could result in the omission of heavier operational times at certain facilities.

- Identification of individual vessel transits (AIS transits) using the unique vessel identifier (MMSI). Eleven individual vessels with the most frequent transits within the SIB are listed and visualized in Figure 6-31 under "AIS Transits."

Recreational vessel traffic represents a small fraction of the overall vessel traffic and was not differentiated. Vessel traffic conflict locations and frequency are summarized in Section 6.3.3.

6.3.1.2 Existing Business Operations

This section presents operations at existing marine facilities within the SIB Project Area that could potentially be affected by RA activities. The following subsections describe existing operations, by facility (Figure 6-29), based on owner/operator survey responses during the PDI and compiled vessel traffic data.

6.3.1.2.1 U.S. Coast Guard

The USCG Marine Safety Office and Group Portland (MSU) are responsible for completing vessel inspections and other operations in Oregon, Southern Washington, and Western Idaho. These operations include promoting marine safety, port security, marine environmental response, maritime law enforcement, and search and rescue. MSU operates an inland buoy tender (100 ft) and an assortment of smaller patrol boats, all under 100 ft in length. Marine operations could occur at any time, 24 hours a day, 7 days per week, and open-water access needs include ingress and egress from the facility.

6.3.1.2.2 The Marine Consortium, Inc.

Operations from the MC facility are currently conducted by a tenant conducting USCG-permitted vessel cleanings of client vessels and barges at the pier. Marine uses at the facility entail boat cleaning and moorage for various vessels, which include environmental response vessels ranging from 26 ft to 36 ft in length, various sized barges, and tugs, as needed. Marine operations could occur at any time, 24 hours a day, 7 days per week, and open-water access needs include ingress and egress from the facility.

6.3.1.2.3 Dredge Base

This Port facility serves as the mooring point for Dredge Oregon and other support equipment. Vessels using the facility include small support craft, tugs, and the dredger. Dredge Oregon is berthed at the facility roughly 6 months per year, from January to June, and is generally dispatched (off basin) between early July and late October. Support barges and tugs also need ingress and egress to the facility. The floating dock is used for metal fabrication to support Port operations.

6.3.1.2.4 Berth 311

This Swan Island Dock Company facility supports a variety of cargo-carrying vessels. Vessels using the facility include smaller, shallow, 8- to 10-ft draft vessels; larger ocean-going vessels ranging in length from 101 ft to 122 ft (requiring a draft of more than 12 ft); barges up to 400 ft with a laden draft of 20 to 21 ft; a Z-drive vessel; and associated tugs. There are two semi-permanent floating docks at the facility. Facility operations are active without seasonal considerations but generally the busier period is between May and October.

6.3.1.2.5 Swan Island Boat Ramp

The Swan Island Boat Ramp is a public facility that is operational year-round. The facility is used as a launch point for small motorized and non-motorized recreational vessels accessing the Willamette River. It is anticipated that access to the boat ramp could be restricted during construction activities, which would impact recreational boat users who could be routed to a temporary access point.

6.3.1.2.6 Wind Tunnel

Freightliner operates a wind tunnel that extends over water. There is minimal vessel traffic or marine operations associated with the facility. A barge comes into the area for maintenance once a year. The facility's air intake is located roughly 15 ft above the water surface. To maintain functionality, an area of a minimum of 150 ft on either side of the facility across the basin must be unobstructed to prevent disruption of the flow of air from the basin through the wind tunnel. The facility operates year-round from 7:00 a.m. to 5:30 p.m.

6.3.1.2.7 Shipyard Commerce Center

The SCC includes Berths 301 through 307, Dry Dock 3, Dry Dock 5, Vigorous Dry Dock, and Berths 312 to 314 on the Willamette River. Vessels using the facility include cruise ships, oil tankers, military and research vessels, tugs, and barges. The length of vessels serviced at the facility ranges from 100 ft to nearly 1,000 ft.

Ship repair work at the facility is heavily schedule-driven with tight time windows for ships to arrive and depart. The facility is also a major repair contractor for U.S. Navy, Military Sealift Command, Marad, USACE, USCG, and National Oceanic and Atmospheric Administration vessels positioned on the West Coast.

6.3.1.2.8 Berths 306 and 307

Berths 306 and 307 are lay berths consisting of mooring piers and breasting dolphins. A non-self-propelled auxiliary floating dry dock (AFDB-4) is moored at Berth 306, and Berth 307 is leased for storage of a historical "PT boat."

6.3.1.2.9 Pier A/Lagoon Wharf (Berths 301 through 305)

Pier A (Berth 301) and Lagoon Wharf (Berths 302 through 305) are located on the northwest side of the Swan Island peninsula and support active marine operations associated with ship repair and ship homeporting which occur year-round. Vessels transiting to and from the facility could include large vessels, such as cruise ships, tankers, large military watercraft, medium vessels, and associated tugs.

6.3.1.2.10 Dry Docks

At the tip of the Swan Island peninsula, in the mouth of the basin, three floating dry docks are used for ship repair. The dry docks may be used 80 to 90 percent of the year. Vessels may occupy a dry dock for extended periods during major overhauls. Most vessels use tugs for assistance for ingress/egress.

6.3.1.2.11 Berth 312

Berth 312 is located on the river side of the Swan Island peninsula and is used exclusively for ship repair which occurs year-round. Vessels transiting to and from the facility include cruise ships, tankers, and military ships.

The facility operations summarized above are expected to continue during the RA, so discussion with facility operators will be required to align RD implementation needs with facility operational needs. For example, dry docks may be used for most of the year and are difficult to move; therefore, the need to move a dry dock would be coordinated with the anticipated RA schedule during the work planning phase. This alignment will be a part of future discussions with the property owners and facility operators.

6.3.2 Conflicts with Shoreline Operators

This section presents the frequency, location, and impacts of potential conflicts between construction equipment and vessels moving in SIB, based on historical traffic patterns. Table 6-5 provides a summary, by facility, of vessel traffic including number of annual transits, vessel types/sizes, number of potential conflicts, size of transit corridor, and the frequency of transits within the SIB Project Area. A vessel transit is considered an active transit when speeds exceed 1 knot and travel distance is not insignificant (distance is more than several vessel lengths). The vessel movement was extrapolated to 1 year from the 3-month dataset (February to May 2022), which may omit heavier operational times at certain facilities. Maximum vessel lengths within this section are reported based on the 3-month AIS dataset. Owner/operator-specified vessel lengths (if larger) are noted.

6.3.2.1 <u>U.S. Coast Guard</u>

Based on a review of AIS vessel traffic data, USCG vessel transits are estimated to occur 19 times per year. Smaller vessels may not report transits using AIS. The smaller vessels (less than 100 ft) transit over a short corridor from the facility to the main river channel and require only a narrow lane for travel.

USCG marine operations would be minimally impacted by RA activities occurring in the SIB interior. Vessel conflicts would be localized and limited to RA activities occurring in the vicinity of the facility terminal.

6.3.2.2 The Marine Consortium, Inc.

Based on a review of AIS vessel traffic data, vessel transits associated with the MC facility occur seven times per year. The smaller vessels (less than 100 ft) transit over a short to moderate corridor from the facility to the main river channel and generally require only a narrow lane. Long-term mooring could occur at the facility.

Impacts to MC marine operations would be minimally impacted by RA activities occurring downstream of the facility in the interior of the basin. Vessel conflicts would be localized and limited to RA activities in the vicinity of the facility terminal.

6.3.2.3 Dredge Base

Based on a review of AIS vessel traffic data, vessel transits associated with the Dredge Base facility occur 535 times per year, with approximately 400 occurring in SIB. Many of these transits are support vessels moving around the facility. The dredger and tug vessels transit over a moderate to long corridor from the facility to the main river channel and require a larger lane for travel. The dredger is berthed at the facility for 6 months per year but generally would not require access to SIB during the 6 months of the year when deployed elsewhere.

Impacts to Dredge Base marine operations would be minimally impacted by RA activities occurring near the head of the basin. Vessel conflicts would be localized and limited to RA activities in the vicinity of the facility. Dredge Base vessels may be required to move to provide clearance for larger vessels transiting to and from Berths 304, 305, and 311 (Swan Island Dock Co.).

6.3.2.4 Berth 311

Based on a review of AIS vessel traffic data, vessel transits associated with the Swan Island Dock Co. facility are estimated to occur 533 times per year with 41 occurring within SIB. The vessels (maximum length of 400 ft) transit over a long corridor, approach the facility from the center of the basin, and require a large navigation lane.

Marine operations at Swan Island Dock Co. are anticipated to be impacted during RA activities occurring northwest of the facility, based on the frequency and size of vessels transiting through the basin. Additional localized impacts are anticipated during RA activities in the vicinity of the berth.

6.3.2.5 Shipyard Commerce Center

As indicated in Section 6.3.1, the SCC includes Berths 301 through 307, Dry Dock 3, Dry Dock 5, Vigorous Dry Dock, and Berths 312 to 314 on the Willamette River. The following subsections discuss potential vessel conflicts in the SIB waterway (not Berth 313 or Berth 314 on the Willamette River) where maneuverability and space constraints are not as significant.

6.3.2.5.1 Berths 306 and 307

AIS vessel traffic data indicate that vessel transits associated with Berth 306 occur 15 times per year, with no transits associated with Berth 307. Vessel movement was localized to the interior of the basin. Long-term mooring of semi-permanent vessels occurs at both berths.

Marine operations at Berths 306 and 307 would be minimally impacted by RA activities occurring upstream and downstream of the facility. Vessel conflicts would be localized and limited to RA activities in the vicinity of the berths.

6.3.2.5.2 Pier A/Lagoon Wharf (Berths 301-305)

AIS vessel traffic data indicate that vessel transits associated with Berths 301 through 305 vary from 29 to 98 times per year (approximately 2.5 to 8.2 times per month). Large vessels transit 10 to 22 times per year over a short-to-long corridor from the berth located near the mouth of the basin to the main river channel and require a large navigation lane. Vessels may be moored at Berths 301 to 305 for extended periods, as needed, for repair and/or operations. Berth-specific transits and large vessel (overall length greater than 400 ft) transit counts are shown in Table 6-6.

Marine operations at Berths 301 through 304 would be minimally impacted by RA activities in the interior of the basin, but maneuverability would be impacted by work in the narrow area between the end of Pier A and the adjacent shoreline. Marine operations at Berth 305 will be impacted by RA activities northwest of the facility, based on the frequency and size of vessels transiting through the basin, along with impacts from work at the mouth of the basin. Additional impacts will occur during RA activities in the vicinity of Berths 301 through 305.

Table 6-6. Transits Per Year for Berths 301 through 305

Berth	Transits/Year	Large Vessel Transit/Year	Longest Vessel (AIS) [ft]
301	56	10	686
302	98	20	686
303	31	11	564
304	52	22	683
305	29	Not Available	480

6.3.2.5.3 Pier D (Berth 312)

AIS vessel traffic data indicate that vessel transits associated with Berth 312 occur 98 times per year. The event frequency data indicate that vessels (ranging from smaller support vessels up to maximum length of 860 ft) infrequently transit from the berth location on the main river into the interior of SIB Project Area and require a large navigation lane. Vessels may be moored at the berth for an extended period, as needed, for repair and/or operations.

Marine operations at Berth 312 would be impacted by RA activities in the interior of the basin and would require coordination with vessel movements from the berth into the basin. Localized impacts are anticipated during RA activities at the mouth of the basin.

6.3.2.5.4 Dry Docks

The Dry Docks at the SCC include Dry Dock 5, Dry Dock 3, and Vigorous Dry Dock. AIS vessel traffic data indicate that vessel transits occur 30 to 34 times per year. The event frequency data indicate that vessels infrequently transit from the dry docks near the mouth of the basin into the SIB Project Area interior (Berths 303 through 305, and 311) and require a large navigation lane. Vessels may remain at the dry dock facilities for an extended period as needed for repair.

Marine operations at Dry Dock 5, Dry Dock 3, and Vigorous Dry Dock would be unaffected by RA activities occurring in the interior of the basin but would require coordination with vessel movements from the dry dock area into the basin. Localized impacts are anticipated during RA activities at the mouth of the basin and in the vicinity of each dry dock.

6.3.2.6 Summary of Conflict Frequency and Location

Potential conflicts between marine traffic in SIB and construction equipment were compiled for each facility and the full range of potential locations where construction equipment may be located during RA. Figure 6-32 illustrates the annual total number of potential conflicts in each construction polygon from all vessel traffic in SIB. The largest conflict area is located between Berths 304 and 305 due to numerous vessels moving internally within the basin, (not entering or exiting the basin). Most of the potential conflicts occur along the SIB centerline where vessel traffic is presently concentrated. Few vessel traffic conflicts are likely to occur at the head of SIB, in the shipyard area, or at the berth on the main river.

6.3.2.7 Mitigation Measures for Limiting Remedial Action Impacts on Vessel Traffic And Facility Operations

This section presents potential impacts on vessel traffic operations at individual facilities while dredging and/or capping is performed within the footprint of each facility, as well as conceptual mitigation measures. Operations at all facilities described in Section 6.3.2 are likely to be impacted by RA activities. Vessel traffic impacts could occur at the construction location but also during mobilization, demobilization, and construction material transport. Impacts include:

- Downtime and/or relocation of operations temporarily required and
- Removal of non-permanent structures (floating structures).

Operational impacts at each facility include the following:

- All facilities:
  - Limitations of barge maneuverability/access in the narrow area between the end of Pier A and the adjacent shoreline; and
  - Vessels would need to use alternate location(s) during terminal construction;
- Dredge base: temporary relocation of larger vessels to provide clearance as well as limitations of barge maneuverability/access at the mouth of the basin and between Berth 304 and Dredge Base;

- Swan Island Dock Co.: temporary relocation of moored barges for clearance as well as limitations of barge maneuverability/access at the mouth of the basin and between Berths 306 and 307 and Berth 311;
- SCC: vessel maneuverability limited by work at the SIB entrance through mid-channel SIB (large vessels, clearance with Dredge Base);
- Wind tunnel: wind tunnel cannot operate when barges are in front of the air intake; and
- Floating structures: likely need to be removed during construction.

Conceptual measures for limiting operational downtime at individual facilities based on the types of impacts anticipated during RA include:

- Optimizing construction plant configuration(s) to clear navigation lane(s);
- Evaluating required safe zones around vessels;
- Using tug assistance to maneuver at lower speeds in tight spaces;
- Developing construction windows intended to minimize the duration of impact and/or optimize the timing of impacts to occur at more favorable times;
- Coordinating between operators and designers/contractors prior to and during construction; and
- Considering phased dredging and capping to avoid construction plants being in the same location for long time periods.

6.3.3 Community Impacts

Recreational use of SIB during construction will likely be prohibited. Coordination with Oregon DSL, the City, and other entities, will be initiated, as necessary, to effectively close or restrict use of submerged or submersible land in SIB to recreational use during construction. For example, City's public boat ramp will have to be closed during the RA construction and this closure will need to be communicated and arranged for with the EPA. Community engagement is discussed in Section 2.6.8.

6.4 GREEN REMEDIATION PRACTICES

Some activities necessary to implement the remedy for the SIB Project Area will impose negative environmental impacts but are necessary in exchange for the protections associated with the removal of hazardous substances as stated in the ROD. The ROD also requires that the selected actions and implementation methods be consistent with EPA Region 10 Clean and Green Policy (EPA, 2009) and the Superfund Green Remediation Strategy (EPA, 2010). To be consistent with these policies, a green remediation evaluation will be performed as part of the RD and will include an analysis to evaluate implementation options to reduce the environmental impact of the remedy. The analysis will quantify environmental impacts where feasible to define the environmental impact footprint and evaluate technologies and options to reduce the environmental footprint without compromising the goals of the remedy. As the design progresses, recent advances in green remediation technology will be incorporated via an ongoing literature review. A Green

Remediation Plan will be developed that includes a discussion on how baseline versus reductions in energy and water usage, particulate emissions, waste generation and handling, and other improvements will be tracked and reported during construction.

The strategy for the green remediation evaluation is based on EPA's recommendations in the memorandum *Consideration of Greener Cleanup Activities in the Superfund Cleanup Process* (Woolford, 2016). Following this approach, selected technologies and the implementation methods will be assessed, and a site environmental impact footprint will be developed. The footprint will serve as the basis to assess other viable options that could be selected to reduce the impact footprint. Options will also be evaluated to ensure that the protections and RAOs of the ROD and goals of the ASAOC are not compromised.

6.4.1 Environmental Impact Footprint Reduction Methodology

Methodologies to analyze the environmental impact footprint of remediation activities are outlined in EPA's *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA, 2012) as noted below:

1. Set goals and scope of analysis;
2. Gather remedy information;
3. Quantify on-site materials and waste metrics;
4. Quantify on-site water metrics;
5. Quantify energy and air metrics;
6. Qualitatively describe affected ecosystem services; and
7. Present results.

Methods, technologies, and practices will be evaluated in their contribution to reduce the environmental impact footprint in the following core environmental elements:

- Energy – Minimize total energy use and maximize renewable energy,
- Air – Minimize air pollutants and greenhouse gas emissions,
- Water – Minimize water use (primarily treated water) and preserve water quality,
- Waste – Conserve materials and reduce waste, and
- Land – Land and ecosystem protection.

To provide the platform for the footprint analysis, EPA's Spreadsheets for Environmental Footprint Analysis will be used as the basis for quantifying the impact footprint and to evaluate footprint reduction. The Draft 50% RD will report the analysis findings, including the evaluation footprint of the RD, and the technologies, methods, and practices estimated to reduce the impact footprint. Final selection of implementation elements will be determined in the Final 100% RD balancing footprint reduction benefits, level of effort, and cost.

The assembly of the impact footprint can inform a thorough Life Cycle Assessment (LCA); however, the scope of an LCA encompasses all processes and includes an expanded assessment of wider health and environmental impacts. For example, the LCA would evaluate the health and environmental costs of increased emissions whereas the footprint analysis only compares the emission output of options evaluated. Ultimately, the effect boundaries of cleanup activities in the RD are understood sufficiently that the environmental impact footprint analysis is determined to be sufficient to capture and compare options for green remediation and still meet the requirements specified in the ROD.

6.4.2 Preliminary Methods and Practices for Evaluation

The following discussion outlines a selection of preliminary potential methods and practices in each of the core environmental elements that are likely to be evaluated as part of the Draft 50% RD. A thorough investigation of applicable best practices will be performed in the development of the Draft 50% RD. Additional elements are expected to be identified during design development as the RA is developed and the scope and scale of associated negative environmental impacts are determined. The items are listed explicitly in the ROD and will be evaluated for inclusion in the Draft 50% RD.

6.4.2.1 Energy and Air

Energy use and reduction in air pollutants are intrinsically connected in the activities to be performed for this remedy. Further, while reductions in energy and air emissions will reduce the impact footprint for local air quality, the reductions also apply to minimizing contributions toward climate change. Potential methods and practices to be evaluated include:

- Use renewable energy and energy conservation and efficiency approaches, including Energy Star equipment;
- Use cleaner fuels such as low-sulfur fuel or biodiesel, diesel emissions controls and retrofits, and emission reduction strategies;
- Minimize transportation of materials and wastes and use rail rather than truck transport to the extent practicable;
- Select transload sites to minimize energy necessary for disposal transportation;
- Use newer equipment with improved emission reduction;
- Implement low idling practices;
- Determine construction sequencing considerations for energy conservation; and
- Minimize off-site migration of dust during construction.

Greenhouse gas (GHG) emissions reduction will also be evaluated from offsets derived from revegetation activities.

6.4.2.2 Water

Goals related to water include minimizing water use (primarily treated water) and preserving water quality. Potential methods and practices to be evaluated include:

- Use water conservation and efficiency approaches including Water Sense products;
- Employ temporary erosion and sediment control, particularly to exclude fish from the in-water work area and contain suspended sediment within the active work area;
- Incorporate BMPs for treatment of long-term stormwater impacts on the site, including treatment of stormwater runoff and installation of bioswales along paved areas;
- Incorporate native wetland plantings within the shoreline areas to provide shade, nutrient uptake and promote mixing of surface waters to improve local water quality, and habitat for native fish, amphibians, invertebrates and insects. The Draft 50% RD will incorporate actions to support the life cycle of key water quality bio-indicator species such as dragonflies;
- Minimize use of potable water; and
- Use high-efficiency fixtures.

6.4.2.3 Waste

The goals to conserve materials and reduce waste will be approached considering at least the following preliminary approaches:

- Use reused or recycled materials within regulatory requirements;
- Use deconstruction techniques in lieu of demolition;
- Use reusable and green materials;
- Incorporate cleared vegetation as wood chips to be used on site as soil amendment; and
- Use on-site storage and processing of uncontaminated soils to reuse on site for clean fill as part of the site restoration.

6.4.2.4 Land

Land and ecosystem protection will consider approaches to restore the surrounding lands by revegetating natural areas to create riparian and wetland conditions to support the life cycles of species native to this location. Particular attention will focus on how the revegetation approach supports the life cycle of the aquatic community including fish, invertebrates and amphibians. The habitat impacts identified in Section 8 will be evaluated for the Draft 50% RD development and recommended green remediation strategies will be incorporated into a future design study (Green Remediation Practice Evaluation). Initial items preliminarily identified include the following:

- Bioengineering of riverbanks, coupled where possible with reducing bank angles to replace the use of riprap with soft-bank using finer-grained substrates and root mass to provide needed bank stability;
- Planting of native vegetation in treated riverbanks;
- Revising methods to minimize disturbance of mature native vegetation;
- Incorporating large wood along the shallow water near the banks, coupled with low-slope bank angles with emergent wetland planting to reduce wave-caused erosional forces on riverbanks;
- Incorporating actions to support the life cycle of key ecosystem health bio-indicator species such as butterflies and birds, particularly actions that are consistent with the USGS-sponsored Partners in Flight as part of the strategic framework for the Willamette River and species identified in plan; and
- Controlling invasive plant species through physical removal and herbicide application, as applicable.

In addition to these preliminary methods to be evaluated for footprint reduction, other BMPs will be assessed for applicability as the RD progresses, each prioritized for inclusion in the footprint reduction analysis. Other BMP categories to be evaluated include:

- Project planning and staff management,
- Sampling and analysis,
- Efficient use of materials,
- Vehicles and equipment,
- Site preparations/land restoration,
- Buildings use,
- Surface water and storm water management,
- Residual solid and liquid waste, and
- Wastewater.

7.0 FLOOD IMPACT AND CLIMATE CHANGE

The implications of climate change on various aspects of capping, recontamination, and flood impacts are multifaceted and warrant careful consideration. Climate change introduces a spectrum of challenges and uncertainties that intersect with environmental management strategies. In the context of capping, the evolving landscape due to climate change presents shifts in erosion protection requirements. Factors such as sea level rise, larger river flows, and increased outfall discharges all pose unique challenges, influencing water depths, velocities, and cap stability. Amidst uncertainties, addressing climate change implications demands a comprehensive approach to ensure the resilience and effectiveness of environmental protection measures.

EPA has prepared a Climate Adaptation Implementation Plan, which serves as EPA Region 10's response to Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad," and the EPA Administrator's direction to update regional implementation plans as stated in the EPA Climate Adaptation Action Plan (EPA, 2022a). The EPA plan highlights regional vulnerabilities and identifies the strategies and priority actions to focus resources in areas of the greatest impact. Rising sea level may cause increases in shoreline erosion, groundwater elevations, salinity in groundwater, as well as changes in water chemistry at surface water near-shore cleanups. Significant regional vulnerabilities include increased precipitation frequency and intensity, flooding and fluctuating groundwater elevation levels, an increase in the frequency and severity of droughts throughout the region, along with the potential for increased number and severity of wildfires, which can impact the porosity of surface soils modifying the groundwater flow and exposure pathways (EPA, 2022a).

In coordination with the EPA regional plan for climate adaptation, flood impact considerations and climate change impacts on capping will be evaluated and quantified in greater detail during RD, when the cap elevations and other important parameters are known.

7.1 CLIMATE CHANGE IMPLICATIONS FOR CAPPING

Potential climate change impacts that may affect design of a cap include sea level rise, larger river flow, drought, higher peak and total rainfall (leading to larger outfall discharges and higher riverbank erosion), changing temperatures, and higher winds.

The rise in sea level would likely reduce velocities over the cap as greater water columns would be above it. Changing temperatures would likely not have a substantial impact on the cap. Higher winds may impact storm wave size but would also likely only be applicable to caps on high-elevation slopes and riverbanks. Drought may affect the top layer of the cap and/or erosion layer in areas of the cap placed on or near riverbanks and at higher general elevations. Drought may also have implications on increased prop wash due to shallower water depths. Larger river flows due to heavy precipitation and snowmelt would likely result in stronger river currents and increased water depth, but also larger stormwater outfall discharges that may cause higher velocities near outfalls.

The greatest potential for cap impacts would likely be anticipated near stormwater outfalls and riverbanks (to be confirmed during RD). Erosion protection design near outfalls and around shorelines/riverbanks will be developed during RD. The overall project approach to evaluating implications of climate change will be coordinated with EPA, and will be considered during RD.

Potential for change in erosion protection requirements due to climate change based on the following factors should be considered:

- Sea level rise – deeper water over the cap, largely reduces velocities over cap;
- Extreme drought – less water over the cap, could increase velocities or cause emergent cap desiccation;
- Larger river flow – stronger river currents, but with larger water depth;
- Larger outfall discharges – higher velocities near outfalls;
- Changing temperatures – uncertain if any effect to cap; and
- Higher winds – larger storm waves, only applicable on shoreline slopes. There is currently no literature to support any estimates of potential wave heights associated with intense storm development from climate change.

7.2 CLIMATE CHANGE IMPLICATIONS FOR RECONTAMINATION

Climate change introduces complexities in understanding recontamination dynamics, with variables like sea level rise, increased outfall discharges, and changing river flows potentially altering sediment and contaminant loading to the site.

Information to substantiate any long-term effects or impacts has not been established; however, potential implications for recontamination due to climate change may include the following factors to be considered:

- Sea level rise – changes tidal currents (potentially reducing velocities). It is not certain if any impact on recontamination would be the result of a rise in sea levels;
- Extreme drought – reduces sediment/COC loading to the site;
- Larger river flow – increases sediment/COC loading to the site;
- Larger outfall discharges – increases sediment/COC loading to the site; and
- Changing temperatures – uncertain if any effect on recontamination could be attributed to the change in temperatures associated with climate change.

7.3 CLIMATE CHANGE IMPLICATIONS FOR FLOOD IMPACTS

Climate change's influence on flood impacts underscores the need for proactive planning, as sea level rise and fluctuating river flows may exacerbate or alleviate flooding, necessitating adaptive strategies for flood management.

The same factors that should be considered for potential climate change impacts to capping and recontamination should also be considered for potential flood impacts:

- Sea level rise – may exacerbate flooding caused by the project (if any),
- Extreme drought – likely reduces flooding caused by the project (if any),
- Larger river flow – may exacerbate flooding caused by the project (if any),
- Larger outfall discharges – uncertain, if any, effect on flood impacts, and
- Changing temperatures – uncertain, if any, effect on flood impacts.

As further discussed in Section 11.6, engineering analysis of flood impacts will be completed as a future design study. Flood impact modeling will be conducted using the USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) and the EPA-approved Corrected Effective Model (CEM) to evaluate potential flood impact and to demonstrate no-rise condition of RD on the SIB Project Area. This potential flood impact will account for scenarios associated with climate change.

8.0 HABITAT IMPACTS

This BODR section includes a discussion of existing habitat conditions within the SIB Project Area and a qualitative discussion of the types of impacts that would occur due to RA implementation. The habitat impact evaluation will be refined as the RD advances by determining quantitative habitat impacts based on overlaying technology assignments on a map of existing habitat conditions.

8.1 RIVERBANK EDGE HABITAT COMPLEXITY AND STABILITY

The lack of complex edge habitats profoundly affects aquatic-dependent species (Ward et al, 2002). For example, juvenile salmonids use the "safe harbor" opportunities that more complex embankment habitats provide. Complex edge habitats contain features such as large woody debris, root wads and aquatic dependent plant species that provide shelter from predation, offer high-flow refugia, improved feeding opportunities, and diverse food resources.

Riverbank edge habitat within the SIB Project Area has been effectively eliminated except for a small band identified as the active channel margin (ACM). The effects have been incremental, but most pronounced at the culmination of the habitat isolation and alterations that isolated the wetland functions of Mocks Bottom from main channel processes. In current conditions, the ACM, defined as ordinary high water (20.075 ft NAVD88) to ordinary low water (5.1 ft NAVD88), has a range of ~15 ft, as seen in Appendix J of PDI ER (HGL, 2024), The ACM area encompasses a relatively small footprint of 14 acres.

Since the ROD differentiates between situations where a contaminated riverbank poses a recontamination risk versus situations where remediation of contaminated riverbank soils must be addressed, the RD will work to address this degraded condition by employing ENR in those locations where remediation is required while minimizing the disturbance of existing habitats by avoiding the bank edge with COC concentrations below CUL. The RD recognizes that areas requiring remediation will significantly impact existing habitat conditions. In areas where riverbank soil contamination exceeds the RAL/PQL, remediation of the riverbank soils through activities such as excavation or dredging with subsequent stabilization, backfilling, and regrading will incorporate ENR design measures that work to improve the structural complexity and functionality of edge habitats.

The consideration of potential RA impacts to habitat includes the identification of potential habitat enhancement opportunities within the SIB Project Area that could be developed to satisfy habitat mitigation requirements. The existing habitat conditions survey identified the lack of complex edge habitats. Habitat enhancement opportunities that would restore complex edge habitats exist primarily within undeveloped riverbank areas, shorelines, and shallow nearshore areas. Figure 5-2 illustrates the preferred remedial approach for the SMA and identifies potential revegetation areas on the riverbanks. Undeveloped shoreline and nearshore areas along Mocks Bottom and at the head of the basin present potential opportunities for shoreline and benthic habitat enhancement. Those areas are located within zones mapped in Figure 5-2 as “Monitored Natural Recovery” and “Enhanced Natural Recovery.” Potential habitat enhancement opportunities will be evaluated for compatibility with the remedy during the development of the Draft 50% RD.

8.2 RIPARIAN HABITAT CONDITION

As with edge habitat complexity, riparian conditions within SIB have also been greatly diminished over time. Historically, riparian habitats would have enveloped the entirety of the basin and provided ecological function to the entirety of the historical footprint of the site (Lovell & Ketcham, 2016). Present day conditions are dramatically diminished and represent only a fraction of what existed historically. Functional riparian habitats now only occupy a fraction of the plausible riparian area under current conditions (76 acres). The RD treatment of remaining riparian habitats is primarily driven by the same strategy that is employed for riverbank edge habitat.

Current habitat conditions identified in the PDI indicate 76 acres in what could be a potential riparian habitat within SIB. Of these, 55.5 acres (73 percent) are presently developed as impervious surfaces (Appendix J in PDI ER [HGL, 2024]).

Implementing the RD will impact the functional acreage of these existing riparian habitats due to the necessity of removing identified contaminants along the ACM. In those areas where COC levels are above RAL/PQL limits or in areas where MNR is not possible due to ecological risk, potential erodibility, or human exposure, disturbance of existing riparian habitats will be required. At these areas, strategies will be employed to mitigate the loss of riparian function. In areas where COC levels are below RAL/PQL limits, the riparian impacts will be minimized through actions that emphasize the vitality of native riparian species.

8.3 IMPACT ON BENTHIC HABITATS

Within SIB, the SMA in the main channel has been characterized as either shallow (mean low water to –10 ft) or deep (–10 ft +). Shallow water habitats encompass about 17.5 acres, and deepwater habitats are about 66 acres. Because deepwater habitats have less available light, the abundance and diversity of benthic communities associated with these habitat areas will differ from those associated with shallower habitats. Impacts on each habitat strata will also have differing consequences on predator-prey relationships depending on the species targeting the prey resources. For example, salmonids will target prey species in shallow water habitats, while sturgeons feed more heavily in deep water habitats.

Because of the extent and nature of the contamination, the SMA is an extensive 107 acres cutting across both strata. The estimated 1,409,000 CY of materials exceeding SMA thresholds for RAL, PQL, or PTW will result in the entirety of the SIB benthic habitat and the associated aquatic communities being reset until benthic habitats can reestablish and be recolonized by macro and micro community biomes once RA construction is complete.

8.4 AQUATIC HABITAT CONDITIONS

Isolation of the SIB from the main river channel has created potentially lethal aquatic conditions for many cold-water-dependent species. Dissolved oxygen and temperature are two key non-point metrics that suffer implications from being disconnected from cold water inputs. These two metrics can become too low (dissolved oxygen) or too high (water temperature) to support many native species during late summer events where atmospheric temperatures drive water temperatures to extremes. This can be a problem for resident or anadromous species of salmonids that might be present in SIB during late summer or early fall.

Given SIB's isolation from the main channel connection, point source discharges also play a significant role. The continued contribution of point source outfalls is hard to measure without long-term monitoring and source correction of identified inputs. Contamination in stormwater outfalls is discussed in Section 2.3.2.

Aside from future in-water direct discharge of contaminants from adjoining industry, the risk of stormwater outfall discharges contributing to SIB is substantial. There are mechanisms through implementing the RD and source control efforts to mitigate, or even eliminate, contaminants from adjoining industry. The risk of combined sewer overflow discharge contribution to SIB should be considered, necessitating the inclusion of ENR features.

8.5 HABITAT IMPLICATIONS OF GREENHOUSE GAS EMISSIONS

GHG emissions from implementing the remedy will be evaluated in the RD and presented in the Final 100% RD, and will likely be significant given the extensive work required over the extent of the SIB Project Area. GHG emissions, such as those from the operation of heavy equipment, materials transportation, and disposal actions have quantifiable impacts to GHG emissions. These emissions have increasingly profound and recognized impact on habitats locally and globally (IPCC, 2023). The specific impacts on habitats related to these emissions are generalized in nature, climate-driven, and difficult to quantify precisely. However, globally accepted methods have been established to quantify the source emissions from activities grouped into categories defined as either Scope 1, 2, or 3 (IPCC, 2023). Once the RD action has been finalized, GHG emissions from Scope 1 and Scope 2 sources will be quantified, and appropriate sequestration actions will be identified to address the long-term implications of the action.

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9.0 MONITORING AND MAINTENANCE

As discussed in ROD Section 10.1.1.9, "*Monitoring is an integral component of all alternatives and will be conducted to evaluate short- and long-term effectiveness. The monitoring program will include analysis of sediment, river banks, surface water, pore water, fish tissue, and air (before, during, and after construction)*" (EPA, 2017). As further discussed in the ROD, monitoring efforts will include baseline monitoring, short-term monitoring, long-term monitoring, and O&M. ROD Section 15.2.1 specified that: "*The Selected Remedy includes short-term monitoring during construction and long-term monitoring of caps, dredge areas, and MNR areas after construction to evaluate long-term effectiveness and ensure the remedies function as designed*" (EPA, 2017).

Per RDGC Section 4, "*The project area-specific details of the monitoring plan(s) will be developed in the project area monitoring plan (PAMP). Remedy construction quality assurance and water quality monitoring during construction will be addressed separately in project area-specific construction quality assurance/quality control plans (CQA/QCPs) and Clean Water Act analyses*" (EPA, 2021b). The PAMP, CQA/QCP, and CWA analyses will be presented in the Draft 50% RD. CQA/QCP development may also include additional plans for monitoring to evaluate impacts to surrounding communities to consider air quality, odor, noise, light, and any other parameters deemed necessary (EPA, 2021b). This section discusses the main considerations for baseline monitoring (Section 9.1), short-term monitoring (Section 9.2), long-term monitoring (Section 9.3), and O&M (Section 9.4).

9.1 BASELINE MONITORING

As discussed in ROD Section 10.1.19, "*New baseline sampling and monitoring will be conducted prior to implementation of remedial activities to establish current baseline conditions (pre-construction), to delineate construction areas, and to evaluate construction activities and the performance of the remedy*" (EPA, 2017). Baseline monitoring will be completed prior to RA to establish pre-construction baseline conditions. These baseline conditions will be collected for surface and subsurface sediment sitewide and used to evaluate performance of the remedy. Additional data collected will be for riverbanks, surface water, porewater (at 1 ft [30 cm] below sediment-water interface as the maximum presumed depth of the bioturbation layer), fish tissue, and air. Prior to material procurement, cap material such as sand and potential fill materials used in RA will be tested to evaluate if all materials are clean (have no CUL threshold exceedances).

9.2 SHORT-TERM MONITORING

Short-term monitoring will be conducted during construction and post construction to confirm that the remedy is constructed as designed and to evaluate if RA construction activities may be causing adverse impact for human and ecological receptors. Per ROD Section 10.1.19, "*Short-term monitoring will be conducted during construction and post construction until remedial action performance goals and cleanup levels are met*"(EPA, 2017). For cap placement, material placement will be tracked for quantity and locations. Thickness of cap material will be confirmed using diver-performed monitoring, if needed, and bathymetric surveys. For dredging efforts, post-dredge surveying will be used to confirm achievement of designed elevation and required tolerances. For locations where dredging to RAL will be performed, confirmation sampling will be used to confirm that sediment concentrations are below RALs.

As stated in ROD Section 15.2.1: "*during implementation of the Selected Remedy potential short-term exceedances of some water quality criteria are possible. Under state law, OAR 340-041-004, short-term degradation is allowable if the benefits of the lowered water quality outweigh the environmental costs of the reduced water quality as determined through an analysis of the specific water quality impacts and the development of a water quality monitoring plan during design. The water quality monitoring plan will specify the BMPs and other conditions and restrictions on the dredging and capping activity necessary to ensure that the activity will be conducted in a manner which will comply with state water quality standards and meet other ARAR-based surface water cleanup standards (also see CWA in Section 14.2.3, Action-Specific ARARs)"* (EPA, 2017). During RA construction activities, water quality and turbidity monitoring will be completed to evaluate impacts of RA construction on the river system. The monitoring plan will be included in the PAMP developed for the Draft 50% RD.

9.3 LONG-TERM MONITORING

Long-term monitoring will be used to monitor the performance of the constructed remedy and determine whether it is functioning as intended to be protective of human health and the environment. As discussed in ROD Section 10.1.19," Long-*term monitoring will be conducted periodically after cleanup levels are met where waste is left in place to ensure the remedy is still protective of human health and the environment. Statutory five-year reviews of the remedy will be conducted until unlimited use/unlimited exposure for the whole Site is achieved*" (EPA, 2017). Data will be used to evaluate if the remedy is performing as designed. Data from this monitoring effort will be used to inform fish consumption advisories and/or whether other ICs should be changed based on long-term modeling outcomes. Data collection will be attempted at a similar time in the year to allow for the best possible comparability. Tissue data will be collected and used to inform fish advisories and evaluate progress toward achieving RAOs or targets. In addition to data collection, diver-performed monitoring and bathymetric surveys will be performed to confirm the thickness of the capping material.

As stated in ROD Section 15.2.1, "*long-term monitoring and maintenance of engineering controls, monitoring of pore water, and surface water will assist in confirming the ability of the Selected Remedy to achieve chemical-specific ARARs. If long-term monitoring indicates that surface water quality ARARs cannot be met, EPA will review the data and consider whether additional technically practicable response action would further reduce contaminant concentrations in surface water"* (EPA, 2017). The main considerations for cap monitoring will be to ensure that cap performance is as expected by measuring porewater at the cap performance point (to remain protective of human health and the environment) and to ensure that the chemical isolation layer and EPL are not showing significant signs of erosion. For non-erodible riverbanks with COC concentrations above CUL but below RAL/PQL thresholds, monitoring and routine inspections will be used to assess signs of potential erosion and confirm that the riverbank remained non-erodible and potential for future erosion is minimized. This monitoring may initiate additional control measures or RA.

9.4 OPERATION AND MAINTENANCE

As specified in ROD Sections 12.3 and 14.2.7, O&M will be required in perpetuity for caps, in situ treatment, MNR and ENR areas following ground motion triggers (seismic events) for post-event cap inspections, or any other potential events that may substantially impact remedy performance. Per the RDGC, the maintenance and repair plan will establish cap monitoring frequency and methods for these events, including post-event cap inspections, target durations for cap repair after damaging earthquake events, and any other appropriate measures to be applied over the defined long-term monitoring period. If monitoring efforts indicate that the remedy is compromised or not performing as expected, maintenance activities will be implemented to improve remedy performance. Potential maintenance may include repair or replenishment of the EPL. If MNR is not achieving RAOs in a sufficient timeline, additional RA may be needed. The monitoring plan will be included in the PAMP developed for the Draft 50% RD. Additional considerations for potential O&M needs will be identified in the O&M Plan in the Draft 50% RD.

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10.0 CONCEPTUAL LEVEL QUANTITY AND COST ANALYSIS

Each version of the RD (Draft 50%, Pre-Final 90%, and Final 100%) will include a cost analysis and estimate of the preferred work elements for the SIB Project Area. This section outlines the approach and methodology to complete the cost analysis and the rationale for the reported cost estimate. The analysis will inform the engineering design and strategic decisions throughout RD development. The cost analysis of individual construction elements of the design will be included in the Pre-Final 90% RD, which will also include green remediation assessment.

The cost analysis for the Draft 50% RD will include the central work elements:

- Dredging,
- Capping,
- MNR,
- ENR,
- In situ treatment,
- Riverbank remediation,
- On-site material handling,
- Off-site transport and disposal, and
- Construction management (inspection, compliance monitoring, administration).

The cost analysis will be developed in compliance with the Methodology and Organization of Selected Remedy Cost Estimate (EPA, 2017).

10.1 METHODOLOGY AND APPROACH

The cost estimate will be derived from the output of probabilistic cost modeling. There is anticipated variability associated with the construction quantities, as well as uncertainty associated with the contractor's proposed unit costs. The uncertainty associated with construction quantities will be minimized to the degree possible for the Pre-Final 90% RD by detailed analysis of each construction component. Some elements, such as the impacts of weather delays on the construction duration, are outside of the contractor's control and will be incorporated as an element of the probabilistic analysis. The variability associated with unit costs will be reduced as much as possible during the development of the 90% RD by a comprehensive review of unit costs from recent, relevant similar projects.

The probabilistic modeling will incorporate uncertainty and risk based on variability within the input variables. Cost models run a statistically significant number of simulations (typically at least 10,000) using the Monte Carlo method. This method organizes the output of the simulations and presents them in graphics that illustrate the probability of different cost outcomes (Figure 10-1).

The output will present the full range of possible costs with associated probability while incorporating risks throughout the project life cycle. The analysis will highlight construction cost elements that contribute to the greatest potential risk. The analysis will be performed at intermittent points during RD development to determine if there is a need to consider a different construction approach, or areas which may require tighter oversight during construction to manage overall project costs. A final cost distribution of the preferred design will be presented as a part of the Pre-Final 90% RD.

This approach avoids the inability of conventional deterministic cost estimation methodology to represent uncertainty in individual unit costs or to capture risk factors inherit to individual cost items. The single additive formula of deterministic cost estimation is less complex and employs the use of a contingency applied to the total estimate to capture cost uncertainty.

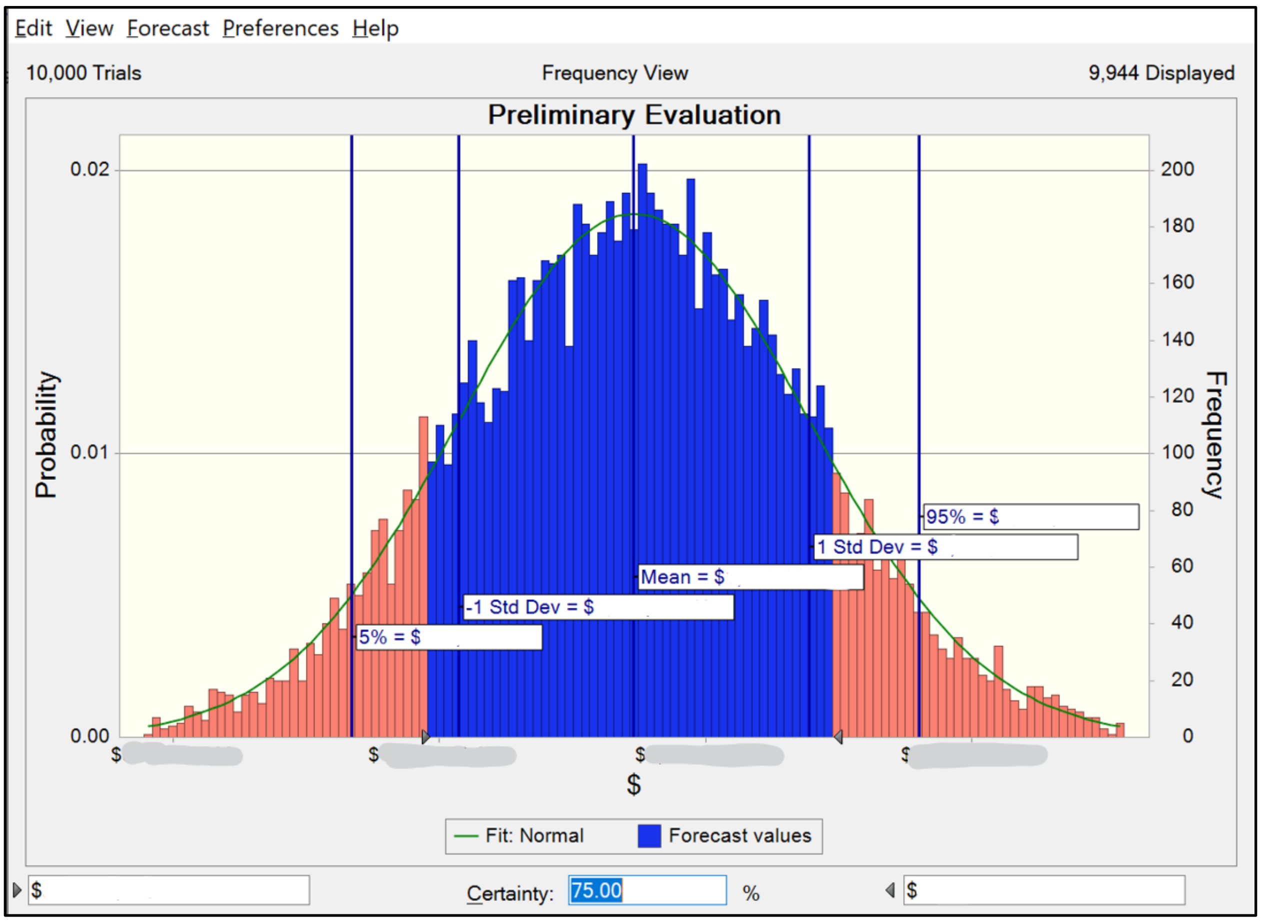

Figure 10-1. Example of Probabilistic Cost Frequency Chart

A probabilistic cost model uses the same base construction cost estimate relationships as that with deterministic cost estimating. However, it varies significantly in the ways described below:

- The cost model will be revised at each of the design phases (Draft 50%, Pre-Final 90%, and Final 100%) and will portray a range of possible construction costs, with a probability distribution of costs occurring based on an evaluation of many iterations of cost scenarios, each using different combinations of unit costs and quantities;

- The model can predict significant changes in probable costs due to occurrence of events such as project delays with a detail that allows examination of the effects on individual cost items, some of which may be affected differently than others by a delay in one part of the project;
- Each unit cost element is assigned a range of potential costs rather than a single cost. The range is applied to each cost element and developed based on a database of historical costs, or effects by a potential change in project conditions as developed within a risk register. A distribution is typically assigned to each element using a maximum, minimum, and expected values that weight the probability distribution across a range; and
- This approach allows for incorporation of different design methodologies to evaluate the cost-related risks of different approaches.

10.2 UNIT COST ANALYSIS

The Draft 50% RD will include an identification of recent, relevant unit costs and an assessment of risk elements that can alter anticipated costs. Cost identification will be performed by obtaining unit costs from the following sources, ranked in order from highest priority to lowest. A weighting strategy would be employed to differentiate between the highest priority/highest value sources and the remaining sources of varying value. The cost source will also inform cost variability in the probabilistic cost model.

1. Firm-specific historical project costs: highest priority resource, identify unit costs that are specific, recent, local, and relevant to the types of work to be performed within the SIB Project Area. For example, the 100% design unit costs from the Lower Duwamish Waterway Project will be obtained and used as a primary source for estimating unit costs for the SIB project;
2. Commercially available cost databases: a low priority resource, these databases provide summary values from aggregated data with no transparency. Aggregated data typically cover a large geographic area producing results that are not region or market specific. Regional adjustment factors may be applied, but that approach is usually inferior to obtaining region-specific cost data. Review of these sources would only be done as a last resort if sufficient information is not obtained via the highest priority resource; and
3. Publicly available cost databases are the lowest priority resource because they typically do not focus on remediation projects and would only be reviewed if sufficient information is not obtained used from higher priority resources.

Unit costs will be recorded documenting the source, year, information related to their variability and confidence, and any suggested modifications to tailor them to the work anticipated in the SIB Project Area. Cost information will be escalated to anticipated time periods using the appropriate Consumer Price Index.

Each unit cost shall also be assigned a statistical distribution that represents the sources and supporting data obtained for each element. The RD team will review these distributions as a part of each phase of the RD (50%, 90%, and 100%), narrowing estimates of unit costs as justified with new supporting data.

Cost modeling will be used to perform a sensitivity analysis evaluating cost sensitivity to variations in quantity and unit price. Those cost elements will be identified that have the greatest influence on cost variability and will be investigated to determine whether additional data can be added to the unit cost dataset to reduce uncertainty or whether the cost element can be broken out into smaller components to isolate the sub-elements that have the greatest uncertainty. The sensitivity analysis will also examine the different scenarios to understand the connected interactions between different issues and identify which scenarios produce the greatest project risk.

10.3 ANALYSIS OF COST AND SCHEDULE RISKS

The RD team will advance the draft risk register from the preferred remedial approach applicable to the Draft 50% RD (Table 10-1). The risk register will be continually updated to reflect newly recognized risks throughout the RD process and as the design effort focuses on evaluating certain risks. The risk register will serve as the basis of informing variability of cost elements used in the cost model.

The risks are separated into four categories, as presented below along with two key risks and risk management strategies from each of the categories.

Design Phase Risks – these are risks which can be managed during the design phase. Examples include:

- Contracting Strategy. The risk is that a sub-optimal contracting strategy is used, which results in the selection of a contractor who misrepresents their ability to perform required work and is incapable of performing the project in conformance with the design and/or permitting requirements. This risk can be managed by identifying an optimal strategy for contractor selection to ensure that a highly qualified contractor will be selected who will be professional, competent, fair and reasonable in execution of the project and is capable of adapting to the range of possible changes which could occur during the contract duration; and
- Sediment Removal or Cap Extents. The risk is that the volume and/or lateral extent of contaminated sediment needed to be removed or capped is not accurately identified in the design phase, such that during construction additional sediment is identified for removal/capping, triggering a change order and/or change of conditions claim by the contractor, potentially leading to additional costs and/or project delays.

Construction Phase Risks – Internal – these are risks which the contractor can pro-actively manage prior to and/or during construction. Examples include:

- Procurement. The risk is that the contractor is unable to source sufficient quantities and/or appropriate types of equipment such as dredge(s), barges, hauling equipment, and/or have sufficient on-site or nearby storage for sufficient quantities of construction materials such as sand, GAC, etc. to ensure continuous efficient operation and avoid construction delays. This risk can be managed by requiring the contractor to designate a procurement lead who is responsible for developing and maintaining a Procurement Plan for all major equipment, materials and consumables on a schedule using an early-finish scheduling approach and presenting at least monthly reporting on status. Further, a minimum lead time can be established for critical elements during RD design and requiring conformance with this as a part of the procurement documents; and

- Dredging Operations. The risk is that the contractor is unable to complete the dredging of contaminated sediments in an effective and timely manner to meet the project schedule, triggering extra costs associated with extension of the project timeline. This risk can be managed by requiring the contractor to submit a dredging schedule as a part of the operations plan, as well as including daily financial penalties for inability to meet performance and/or schedule requirements.

Construction Phase Risks – Community – These are construction-phase risks which may involve community members within the project area. Examples include:

- Site Security. The risk is that there may be an incident or accident arising from unauthorized access by community member(s) to land or river operations causing death, injury and/or damage to equipment or property causing a lawsuit, project delays or unforeseen costs. This risk can be managed by requiring the contractor to develop a site security plan which includes on-site security personnel and video monitoring prior to start of construction and revisit the security plan at least monthly during construction; and
- River Operations. The risk is that there is an accident between contractor-operated vessels and private vessels, contractor-operated vessel and shore structures, or contractor-operated vessel and supply/repair/maintenance service vessels. This risk can be managed by requiring the contractor to develop a River Operations Safety Plan and discuss the effectiveness of the Plan in ensuring ongoing safe operations at each weekly safety meeting.

Construction Phase Risks – Extrinsic - These are construction-phase risks which are largely outside of the control of the designer or contractor. Examples include:

- Major Utilities Outage. This risk may occur due to a storm, flood and/or off-site activity that severs one or more major utility feed(s) to the site, causing a disruption in supply of power and/or water. To manage this risk, the contractor will be required to prepare a contingency plan to alter operations and/or ensure self-sufficiency in supplying utilities to critical site operations in case of outage.
- Archaeological find. This risk is that the contractor encounters archaeological materials during streambank excavation causing a temporary or long-term work stoppage to allow archaeological examination of the site. This risk can be managed by having the archaeological analysis complete and reviewed by stakeholders greater than 6 months prior to excavation. The contractor will be required to have an archaeologist on site during excavation in high-risk areas and develop a construction sequence which allows two or more work areas prepared at the start of streambank excavation so the contractor can move equipment to a secondary area if work has to be stopped in the primary area.

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11.0 FUTURE DESIGN STUDIES

The studies listed below are anticipated as part of the Draft 50% RD and treatability study and are necessary to support the area-specific design development and remedial technology assignment for the Draft 50% RD. The RD WP will provide a detailed schedule of the timing of future design studies. The outcomes of the studies and evaluations will be presented in the RD deliverables. Studies in Sections 11.1 through 11.9 will be performed and funded through RD efforts, whereas the porewater chemistry study in Section 11.10 will be completed as a treatability study. Out of all future design studies, the porewater chemistry study is the only one where field efforts are anticipated to occur.

11.1 CAP EVALUATION UPDATE

This work represents an update to Section 4.1 and Appendix A to be refined after the Draft 50% RD is developed. Erosion protection requirements will be refined as is typically performed as part of RD to optimize placement locations and material quantities. Chemical isolation requirements will be refined based on location-specific and COC-specific variations within the site. Additional geotechnical evaluation will be performed related to differential settlement and cap slope stability.

11.2 DREDGING EVALUATION UPDATE

As indicated in Section 4.2, data gaps remain for certain key considerations, such as subsurface debris locations or future structure repairs and maintenance, but the available data have informed the criteria for the successful application of dredging technology. Further analyses of the dredging methodologies will be presented in the Draft 50% RD.

11.3 MATERIAL DISPOSAL UPDATE

Dredged sediment and contaminated riverbank materials will be managed in accordance with the ROD and disposed of at the appropriate off-site facility. Evaluation of the transload facilities, transport, and material staging and loading will be updated with each RD submittal based on continuing assessment of data. Additional updates will include analysis and evaluation of transload facilities selected for the RA based on costs and feasibility.

11.4 CONSTRUCTABILITY UPDATES

Constructability updates will occur throughout the RD as aspects such as production rates and methodologies are further defined based on the constructability considerations presented in Section 6.0. Additionally, it is understood that the RD and subsequent RA will have impacts on property owners and active businesses within the SIB. As presented in Section 2.6.8, special care will be taken during RD to minimize impacts of RA to the existing businesses within the SIB Project Area. Additional constructability updates will come from programs designed to engage property and business owners, operators, and stakeholders during the development of the Draft 50% RD to further understand the leases, licenses, and riparian or other rights these persons and entities have, as well as impacts the RA would have not only on the physical structures, but also the operations within the SIB Project Area.

11.5 GREEN REMEDIATION PLAN

Green remediation practices will be evaluated according to Section 14.2.12 of the ROD related to construction, and the RA contractors will apply those practices when and where practical. The Green Remediation Plan will be developed in accordance with the RDGC (EPA, 2021b) and will discuss how resource impacts will be mitigated to the extent possible.

11.6 FLOOD IMPACT EVALUATION

Potential flood impacts will be evaluated using HEC-RAS and the CEM as a base tool, with modifications made to the tool to have 2-D modeling capability. Re-calibration will be performed to verify modeling results. The flood impact evaluation will be used to demonstrate no flooding is caused by RD implementation, in accordance with ARARs (Table 3-1). This analysis will occur for the Draft 50% RD.

11.7 CLIMATE CHANGE IMPACTS

This work represents an update to Section 7.0 to be refined after the Draft 50% RD is developed. Changes in physical conditions due to climate change can affect the remedial technologies such as cap and in situ treatment, recontamination potential, and the potential for the project to cause flood impacts. The climate change evaluation will be performed in accordance with EPA design guidelines and coordinated with EPA. Effects of climate change will be quantified using numerical modeling tools.

11.8 HABITAT IMPACT EVALUATION

This work represents an update to Section 8.0 to be refined after the Draft 50% RD is developed. The habitat impact evaluation will be conducted in accordance with the RDGC (EPA, 2021b) to demonstrate compliance of the RA approach with action-specific or location-specific ARARs. The evaluation will identify and include BMPs to minimize habitat impacts during and after construction of the remedy.

11.9 STRUCTURAL ANALYSIS

This analysis entails evaluating the assigned area-specific remedial technology at each structure to determine recommended structural or slope mitigation approach to facilitate RA implementation. Working with facility owners/operators, structure-specific design criteria will be developed. The additional work will include geotechnical analysis to support the evaluation of structural or slope mitigation approach options.

11.10 POREWATER CHEMISTRY STUDY

As discussed in Section 3,7 of the ASAOC, a porewater chemistry study is proposed as a treatability study. Per RDGC Section 5.1.4, porewater concentrations are a key input in cap design evaluations and are also used in recontamination potential. This BODR used a literature-based range of values as partition coefficients to estimate partitioning between bulk sediment concentrations and porewater concentrations (Appendix A). Porewater sampling will be conducted using passive sampling technology to evaluate porewater concentrations at locations collocated with sediment cores already collected during the PDI and where maximum porewater upwelling was detected during the porewater upwelling study (Appendix B of PDI ER [HGL, 2024]). The timing of the study will be planned to detect maximum porewater upwelling (late summer/early fall). The sampling will focus on areas where capping is assigned as the remedial technology. The site-specific porewater chemistry data will be used to:

- Establish site-specific partition coefficients,
- Verify area-specific cap design in the RD; and
- Validate recontamination potential results.

Details of the porewater chemistry study, including locations, number of data points collected, data collection methods, and analyte list will be outlined in the treatability study. The schedule will be further developed in the RD WP.

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12.0 REMEDIAL DESIGN SEQUENCING

This section provides an overview of the RD sequencing. After finalization and approval of this BODR, the schedule for RD deliverables will be further established as the project progresses in discussions with EPA. The RD will start with the development of an RD WP followed by the submittal of the Draft 50% RD and supporting documents. The Draft 50% RD will progress in stages through the Pre-Final 90% and Final 100% RD.

Additional RD investigations may be pursued if data gaps are identified between the submittal of the BODR and the Draft 50% RD. Any additional investigations will be coordinated with EPA and the RD design team to determine an appropriate schedule in support of the RD.

12.1 REMEDIAL DESIGN WORK PLAN

After the BODR has been finalized, the first design submittal will be the RD WP providing plans and scope for implementing the treatability study and all RD activities for the SIB Project Area. A description of the overall management strategy for performing the RD, including a proposal for phasing of design and construction, will be presented in the RD WP.

12.2 DRAFT 50% REMEDIAL DESIGN

A Draft 50% RD schedule will be developed in the RD WP. The main elements of the Draft 50% RD will include the following:

- A design criteria report, as described in EPA's *Remedial Design/Remedial Action Handbook* (EPA, 1995);
- Preliminary drawings and specifications;
- Descriptions of permit requirements;
- Description of monitoring and control measures to protect human health and the environment;
- Updates to supporting deliverables required to accompany the RD WP;
- Additional supporting deliverables, including:
    - Institutional Controls Implementation and Assurance Plan,
    - Waste Designation Memo,
    - Habitat Impact Evaluation Report,
    - Green Remediation Plan,
    - Project Area Monitoring Plan,
    - CQA/QCP,
    - Transportation and Off-Site Disposal Plan; and
    - O&M Plan and Manual.

- Demonstration that transload facility(ies) is (are) appropriate for handling and transloading dredged materials.

12.3 PRE-FINAL 90% REMEDIAL DESIGN

The Pre-Final 90% RD will be a continuation and expansion of the Draft 50% RD and address EPA's comments on the Draft 50% RD submittal. The Pre-Final RD 90% will serve as the approved Final 100% RD if EPA approves the Pre-Final 90% RD without comments. The Pre-Final 90% RD will include the complete set of certified construction drawings and specifications, updates to the Draft 50% RD components, as needed, to reflect ongoing work elements as well as to address EPA comments on the Draft 50% RD, and a final sufficiency assessment summary table.

12.4 FINAL 100% REMEDIAL DESIGN

The Final 100% RD will be submitted to address EPA's comments on the Pre-Final 90% RD and will include final versions of all pre-final deliverables for EPA approval.

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TABLES

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Table 2-1
Estimated Percent Change in Swan Island Basin Land Area
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Year	Estimated Swan Island Basin Land (square feet)	Estimated % Change in Land Area (+ is gain)
1888	10,803,428	N/A
1909	10,803,428	0%
1927	16,594,158	54%
1929	10,557,112	-36%
1932	9,508,073	-10%
1939	9,508,073	0%
1951	9,141,486	-4%
1955	9,141,486	0%
1960	9,451,952	3%
1970	10,698,273	13%
1988	12,934,092	21%
1994	12,877,736	0%
2002	12,747,039	-1%
2023	12,555,223	-2%

Notes:
% = percent
N/A = not applicable

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Table 2-2
Current Shoreline and Overwater Structure Use
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Structure Number(s)	Structure	Owner/Operator	Currently Used?	Current Function / Use
1	USCG Pier	USCG	Yes	Fixed pier boat dock used for operations.
2	USCG Floating Dock	USCG	Yes	Floating docks for small craft used for operations.
3	U.S. Navy Pier	Department of the Navy	No	Fixed pier used for operations.
4	MC Pier	MC	Yes	Fixed pier used for operations.
5	Dredge Base	Port of Portland	Yes	Access trestle for floating docks to support dredge operations.
6	Berth 311	Swan Island Dock Company	Yes	Fixed pier used for operations.
7	Swan Island Boat Ramp	City of Portland	Yes	Public floating dock for recreational small craft.
8	Wind Tunnel	Freightliner	Yes	Wind tunnel shroud over water used for aerodynamic testing of vehicles, no in-water activities.
9	Berth 308	Port of Portland	No	Lay Berth.
10	Berth 307	Project Fleet Owner LLC	Yes	Lay Berth.
11	Berth 306	Project Fleet Owner LLC	Yes	Lay Berth.
12-15	Lagoon Wharf – Berths 302 – 305	Project Fleet Owner LLC	Yes	Fixed wharf along the riverbank support portal cranes on rails.
16	Pier A	Project Fleet Owner LLC	Yes	Berth 301 and Floating Dry Dock 5. Cellular cofferdam.
17	Pier C	Project Fleet Owner LLC	Yes	Berth 309 and 310. Fixed pier.
18	Quay Wall	Project Fleet Owner LLC	Yes	Cellular cofferdam.
19	SCC Floating Docks	Project Fleet Owner LLC	Yes	Floating dock for small craft used for operations.
20	East Pier	Project Fleet Owner LLC	Yes	Fixed pier and gangway for pedestrian access to dry dock.
21	West Pier	Project Fleet Owner LLC	Yes	Fixed pier and hinged bridge for vehicle access to dry dock.
22	Demo Pier	Project Fleet Owner LLC	Yes	Fixed pier used for operations.
23	Pier D	Project Fleet Owner LLC	Yes	Berth 312.

Notes:
MC = The Marine Consortium, Inc.
SCC = Shipyard Commerce Center
USCG = U.S. Coast Guard

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Table 2-3
Debris Weight Estimation Bounds Based on Assumed Density
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Debris Size Range (ft)	Count	Total Volume (eps) (ft^3)	Weight Bounds (US Ton)	Total Volume (box) (ft^3)	Cumulative Weight Bound Ranges (US Ton)
0-2	111	74	2.1-5.7	141	4-11
2-5	679	2,629	74-202	5,020	141-385
[5, >5]	780	41,448	1,164-3,183	79,161	2,224-6,078
∑	1,570	44,151	1,240-3,390	84,322	2,369-6,475
>2	1,459	44,077	1,238-3,385	84,181	2365-6463

Notes:

Debris was grouped according to size and the total volume was computed using both ellipsoid (eps) and box volumes. An ellipsoid volume is less conservative, while a box volume is more conservative.

Basis of volumes, weights, and cumulative weights are discussed in BODR Section 2.6.5.

∑ = sum of all

> = greater than

ft = feet

ft^3 = cubic feet

eps = ellipsoid

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Table 3-1
Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBCs)
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Type of ARAR	Medium	Regulation/Citation	Criterion/Standard	ARAR/TBC Designation and Other Comments
Chemical-Specific ARAR	Protection of surface water	Clean Water Act, 33 U.S.C. 1313 and 1314 (Sections 303 and 304). Most recent 304{a) list of recommended water quality criteria, as updated up to issuance of the ROD	Under CWA Section 304{a), EPA develops recommended water quality criteria for water quality programs established by states. Two kinds of water quality criteria are developed: one for protection of human health, and one for protection of aquatic life. CWA §303 requires States to develop water quality standards based on Federal water quality criteria to protect existing and attainable use or uses (e.g., recreation, public water supply) of the receiving waters.	The most recent 304{a) recommended water quality criteria are: (1) **Relevant and Appropriate** for cleanup standards for surface water and contaminated groundwater discharging to surface water if more stringent than promulgated state criteria; (2) **Relevant and Appropriate** as criterion to apply to limit short- term impacts from dredging and capping if more stringent than promulgated state criteria; and (3) **Relevant and Appropriate** as criterion to apply to point source discharges that may occur in implementing the remedy if more stringent than promulgated state criteria.
Chemical-Specific ARAR	Protection of potential drinking water sources	Safe Drinking Water Act, 42 U.S.C. 300f, 40 CFR Part 141, Subpart 0, App. A. 40 CFR Part 143	Establishes Maximum Contaminant Level Goals (MCLGs) and Maximum Contaminant Levels (MCLs) to protect human health from contaminants in drinking water.	**Relevant and Appropriate** as cleanup standards for groundwater and surface water at the Site, which are potential drinking water sources.
Chemical-Specific ARAR		EPA Regional Screening Level {RSL) for Groundwater. Office of Superfund Remediation and Technology Innovation, Assessment and Remediation Division. November 2015.	Establishes acceptable risk levels for individual contaminants to protect the human health drinking water use at the $1x10^{-6}$ level for individual carcinogens or hazard quotient of 1. They are risk-based concentrations derived from standardized equations combining exposure information assumptions with EPA toxicity data.	**To Be Considered** criteria for cleanup standards for groundwater and surface water at the Site only for contaminants of concern for which there are no MCLGs or MCLs established because the groundwater and surface water are potential drinking water sources.
Chemical-Specific ARAR	Measure of protectiveness of human health and the environment in all media	Oregon Environmental Cleanup Law ORS 465.315(b){A). Oregon Hazardous Substance Remedial Action Rules OAR 340- 122-0040(2)(a) and (c), 0115(2-4).	Sets standards for degree of cleanup required for hazardous substances. Establishes acceptable risk levels for human health at $1x10^{-6}$ for individual carcinogens, $1x10^{-5}$ for multiple carcinogens, and Hazard Index of **1** for noncarcinogens.	**Applicable** standards for the final selected remedy to achieve these human health carcinogen and noncarcinogen risk levels by implementation of dredging, capping, enhanced natural recovery, monitored natural recovery, off-site disposal, implementation of institutional controls and other response actions set forth in the ROD.
Chemical-Specific ARAR	Protection of surface water	Water Pollution Control Act ORS 468B.048. State-wide Numeric water quality criteria set forth in OAR Part 340, Division 41, including, Toxic Substances criterion at OAR Part 340-41-0033 (Tables 30 and 40), and Designated Uses for the Willamette Basin and Numeric Water Quality Criteria specified for the Willamette Basin at OAR 340-041-340 and 340-041-0345	DEQ is authorized to administer and enforce CWA program in Oregon. The state has promulgated numeric water criteria, state- wide and specific Willamette Basin criteria, to protect Willamette Basin designated beneficial uses.	Oregon's numeric toxics water quality standards (Tables 30 and 40) are **Applicable** requirements as cleanup standards for surface water to the extent they are more stringent than CWA 304{a) recommended criterion. State promulgated numeric water quality criteria are **Applicable** standards for controls on discharges of pollutants to state waters that may violate such criteria during the implementation of remedial actions, such as setting limits on short-term impacts from dredging and capping, and limits on point source discharges that may occur in implementing the remedy. Oregon's promulgated numeric water quality criteria are **Relevant and Appropriate** as cleanup standards for contaminated groundwater discharging to surface water.

Table 3-1 (continued)
Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBCs)
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Type of ARAR	Medium	Regulation/Citation	Criterion/Standard	ARAR/TBC Designation and Other Comments
Action-Specific ARAR	Actions that discharge dredged or fill material into navigable waters	Clean Water Act, Section 404, 33 U.S.C. 1344 and Section 404(b)(1) Guidelines, 40 CFR Part 230 (Guidelines for Specification of Disposal Sites for Dredged or Fill Material)	CWA §404 regulates the discharge of dredged or fill material into waters of the U.S, including return flows from such activity. This program is implemented through regulations set forth in the 404(b)(l) guidelines, 40 CFR Part 230. The guidelines specify: the restrictions on discharge (40 CFR 230.10); the factual determinations that need to be made on short-term and long-term effects of a proposed discharge of dredged or fill material on the physical, chemical, and biological components of the aquatic environment (40 CFR 230.11) in light of Subparts C through F of the guidelines; and the findings of compliance on the restrictions (40 CFR 230.12). Subpart J of the guidelines provide the standards and criteria for the use of all types of compensatory mitigation when the response action will result in unavoidable impacts to the aquatic environment.	Applicable criteria and guidelines for evaluating impacts to the aquatic environment from dredging contaminated sediment, placement of capping material and enhanced monitored natural recovery material, and in-situ treatment of sediments that will occur in implementing the remedy. Through an initial Section 404 analysis with RI/FS information, it was determined that the remedy can be implemented in compliance with Section 404 requirements. However, more detailed RD information will be required to fully assess impacts and specify all of the requirements and controls that will need to be placed on dredging and placement of capping or other materials in the river, including return flows, and riverbank remediation, to minimize or avoid the impacts, Also through the 404 analysis in RD, exact amounts of compensatory mitigation for unavoidable loss of aquatic habitat will be determined and mitigation plans developed.
Action-Specific ARAR	Actions that discharge pollutants to waters of U.S.	Clean Water Act, Section 402, 33 U.S.C. 1342	Regulates discharges of pollutants from point sources to waters of the U.S., and requires compliance with the standards, limitations and regulations promulgated per Sections 301, 304, 306, 307, 308 of the CWA. CWA §301(b) requires all direct dischargers to meet technology-based requirements. These requirements include, for conventional pollutants, application of the best conventional pollutant control technology (BCT), and for toxic and nonconventional pollutants, the best available technology economically achievable (BAT). Where effluent guidelines for a specific type of discharge do not exist, BCT/BAT technology-based treatment requirements are determined on a case-by-case basis using best professional judgment (BPJ). Once the BPJ determination is made, the numerical effluent discharge limits are derived by applying the levels of performance of a treatment technology to the wastewater discharge.	Relevant and Appropriate to remedial activities that result in a point source discharge of pollutants to the river if more stringent than state promulgated point source requirements.
Action-Specific ARAR		Clean Water Act, 33 U.S.C. 1341, (Section 401), 40 CFR Section, 121.2(a)(3), (4) and (5) Also see OAR 340-048-0015 "When Certification Required" pursuant to Oregon state law.	Any federally authorized activity which may result in any discharge into navigable waters requires reasonable assurances that the activity will be conducted in a manner which will not violate applicable water quality standards by the imposition of any effluent limitations, other limitations, and monitoring requirements necessary to assure the discharge will comply with applicable provisions of sections 1311, 1312, 1313, 1316, and 1317 of the Clean Water Act. Oregon administrative rule OAR 340-048-0015, Provides that federally-approved activities that may result in a discharge to waters of the State requires evaluation whether an activity may proceed and meet water quality standards with conditions, which if met, will ensure that water quality standards are met.	Relevant and Appropriate CWA 401 requirement, if more stringent than state implementation regulations, that in-water response actions that result in a discharge of pollutants comply with water quality standards through the placement of water quality- based conditions and other requirements on the discharge deemed necessary. The applicable state regulations require reasonable assurance that any discharge to state waters will comply with state water quality standards. Actions to implement the remedial action that may result in discharges to state waters include, but may not be limited to, dredging, capping, placement of material for enhanced natural recovery, riverbank remediation, return flows or de-watering sediments. Conditions and other requirements deemed necessary so that state water quality standards are not violated will be placed on any such discharge.

Table 3-1 (continued)
Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBCs)
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Type of ARAR	Medium	Regulation/Citation	Criterion/Standard	ARAR/TBC Designation and Other Comments
Action-Specific ARAR	Actions resulting in discharges to waters of the State of Oregon, including removal and fill activities	ORS 468B.025 and State water quality standards established by rule: OAR 340-041-0002 through 0059, and Willamette Basin Designated Uses and Basin-specific water quality standards at OAR 340-041-340 and OAR 340-041-345.	ORS 468B.025 prohibits pollution of any waters of the state and prohibits the discharge of any wastes into state waters if the discharge reduces the quality of the water below state water quality standards. By rule, the State establishes standards of quality and purity for the waters of the state	All state-wide and Willamette Basin-specific water quality standards, including numeric, narrative, and designated uses, are Applicable requirements for any discharges to surface water from point sources and remedial activities that may result in discharges to waters of the state, such as, dredge and fill, capping, placement of material for enhanced natural recovery, riverbank remediation, and return flows or de-watering sediments. State-wide and Willamette Basin-specific water quality standards are Relevant and Appropriate to measuring effectiveness of controls on contaminated groundwater discharging to surface water.
Action-Specific ARAR	Actions resulting in discharges from removal and fill activities	ORS 196.825(5) -Statutory requirement to mitigate for expected adverse effects of removal and fill activities. Applicable substantive mitigation rules are: OAR 141- 085-510, 141-085-680, 141-085 0685, 141-085-0690, 141-085-0710, 141-085-715.	State substantive requirements for mitigation for the reasonably expected adverse effects of removal or fill in a project development in waters of the state, including in designated Essential Indigenous Anadromous Salmonid Habitat.	Applicable compensatory mitigation standards and requirements for reasonably expected adverse effects, if any, from dredging, capping, placement of material for enhanced natural recovery, and riverbank remediation. The Site includes Essential Indigenous Anadromous Salmonid Habitat and the specifically-listed state regulations contain specific habitat mitigation standards not found in CWA Section 404 regulations for reasonably expected adverse effects of the dredging, capping and other remedial action activities, which will be incorporated into compensatory mitigation plans developed during RD.
Action-Specific ARAR	Actions in federal navigation channels	River and Harbors Act of 1899, Section 10, 33 U.S.C. Section 403 and implementing regulations at 33 CFR Sections 322{e), 323.3, 323.4(b)-(c) and 329	The creation of any obstruction not affirmatively authorized by Congress, to the navigable capacity of any of the waters of the United States is prohibited; and it shall not be lawful to build or commence the building of any wharf, pier, dolphin, boom, weir, breakwater, bulkhead, jetty, or other structures in any port, roadstead, haven, harbor, canal, navigable river, or other water of the United States, outside established harbor lines. 33 CFR 322(e) addresses placing of aids to navigation in navigable waters is under the purview of Section 10, and must meet requirements of the U.S. Coast Guard (33 CFR 330.S(a)(l)). 33 CFR Section 323.4(b) and (c) provide if any discharge of dredged or fill material contains any toxic pollutant listed under section 307 of the CWA such discharge shall require compliance with Section 404 of the CWA. Placement of pilings, or discharge of dredged material where the flow or circulation of waters of the United States may be impaired or the reach of such waters reduced must comply with Section 10. 33 CFR 329.4 defines the term "navigable water of the United States" for purposes of the USACE regulations, including those addressing the discharge of dredged or fill material.	Applicable requirement for how remedial actions are taken or constructed in the navigation channel so as not to create an obstruction to the navigable capacity. Applicable to the use of aids to navigation as institutional controls for maintaining the integrity of the selected remedy. Applicable to the placement of pilings or discharge of dredged material that may impair the flow or circulation of waters or reach of waters of the United States.
Action-Specific ARAR	Actions generating pesticide residue	Hazardous Waste and Hazardous Materials II. Identification and Listing of Hazardous Waste OAR 340-101-0033(6) and (7); OAR 340-100-00lO(j); and OAR 340-109-0010(3) and (4)	State regulations that identify and define pesticide residue as a state hazardous waste, but which are not subject to land disposal restrictions.	Applicable regulations for characterizing dredged material as a state hazardous waste for off-site disposal.

Table 3-1 (continued)
Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBCs)
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Type of ARAR	Medium	Regulation/Citation	Criterion/Standard	ARAR/TBC Designation and Other Comments
Action-Specific ARAR	Actions handling PCB remediation wastes and PCB containing material	Toxic Substances Control Act, 15 U.S.C. §2601 et seq., 40 CFR Part 761, Subpart D and OAR 340-110-0065 (1) and (2)	TSCA Subpart D regulates storage and disposal of PCB wastes and establishes requirements for handling, storage, and disposal of PCB-containing materials, including PCB remediation wastes, and sets performance standards for disposal technologies for materials/wastes with concentrations in excess of 50 mg/kg. Establishes decontamination standards for PCB contaminated debris. Oregon PCB storage for disposal regulations require the owners or operators of any facility using containers described in CFR 761.65(c)(7)(i) prepare and implement a Spill Prevention Control and Countermeasure plan as described in 40 CFR Part 112. In complying with 40 CFR Part 112, the owner or operator shall read "oil(s)" as "PCB(s)" whenever it appears. Because the remedy requires removal of sediment to specific depths and the maximum PCB concentrations detected in areas of the river to be dredged do not exceed 50 mg/kg, no substantive requirements triggered. If additional testing during RD identifies sediments at concentrations of 50 mg/kg PCBs, TSCA regulations may be applicable for managing dredged material for off-site disposal and listed here: 40 CFR 761.l(b)(S), 40 CFR 761.3, 40 CFR 761.SO(a) and (b)3, 40 CFR 761.61(a)(S) and (b), 40 CFR 761.65(c)(9)(i)-(iii), and 40 CFR 761(c).	TSCA decontamination and disposal requirements are Applicable to the disposal of contaminated dredged material, debris, or surface water with PCB contamination if dredged sediment is found to contain 50 mg/kg in concentration. Based on current data, PCB concentrations in dredged sediment at or above 50 mg/kg are not expected, but if found, the cleanup will comport with this standard. Certain types of debris that may be encountered and which appear to be PCB equipment or potentially from a PCB Containing source will require sampling and analysis compliant with TSCA to determine if it is PCB remediation waste and needs to be disposed of as such.
Action-Specific ARAR	Risk-based limits protective of human health for air emissions associated with soil or sediment removal	Clean Air Act, 40 CFR Parts 50 and 52	Places restrictions on air emissions from stationary and mobile sources that creates threats to human health as defined in the regulations and which may be generated from equipment used to construct the remedy.	These regulations are Relevant and Appropriate to evaluating how emissions may be minimized or reduced during construction of the remedy.
Action-Specific ARAR	Actions generating air emissions	Oregon Air Pollution Control ORS 468A et. seq., General Emissions Standards OAR 340-226	DEQ is authorized to administer and enforce Clean Air program in Oregon. Rules provide general emission standards for fugitive emissions of air contaminants and require highest and best practicable treatment or control of such emissions.	Applicable to remedial actions taking place on-site on upland properties. Could apply to earth-moving equipment, dust from vehicle traffic, and mobile-source exhaust, among other things.
Action-Specific ARAR	Actions that involve handling of dredged sediment or riverbank soils containing asbestos	National Emission Standards for Asbestos, 40 CFR 61.lS0(a)(l)(i) - (v)	40 CFR 61.lS0(a) requires that there be no visible emissions to the outside air during collection, processing, packaging, or transporting of any asbestos-containing waste material. Subsections (a)(l)(i) and (ii) require that asbestos-containing waste material be adequately kept wet and provide how to keep such wet so as not to discharge any visible emissions to the outside air. Subsection (a)(l)(iii) requires that after wetting, seal all asbestos-containing waste material in leak-tight containers while wet; or, for materials that will not fit into containers without additional breaking, put materials into leak-tight wrapping. Subsections (a)(l)(iv) and (v) require: Label the containers or wrapped materials specified in paragraph (a)(l)(iii) of this section using warning labels specified by Occupational Safety and Health Standards of the Department of Labor, Occupational Safety and Health Administration under 29 CFR 1910.1001(j)(4) or 1926.ll0l(k)(B). The labels shall be printed in letters of sufficient size and contrast so as to be readily visible and legible. For asbestos-containing waste material to be transported off the facility site, label containers or wrapped materials with the name of the waste generator and the location at which the waste was generated.	Relevant and Appropriate as standards for handling dredged sediment or riverbank soils containing asbestos that is going to on-site or off-site disposal facilities. Friable asbestos may be encountered during remediation in riverbanks and in the river where landfilling or disposal of friable asbestos occurred at industrial operations using such material, such as, chemical manufacturers and ship building and dismantling operations, and where encountered the cleanup will comport with this standard.

Table 3-1 (continued)
Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBCs)
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Type of ARAR	Medium	Regulation/Citation	Criterion/Standard	ARAR/TBC Designation and Other Comments
Action-Specific ARAR	Actions that involve off-site disposal of dredged sediment or riverbank soils containing asbestos	National Emission Standards for Asbestos, 40 CFR 61.150(b)(l) and (2) and (c)	40 CFR 61.150(b)(l) and (2) require: All asbestos-containing waste material shall be deposited as soon as is practical by the waste generator at a waste disposal site operated in accordance with the provisions of§ 61.154, or an EPA-approved site that converts regulated asbesots-containing material and asbestos-containing waste material into nonasbestos (asbestos-free) material according to the provisions of § 61.155. Subsection (c) requires: Mark vehicles used to transport asbestos-containing waste material during the loading and unloading of waste so that the signs are visible. The markings must conform to the requirements of §§ 61.149(d)(l)(i), (ii), and (iii).	Applicable to offsite transportation, treatment and disposal of asbestos-containing waste material segregated from contaminated environmental media such as sediment and soil that is generated during dredging or excavation of sediment and riverbank soils.
Action-Specific ARAR	Actions on the riverbanks that expose and manage on-site soils containing asbestos	National Emission Standards for Asbestos, 40 CFR 61.151(a)(2) and (3), 40 CFR 61.lSl(b)(l)(i) through (iii) and 40 CFR 61.15l(b)(2)	40 CFR 61.151(a)(2) requires: Cover the asbestos-containing waste material with at least 15 centimeters (6 inches) of compacted nonasbestos-containing material, and grow and maintain a cover of vegetation on the area adequate to prevent exposure of the asbestos- containing waste material. In desert areas where vegetation would be difficult to maintain, at least 8 additional centimeters (3 inches) of well-graded, nonasbestos crushed rock may be placed on top of the final cover instead of vegetation and maintained to prevent emissions. 40 CFR 61.15llb)(3) requires: Cover the asbestos-containing waste material with at least 60 centimeters (2 feet) of compacted nonasbestos-containing material, and maintain it to prevent exposure of the asbestos-containing waste. 40 CFR 61.lSl(b)(l)(i) through (iii) requires: (1) Display warning signs at all entrances and at intervals of 100 meters (328 feet) or less along the property line of the site or along the perimeter of the sections of the site where asbestos-containing waste material was deposited. The warning signs must: (i) Be posted in such a manner and location that a person can easily read the legend; and (ii) Conform to the requirements for 51 centimeters x 36 centimeters (20 inches x 14 inches) upright format signs specified in 29 CFR 1910.14S(d)(4) and this paragraph; and (iii) Display the following legend in the lower panel with letter sizes and styles of visibility at least equal to those specified in this paragraph. Spacing between any two lines must be at least equal to the height of the upper of the two lines. 40 CFR 61.151(b)(2) requires: Fence the perimeter of the site in a manner adequate to deter access by the general public.	Applicable to exposed asbestos-containing waste material and soils managed in situ on riverbanks during remediation or taken off-site for disposal.
Action-Specific ARAR	Actions generating air emissions	Fugitive Emission Requirements OAR 340- 208-0205, 0208, and 0209	State regulations that prohibit any person from openly accumulating asbestos material or asbestos-containing material and sets disposal requirements for Friable Asbestos and Nonfriable Asbestos	Applicable to remedial actions that may encounter friable or nonfriable asbestos material or asbestos-containing material and the off-site disposal of such.
Action-Specific ARAR	Actions that may alter waterbodies and that may effect fish and wildlife	Fish and Wildlife Coordination Act. 16 U.S.C. 662 and 663, SO CFR 6.302(g)	Requires federal agencies to consider effects on fish and wildlife from projects that may alter a body of water and mitigate or compensate for project-related losses, which includes discharges of pollutants to water bodies.	Applicable to determining impacts and appropriate mitigation, if necessary, for effects on fish and wildlife from filling activities or discharges from point sources.
Action-Specific ARAR	Actions that may affect ESA listed and State protected fish and wildlife species	ODFW Fish Management Plans for the Willamette River. OAR 635, div 500	Provides basis for in-water work (dredging and filling) windows in the Willamette River.	Applicable to placing restrictions on when dredging and filling can occur in the Willamette River due to presence of ESA listed and state protected species at the site.
Action-Specific ARAR	Actions that may affect marine mammals	Marine Mammal Protection Act. 16 U.S.C. §1361 et seq. 50 CFR 216	Imposes restrictions on the taking, possession, transportation, selling, offering for sale, and importing of marine mammals.	Applicable to response actions that could harm marine mammals in the Willamette River and may require best management practices be used for observing and avoiding contact with such species during construction of the remedy.

Table 3-1 (continued)
Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBCs)
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Type of ARAR	Medium	Regulation/Citation	Criterion/Standard	ARAR/TBC Designation and Other Comments
Action-Specific ARAR	Actions that may affect migratory birds	Migratory Bird Treaty Act. 16 U.S.C. §703 50 CFR §10.12	Makes it unlawful to take any migratory bird. "Take" is defined as pursuing, hunting, wounding, killing, capturing, trapping and collecting.	Applicable to response actions that could harm migratory birds using the Willamette River and may require use of best management practices for observing and avoiding contact with such species during construction of the remedy.
Action-Specific ARAR	On-site actions that involve generating, handling and disposal of hazardous waste	OAR 340-100-0001(3) and OAR 340-100-0002(1)	Oregon has adopted and incorporates by reference the federal RCRA hazardous waste management program. Oregon adopted the federal Hazardous Waste Identification Rule that provides for an exclusion for dredged materials subject to the requirements of a permit under the CWA or the Marine Protection, Research, and Sanctuaries Act from RCRA Subtitle C.	Oregon's hazardous waste and materials regulations are Applicable to the generation, storage, handling, treatment and disposal of hazardous waste on-site and slated for off- site disposal. Oregon's hazardous waste identification rule exempts handling and on- site management of dredged materials subject to the requirements of a permit under the CWA or Marine Protection, Research, and Sanctuaries Act. However, any dredged material that will be disposed of in an off-site disposal facility must comply with these standards.
Action-Specific ARAR	Actions generating solid wastes or hazardous wastes for off-site disposal	Solid waste defined in 40 CFR 261.2. Determining if solid waste is hazardous per 40 CFR § 262.ll(a-c) and OAR 340-102-0011 - Hazardous Waste Determination	Must determine if solid waste (residue as defined in OAR 340-100-0010) is a hazardous waste using the following method: • Should first determine if waste is excluded from regulation under 40 CFR 261.4; and • Must then determine if waste is listed as a hazardous waste under subpart D 40 CFR 261 or whether the waste is (characteristic waste) identified in subpart C of 40 CFR 261 by either: (1) Testing the waste according to the methods set forth in subpart C of 40 CFR 261, or according to an equivalent method approved by the Administrator under 40 CFR 260.21; or (2) Applying knowledge of the hazard characteristic of the waste in light of the materials or the processes used. Additionally, Oregon has promulgated its own hazardous waste determination regulation: "(1) The provisions of this rule replace the requirements of 40 CFR 262.11. (2) A person who generates a residue as defined in OAR 340-100-0010 must determine if that residue is a hazardous waste using the following method: (a) Persons should first determine if the waste is excluded from regulation under 40 CFR 261.4 or OAR 340-101-0004; (b) Persons must then determine if the waste is listed as a hazardous waste in Subpart D of 40 CFR 261; (c) Persons must then determine if the waste is listed under the following listings: NOTE: Even if the waste is listed, the person still has an opportunity under OAR 340-100- 0022 to demonstrate to the Commission that the waste from their particular facility or operation is not a hazardous waste. (d) Regardless of whether a hazardous waste is listed through application of subsections (2)(b) or (2)(c) of this rule, persons must also determine whether the waste is hazardous under Subpart C of 40 CFR 261 by either: (A) Testing the waste according to the methods set forth in Subpart C of 40 CFR 261, or according to an equivalent method the Department approves under OAR 340-100- 0021, or NOTE: In most instances, the Department will not consider approving a test method until the EPA approves it. (B) Applying knowledge of the hazard characteristic of the waste in light of the materials or the processes used."	Hazardous waste characterization and determination is Applicable for off-site disposal.
Action-Specific ARAR	Actions generating dredged material hazardous waste	40 CFR § 261.4(g)	Dredged material that is subject to the requirements of Section 404 of the CWA is not a hazardous waste for purposes of regulation under RCRA.	The exemption is Applicable to the dredging, in-situ treatment, handling, storage or other on-site activities of dredged materials that are being managed in accordance with Section 404 analysis and approvals.

Table 3-1 (continued)
Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBCs)
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Type of ARAR	Medium	Regulation/Citation	Criterion/Standard	ARAR/TBC Designation and Other Comments
Action-Specific ARAR	Actions generating RCRA hazardous waste that will be disposed of in a permitted off- site disposal facility	40 CFR § 264.B(a)(l)	Must obtain a detailed chemical and physical analysis on a representative sample of the waste(s), which at a minimum contains all the information that must be known to treat, store, or dispose of the waste in accordance with pertinent sections of 40 CFR 264 and 268.	This requirement is Applicable to characterizing dredged materials for off-site disposal.
Action-Specific ARAR	Actions generating RCRA hazardous waste	40 CFR § 268.7(a)(l)	Must determine if the hazardous waste has to be treated before land disposed. This is done by determining if the waste meets the treatment standards in 40 CFR 268.40, 268.45, or 268.49 by testing in accordance with prescribed methods or use of generator knowledge of waste. This determination can be made concurrently with the hazardous waste determination required in 40 CFR 262.11. Must comply with the special requirements of 40 CFR § 268.9 in addition to any applicable requirements in 40 CFR § 268.7.	This requirement is Applicable to characterizing and treating dredged materials slated for off-site disposal.
Action-Specific ARAR		40 CFR § 268.9(a)	Must determine each EPA Hazardous Waste Number (waste code) applicable to the waste in order to determine the applicable treatment standards under 40 CFR 268 et seq. This determination may be made concurrently with the hazardous waste determination required in Sec. 262.11 of this chapter. Must determine the underlying hazardous constituents [as defined in 40 CFR 268.2(i)] in the characteristic waste.	This requirement is Applicable to characterizing and treating dredged materials slated for off-site disposal.
Action-Specific ARAR	Actions generating industrial wastewater	40 CFR § 261.4(a)(2)	Industrial wastewater discharges that are point source discharges subject to regulation under section 402 of the CWA, as amended, are not solid wastes for the purpose of hazardous waste management. [Comment: This exclusion applies only to the actual point source discharge. It does not exclude industrial wastewaters while they are being collected, stored or treated before discharge, nor does it exclude sludges that are generated by industrial wastewater treatment.]	This requirement is Applicable to wastewater generated by the remedy that will be discharged from a point source in accordance with Section 402 of the CWA.
Action-Specific ARAR	Actions requiring temporary storage of hazardous waste	OAR 340-102-0034 40 CFR 262.34(a); 40 CFR 262.34(a)(l)(i); 40 CFR 262.34(a)(2) and (3) 40 CFR 262.34(c)(l)	A generator may accumulate hazardous waste at the facility provided that (accumulation of RCRA hazardous waste on site as defined in 40 CFR 260.10): • waste is placed in containers that comply with 40 CFR 265.171-173; and • the date upon which accumulation begins is dearly marked and visible for inspection on each container; • container is marked with the words "hazardous waste"; or • container may be marked with other words that identify the contents if accumulation of 55 gallon or less of RCRA hazardous waste or one quart of acutely hazardous waste listed in § 261.33(e) at or near any point of generation Oregon hazardous waste regulations further require: (1) In addition to the requirements of 40 CFR 262.34, a generator may accumulate hazardous waste on-site for 90 days or less without a permit provided that, if storing in excess of 100 containers, the waste is placed in a storage unit that meets the Accumulation requirements of 40 CFR 264.175 and (2) A generator shall comply with provisions found in 40 CFR 262 and each applicable requirement of 40 CFR 262.34(a), (b), (c), (d), (e), and (f).	The substantive requirements are Applicable to temporary storage of hazardous waste at an on-site transloading facility, but no permit will be required.

Table 3-1 (continued)
Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBCs)
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Type of ARAR	Medium	Regulation/Citation	Criterion/Standard	ARAR/TBC Designation and Other Comments
Action-Specific ARAR	Actions resulting in the storage of solid waste	OAR 340-093-0210 and 0220	State of Oregon solid waste general provisions regarding storage and collection of solid waste and transportation related requirements for trucks servicing a solid waste collection facility.	Applicable requirements to operation of an on-site transloading facility for dredged materials slated for off-site disposal.
Action-Specific ARAR	Actions resulting in the storage of solid waste	OAR 340-095-0010, 0020, 0030, 0050(1) & (2), 0070(2)	State of Oregon solid waste regulations for solid waste land disposal sites other than municipal solid waste landfills. Specifically, regulations related to the location siting, operating criteria, design criteria, groundwater monitoring and closure requirements for a non-municipal solid waste landfill.	Applicable requirements to the siting, design, operation and closure of an on-site transloading facility for dredged material slated for off-site disposal.
Action-Specific ARAR	Actions transporting hazardous materials	49 CFR 171.l(b)	Any person who, under contract with a department or agency of the federal government, transports "in commerce," or causes to be transported or shipped, a hazardous material shall be subject to and must comply with all applicable provisions of the HMTA and HMR at 49 CFR 171 - 180 related to marking, labeling, placarding, packaging, emergency response, etc.	**Applicable** to transportation of hazardous materials.
Action-Specific ARAR	Actions that involve storage and treatment of hazardous waste at the transloading facility	40 CFR 264, Subparts B, C, F, G, I, J, K, L, M, AA, BB, CC, and DD	These regulations provide standards for location, design, operation, and closure of units in which treatment of hazardous waste may occur at the transloading facility. These regulations also provide requirements for use and management of containers, tank systems, surface impoundments, waste piles, and land treatment units one or more of which may be used for the storage and treatment of hazardous waste at the transloading facility. Subparts AA, BB, and CC provide air emission standards for process vents, equipment leaks, and tanks, surface impoundments and containers may be used at the transloading facility.	The listed requirements of Part 264 are **Applicable** to the siting, design, operation, and closure of any containers, tank systems, surface impoundments, waste piles or land treatment areas used for the storage (over 90 days) and/or treatment of hazardous waste on-site prior to disposal off-site. The specific storage system and treatment methods that may be employed at the on-site transloading facility will be determined during RD.
Location-Specific ARAR	Presence of archaeologically or historically sensitive area	Native American Graves Protection and Reparation Act, 25 U.S.C. 3001-3013, 43 CFR 10	Requires Federal agencies and museums which have possession of or control over Native American cultural items (including human remains, associated and unassociated funerary items, sacred objects and objects of cultural patrimony) to compile an inventory of such items. Prescribes when such Federal agencies and museums must return Native American cultural items. "Museums" are defined as any institution or State or local government agency that receives Federal funds and has possession of, or control over, Native American cultural items.	If Native American cultural items are present on property belonging to the Oregon Division of State Lands (DSL) that is a part of the response action area, this requirement is **Applicable.** If Native American cultural items are collected by an entity which is either a federal agency or museum, then the requirements of the law are **Applicable.**
Location-Specific ARAR		Indian Graves and Protected Objects ORS 97.740-760	Prohibits willful removal of cairn, burial, human remains, funerary object, sacred object or object of cultural patrimony. Provides for re-interment of human remains or funerary objects under the supervision of the appropriate Indian tribe. Proposed excavation by a professional archaeologist of a native Indian cairn or burial requires written notification to the State Historic Preservation Officer and prior written consent of the appropriate Indian tribe. Prohibits persons from excavating, injuring, destroying, or damaging archaeological sites or objects on public or private lands unless authorized.	**Relevant and Appropriate** if archaeological material is encountered.
Location-Specific ARAR		Archaeological Objects and Sites ORS 358.905- 955 ORS 390.235	Imposes conditions for excavation or removal of archaeological or historical materials.	**Relevant and appropriate** if archaeological material encountered.

Table 3-1 (continued)
Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBCs)
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Type of ARAR	Medium	Regulation/Citation	Criterion/Standard	ARAR/TBC Designation and Other Comments
Location-Specific ARAR	Presence of archaeologically or historically sensitive area	National Historic Preservation Act. 16 U.S.C. 470 et seq. 36 CFR Part 800	Requires the identification of historic properties potentially affected by the agency undertaking, and assessment of the effects on the historic property and seek ways to avoid, minimize or mitigate such effects. Historic property is any district, site, building, structure, or object included in or eligible for the National Register of Historic Places, including artifacts, records, and material remains related to such a property.	**Applicable** if historic properties are potentially affected by remedial activities.
Location-Specific ARAR	Presence of archaeologically or historically sensitive area	Archaeological and Historic Preservation Act. 16 U.S.C. 469a-1	Provides for the preservation of historical and archaeological data that may be irreparably lost as a result of a federally-approved project and mandates only preservation of the data.	**Applicable** if historical and archaeological data may be irreparably lost by implementation of the remedial activities.
Location-Specific ARAR	Presence of floodplain as designated on FEMA Flood Insurance map	44 CFR 60.3(d){2) and (3)	Prohibits encroachments that would result in any increase in flood levels during occurrence of base flood discharge.	FEMA flood rise requirements are considered **Relevant and Appropriate** requirements for remedial actions that involve capping or other placement of material in the river or on riverbanks that may increase flood levels.
Location-Specific ARAR	Presence of floodplain as designated on map	Federal Emergency Management Act regulations at 44 CFR 9 (which sets forth the policy, procedure and responsibilities to implement and enforce Executive Orders 11988 (Management of Floodplain) **To Be Considered,** as amended by E.O. 13690 and 11990 (Protection of Wetlands) **To Be Considered**	44 CFR 9 (Requirements for Flood Plain Management Regulations Areas) Requires measures to reduce the risk of flood loss, minimize the impact of floods, and restore and preserve the natural and beneficial values of floodplains. Executive Orders 11988 as amended by 13690 direct federal agencies to evaluate the potential effects of action that may be taken in a floodplain and to avoid, to the extent possible, long-term and short-term adverse effects associated with the occupancy and modification of floodplains, and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative. Executive Order 11990 directs that activities conducted by federal agencies avoid, to the extent possible, long-term and short-term adverse effects associated with the modification or destruction of wetlands and to avoid direct or indirect support of new construction in wetlands when there are practicable alternatives.	The substantive identified FEMA regulations are **Relevant and Appropriate** for assessing impacts, if any, to the floodplain and flood storage from the response action and developing compensatory mitigation that is beneficial to floodplain values. Substantive portions of the Executive Order are **To-Be- Considered.**
Location-Specific ARAR	Presence of wetlands	Executive Order for Wetlands Protection. Executive Order 11990 (1977) **To Be Considered**	Requires measures to avoid adversely impacting wetlands whenever possible, minimize wetland destruction, and preserve the value of wetlands.	**To Be Considered** guidelines in assessing impacts to wetlands, if any, from the response action and for developing appropriate compensatory mitigation for the project.
Location-Specific ARAR	Presence of state-listed threatened or endangered wildlife species	Protection and Conservation Programs ORS. 496.171 to 496.182. Survival Guidelines OAR 635-100-0135	Survival Guidelines are rules for state agency actions affecting species listed under Oregon's Threatened or Endangered Wildlife Species law.	Substantive requirements of Survival Guidelines are **Relevant and Appropriate** to remedial activities affecting state-listed species.
Location-Specific ARAR	Presence of essential fish habitat	Magnuson-Stevens Fishery Conservation and Management Act. 50 CFR 600.920	Requires federal agencies consult with NMFS on actions that may adversely affect Essential Fish Habitat (EFH), defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."	**Applicable** because the National Marine Fisheries Service has designated the Lower Willamette River as EFH. EPA evaluated effects to EFH from the proposed remedial action in a biological assessment.

Table 3-1 (continued)
Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBCs)
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Type of ARAR	Medium	Regulation/Citation	Criterion/Standard	ARAR/TBC Designation and Other Comments
Location-Specific ARAR	Presence of federally endangered or threatened species	Endangered Species Act. 16 U.S.C. 1536 (a)(2), Listing of endangered or threatened species per 50 CFR 17.11 and 17.12 or designation of critical habitat of such species listed in 50 CFR 17.95	Actions authorized, funded, or carried out by federal agencies may not jeopardize the continued existence of endangered or threatened species or result in the adverse modification of species' critical habitat. Agencies are to avoid jeopardy or take appropriate mitigation measures to avoid jeopardy.	**Applicable** to RAs that may impact endangered or threatened species or critical habitat that are present at the site. Listed species are found at the Site, and critical habitat for listed salmonids has been designated within the site. Coordination will occur with the National Marine Fisheries Service and US Fish and Wildlife Service regarding actions to be taken, their impacts on listed species, and measures that will be taken to reduce, minimize, or avoid such impacts so as not to jeopardize the continued existence or adversely modify critical habitat. If take cannot be avoided, take permission from the Services will be obtained. EPA evaluated effects to listed and threatened species and critical habitat from the proposed RA in a preliminary biological assessment. As further details are developed in RD, the biological assessment will be supplemented.

Table 5-1
Remedial Technology for Preferred Remedial Approach Areas
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Remedial Approach	Estimated Area (ft^2)	% of Area
In SMA (Figure 5-1)		**79%**
Special Consideration for Work Around Structures	1,282,130	27%
Special Considerations for Potential Erosive Banks	40,648	0.85%
Dredging to RAL	355,548	7.4%
Dredging and/or Capping	3,102,985	65%
Total Area in SMA:	*4,781,311*	*100%*
Riverbank (Figure 5-2)		**10%**
Special Consideration for Work Around Structures	290,344	48%
Special Considerations for Potential Erosive Banks	240,975	39%
Enhanced Natural Recovery/In-Situ Treatment	17,132	2.8%
Monitored Natural Recovery	152	0.02%
Bank Stabilization, Capping and/or Dredging/Excavation	61,569	10%
Total Riverbanks Area:	*610,172*	*100%*
Potential Revegetation Areas (this area overlaps the other areas)	333,086	55%
Outside of SMA Within Project Area (Figure 5-2)		**11%**
Special Consideration for Work Around Structures	375,095	59%
Special Considerations for Potential Erosive Banks	127,836	20%
Enhanced Natural Recovery/In-Situ Treatment	113,365	18%
Monitored Natural Recovery	13,853	2%
Bank Stabilization, Capping and/or Dredging/Excavation	2,516	0.4%
Total Area Outside of SMA, but within Project Area:	*632,665*	*100%*

Notes:
% of Area in highlighted cells calculates the percentage of the preferred remedial approach areas as compared to the total Project Area.
% of assigned remedial technologies/considerations within preferred remedial approach areas are calculated as compared *to the total respective area.*
ft = feet
RAL = remedial action level
RD = Remedial Design
SMA = sediment management area

Table 6-3
Remaining Estimated Service Life Summary
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Structure	Year Built	Age (years)	Estimated Service Life without Rehabilitation or Renewal? (years)	Condition?	May Require Historic Review
USCG Pier	1974	50	30 - 40	Fair	Yes
USCG Dock	1974	50	30 - 40	Fair	Yes
U.S. Navy Pier	1973	51	30 - 40	Fair	Yes
MC Pier	Unknown	Unknown	30 - 40	Fair	Unknown
Dredge Base	1970	54	0 - 10	Serious	Yes
Berth 311	1966	58	0 - 10	Serious	Yes
The Swan Island Boat Ramp	1987	37	30 - 40	Fair	No
Wind Tunnel	2002	22	45 - 50	Satisfactory	No
Berth 308	1971	53	15 - 25	Poor	Yes
Berth 307	1971	53	15 - 25	Poor	Yes
Berth 306	1971	53	30- 40	Fair	Yes
Lagoon Wharf – Berths 302 – 305	1950	74	15 - 25	Poor	Yes
Pier A	1962	62	0 - 10	Serious	Yes
Pier C	1962	62	30 - 40	Fair	Yes
Quay Wall	1962	62	0 - 10	Serious	Yes
SCC Floating Dock	Unknown	Unknown	35 - 50	Satisfactory	Unknown
East Pier	1979	45	30 - 40	Fair	Yes
West Pier	1979	45	15 - 25	Poor	Yes
Demo Pier	1986	38	30 - 40	Fair	Yes
Pier D	1979	45	50+	Fair	No

Notes:
MC = The Marine Consortium, Inc.
SCC = Shipyard Commerce Center
USCG = U.S. Coast Guard

Table 6-4
Potential Remedial Action Construction Impact Risk Summary
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Structure	Potential Remedial Action Construction Impact
USCG Pier	Medium Risk due to shallow slopes and minimal structure.
USCG Floating Dock	Low Risk due to added loads on structure due to capping.
U.S. Navy Pier	Medium Risk due to added loads on structure due to capping.
MC Pier	Medium Risk due to shallower slope and contaminants close to the surface.
Dredge Base	Medium Risk due to shallower slope and minimal structure.
Berth 311	Medium Risk due to unknown depth to contamination and possible dredging to navigation depth.
Swan Island Boat Ramp	Low Risk due to shallow slope and minimal structure, however ramp may require reconstruction.
Wind Tunnel	Medium Risk due to slope and capping loads.
Berth 308	High Risk due to over-steepened slope and unknown extent of contaminated soil.
Berth 307	High Risk due to over-steepened slope and unknown contaminate depth below structure.
Berth 306	High Risk due to over-steepened slope and unknown extent of contaminated soil.
Lagoon Wharf – Berths 302–305	High Risk due to over-steepened slope and unknown extent of contaminated soil.
Pier A	High Risk due to age of structure, known deterioration, and stability concerns.
Pier C	Low Risk due to deep piling and redundant nature of structure.
Quay Wall	High Risk due to age of structure, known deterioration, and stability concerns.
SCC Floating Docks	Low Risk due to shallow slope and minimal structure.
East Pier	Medium Risk due to shallow slope and minimal structure.
West Pier	Medium Risk due to shallow slope and minimal structure.
Demo Pier	Medium Risk due to shallow slope and near surface contaminants.
Pier D	Low Risk due to deep piling and redundant nature of structure.

Notes:
Low Risk = Structure and/or slope likely able to support RA activities with minimal or no modifications.
Medium Risk = Impact of RA activities on structure and/or slope is uncertain, modifications may be required, further evaluation required during RD.
High Risk = Structure and/or slope cannot support RA activities without significant modifications

MC = The Marine Consortium, Inc.
RA = Remedial Action
SCC = Shipyard Commerce Center
USCG = U.S. Coast Guard

Table 6-5
Summary of Vessel Traffic, Frequency, and Potential Conflicts
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

Facility	Transits Per Year	Vessel Types/Sizes	Total Potential Conflicts (Yearly)	Size of Transit Corridor	Vessel Transits within SIB Polygon	Reduce Footprint to Minimize Potential Conflicts?
USCG	19	Small Max LOA <100 ft	104	Short	Infrequent (may be incomplete)	No
The Marine Consortium Inc.	7	Small-Medium Max LOA <400 ft	85	Medium	Infrequent	No
Dredge Base	535	Small-Medium Max LOA <200 ft	5,379	Medium	Moderate	Potentially – Berthed barges/dredgers and multiple vessels lashed together
Berth 311	533	Small-Medium Max LOA <400 ft	12,468	Long	Infrequent	Potentially – Multiple vessels lashed together
Berths 306 / 307	15	Small-Medium Max LOA <200 ft	81	Long	Infrequent	Potentially – Barges lashed to beam of AFDB
Pier A/Lagoon Wharf (Berths 301-305)	266	Small-Large Max LOA >600 ft	4,245	Medium	Infrequent-Moderate	No
Pier D/Berth 312	98	Small-Large Max LOA >600 ft	953	Short	Infrequent-Moderate	No
Dry Docks	83	Small-Large Max LOA >600 ft	1130	Short	Infrequent-Moderate	No

Notes:
> = less than
< = greater than
ft = feet
AFDB = auxiliary floating dry dock
LOA = length overall
SIB = Swan Island Basin
USCG = U.S. Coast Guard

Table 10-1
Concept Remedial Design Risk Register for Cost Analysis
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

ID	Risk Category/ Name	Description	Notes/Assumptions	Mitigation/Avoidance Measures
	Design Phase Risks Risks which can be managed/reduced during the design phase.			
1	EPA/State Regulatory Approvals/Licenses	1. Final approved remedy (dredging vs capping) 2. Extended periods required to obtain and comply with approvals, permits or licenses for land access and operations	None	1. Designer to propose an approach to dredging and/or capping which meets project goals and is acceptable to the owner. 2. Identify the regulators' preferred approach to streamline permits, licenses and/or approvals to meet project timelines.
2	Contracting Strategy	Sub-optimal contracting strategy, contractor selection and ongoing management of activities, costs, and time	None	Identify optimal strategy for contractor selection, contracting and management based on experience of designer and owners, noting any downside risks and fallback strategies.
3	Sediment Removal	1. Volume associated with selected remedial approach 2. Latent conditions associated with removal of the sediment	None	1. Designer to evaluate a range of possible approaches and propose a preferred approach to optimize removal volumes to meet requirements at lowest cost and/or highest effectivity of operations. 2. Complete thorough on-site characterization of sediment to reduce risk of unknown latent conditions.
4	Capping	1. Capping area associated with selected remedial approach 2. Configuration/thickness of cap(s)	None	Designer to evaluate a range of possible approaches and propose a preferred capping area and cap thickness design to meet requirements at lowest cost and/or highest effectivity of operations.
5	Shoreline Remediation	1. Extent of remediation required 2. Configuration of backfill/cap	None	1. Site assessment shall fully characterize limits of required shoreline contamination. 2. Designer shall evaluate how to optimize tradeoff between excavation and capping to meet remediation requirements.

Table 10-1 (continued)
Concept Remedial Design Risk Register for Cost Analysis
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

ID	Risk Category/ Name	Description	Notes/Assumptions	Mitigation/Avoidance Measures
6	contractor Management	Poor contractor(s) selection or ongoing HSEC management	None	1. Performance record qualifications and references shall be clearly identified in solicitation documents and verified during bid review. Contractors shall be disqualified for not meeting bid requirements. 2. Contractor performance requirements shall be fully spelled out in contract documents with financial penalties and/or rationale for dismissal for non-performance. Performance shall be reviewed monthly with reporting and discussion with contractor for any non-performance issues and ramifications for continued non-compliance.
	Construction Phase Risks – Internal Those construction phase risks which the contractor can pro-actively manage prior to and/or during construction			
7	Procurement	Unable to source and/or store sufficient quantities of equipment, construction materials or consumables (dredges, barges, transportation, etc.)	None	Require contractor to designate a procurement lead responsible for developing a procurement plan for all major materials, equipment, and consumables using early-finish scheduling approach with monthly reporting on acquisition and stockpile status. Establish a required minimum lead time for critical elements during design phase and include as part of contract documents.
8	Dredging Operations	Failure to undertake dredging of contaminated sediment in an effective and timely manner	None	Require contractor to submit dredging schedule as a part of the operations plan and include daily penalties for inability to meet performance requirements/schedule, or incentives to exceed performance requirements/schedule.
9	Sediment Processing	Process facility unavailable or method fails to meet treatment requirements	None	Define performance requirements within design documents with contractor daily penalties for inability to meet performance requirements/schedule, or incentives to exceed performance requirements/schedule.

Table 10-1
Concept Remedial Design Risk Register for Cost Analysis
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

ID	Risk Category/ Name	Description	Notes/Assumptions	Mitigation/Avoidance Measures
10	Disposal Facilities	Insufficient capacity or failure of disposal facility during period of remediation	None	Ensure design identifies disposal facility with volumetric capacity and daily operational characteristics in excess of anticipated need.
11	Transportation	Insufficient capability or effective means to transport sediment to the processing and/or disposal facility	None	Require contractor to provide transportation plan sufficient to transport all materials to processing / disposal site with daily penalties for inability to meet performance requirements/schedule, or incentives to exceed performance requirements/schedule.
12	Existing Shoreline Structures Integrity	Damage/Failure of the existing shoreline structures	None	Identify during the design phase all sensitive shoreline structures with construction setback limits that are protective of structures and include daily checks by construction inspection staff to confirm setbacks are being honored. Include penalties for contractor activities which encroach within setback limits and/or damage shoreline structures.
13	Loss of Containment	Unacceptable or excessive in-situ movement, spillage or leakage of material during sediment removal or treatment operations	None	Designer to identify containment requirements in design documents. Require contractor to develop a containment plan which is inspected on a daily basis during construction, with weekly reporting.
14	Construction Safety	Safety-related events arising from construction of project establishment, infrastructure facilities, and key treatment & disposal facilities	None	Require contractor to develop and maintain a site safety plan that meets or exceeds OSHA requirements, with daily reporting of safety events.
15	Occupational Health & Hygiene	Exposure to contaminant's during all operations	None	Require contractor to develop and maintain a site safety plan that meets or exceeds OSHA requirements, with daily reporting of safety events.

Table 10-1
Concept Remedial Design Risk Register for Cost Analysis
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

ID	Risk Category/ Name	Description	Notes/Assumptions	Mitigation/Avoidance Measures
16	Emergency Response	Inadequacy of response to a major river or land based HSEC event	None	Require contractor to develop and maintain an emergency response plan, with at least weekly confirmation of readiness of response materials by construction inspector.
17	Demobilization & Disposal	Construction materials are not removed from site on a timely manner and/or improperly disposed	None	Require contractor to develop a materials disposal plan identifying the materials to be disposed with allowable on-site quantities and an approved off-site disposal facility for each type of material to be disposed of off site.
18	Compensatory Habitat	Compensatory habitat fails to meet regulatory requirements	None	Require contractor to submit all materials, means and methods for creation, establishment and maintenance of the mitigation measures. Inspect at specified intervals to ensure compliance.
	Construction Phase Risks – Community Risks which likely will involve community members due to impacts outside of the project area.			
19	Site Security	Incident or accident arising from unauthorized access to land or river operations	None	Require contractor to develop a site security plan which includes on-site security personnel and video monitoring prior to start of construction and revisit at least monthly during construction.
20	Operational Interactions During Construction	Interactions with third party land-based infrastructure and/or activities	None	Require contractor to develop an operations plan which identifies all possible interactions with off-site third parties and/or privately-owned adjacent infrastructure/land with mitigation strategies.
21	River Operations	Accident between vessels, vessel and shore structure, or vessel and services	None	Require contractor to develop a river operations safety plan.
22	Dust and/or Odor	Sub-optimal management of off-site dust or odor-related impacts arising from construction activities	None	Perform pre-construction baseline air quality monitoring and continuous monitoring during construction to provide early detection and control of possible exceedances.

Table 10-1 (continued)
Concept Remedial Design Risk Register for Cost Analysis
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

ID	Risk Category/ Name	Description	Notes/Assumptions	Mitigation/Avoidance Measures
23	Transportation	Safety-related accident or environmental incident arising from offsite transportation of materials between sites and/or to disposal facility	None	Require contractor's transportation safety plan to incorporate all possible interactions with offsite vehicles and/or community members.
24	Community/Third Party Stakeholders	Disruption to and/or loss of amenity for the local community and/or loss of trust/reputation	None	Identify all possible amenity loss/disruptions during design phase and public outreach process and develop requirements for contractor to pro-actively manage and limit activities which could cause possible loss/disruption.
	Construction Phase Risks – Extrinsic Those construction phase risks which are largely outside of the control of the designer or contractor.			
25	Major Utilities Outage	Disruption in supply of power and/or water	Storm and/or off-site activities severs utilities feed(s) to site	Prepare contingency plan to supply utilities to critical site operations in case of outage.
26	Archaeological find	Encounter archaeological materials during streambank excavation	Need to pause excavation – relocate crew to next sequential excavation area	Archaeological analysis complete and reviewed by stakeholders > 6 months prior to excavation. Have archaeologist on site during excavation in high-risk areas. Have two or more work areas prepped at excavation start.
27	Diesel fuel cost increase	Disruption in national supply causes >20% increase in cost of diesel fuel	Cost impact only significant during peak construction	Identify peak construction period, identify alternate suppliers and/or obtain fuel supply in advance via negotiated fixed price or create stockpile.

Table 10-1 (continued)
Concept Remedial Design Risk Register for Cost Analysis
Basis of Design Report, Swan Island Basin Project Area, Portland, Oregon

ID	Risk Category/ Name	Description	Notes/Assumptions	Mitigation/Avoidance Measures
28	Heavy summer downpour	2-week long heavy rainstorm during summer construction	Heavy long rainstorm will shut down upland excavation activities and slow in-water dredging due to complications in managing dredge materials	Investigate opportunities to perform dredge materials management in facility that is not impacted by rain, consider how upland excavation can be sequenced and/or erosion control options to allow excavation to move forth in heavy rain.
29	Undetonated Explosives	Discovery of historical explosives/undetonated explosives	Pause local excavation, relocate equipment to safe work area	Survey site for unexploded ordinance ahead of contractor mobilization.
30	Smoke Delay	Hazardous air quality due to wildfire smoke	Need to issue masks, shut down if extreme heat and/or low visibility	Monitor weather, fire index and air quality.
31	Public Process	Public opposition/ litigation	Possible shut-down of cleanup activities if public process identifies lack of sufficient/correct public process per EPA protocol	Ensure thorough public process is completed prior to advertisement of Remedial Action documents.

Notes:
EPA = U.S. Environmental Protection Agency
HSEC = Health, Safety, Environment and Community
OHSA = Occupational Health and Safety Administration

FIGURES

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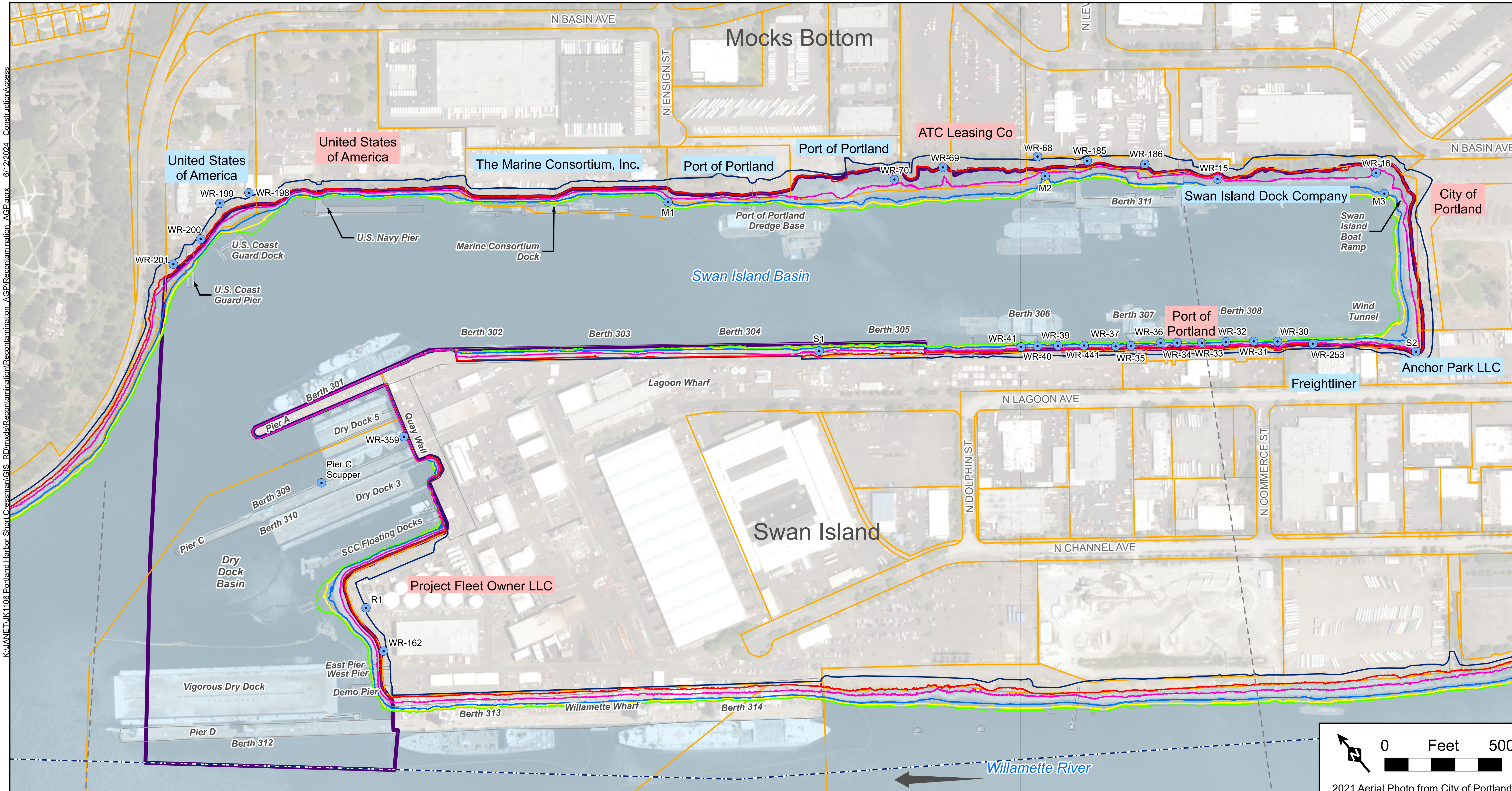

Active Stormwater Outfalls
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
River Mile (RM)
Docks and Structures
Tax Lot Boundary
Name Adjacent Property Owner
Name Adjacent Property Owner with Potential Construction Access

Top of Bank
20.075 ft NAVD88 Ordinary High Water
13 ft NAVD88 Mean High Water
5.1 ft NAVD88 Ordinary Low Water
7.28 ft NAVD88 Mean Low Water
3.28 ft NAVD88
River Flow Direction

Notes:
ft – feet
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

Potential construction access locations are only a suggestion and access has not yet been obtained for any of these locations. This topic will be discussed in the communication with owners and operators.
As discussed in BODR Section 2.6.4, +3.28 NAVD88 is the boundary between intermediate and shallow regions, whereas +13 ft NAVD88 is the boundary between shallow and riverbank regions. Riverbank extends from 13 ft NAVD88 to top of bank.

Figure 2-1
Swan Island Basin Project Area

Prepared on: 6/12/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

Pacific groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP

Image Source: Google Earth Pro. 2024. Image: U.S. Geologic Survey and NASA. Accessed on February 14. At URL: https://earth.google.com/web/search/swan+island+basin/@45.56636525,-122.71316074,-0.29924747a,2136.04217979d,35y,0h,0t,0r/

Figure 2-2

Timeline of Changes to Swan Island Shoreline Resulting from Fill and Dredge Activities

Prepared on: 4/9/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

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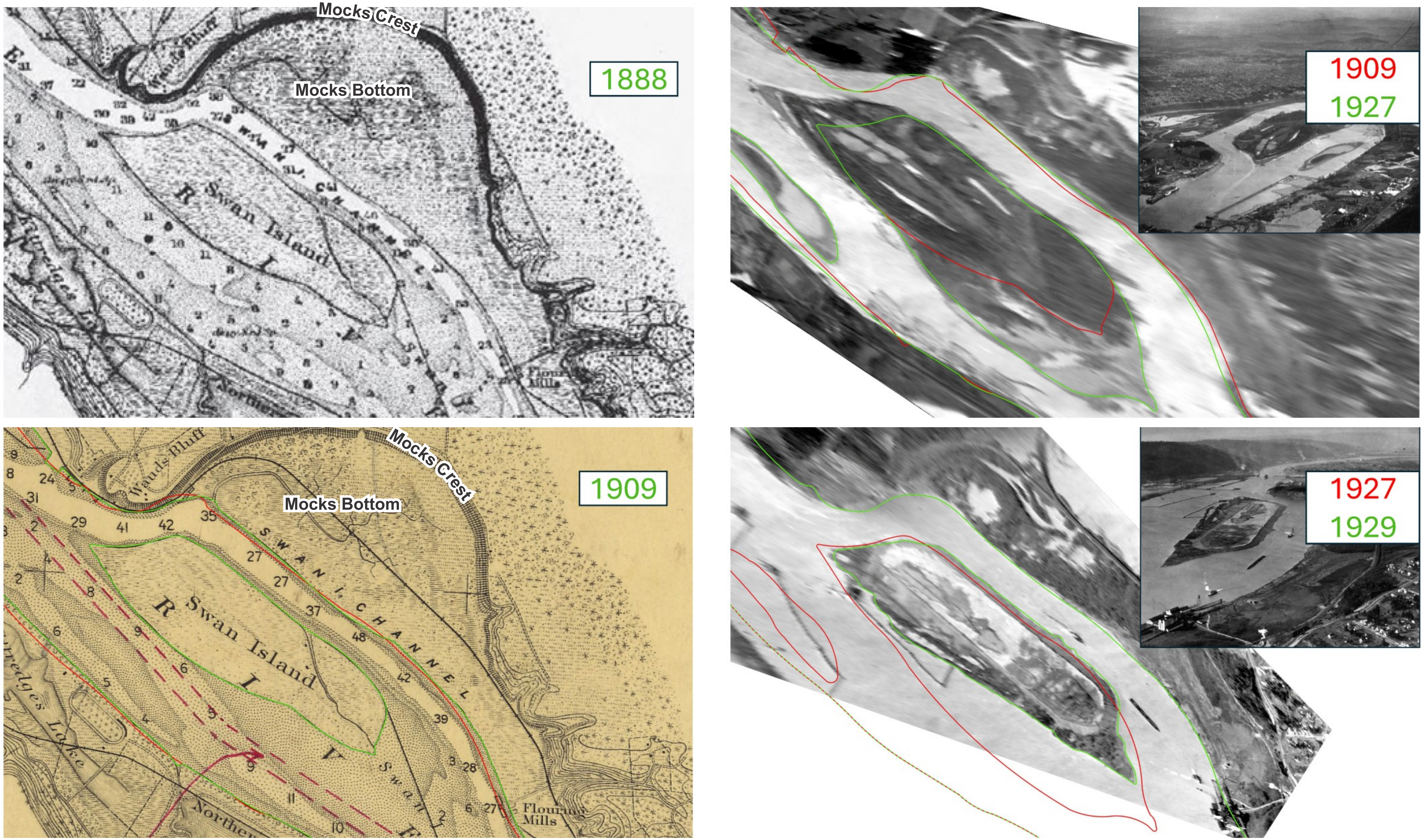

Imagery Sources:
1888: U.S. Coast and Geodetic Survey. 1888. Columbia River: Fales Landing to Portland.
1909: U.S. Coast and Geodetic Survey. 1909. Columbia River Saint Helens to Willamette River including Vancouver and Portland. Scale 40000. No. 6154.
1927-1929: Ash Creek Associates, Inc. 2006. Draft Report Supplemental Preliminary Assessment Swan Island Upland Facility. Port of Portland, Portland, Oregon, 97209. December.

Figure 2-3
Swan Island Basin in 1888-1929

Prepared on 4/23/2024

Basis of Design Report
Swan Island Basin

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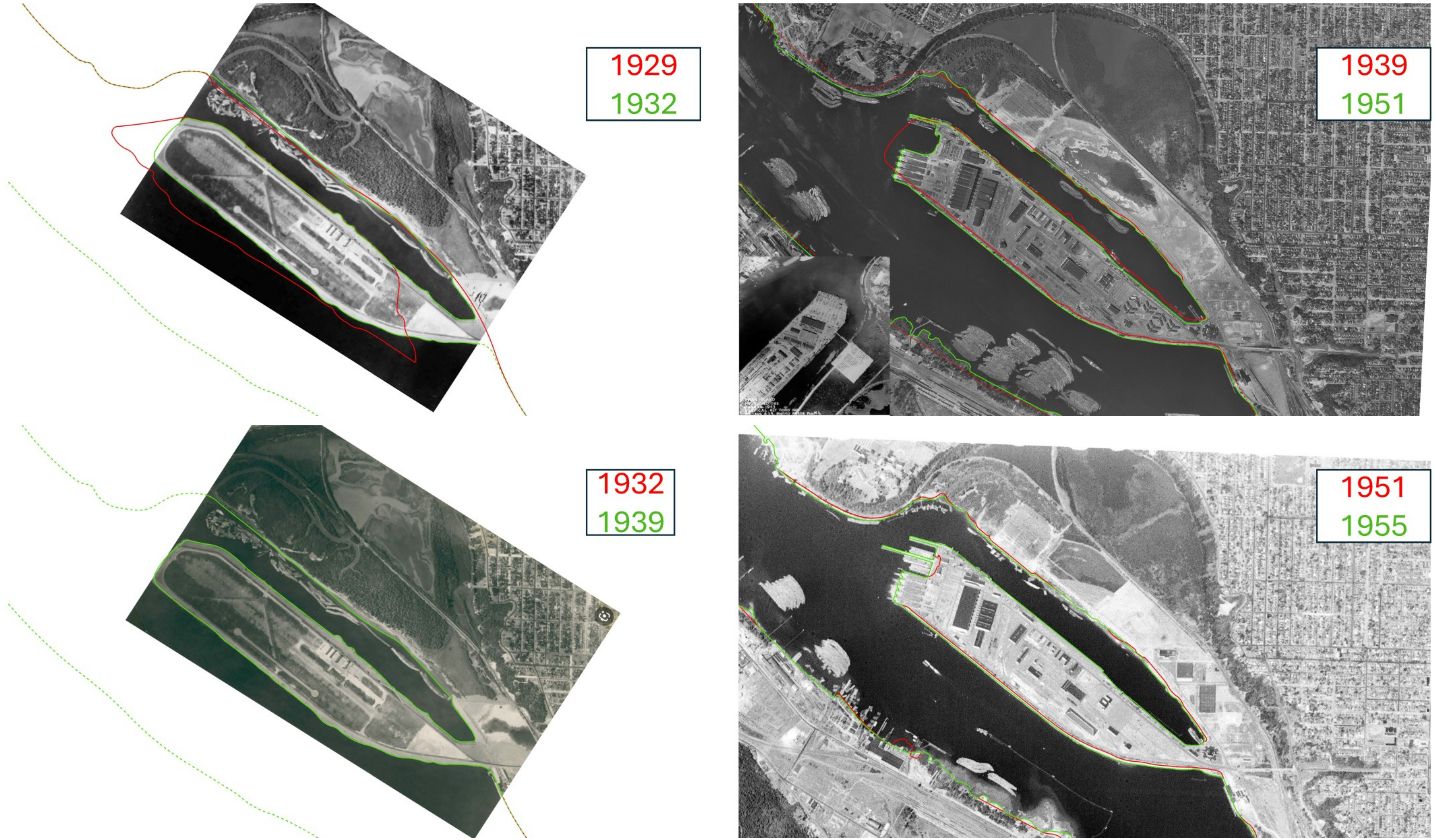

Imagery Sources:

1929-1932: Ash Creek Associates, Inc. 2006. Draft Report Supplemental Preliminary Assessment Swan Island Upland Facility. Port of Portland, Portland, Oregon, 97209. December.

1939: Vintage Portland, 2012. Swan Island, 1939. At URL: https://vintageportland.wordpress.com/2013/06/12/swan-island-airport-1939/. May 15.

1951: U.S. Coast and Geodetic Survey. 1951. Image GS-QO. Originally Kodak Aerographic Safety Film Image 6798. July 27.

1955: U.S. Coast and Geodetic Survey. 1955. Image GVV AS M 8 AMS 1406. Originally Kodak Aerographic Safety Film. August 14.

Figure 2-4
Swan Island Basin in 1929-1955

Prepared on 4/23/2024

Basis of Design Report
Swan Island Basin Remedial Design Group

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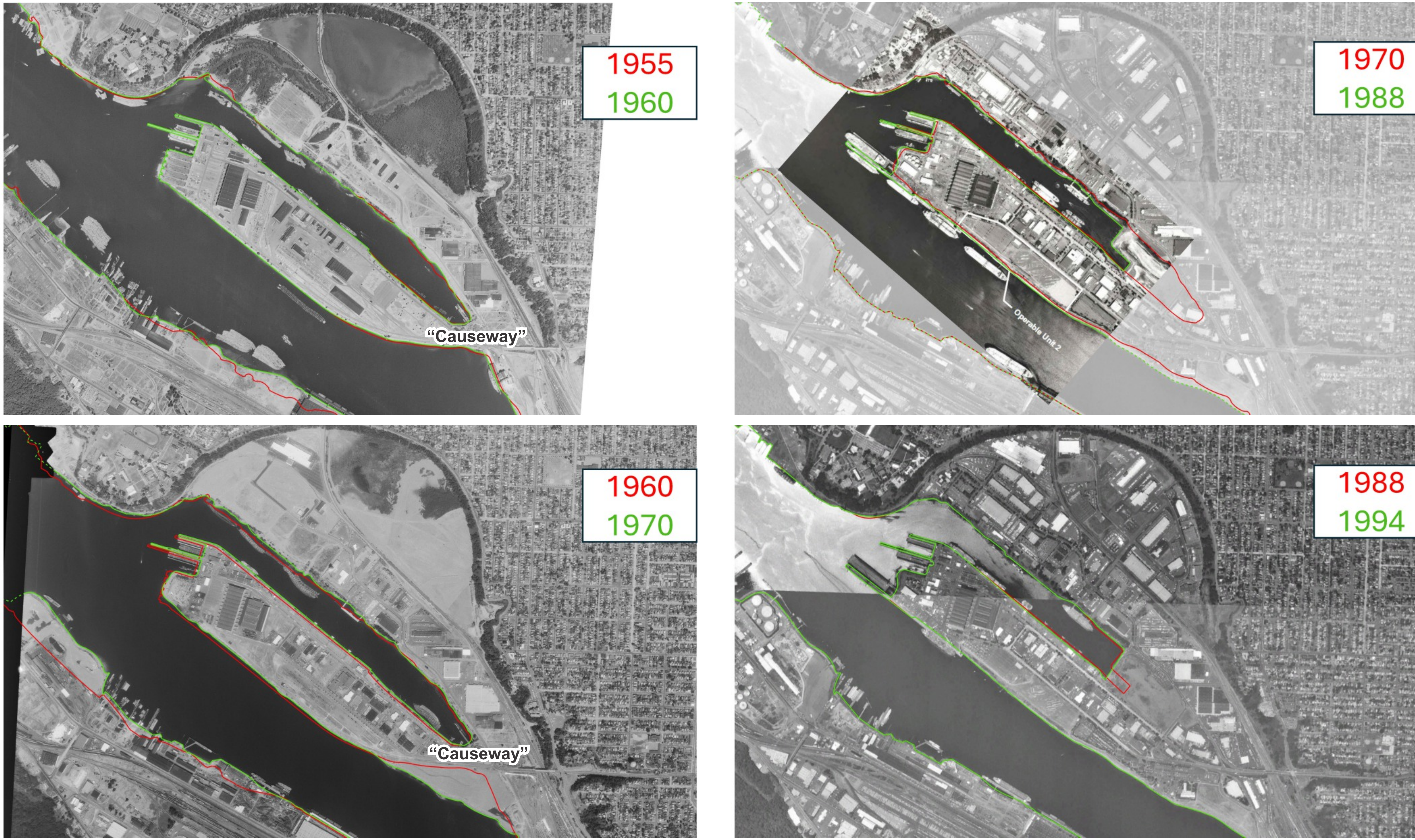

Imagery Sources:
1955: U.S. Coast and Geodetic Survey. 1955. Image GVV AS M 8 AMS 1406. Originally Kodak Aerographic Safety Film. August 14.
1960: U.S. Coast and Geodetic Survey. 1960. Image GS-VACZ 1-122. Originally Kodak Aerographic Safety Film. July 17.
1970: U.S. Coast and Geodetic Survey . 1970. Image GS-VC0A 1-185. Originally Kodak Aerographic Safety Film. July 5.
1988-1994: Ash Creek Associates, Inc. 2006. Draft Report Supplemental Preliminary Assessment Swan Island Upland Facility. Port of Portland, Portland, Oregon, 97209. December.

Figure 2-5
Swan Island Basin in 1955-1994

Prepared on 4/23/2024

Basis of Design Report
Swan Island Basin

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BRIDGEWATER GROUP

Imagery Sources:
1994: Ash Creek Associates, Inc. 2006. Draft Report Supplemental Preliminary Assessment Swan Island Upland Facility. Port of Portland, Portland, Oregon, 97209. December.
2002 & 2023: Google Earth Pro. 2024. Image: U.S. Geologic Survey and NASA. Accessed on February 14.

Figure 2-6
Swan Island Basin in 1994-2023

Prepared on 4/23/2024

Basis of Design Report
Swan Island Basin Remedial Design Group

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Imagery Sources:
1888: U.S. Coast and Geodetic Survey. 1888. Columbia River: Fales Landing to Portland.
2023: Google Earth Pro. 2024. Image: U.S. Geologic Survey and NASA. Accessed on February 14.

Figure 2-7
Swan Island Basin in 1888-2023

Prepared on 4/23/2024

Basis of Design Report
Swan Island Basin Remedial Design Group

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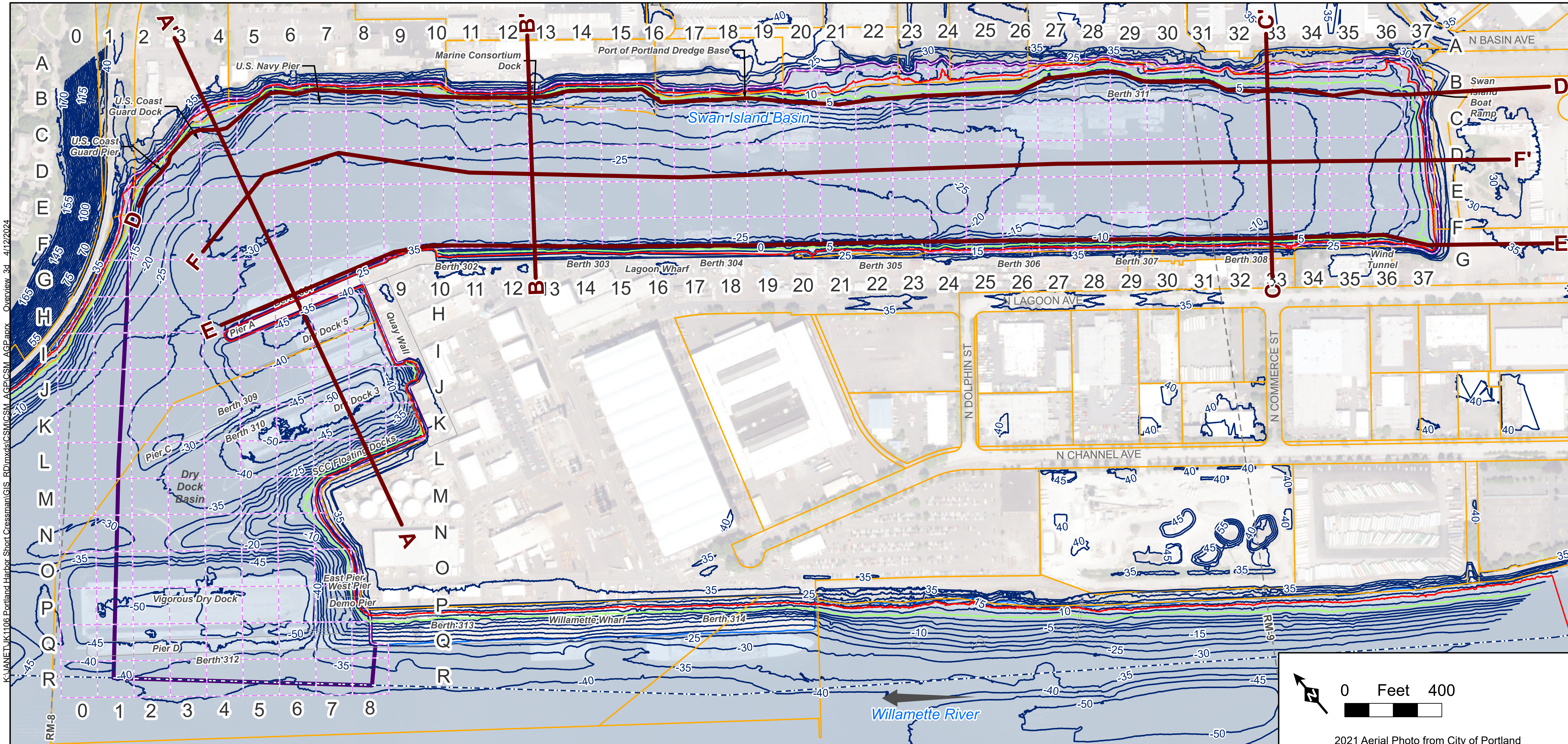


- Project Area Grid
- River Mile (RM)
- Swan Island Sediment Decision Unit (SDU)
- Federal Navigation Channel (USACE, 2020)
- Docks and Structures
- Tax Lot Boundary
- Top of Bank (TOB)
- Ordinary High Water (City of Portland, 2013)
- +13-foot NAVD88 Contour
- Mean Low Water (MLW)
- 5-foot Elevation Contours (NAVD88)
- Sections

M Project Area Grid Label

Notes:
CRD – Columbia River Datum
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

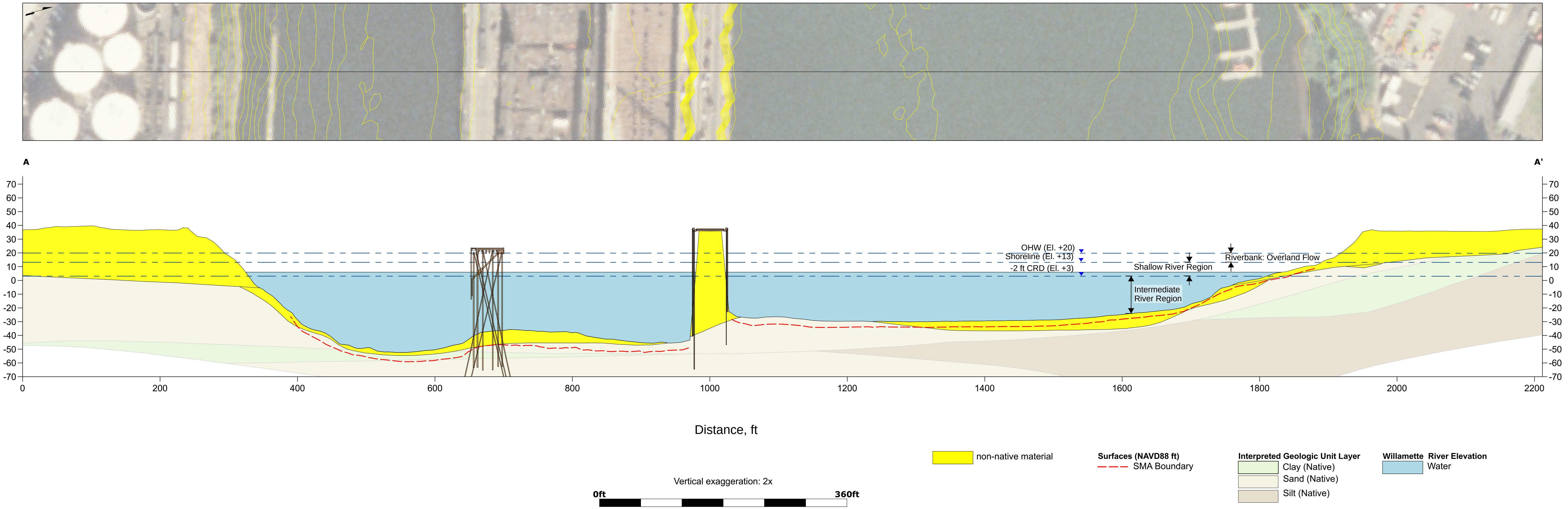
TOB Source – City of Portland Lidar, 2019
OHW and MLW Source – EPA, 2019

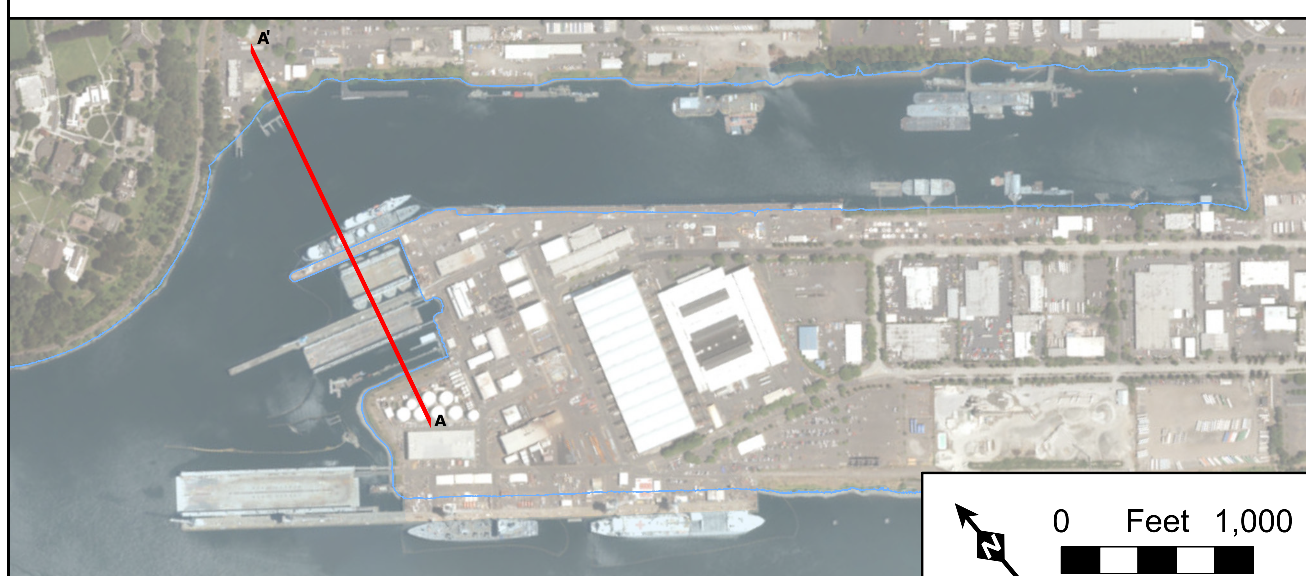
Elevation Sources:
David Evans and Associates, 2015
David Evans and Associates, 2018
City of Portland LiDAR, 2019
HydroGeoLogic, 2022

River Flow Direction

Figure 2-8
Swan Island Basin
Plan View of Section Profiles

Prepared on: 4/12/2024
Basis of Design Report
Swan Island Basin Remedial Design Group





Notes:
CRD – Columbia River Datum
EL. – Elevation
ft – feet
NAVD88 – North American Vertical Datum of 1988
OHW – Ordinary High Water

Figure 2-9
Swan Island Basin
North Basin Conceptual Profile

Prepared on: 4/9/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

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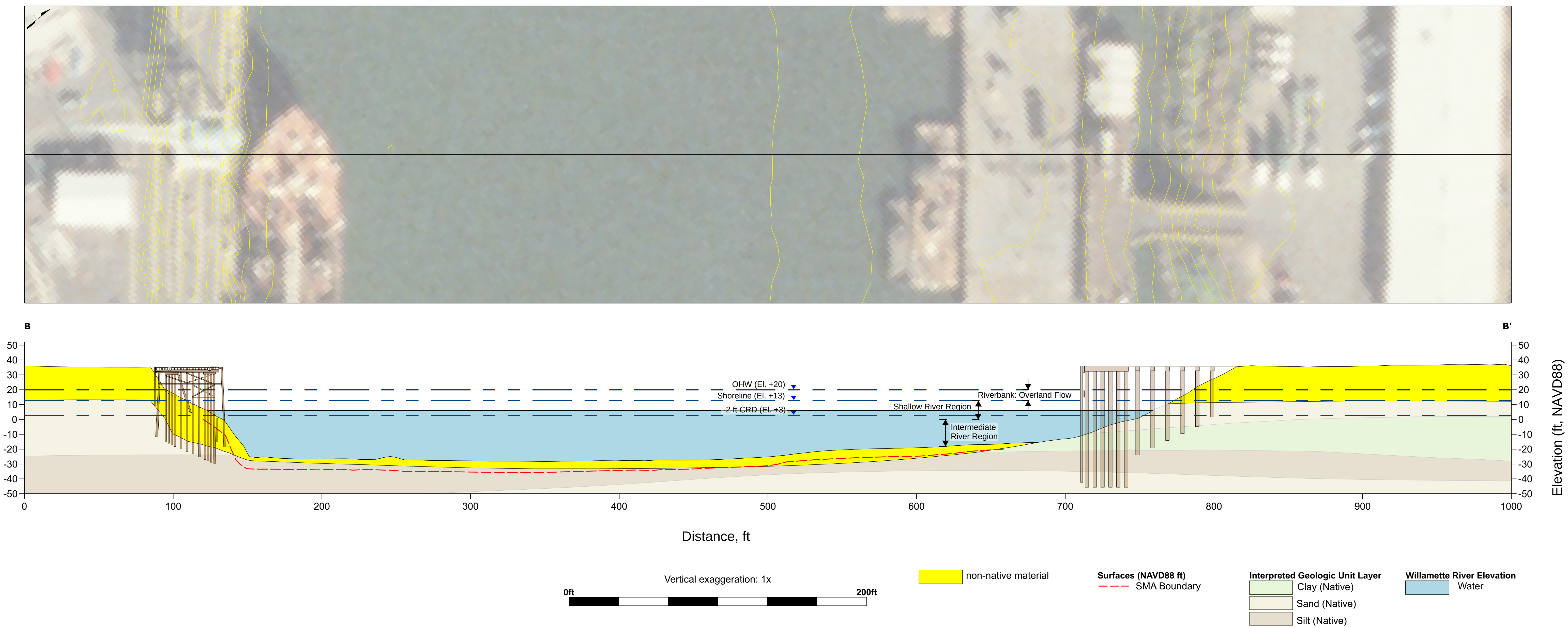

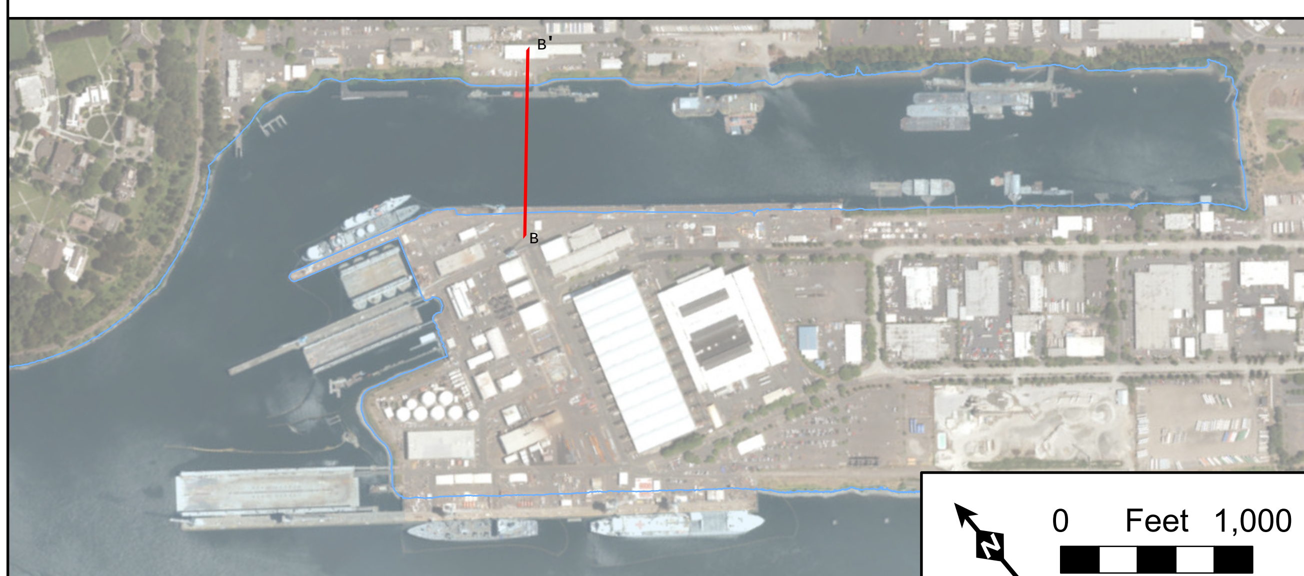

Notes:
CRD – Columbia River Datum
EL. – Elevation
ft – feet
NAVD88 – North American Vertical Datum of 1988
OHW – Ordinary High Water

Figure 2-10
Swan Island Basin
Mid Basin Conceptual Profile

Prepared on: 4/9/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

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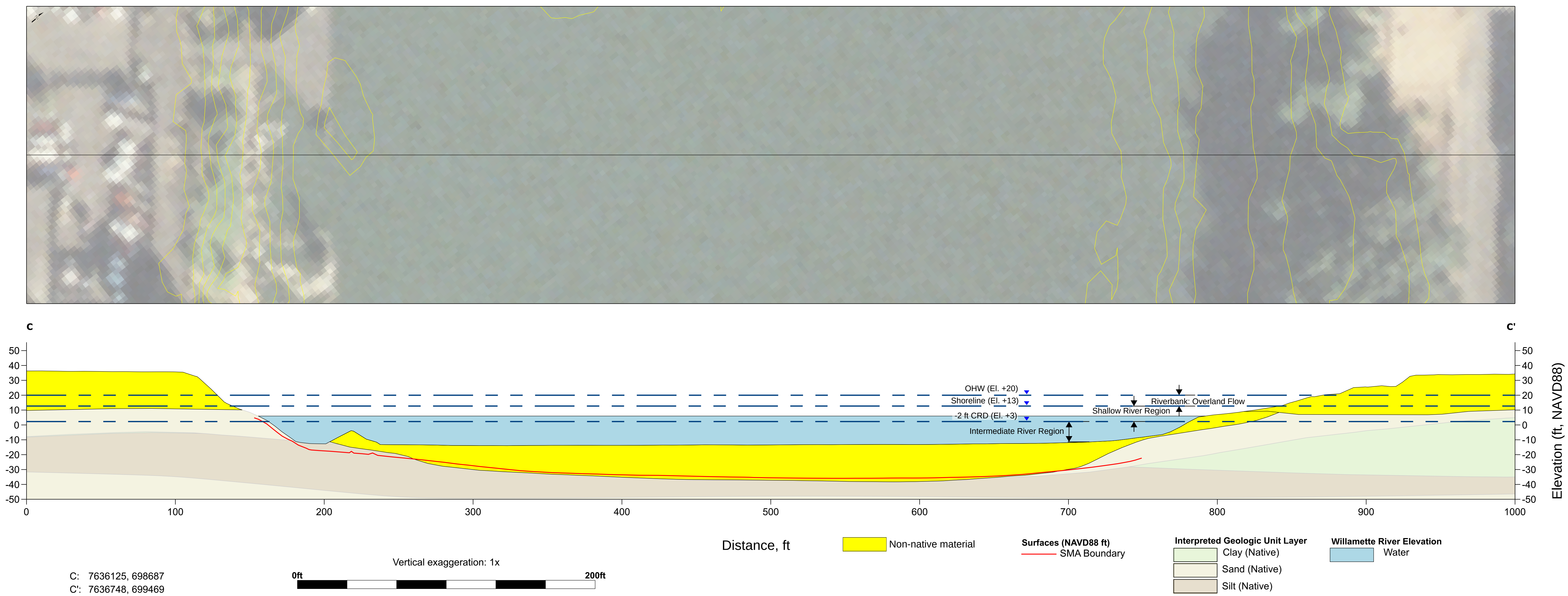
South Basin Conceptual Profile



Notes:
CRD – Columbia River Datum
EL. – Elevation
ft – feet
NAVD88 – North American Vertical Datum of 1988
OHW – Ordinary High Water

Figure 2-11

Swan Island Basin
South Basin Conceptual Profile

Prepared on: 4/9/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

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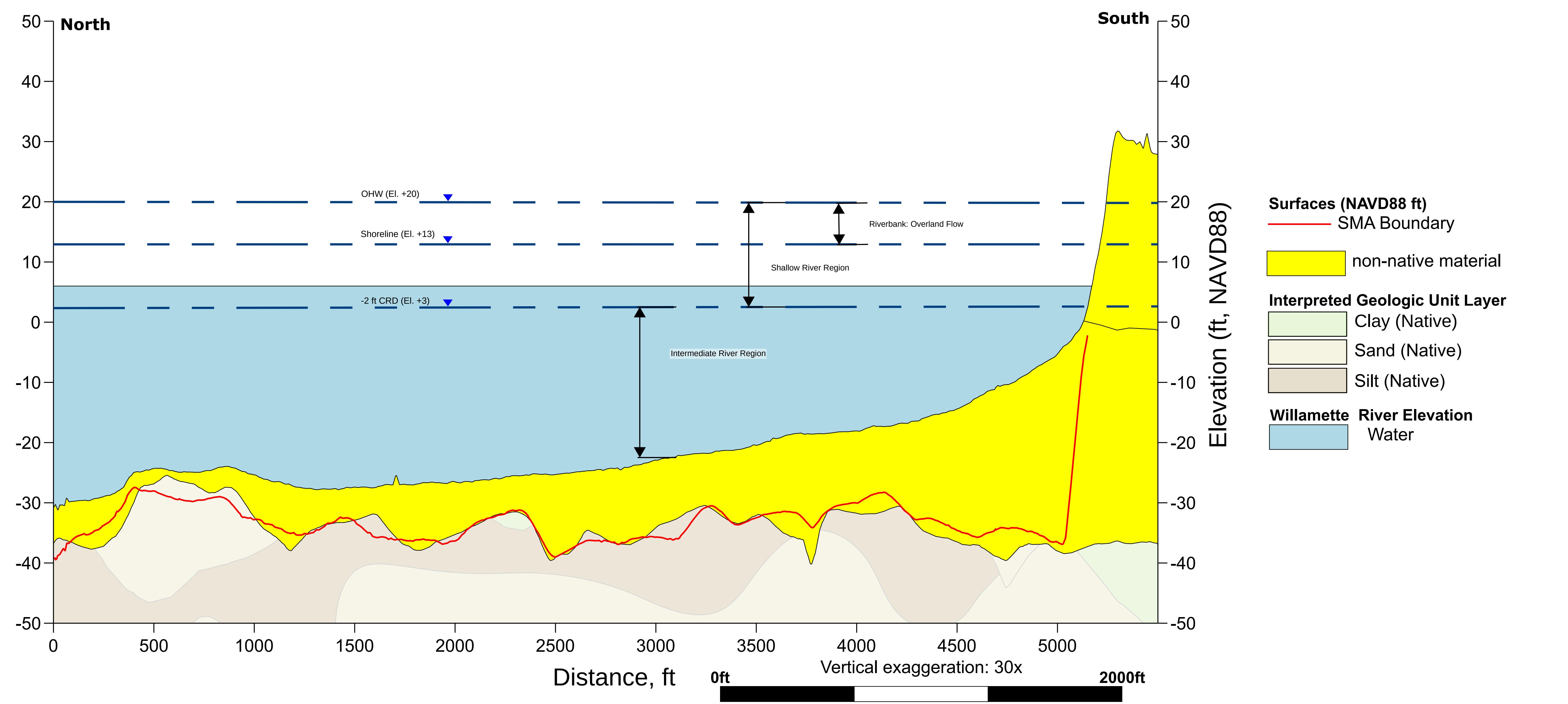

Notes:
CRD – Columbia River Datum
EL. – Elevation
ft – feet
NAVD88 – North American Vertical Datum of 1988
OHW – Ordinary High Water

Figure 2-12

Swan Island Basin
Mid Basin Conceptual Profile

Prepared on: 4/9/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

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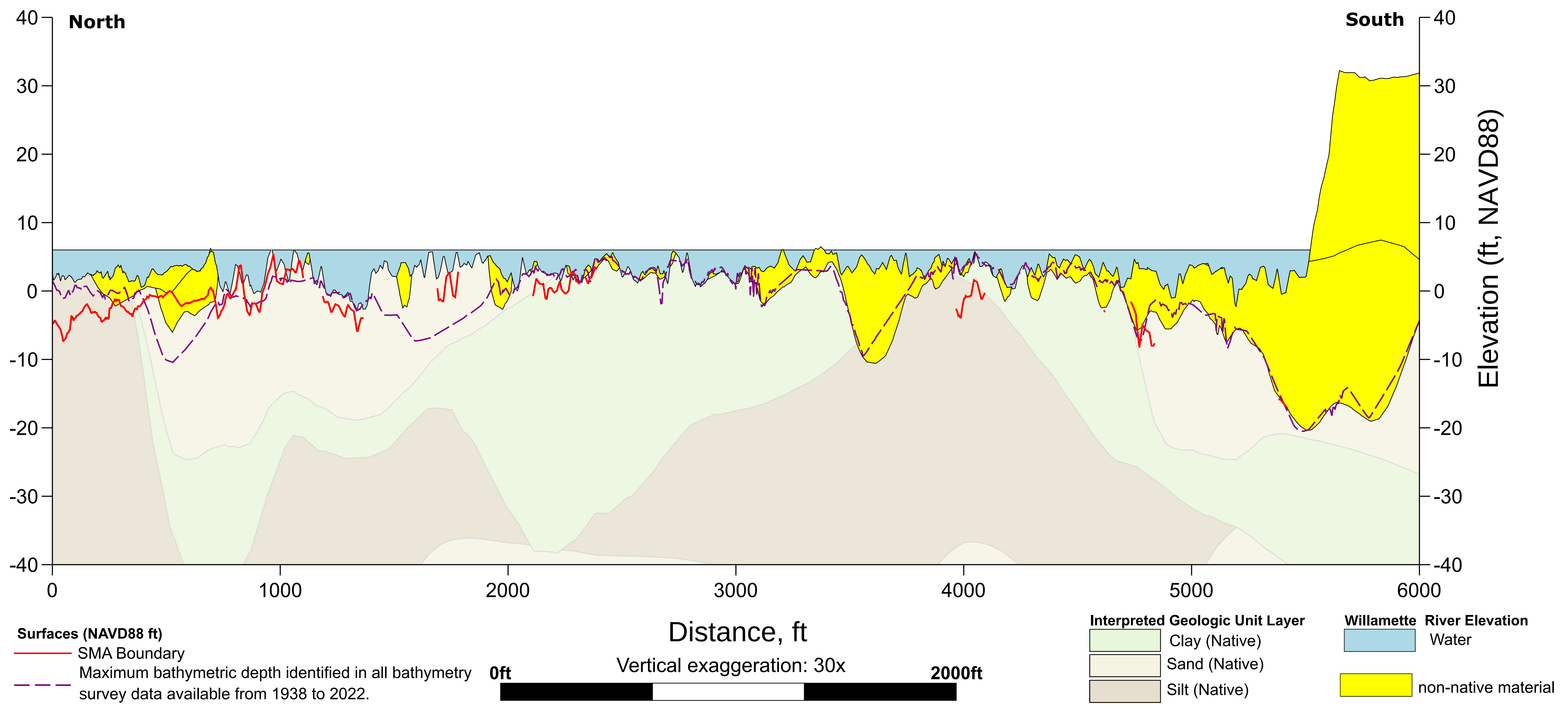

Notes:
ft – feet
NAVD88 – North American Vertical Datum of 1988

Figure 2-13

Swan Island Basin
North East Bank Conceptual Profile

Prepared on: 4/10/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

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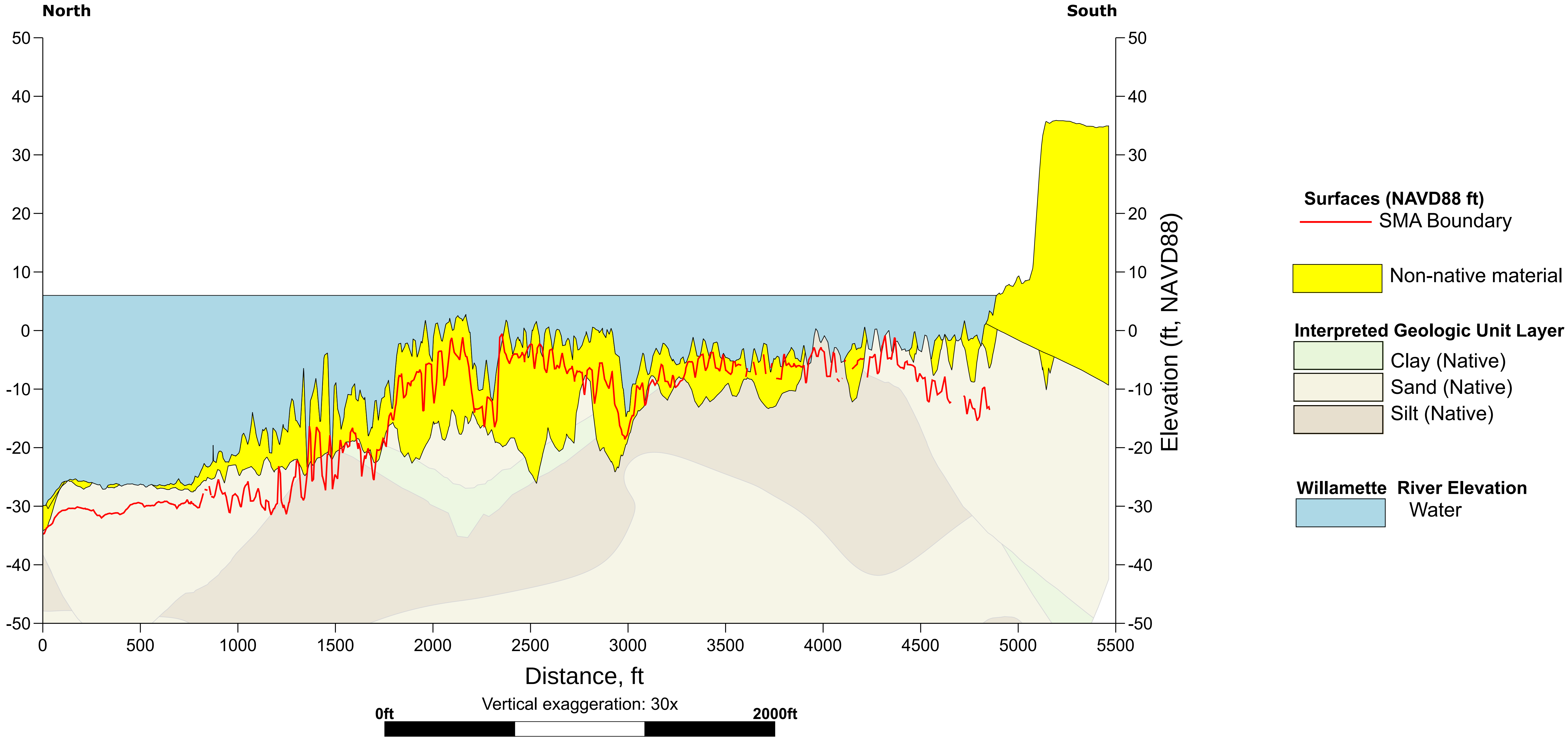
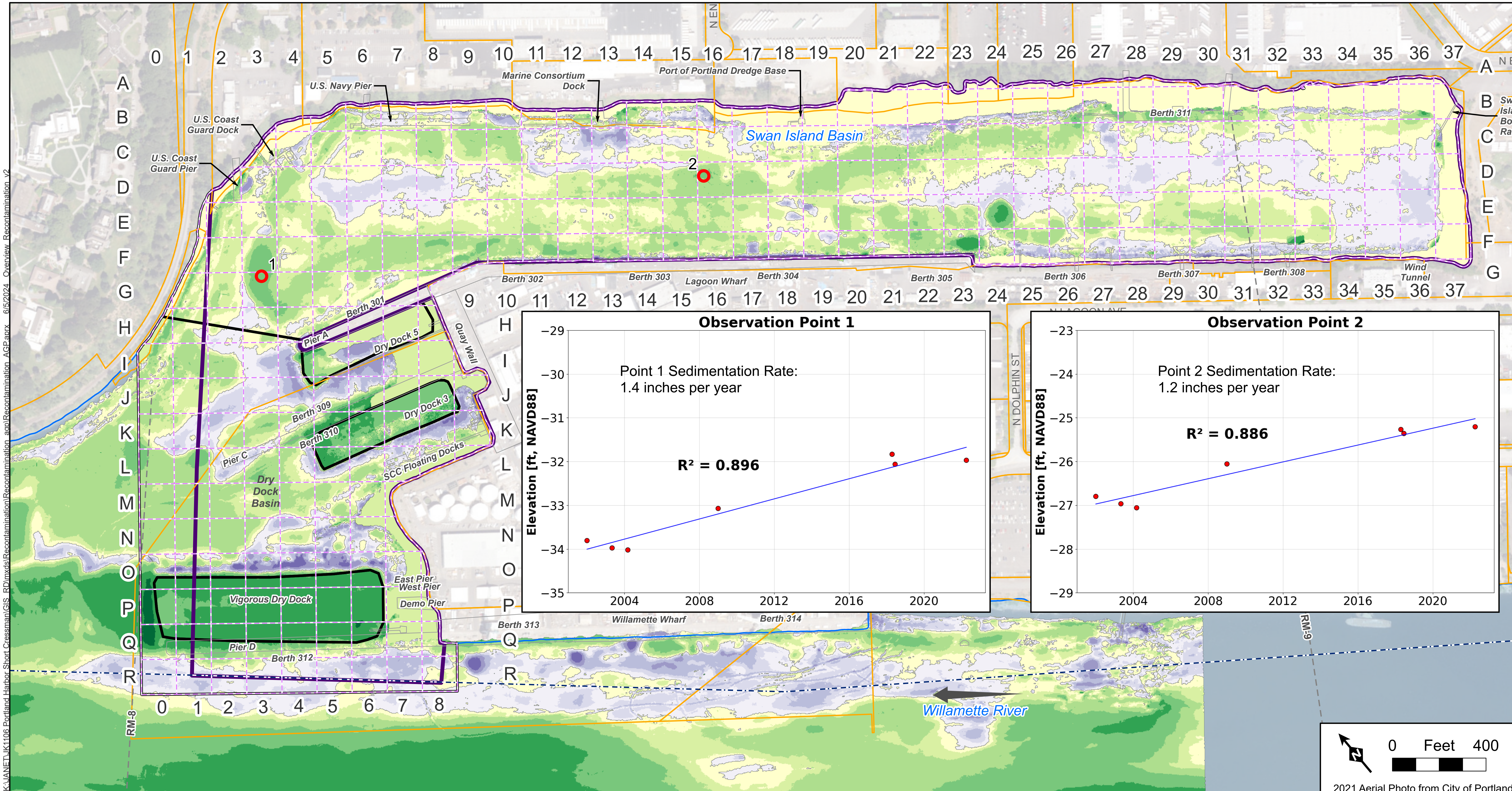


Notes:
ft – feet
NAVD88 – North American Vertical Datum of 1988

Figure 2-14

Swan Island Basin
South West Bank Conceptual Profile

Prepared on: 4/10/2024
Basis of Design Report
Swan Island Basin Remedial Design Group



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- Observation Points
- Project Area Grid
- River Mile (RM)
- Swan Island Sediment Decision Unit (SDU)
- Federal Navigation Channel (USACE, 2020)
- Docks and Structures
- Tax Lot Boundary
- Ordinary High Water (City of Portland, 2013)
- River Flow Direction

Deposition Rate (Erosion) (in/year)
- ≤ -4
- -3.9 - -2
- -1.9 - -1
- -0.9 - -0.51
- -0.5 - -0.25
- -0.24 - 0

Deposition Rate (in/year)
- 0 - 0.25
- 0.26 - 0.5
- 0.51 - 1
- 1.1 - 2
- 2.1 - 4
- >4.0

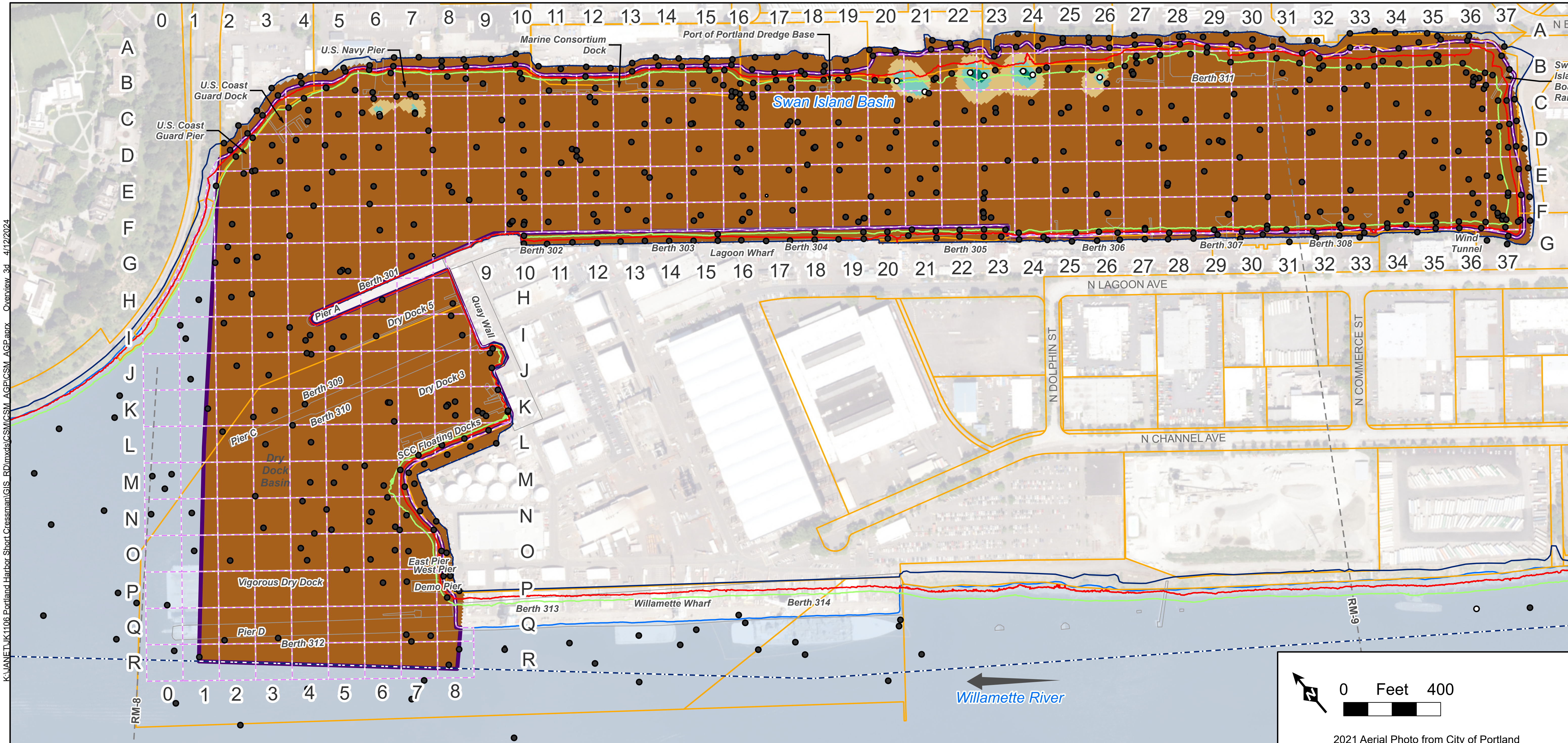
Multibeam hydrographic survey datasets as cited in Section 2.2.1.4

Notes:
ft – feet
NAVD88 – North American Vertical Datum of 1988
R^2 – Coefficient of determination
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 2-15
Sediment Deposition, inches/year

Prepared on: 6/5/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP HGL MOTT MACDONALD BRIDGEWATER GROUP



Project Area Grid
River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Top of Bank (TOB)
Ordinary High Water (City of Portland, 2013)
+13-foot NAVD88 Contour
Mean Low Water (MLW)

M Project Area Grid Label

Indicator Exceedance Data Location
- Point excluded from interpolation
- 0
- 1

Indicator Exceedance Probability
- 0% to 20%
- 20% to 50%
- 50% to 80%
- 80% to 100%

Notes:
CUL – Cleanup Level
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

TOB Source – City of Portland Lidar, 2019
OHW and MLW Source – EPA, 2019

"Surface Sediment" is the top 30 cm of sediment.

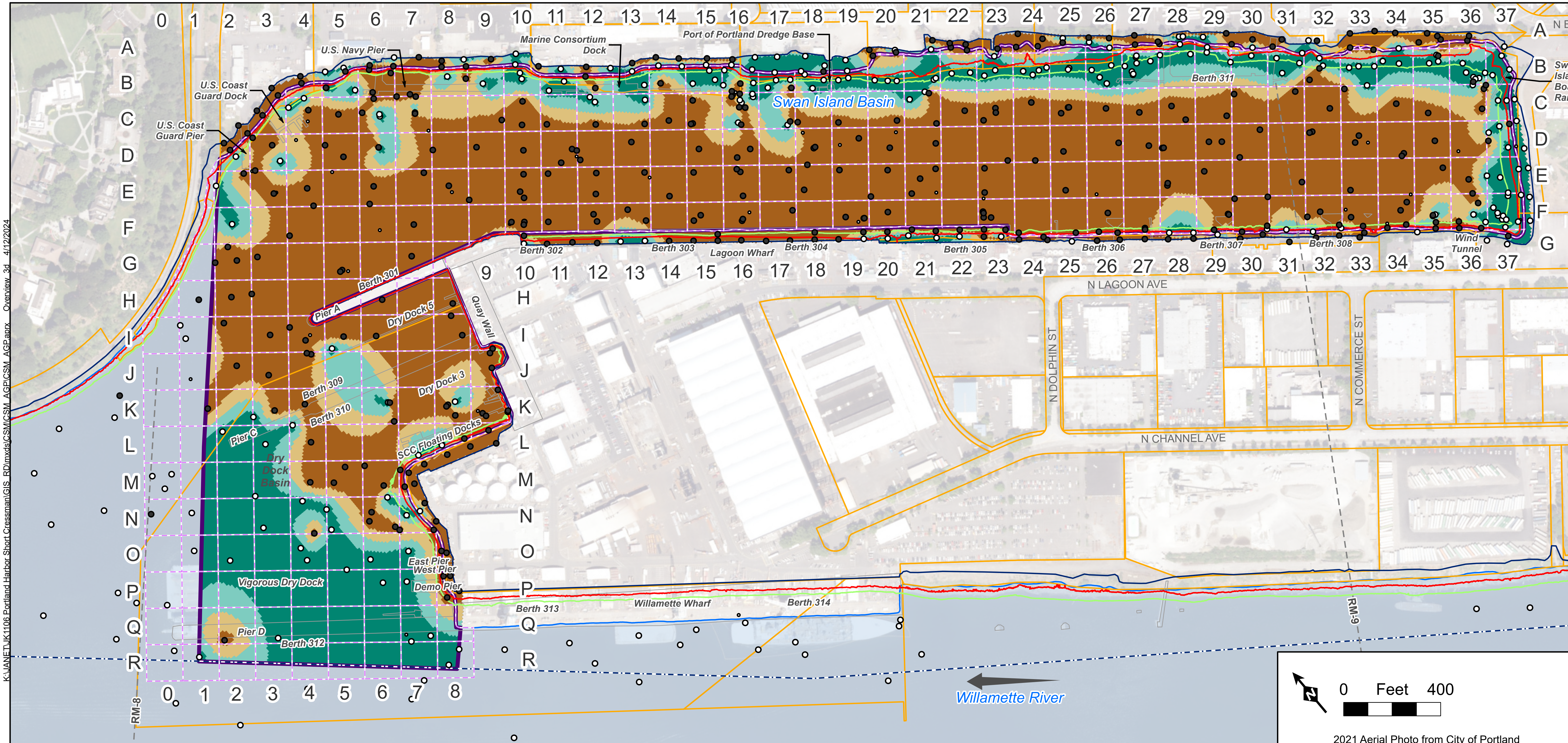
Interpolations are clipped to the SDU.

River Flow Direction

Figure 2-16
Surface Sediment and Riverbank Soil CUL Exceedances

Prepared on: 4/12/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Project Area Grid
River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Top of Bank (TOB)
Ordinary High Water (City of Portland, 2013)
+13-foot NAVD88 Contour
Mean Low Water (MLW)

M Project Area Grid Label

Indicator Exceedance Data Location
- Point excluded from interpolation
- 0
- 1

Indicator Exceedance Probability
- 0% to 20%
- 20% to 50%
- 50% to 80%
- 80% to 100%

River Flow Direction

Notes:
NAVD88 – North American Vertical Datum of 1988
PQL – Practical Quantitation Limit
RAL – Remedial Action Level
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

TOB Source – City of Portland Lidar, 2019
OHW and MLW Source – EPA, 2019

"Surface Sediment" is the top 30 cm of sediment.
Interpolations are clipped to the SDU.

Figure 2-17
Surface Sediment and Riverbank Soil RAL/PQL Exceedances

Prepared on: 4/12/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP

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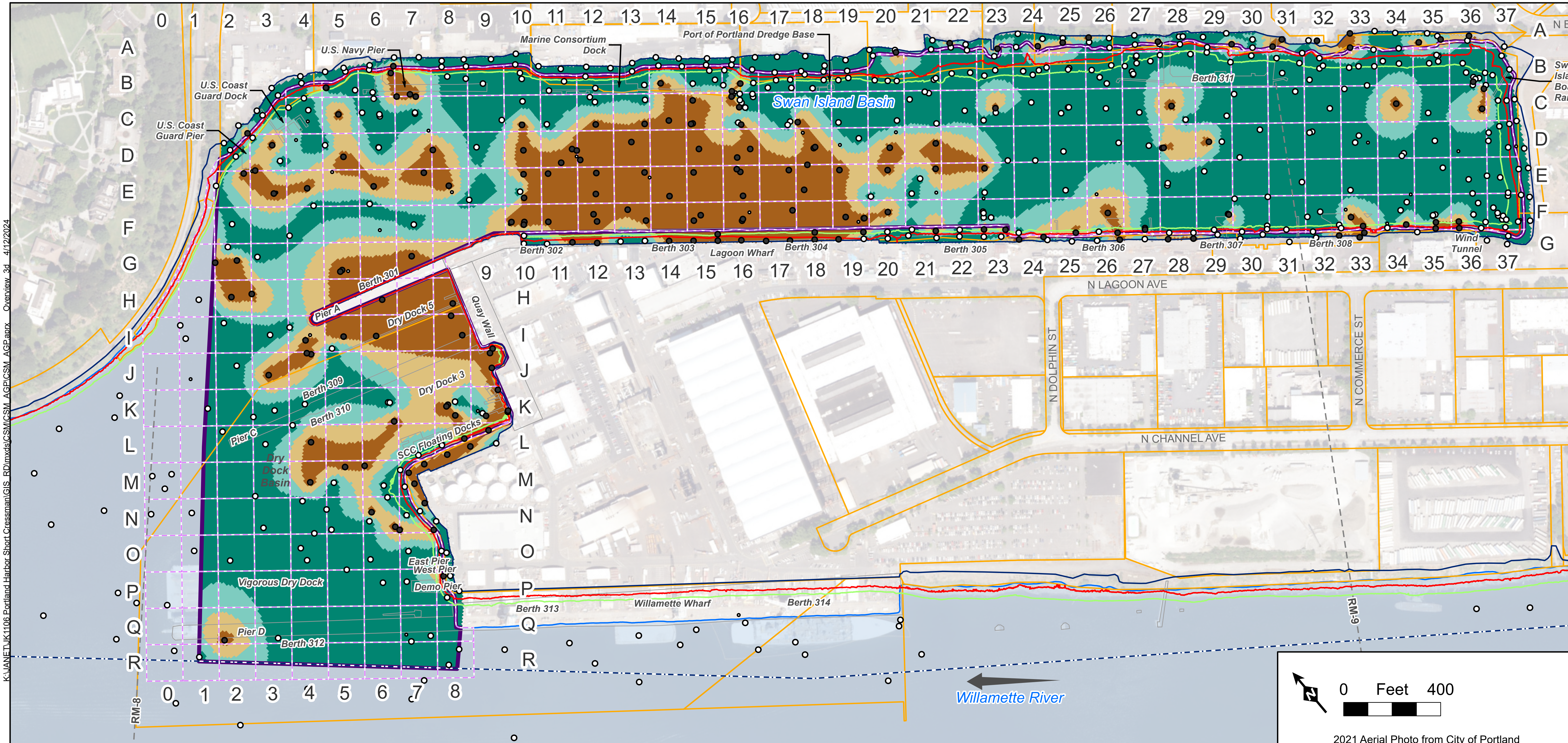

Project Area Grid
River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Top of Bank (TOB)
Ordinary High Water (City of Portland, 2013)
+13-foot NAVD88 Contour
Mean Low Water (MLW)

M Project Area Grid Label

Indicator Exceedance Data Location
- Point excluded from interpolation
- 0
- 1

Indicator Exceedance Probability
- 0% to 20%
- 20% to 50%
- 50% to 80%
- 80% to 100%

River Flow Direction

Notes:
NAVD88 – North American Vertical Datum of 1988
PTW – Principal threat waste
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

TOB Source – City of Portland Lidar, 2019
OHW and MLW Source – EPA, 2019

"Surface Sediment" is the top 30 cm of sediment.
Interpolations are clipped to the Project Area.

Figure 2-18
Surface Sediment and Riverbank Soil PTW Exceedances

Prepared on: 4/12/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
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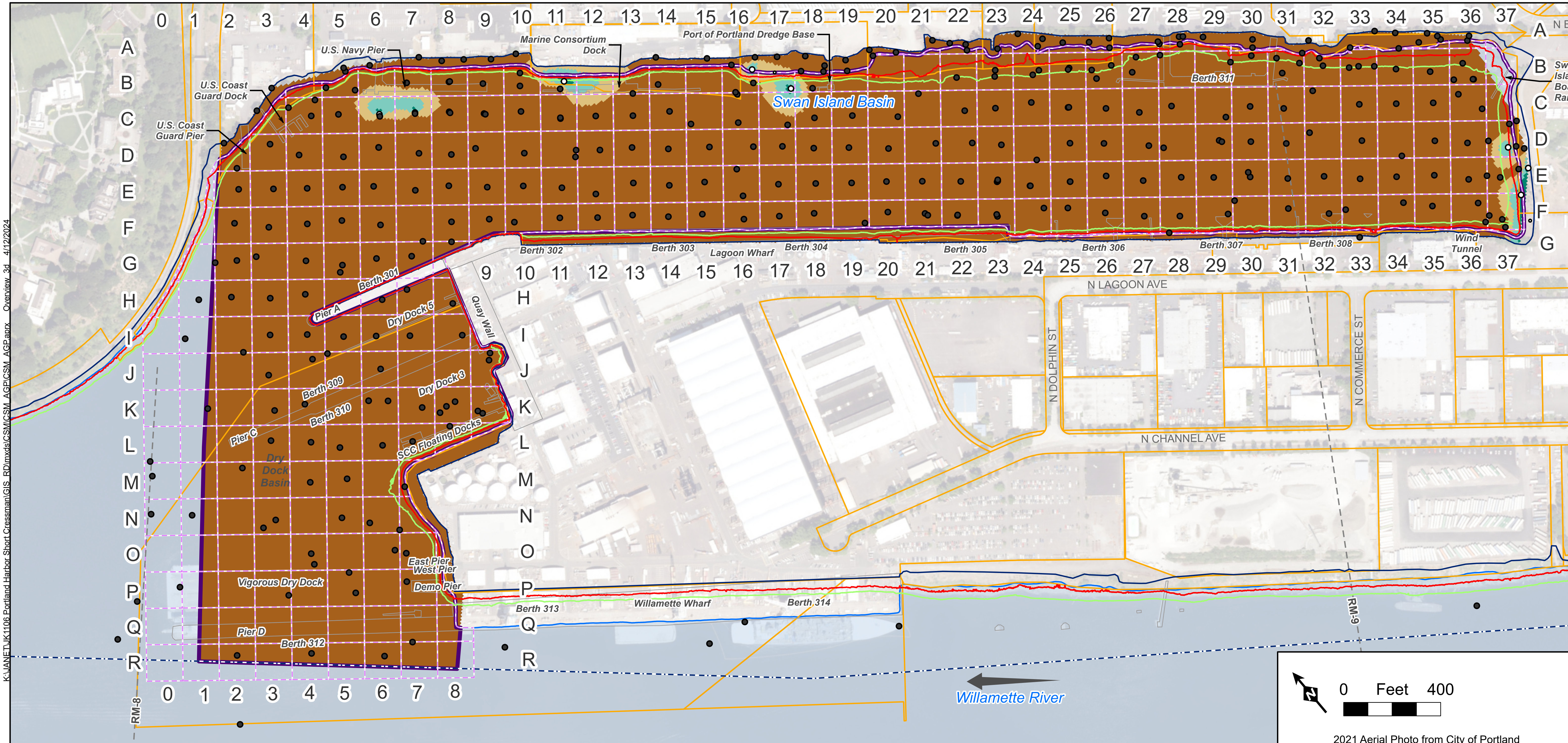
BRIDGEWATER GROUP



Project Area Grid
River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Top of Bank (TOB)
Ordinary High Water (City of Portland, 2013)
+13-foot NAVD88 Contour
Mean Low Water (MLW)

M Project Area Grid Label

Indicator Exceedance Data Location
- Point excluded from interpolation
- 0
- 1

Indicator Exceedance Probability
- 0% to 20%
- 20% to 50%
- 50% to 80%
- 80% to 100%

Notes:
CUL – Cleanup Level
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

TOB Source – City of Portland Lidar, 2019
OHW and MLW Source – EPA, 2019

"Subsurface Sediment" is any sediment deeper than 30 cm.

Interpolations are clipped to the SDU.

River Flow Direction

Figure 2-19
Subsurface Sediment and Riverbank Soil CUL Exceedances

Prepared on: 4/12/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP

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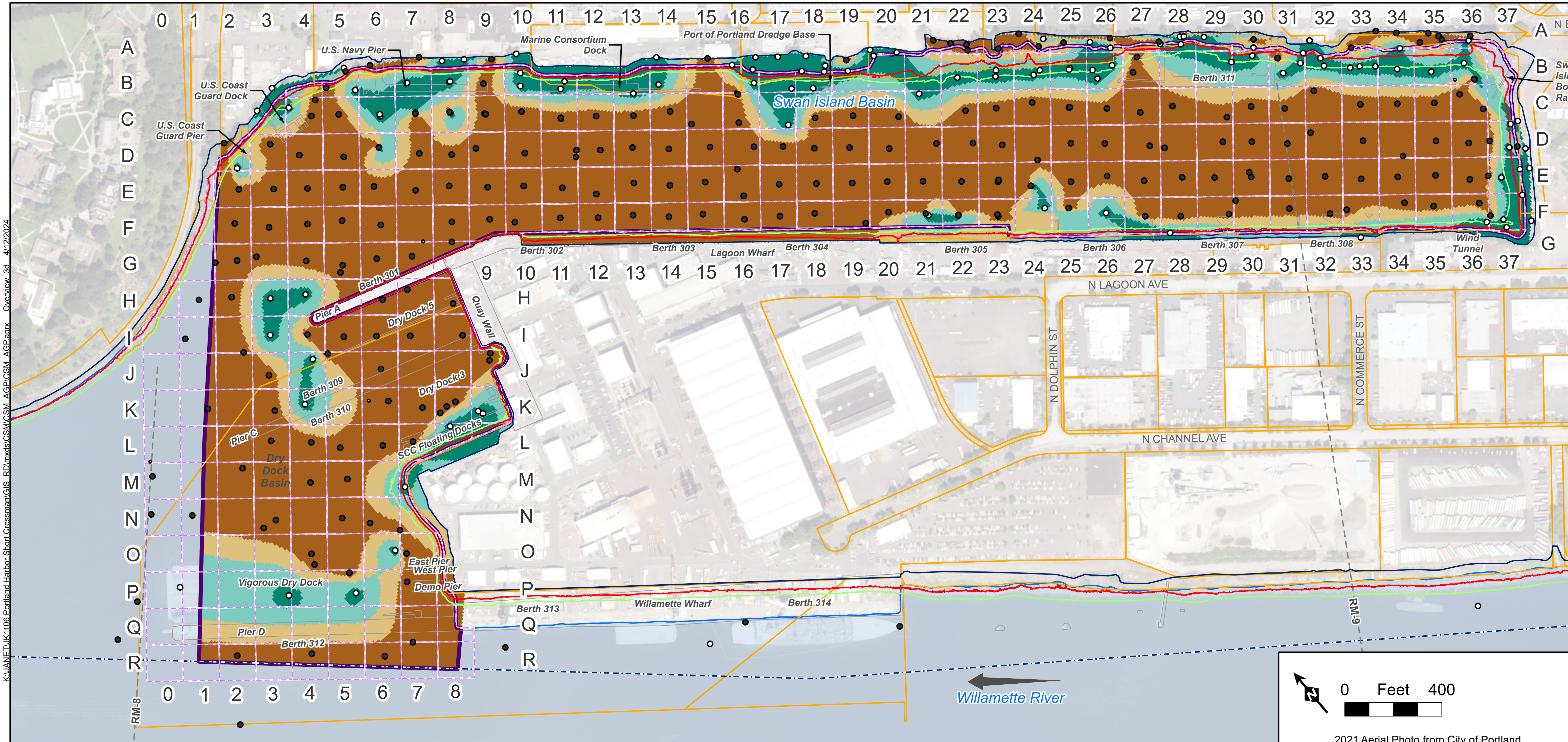


Project Area Grid
River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Top of Bank (TOB)
Ordinary High Water (City of Portland, 2013)
+13-foot NAVD88 Contour
Mean Low Water (MLW)

M Project Area Grid Label

Indicator Exceedance Data Location
- Point excluded from interpolation
- 0
- 1

Indicator Exceedance Probability
- 0% to 20%
- 20% to 50%
- 50% to 80%
- 80% to 100%

River Flow Direction

Notes:
NAVD88 – North American Vertical Datum of 1988
PQL – Practical Quantitation Limit
RAL – Remedial Action Level
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

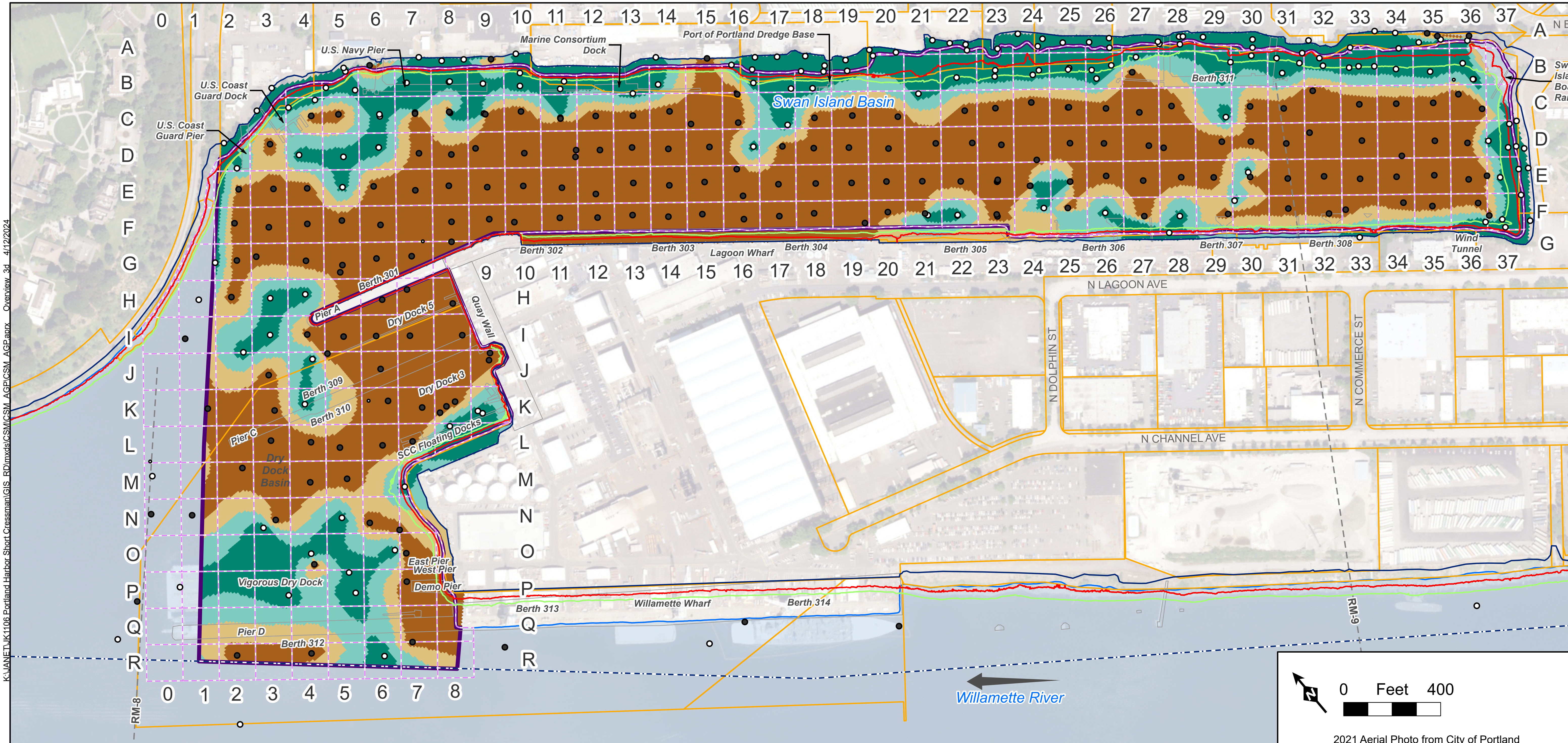
TOB Source – City of Portland Lidar, 2019
OHW and MLW Source – EPA, 2019

"Subsurface Sediment" is any sediment deeper than 30 cm.

Interpolations are clipped to the SDU.

Figure 2-20
Subsurface Sediment and Riverbank Soil RAL/PQL Exceedances

Prepared on: 4/12/2024
Basis of Design Report
Swan Island Basin Remedial Design Group



Project Area Grid
River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Top of Bank (TOB)
Ordinary High Water (City of Portland, 2013)
+13-foot NAVD88 Contour
Mean Low Water (MLW)

M Project Area Grid Label

Indicator Exceedance Data Location
- Point excluded from interpolation
- 0
- 1

Indicator Exceedance Probability
- 0% to 20%
- 20% to 50%
- 50% to 80%
- 80% to 100%

Notes:
NAVD88 – North American Vertical Datum of 1988
PTW – Principal threat waste
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

TOB Source – City of Portland Lidar, 2019
OHW and MLW Source – EPA, 2019

"Subsurface Sediment" is any sediment deeper than 30 cm.

Interpolations are clipped to the SDU.

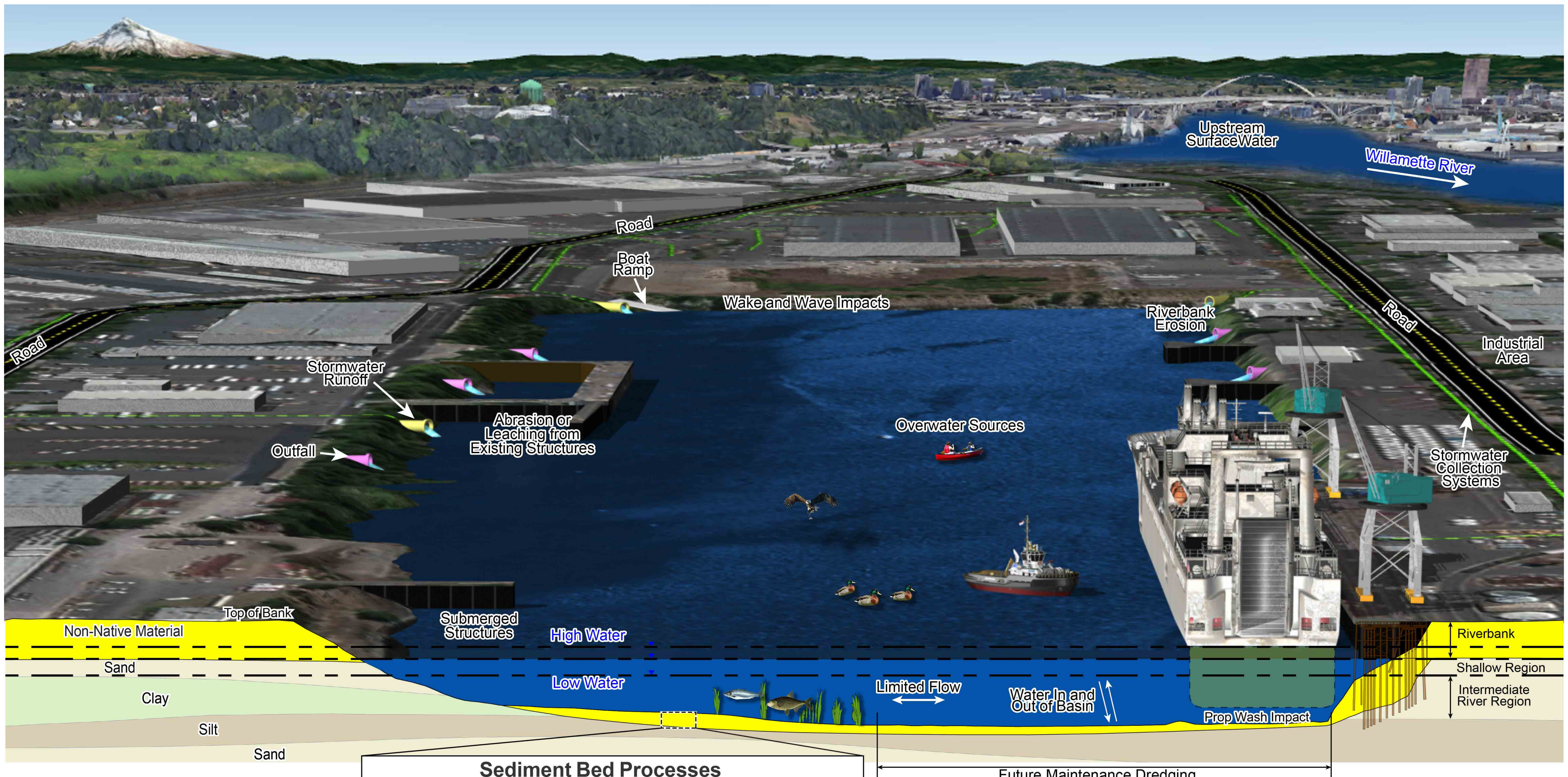
River Flow Direction

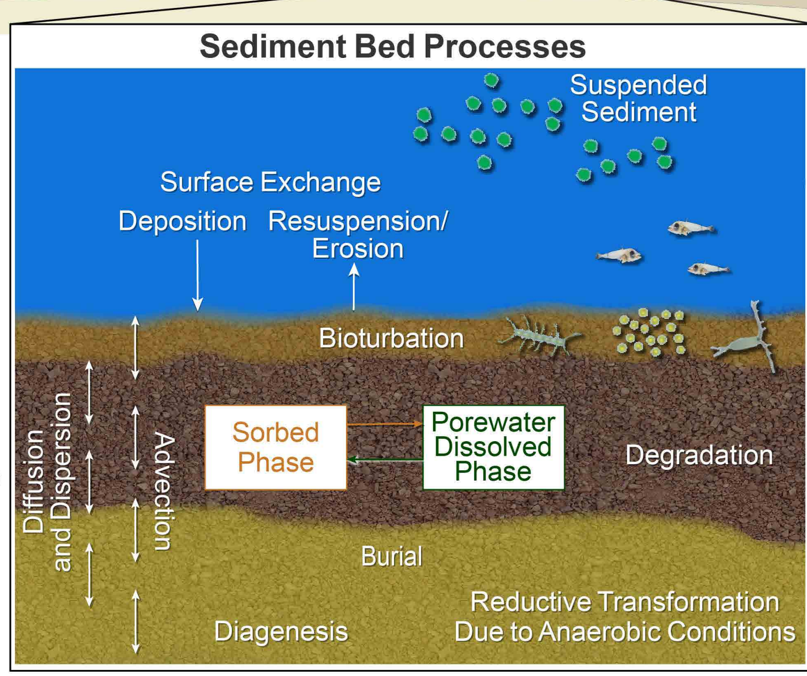
Figure 2-21

Subsurface Sediment and Riverbank Soil PTW Exceedances

Prepared on: 4/12/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP





Not Depicted Sources
- Historical Contamination
- Former Sewer Discharge Points

Depicted Sources
- Upland Sources
- In-Water Sources
- Upstream Surface Water
- Submerged Structures
- Overwater Sources

Depicted Release Mechanisms:
- Riverbank Erosion
- Discharges
- Sediment Bed Processes
- Prop Wash Impact
- Dispersion and Laminar Flow
- Wake and Wave Impact
- Abrasion or Leaching from Existing Structures

Media:
- Surface Water
- Sediment
- Riverbank Soil
- Stormwater and Stormwater Solids
- Porewater
- Biota

Recontamination Pathways:
- Upland
  - Riverbank Erosion
  - Direct Discharges (Stormwater and Overland Flow)
  - Overwater
- In-water
  - Upstream Surface Water
  - Resuspension of Bedded Sediments
  - Advection of Groundwater Through Contaminated Sediment (Porewater)
  - Leaching or Abrasion from Existing Submerged In-water Structures

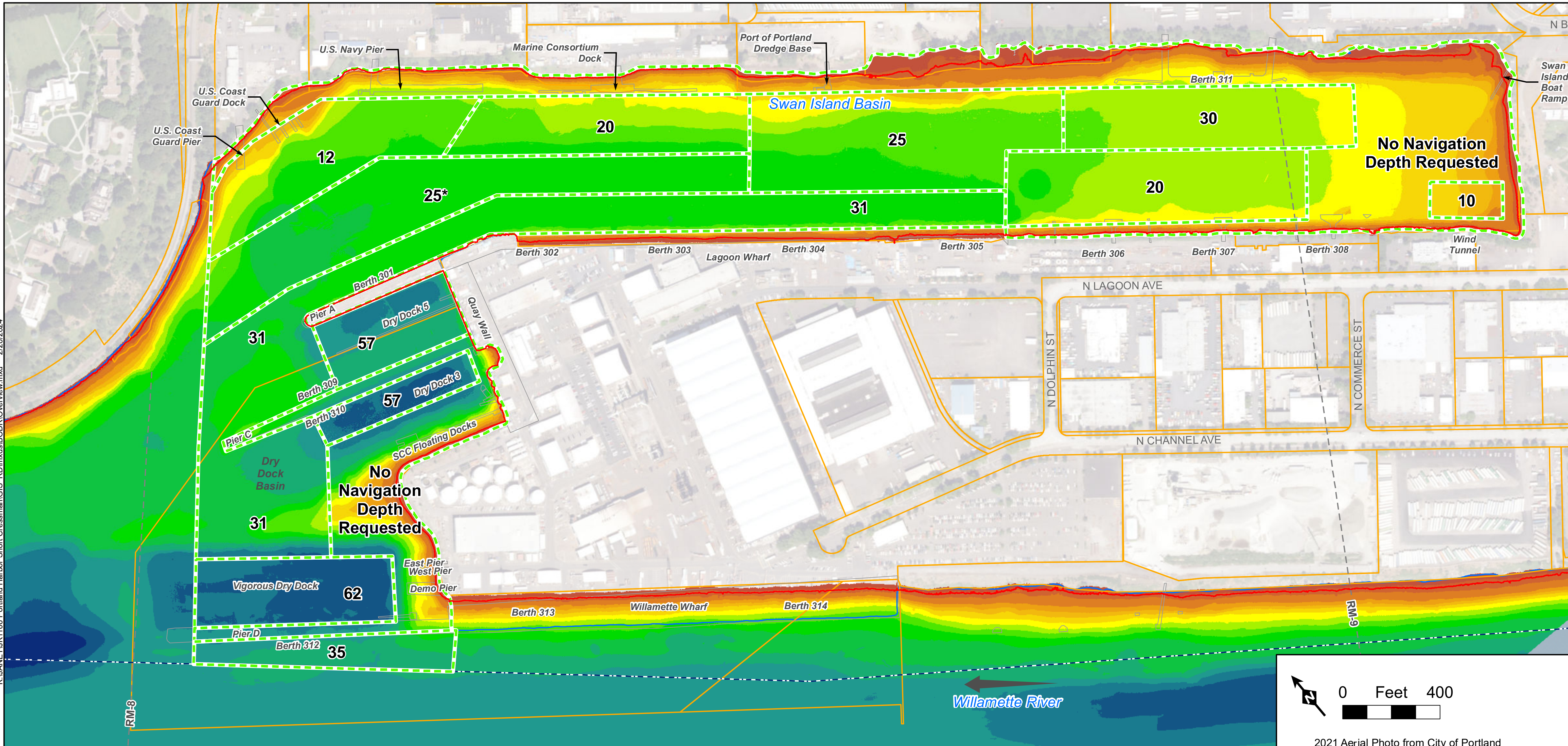
Figure 2-22

Updated Conceptual Site Model – Swan Island Basin

Prepared on: 6/10/2024

Basis of Design Report

Swan Island Basin Remedial Design Group



River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
+13-ft NAVD88 Contour
Requested Navigable Depth Areas (with Depths in Feet CRD)

River Flow Direction

Elevation in feet CRD*

- 10.1 - 15
- 5.1 - 10
- 0.1 - 5
- -4.9 - 0
- -9.9 - -5
- -14.9 - -10
- -19.9 - -15
- -24.9 - -20
- -29.9 - -25
- -34.9 - -30
- -39.9 - -35
- -44.9 - -40
- -49.9 - -45
- -54.9 - -50
- -59.9 - -55
- -62.7 - -60

Notes:
CRD – Columbia River Datum
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

*The depth of the main navigation lane between the Shipyard Commerce Center and the Marine Consortium Dock was set to 25 ft CRD so that vessels from the Port of Portland's dock (which is at 25 ft CRD) would have consistent depth from dock to river.

Figure 2-23

Navigable Depths Requested by Shoreline Property Owners/Operators

Prepared on: 2/20/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP

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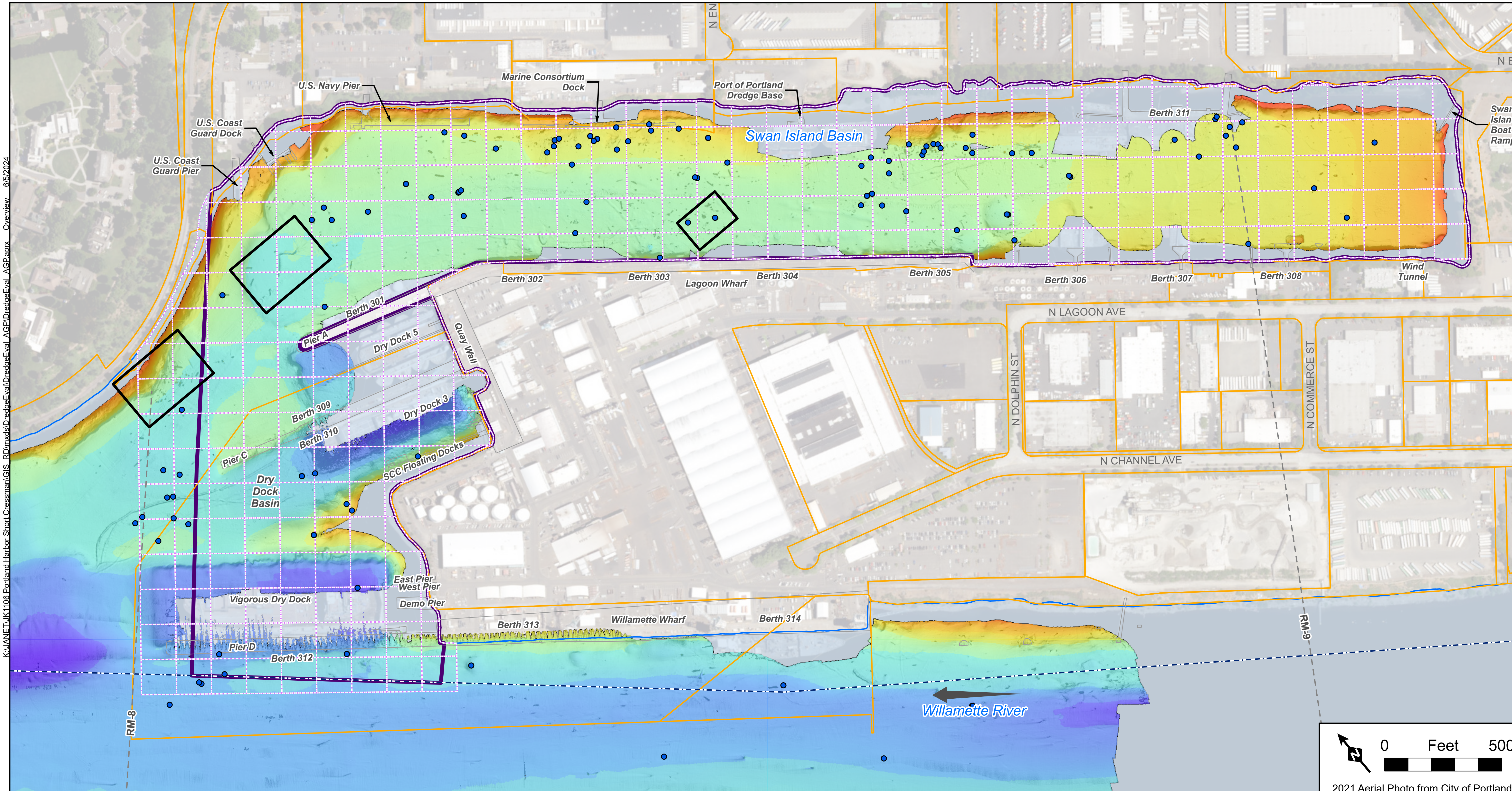

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- River Mile (RM)
- Swan Island Sediment Decision Unit (SDU)
- Federal Navigation Channel (USACE, 2020)
- Docks and Structures
- Tax Lot Boundary
- Ordinary High Water (City of Portland, 2013)
- River Flow Direction

2022 Bathymetry (Feet NAVD88)
7.97
0
-10
-20
-30
-40
-50
-57.63

Debris Features by Size
- 0 to 2 feet
- Test Site

Notes:
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 2-24
Surface Debris Inventory Overview
0 to 2 feet

Prepared on: 6/5/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
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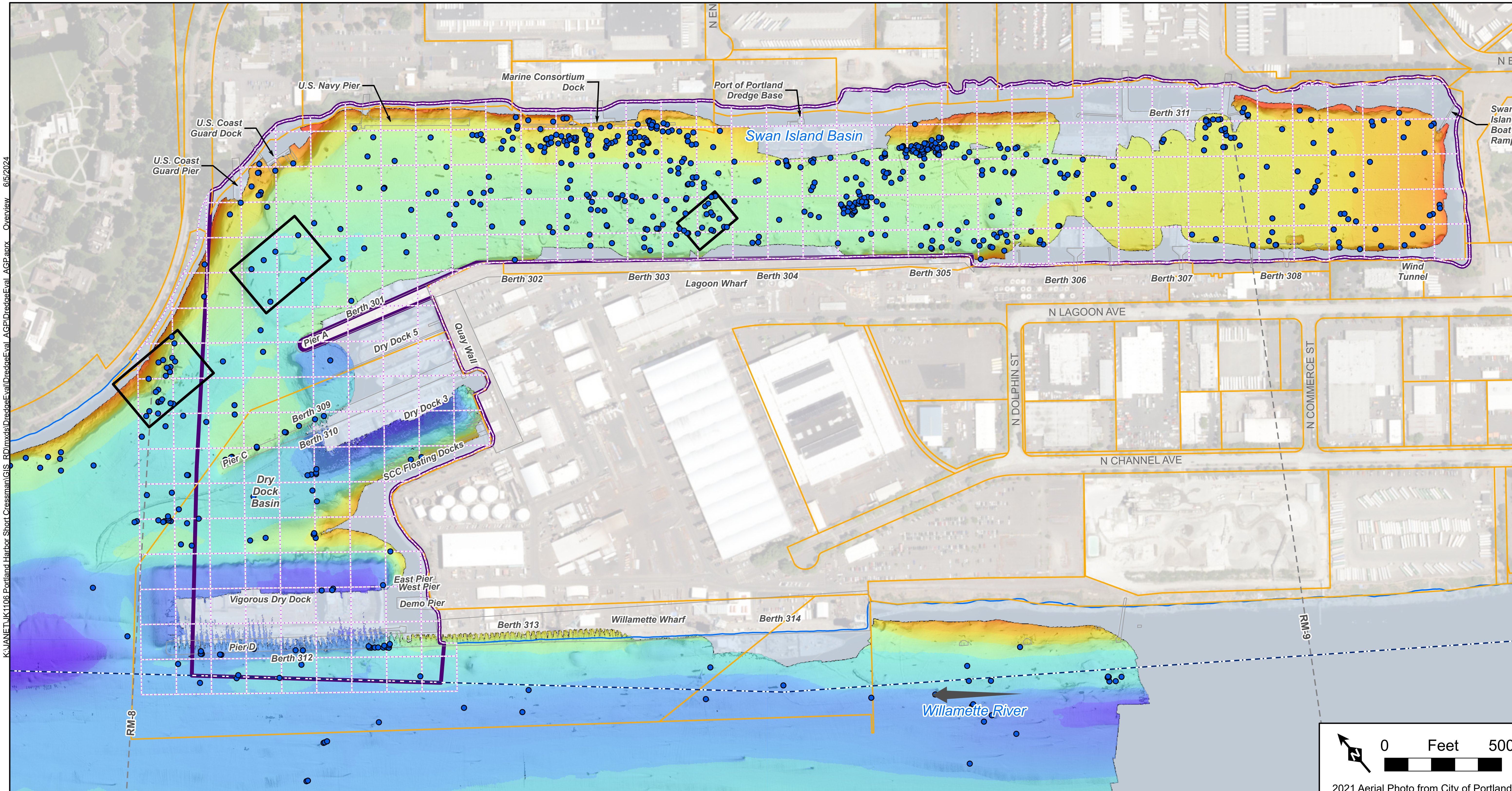
BRIDGEWATER GROUP



River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

2022 Bathymetry (Feet NAVD88)
7.97
0
-10
-20
-30
-40
-50
-57.63

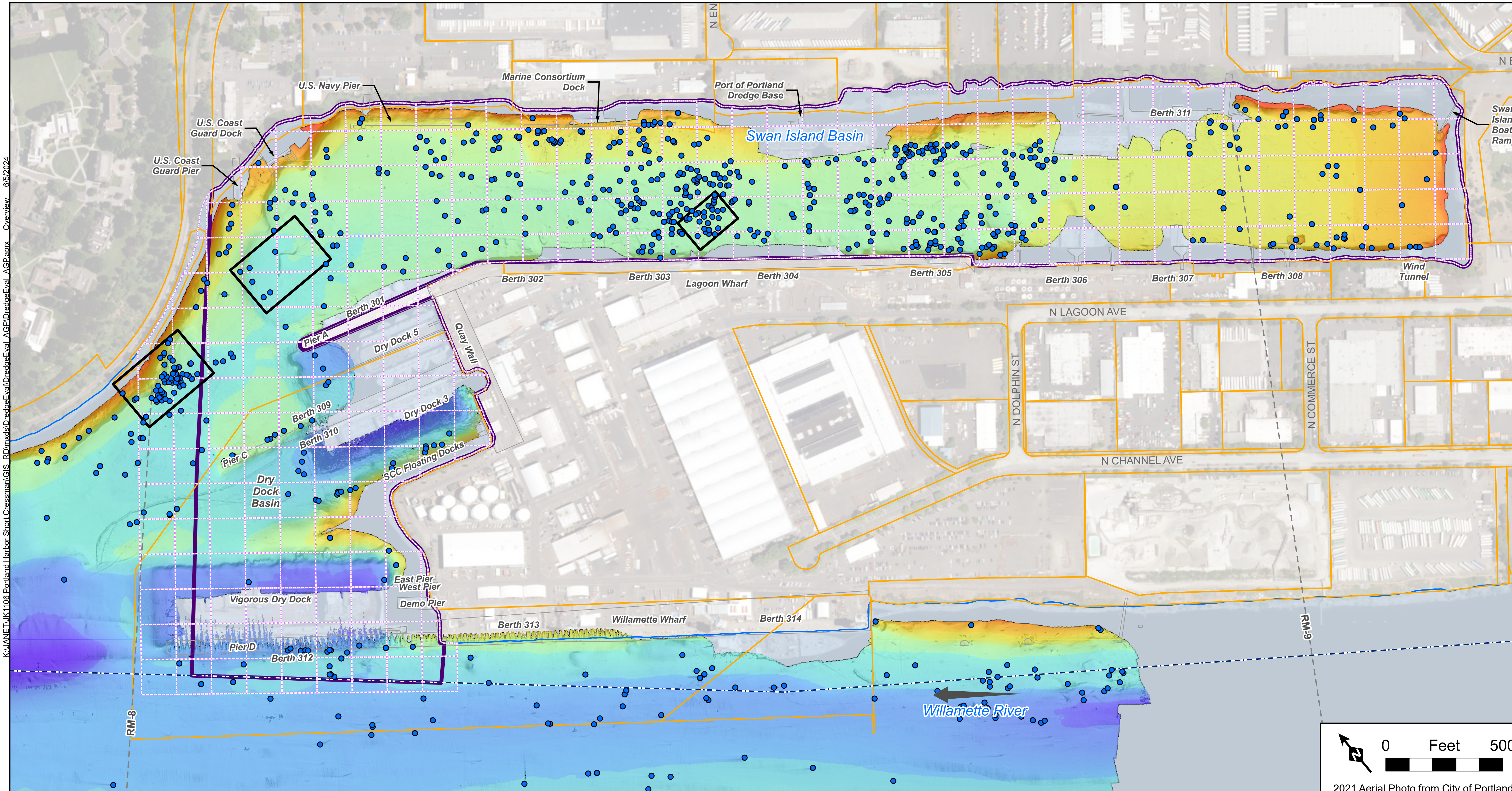
Debris Features by Size
2 to 5 feet
Test Site

Notes:
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 2-25
Surface Debris Inventory Overview
2 to 5 feet

Prepared on: 6/5/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

2022 Bathymetry (Feet NAVD88)
7.97
0
-10
-20
-30
-40
-50
-57.63

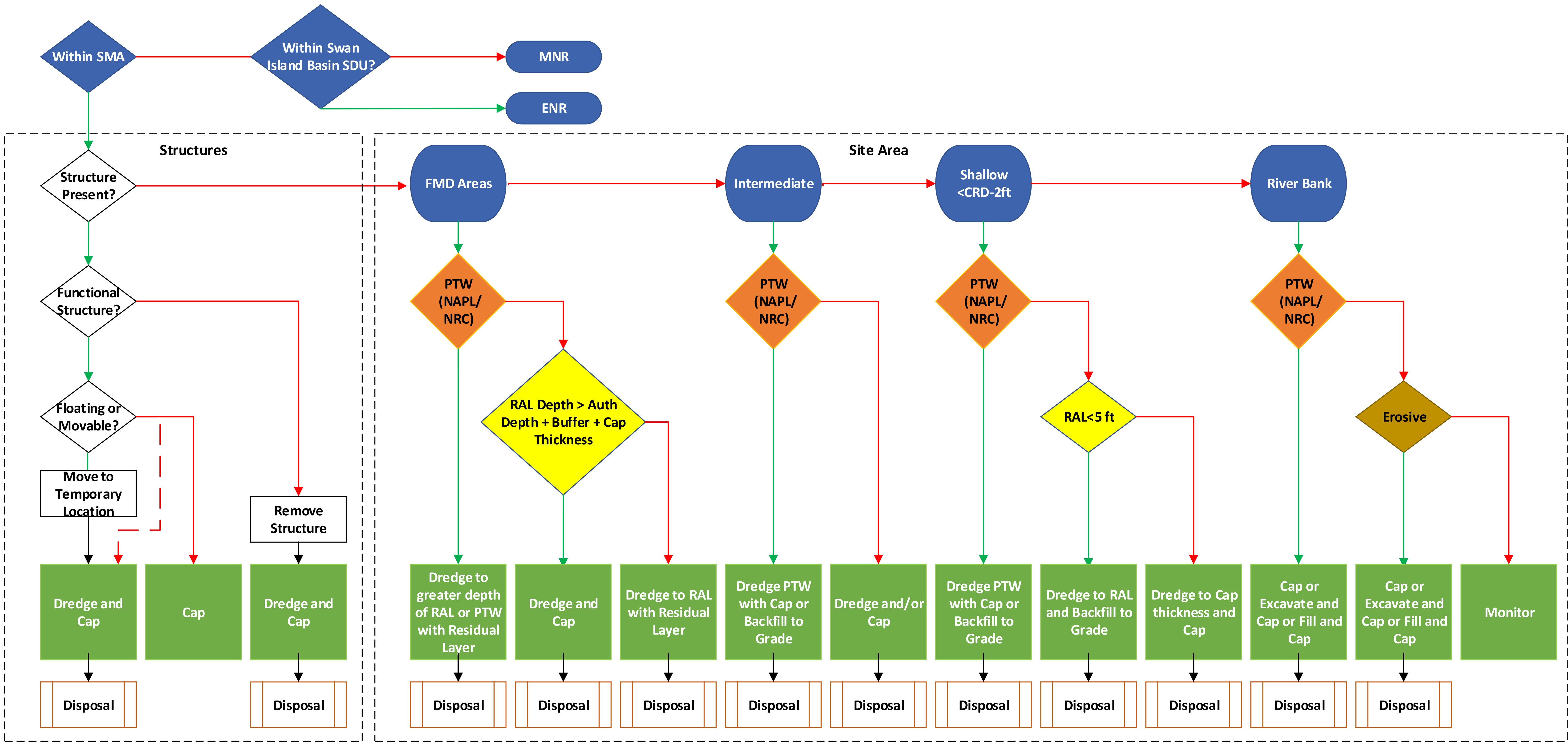
Debris Features by Size
Greater Than 5 feet
Test Site

Notes:
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 2-26
Surface Debris Inventory Overview Greater Than 5 feet

Prepared on: 6/5/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Notes

Yes

No

Added line as compared to the otiginal ROD Figure 28 based on site-specific conditions

Notes:
> – greater than
CRD – Columbia River Datum
CUL – cleanup level
ENR – enhanced natural recovery
FMD – future maintenance dredging
ft – feet
MNR – monitored natural recovery
NAPL – non-aqueous phase liquid
PTW – principal threat waste
RAL – remedial action level
ROD – Record of Decision
SDU – Sediment Decision Unit
SMA – Sediment Management Area

Figure 3-1

SIB Remedial Technology Assignment Decision Tree (Adapted from ROD Figure 28)

Prepared on: 5/13/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
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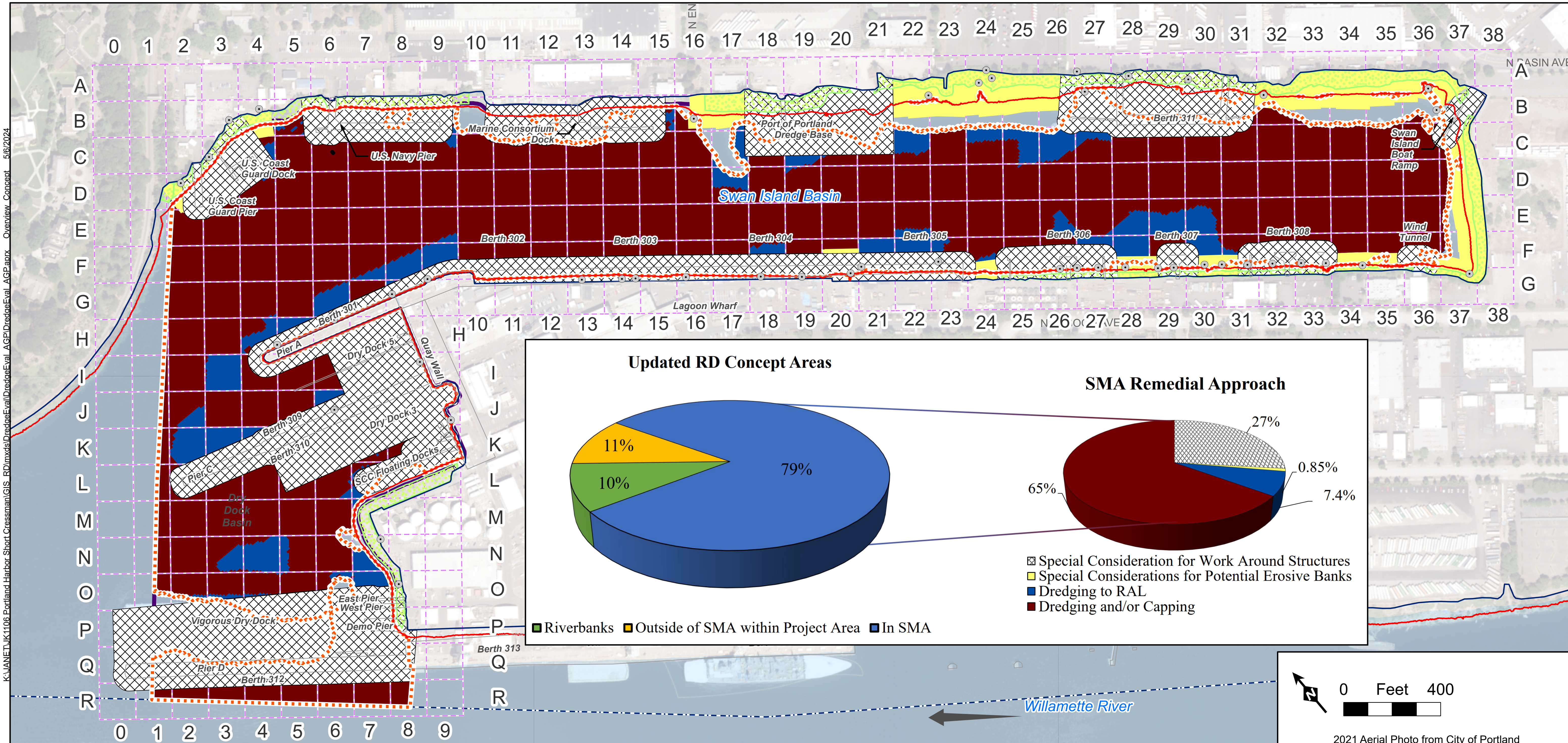
MOTT MACDONALD
BRIDGEWATER GROUP



Project Area Grid
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Top of Bank (TOB)
+13-foot NAVD88 Contour
Outfalls*
Project Area Grid Label
River Flow Direction

Potential Revegetation Areas
Special Consideration for Work Around Structures
Refined SMA Horizontal Extent
Potential Erosive Banks
No Further Action Areas
Dredging to RAL
Dredging and/or Capping

Notes:
NAVD88 – North American Vertical Datum of 1988
RAL – Remedial Action Level
SCC – Shipyard Commerce Center
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

TOB Source – City of Portland Lidar, 2019

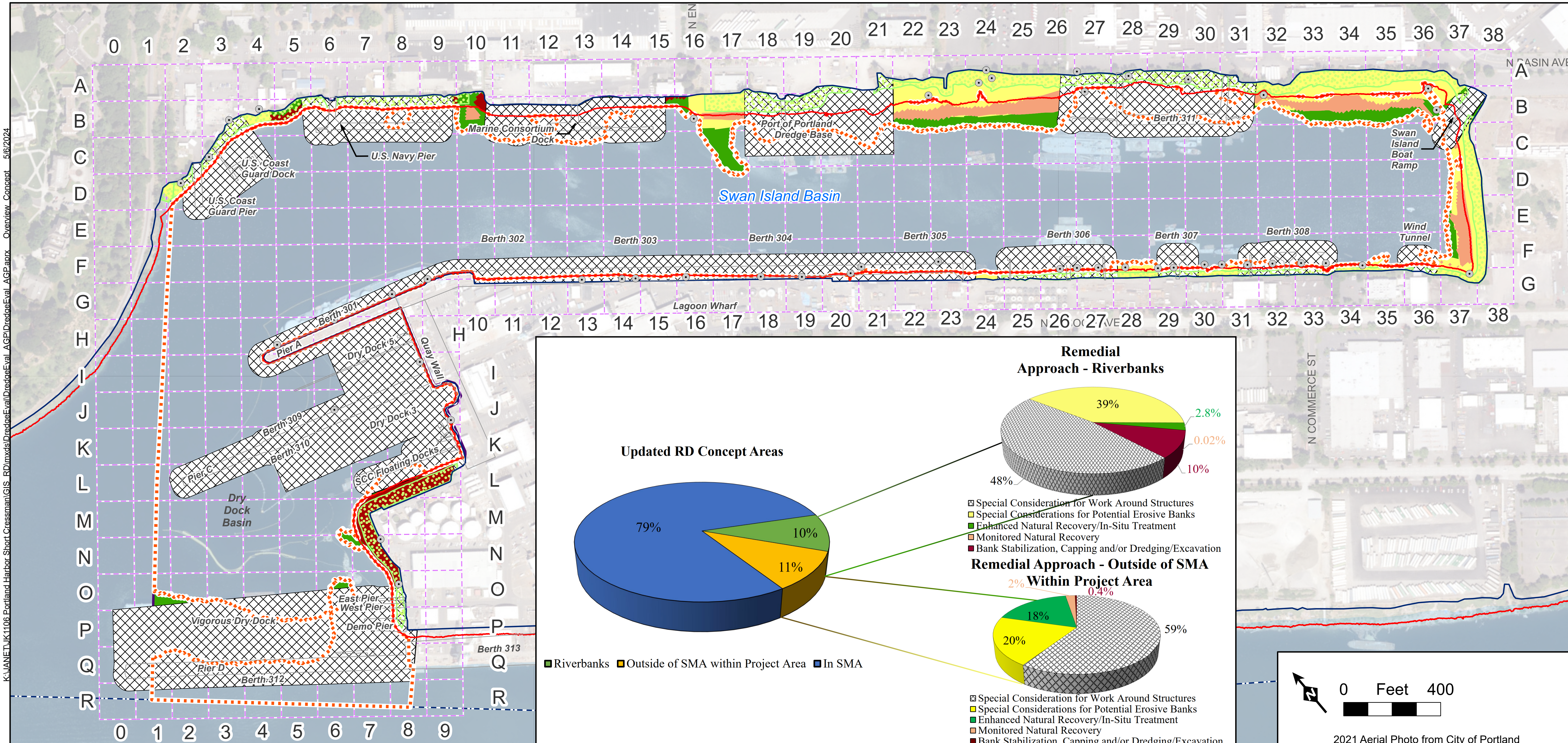
Project area boundary currently under review.

*All outfalls will require special consideration.

Figure 5-1
Preferred Remedial Approach Areas – SMA

Prepared on: 5/6/2024
Basis of Design Report
Swan Island Basin

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Project Area Grid
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Top of Bank (TOB)
+13-foot NAVD88 Contour
Outfalls*
Potential Revegetation Areas
Special Consideration for Work Around Structures
Refined SMA Horizontal Extent
Capping and/or Bank Stabilization
Potential Erosive Banks
Monitored Natural Recovery
Enhanced Natural Recovery

M Project Area Grid Label

River Flow Direction

Notes:
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

TOB Source – City of Portland Lidar, 2019

Project area boundary currently under review.

*All outfalls will require special consideration.

Figure 5-2

Preferred Remedial Approach Areas – Riverbanks and Areas Outside SMA within Project Area

Prepared on: 5/6/2024
Basis of Design Report
Swan Island Basin

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP

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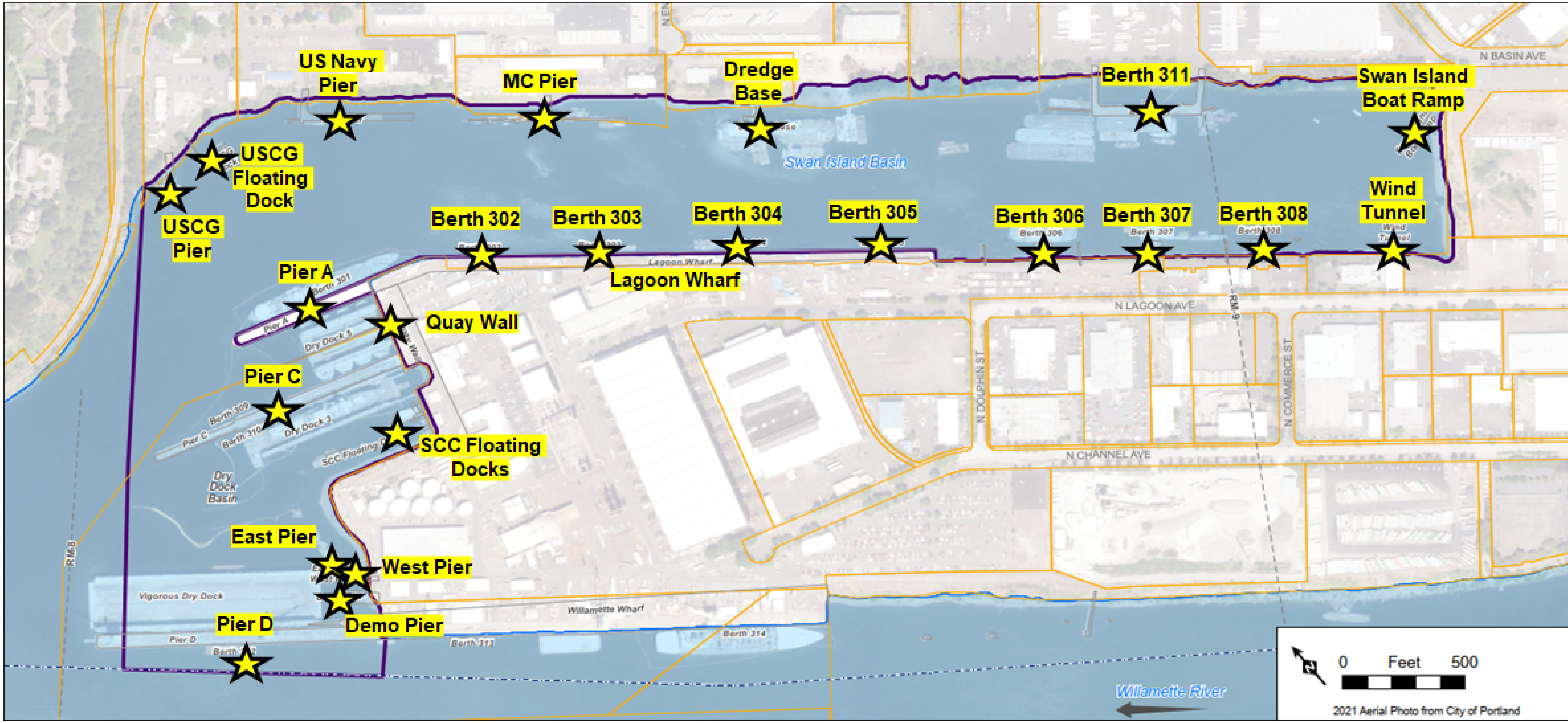
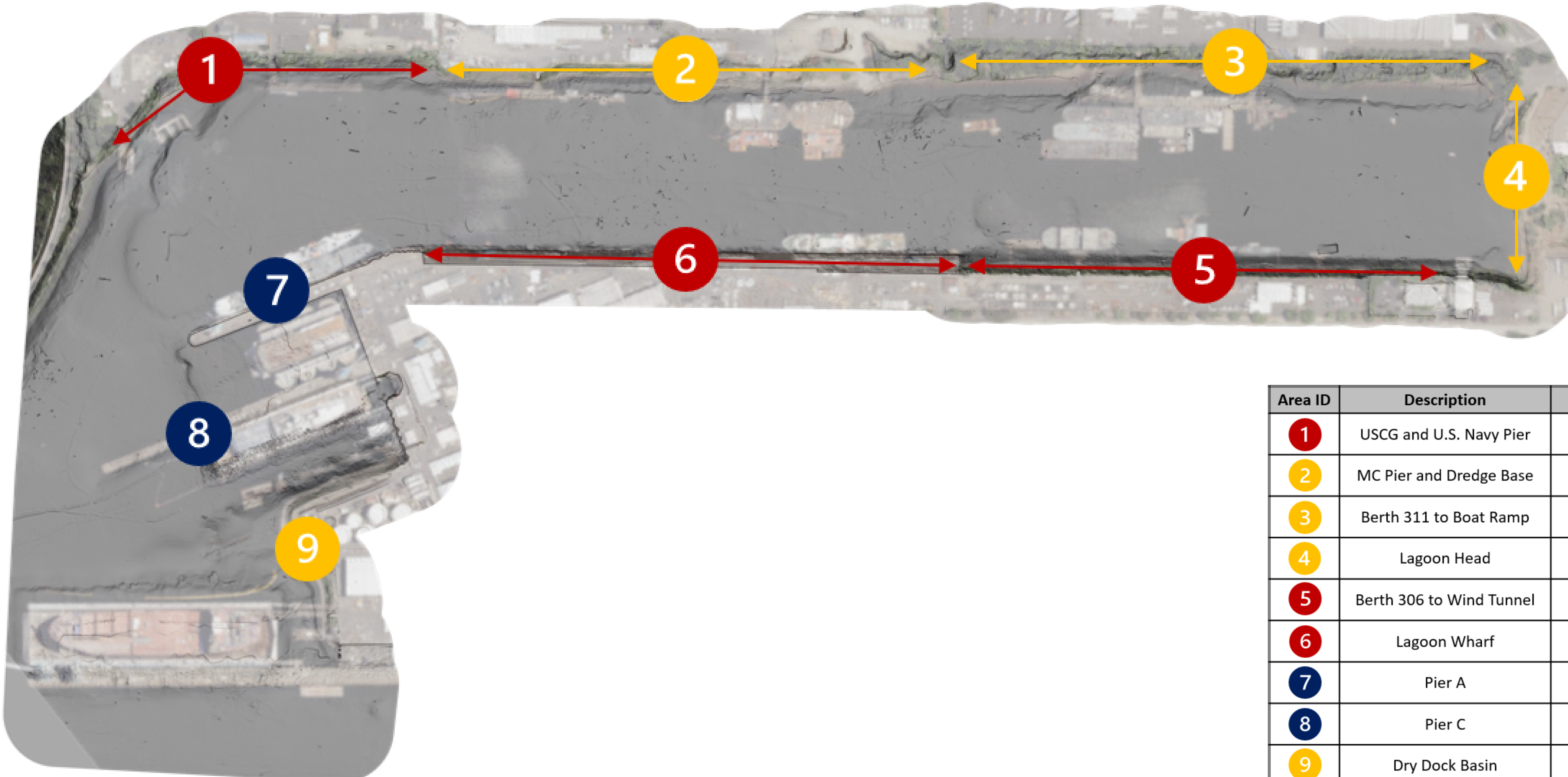


Figure 6-2

Shoreline and Overwater Structures within the SIB Project Area

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group



Area ID	Description	Slope Risk Level
1	USCG and U.S. Navy Pier	Medium to High
2	MC Pier and Dredge Base	Medium
3	Berth 311 to Boat Ramp	Medium
4	Lagoon Head	Low to Medium
5	Berth 306 to Wind Tunnel	High
6	Lagoon Wharf	High
7	Pier A	Not applicable - No slope present
8	Pier C	Not applicable - No slope present
9	Dry Dock Basin	Low to Medium

Notes:
Low Risk: Structure and/or slope likely able to support RA activities with minimal or no modifications
Medium Risk: Impact of RA activities on structure and/or slope is uncertain, modifications may be required, further evaluation required during RD.
High Risk: Structure and/or slope cannot support RA activities without significant modifications
MC = The Marine Consortium, Inc.
USCG = U.S. Coast Guard

Figure 6-3

Riverbank Slopes and Slope Stability

Prepared on: 3/13/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP HGL MOTT MACDONALD BRIDGEWATER GROUP

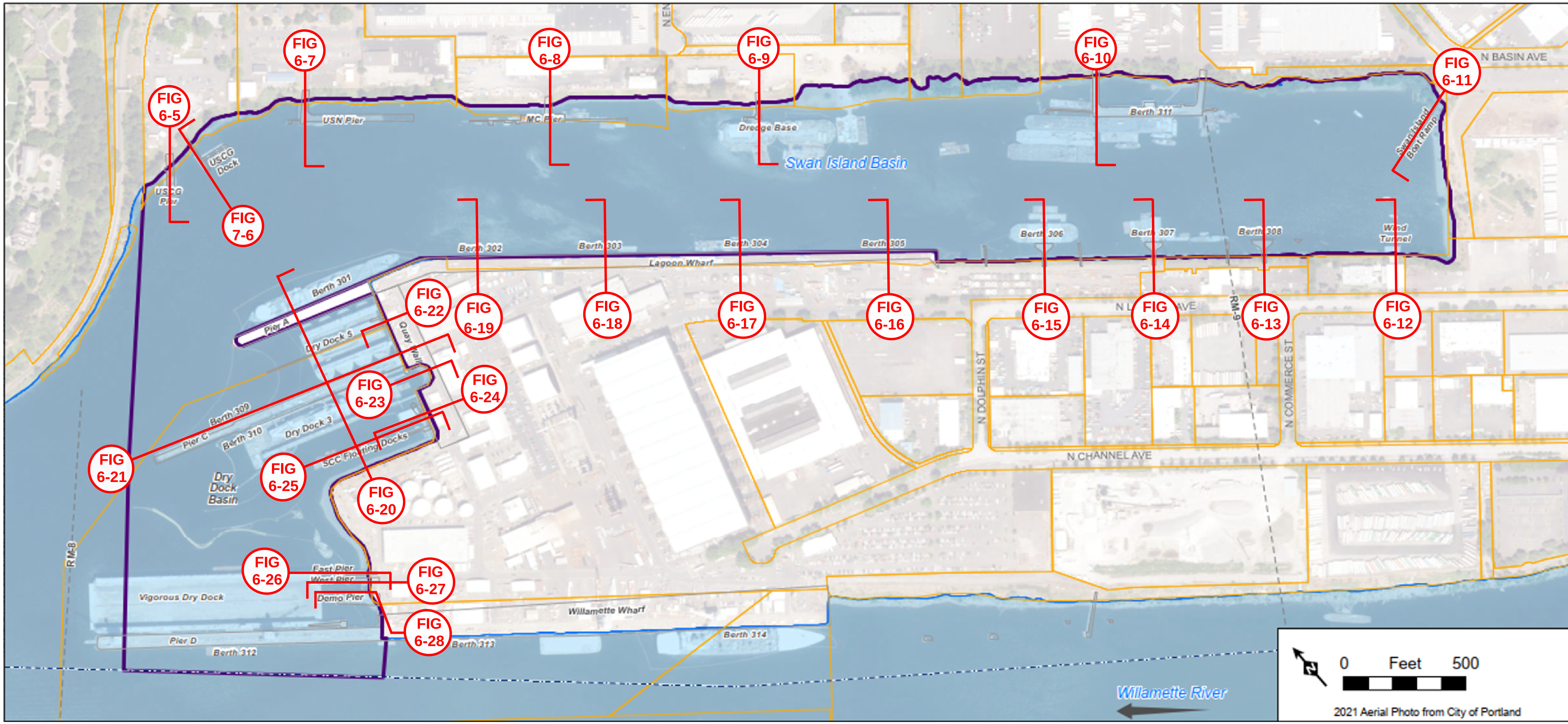


Figure 6-4

Key Map for Transects Shown on Figures 6-5 through 6-28

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
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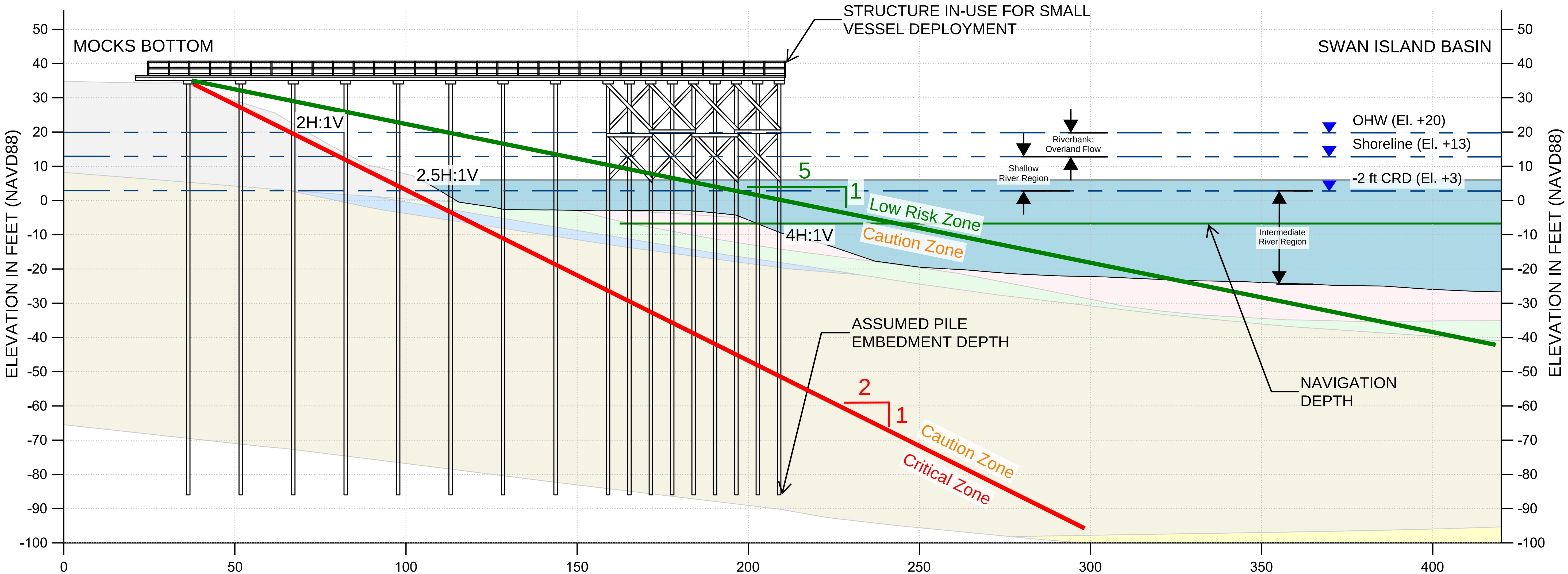
BRIDGEWATER GROUP



Interpreted Geologic Units

- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Willamette River Elevation

- Water

0ft 100ft

ABBREVIATIONS

CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water

Notes:

1. Structure location and dimensions are approximate and for illustration purposes only.
2. For discussion purposes only, not for construction.
3. Existing structure to be evaluated based on chosen remedial actions near and beneath the structure.
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

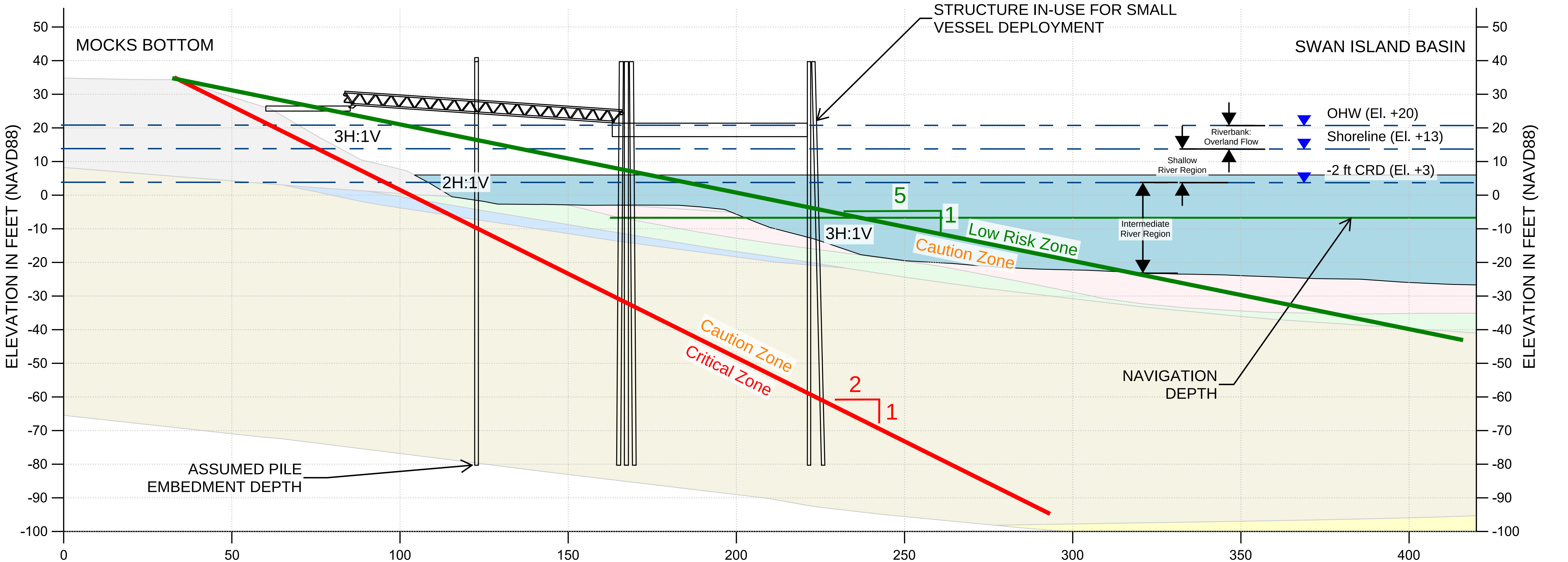
Figure 6-5

USCG Pier Cross-Section

Property ID: R315695

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units
Clay (Native)
Sand (Native)
Silt (Native)
Non-native material

Willamette River Elevation
Water

0ft 100ft

ABBREVIATIONS
CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water

Notes:

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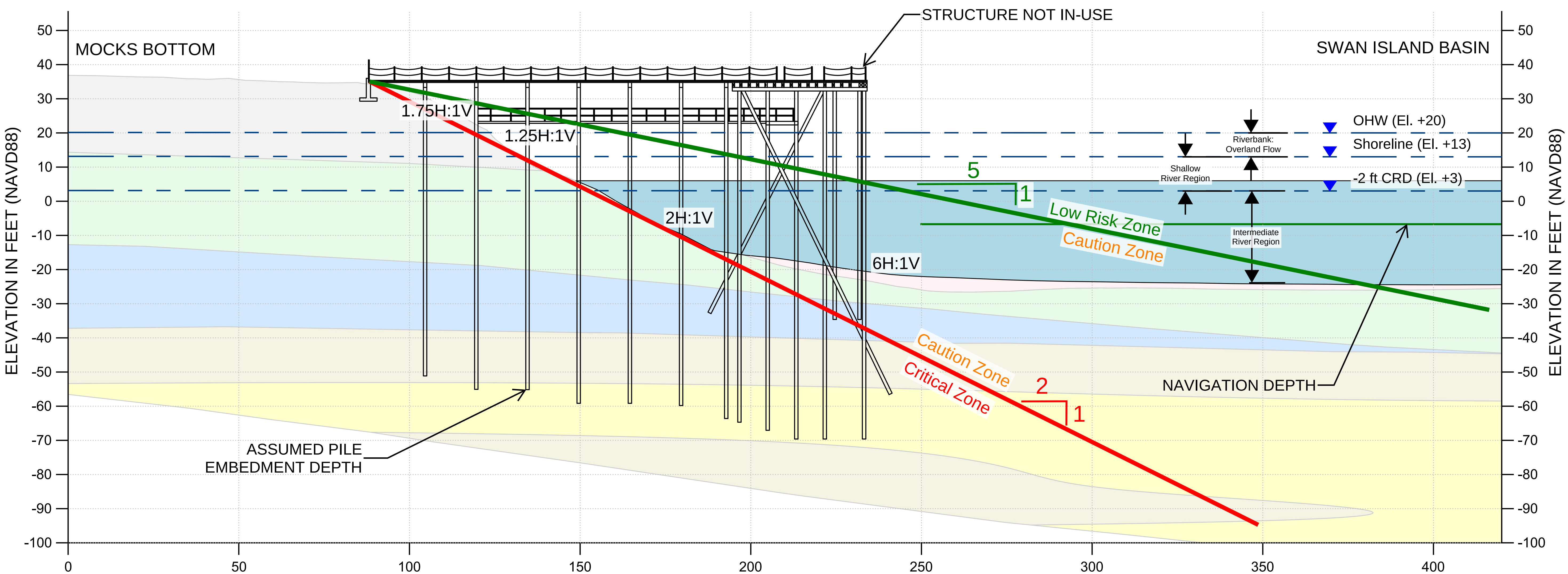
2. For discussion purposes only, not for construction.
3. Existing structure to be evaluated based on chosen remedial actions near and beneath the structure.
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

Figure 6-6
USCG Dock Cross-Section

Property ID: R315695

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units
- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Willamette River Elevation
- Water

0ft 100ft

ABBREVIATIONS
CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water

Notes:

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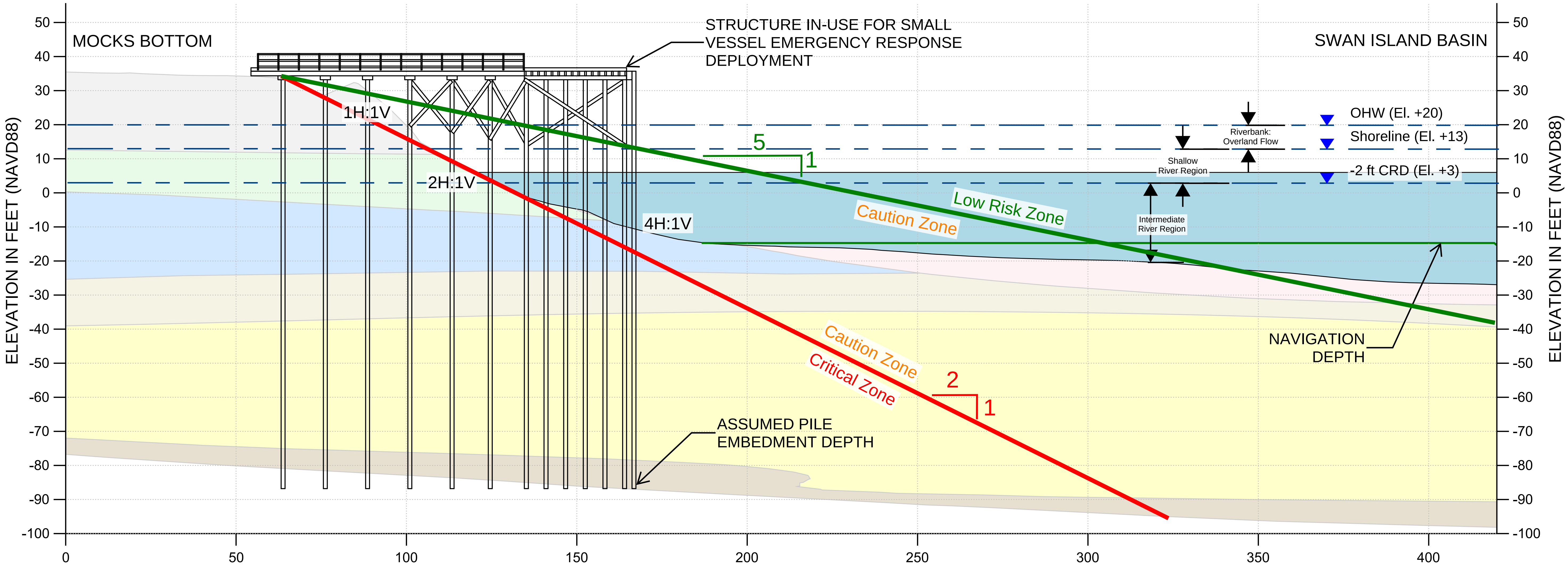
2. For discussion purposes only, not for construction.
3. Existing structure to be evaluated based on chosen remedial actions near and beneath the structure.
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

Figure 6-7
U.S. Navy Pier Cross-Section

Property ID: R315697

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units

- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

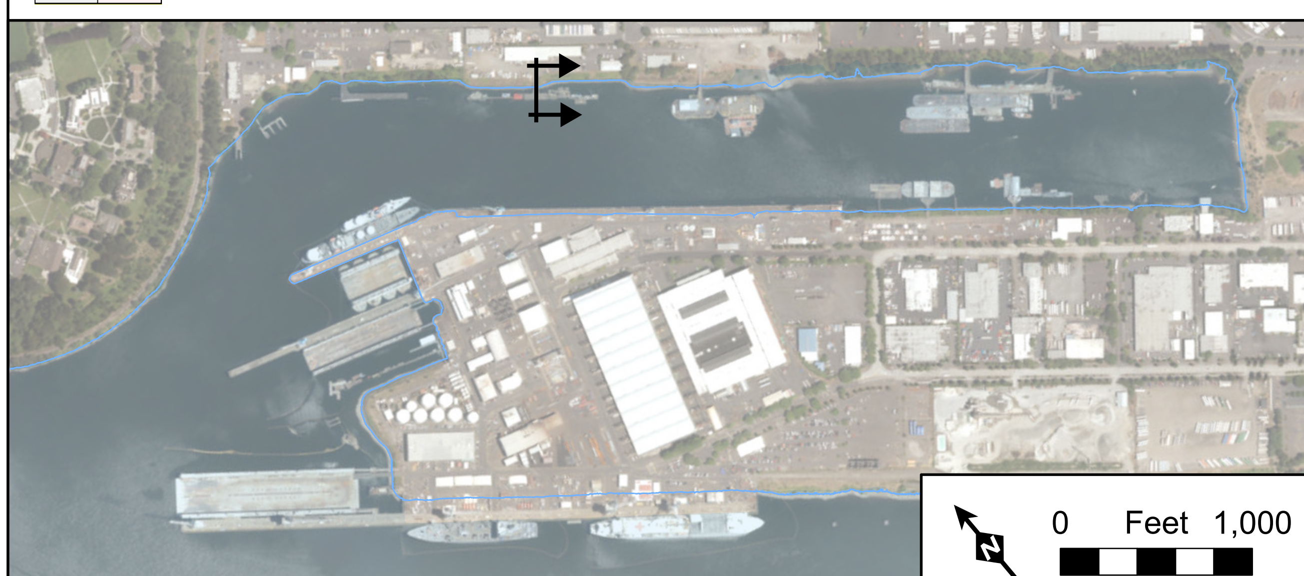
Willamette River Elevation

- Water

0ft 100ft

<u>ABBREVIATIONS</u>

CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water



Notes:

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2. For discussion purposes only, not for construction.
3. Existing structure to be evaluated based on chosen remedial actions near and beneath the structure.
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

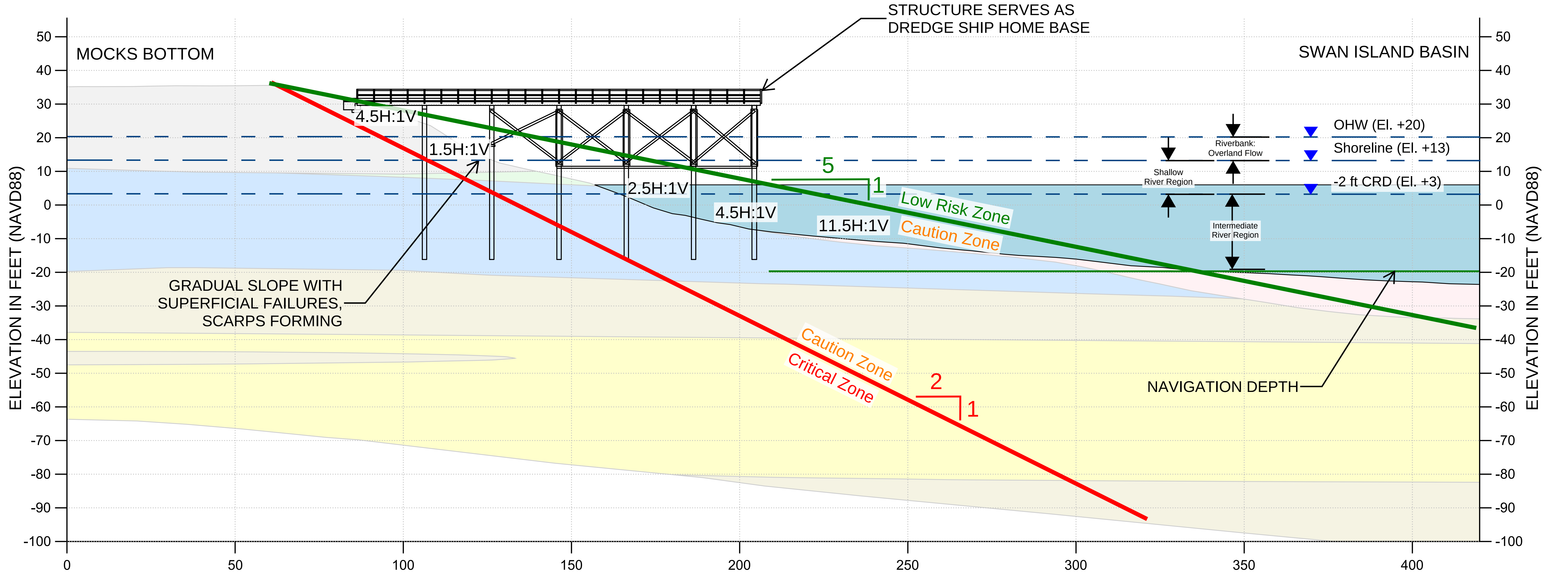
Figure 6-8

MC Pier Cross-Section

Property ID: R315704

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units

- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

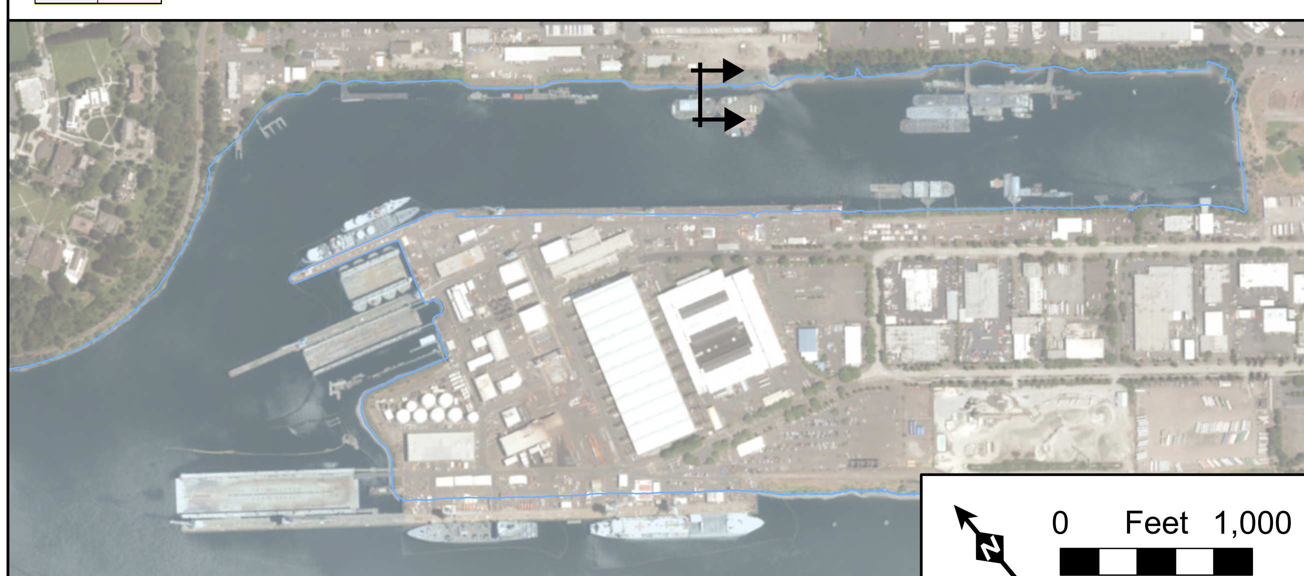
Willamette River Elevation

- Water

0ft — 100ft

ABBREVIATIONS

CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water



Notes:

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2. For discussion purposes only, not for construction.
3. Existing structure to be evaluated based on chosen remedial actions near and beneath the structure.
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

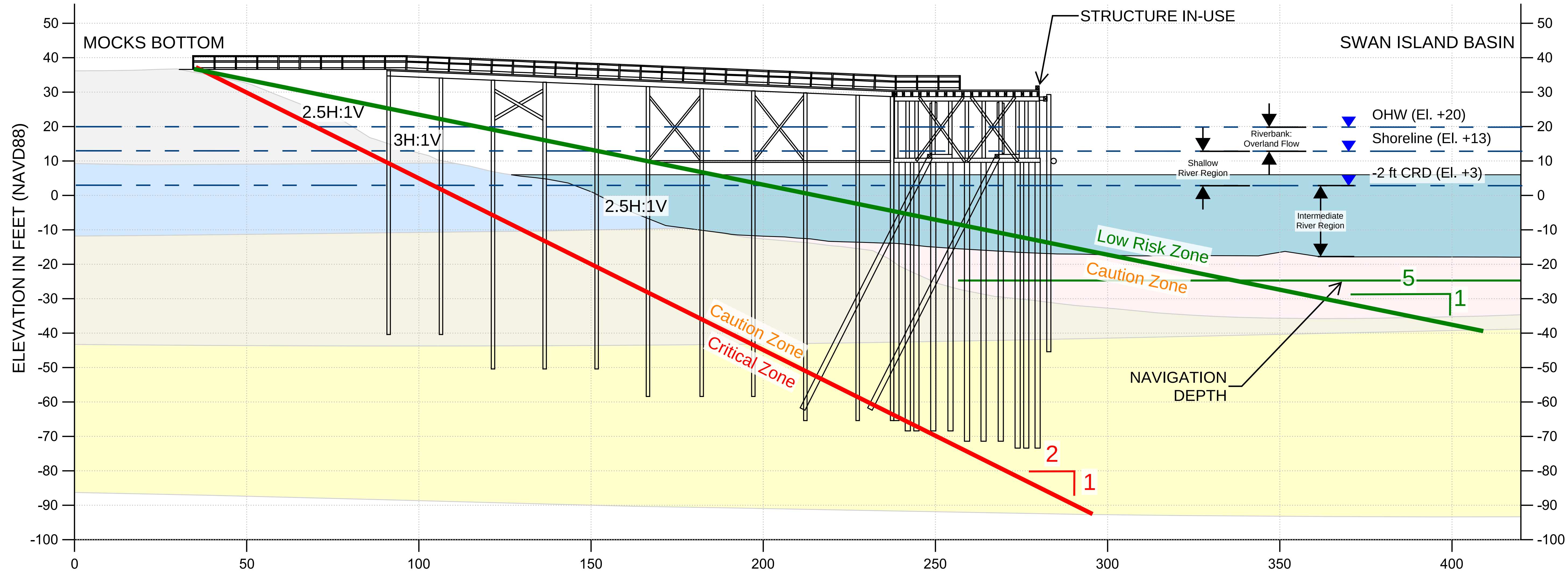
Figure 6-9

Dredge Base Cross-Section

Property ID: R315705

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units

- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Columbia River Elevation

- Water

0ft 100ft

ABBREVIATIONS
CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water

Notes:

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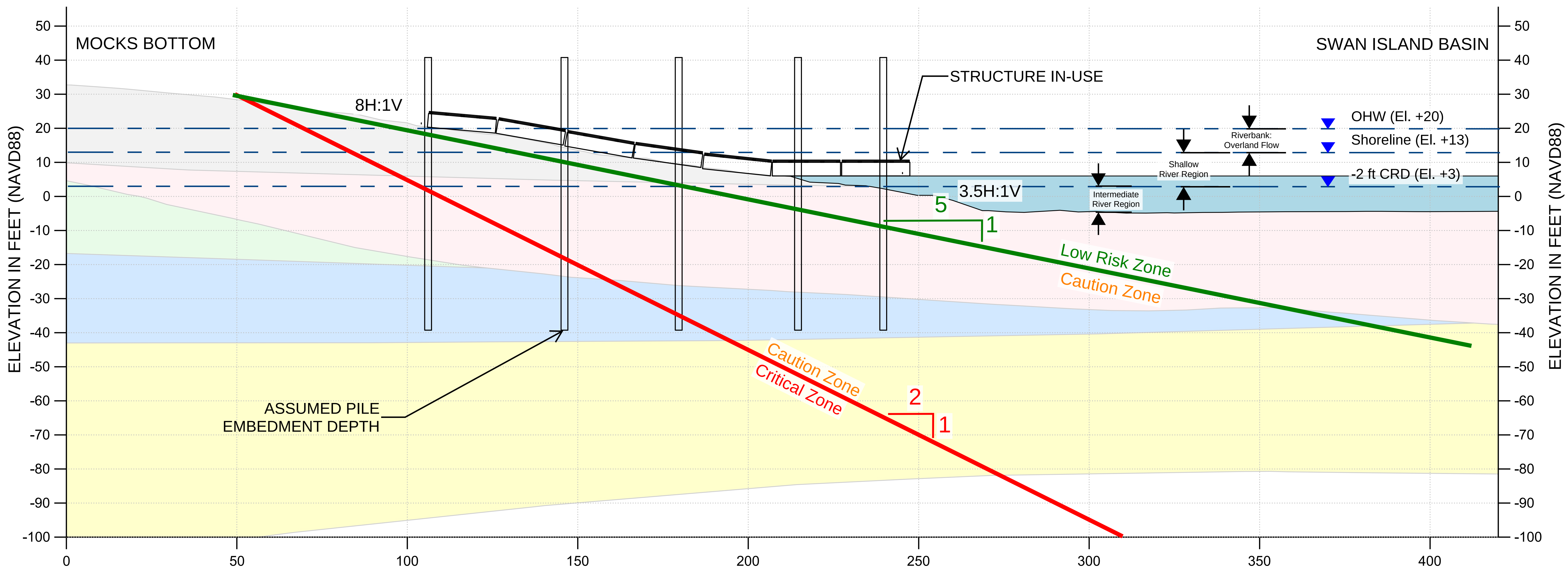
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

Figure 6-10

Berth 311 Cross-Section

Property ID: R673573

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group



Interpreted Geologic Units
- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Willamette River Elevation
- Water

0ft 100ft

ABBREVIATIONS
CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water

Notes:

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2. For discussion purposes only, not for construction.
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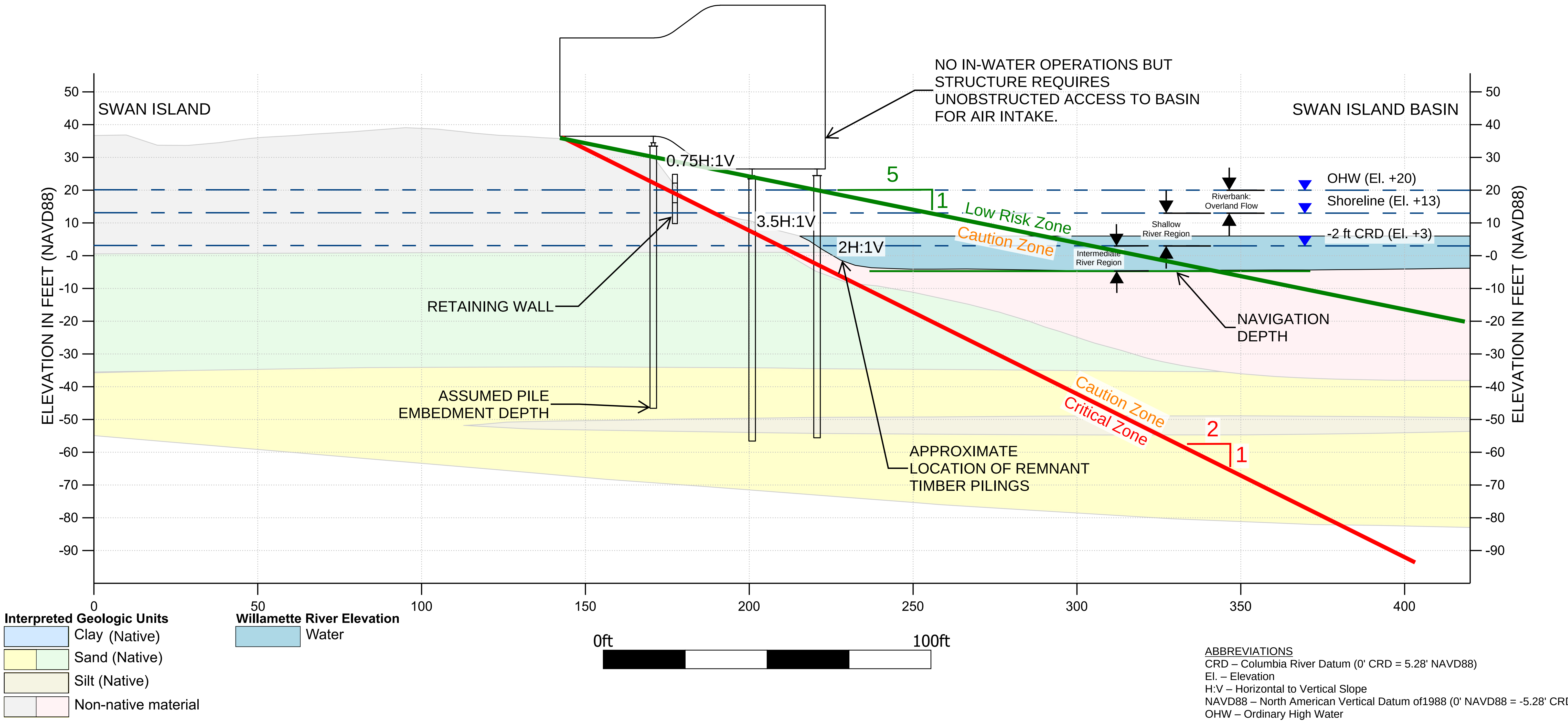
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

Figure 6-11
Swan Island Boat Ramp Cross-Section

Property ID: R592200

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



ABBREVIATIONS
CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water

Notes:

1. Structure location and dimensions are approximate and for illustration purposes only.
2. For discussion purposes only, not for construction.
3. Existing structure to be evaluated based on chosen remedial actions near and beneath the structure.
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

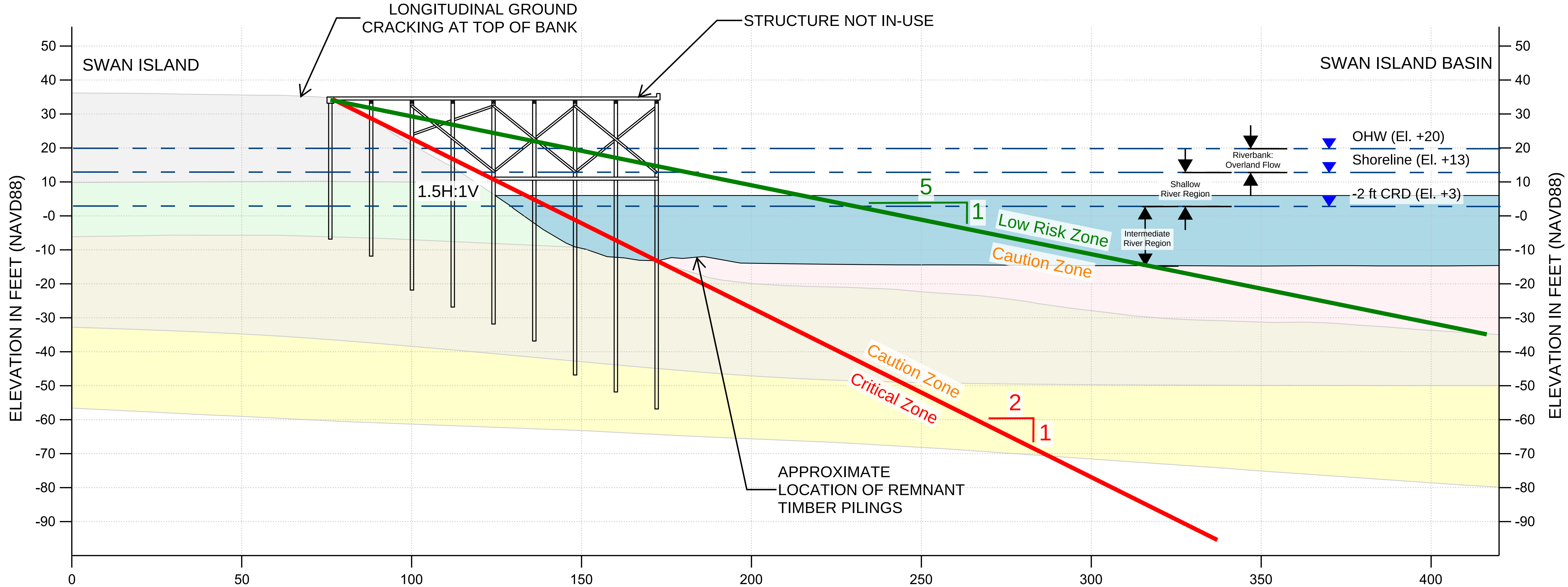
Figure 6-12

Wind Tunnel Cross-Section

Property ID: R315949

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units

- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Willamette River Elevation

- Water

0ft 100ft

ABBREVIATIONS
CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water

Notes:

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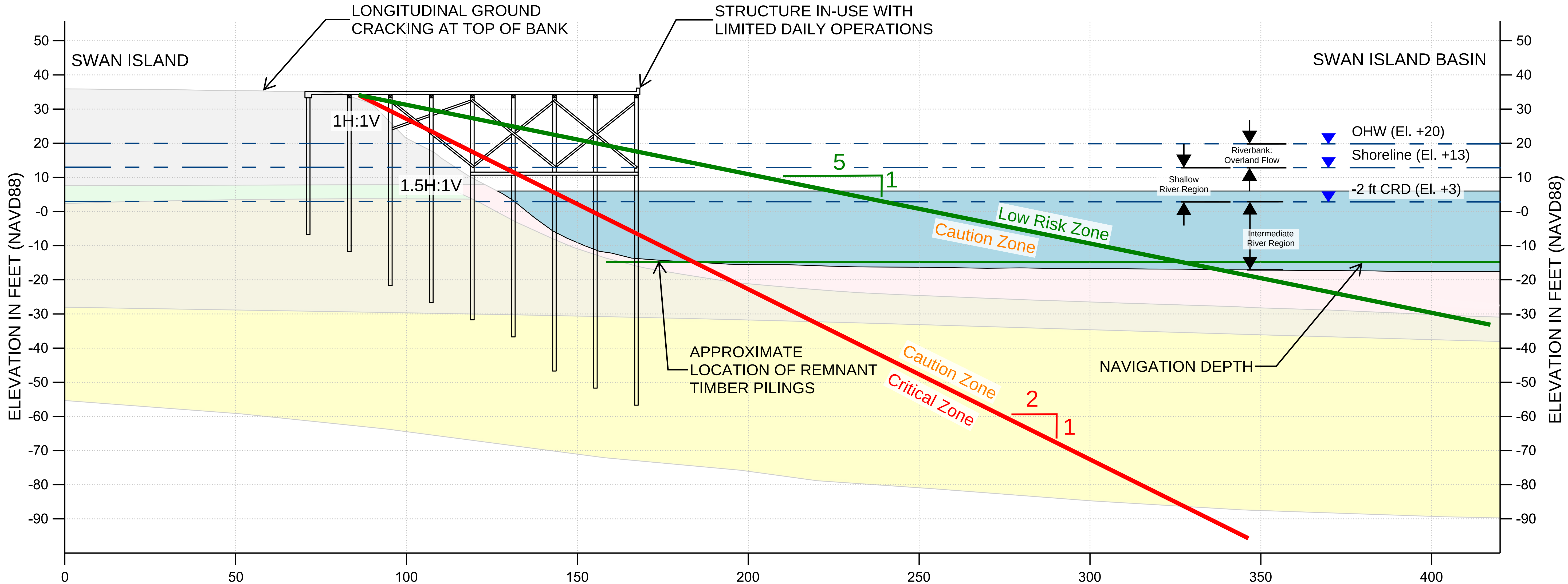
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

Figure 6-13
Berth 308 Cross-Section

Property ID: R543792

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP HGL MOTT MACDONALD BRIDGEWATER GROUP



Interpreted Geologic Units

- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Willamette River Elevation

- Water

0ft 100ft

ABBREVIATIONS
CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water

Notes:

1. Structure location and dimensions are approximate and for illustration purposes only.
2. For discussion purposes only, not for construction.
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4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

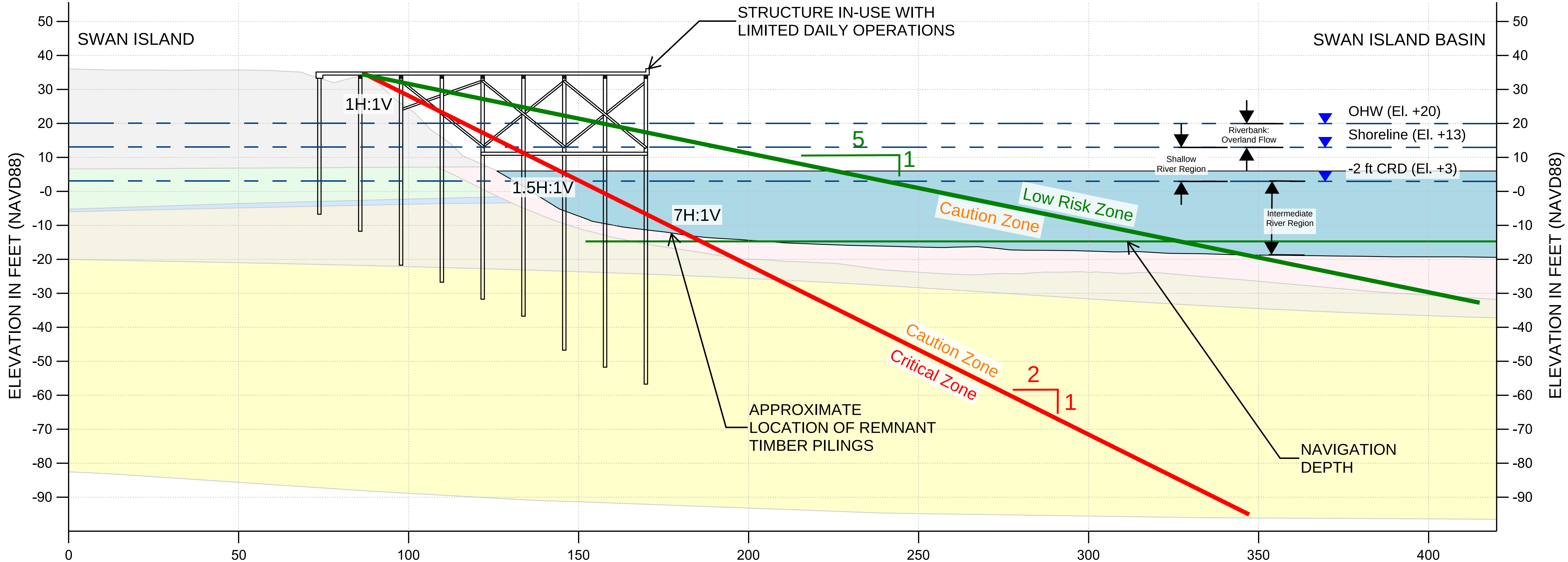
Figure 6-14

Berth 307 Cross-Section

Property ID: R543777

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP

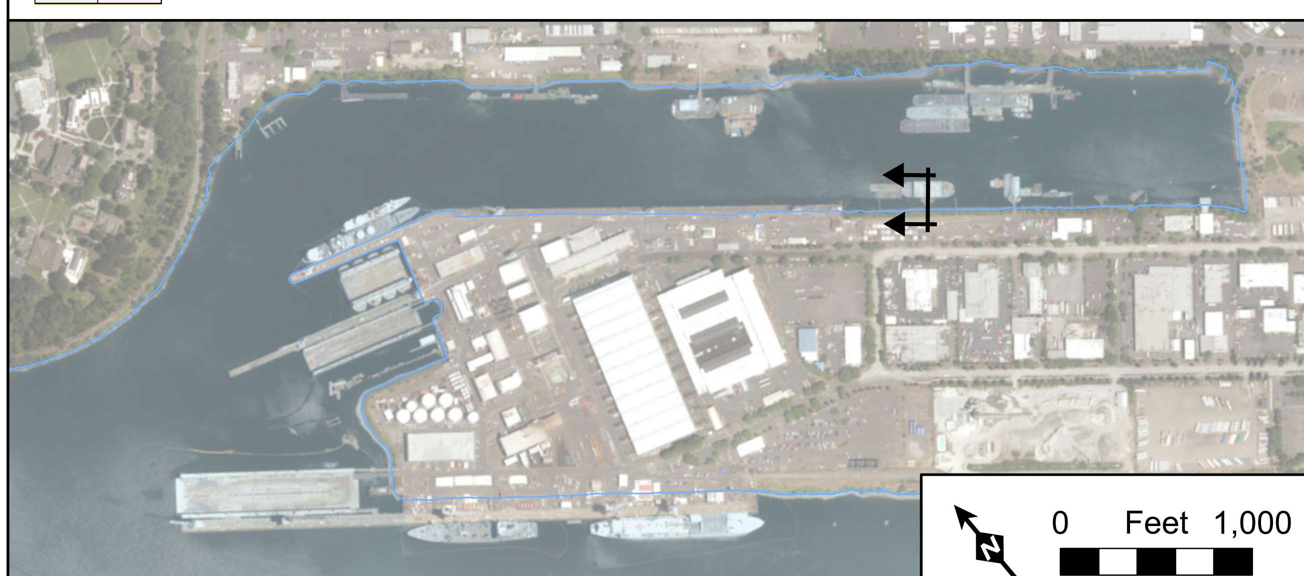


Interpreted Geologic Units
Clay (Native)
Sand (Native)
Silt (Native)
Non-native material

Willamette River Elevation
Water

0ft 100ft

ABBREVIATIONS
CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water



Notes:

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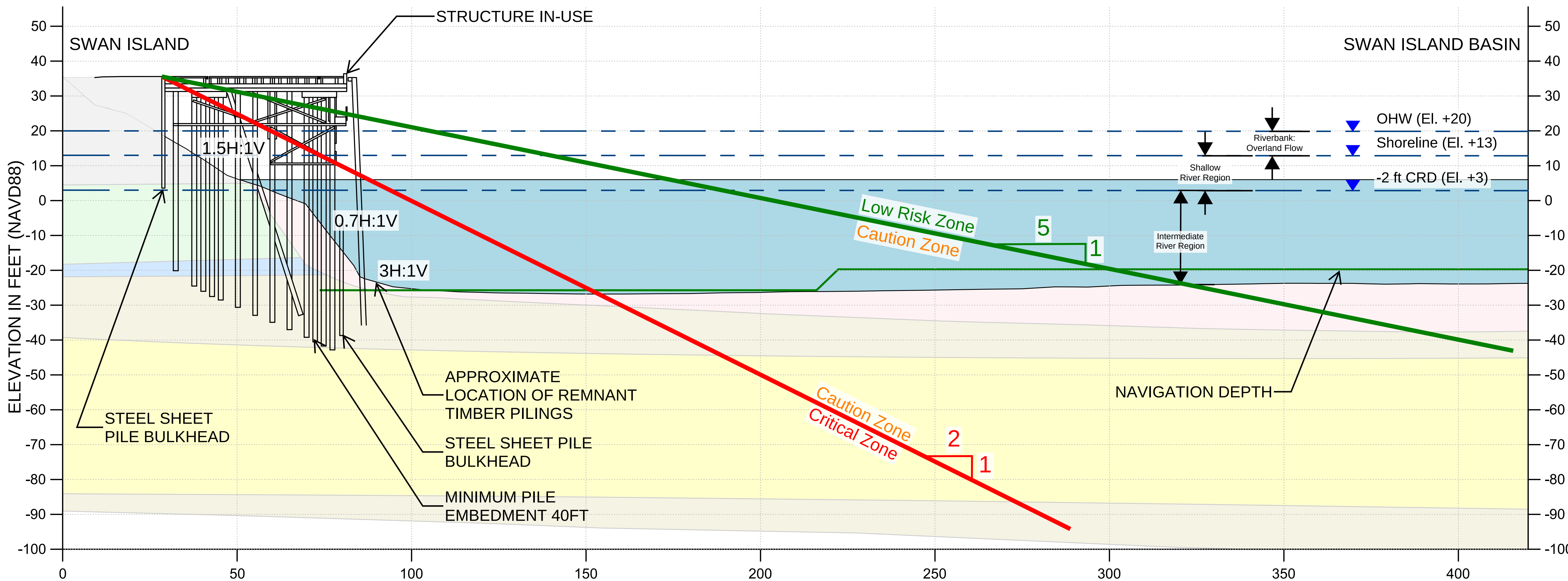
2. For discussion purposes only, not for construction.
3. Existing structure to be evaluated based on chosen remedial actions near and beneath the structure.
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

Figure 6-15
Berth 306 Cross-Section

Property ID: R543777

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units

- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

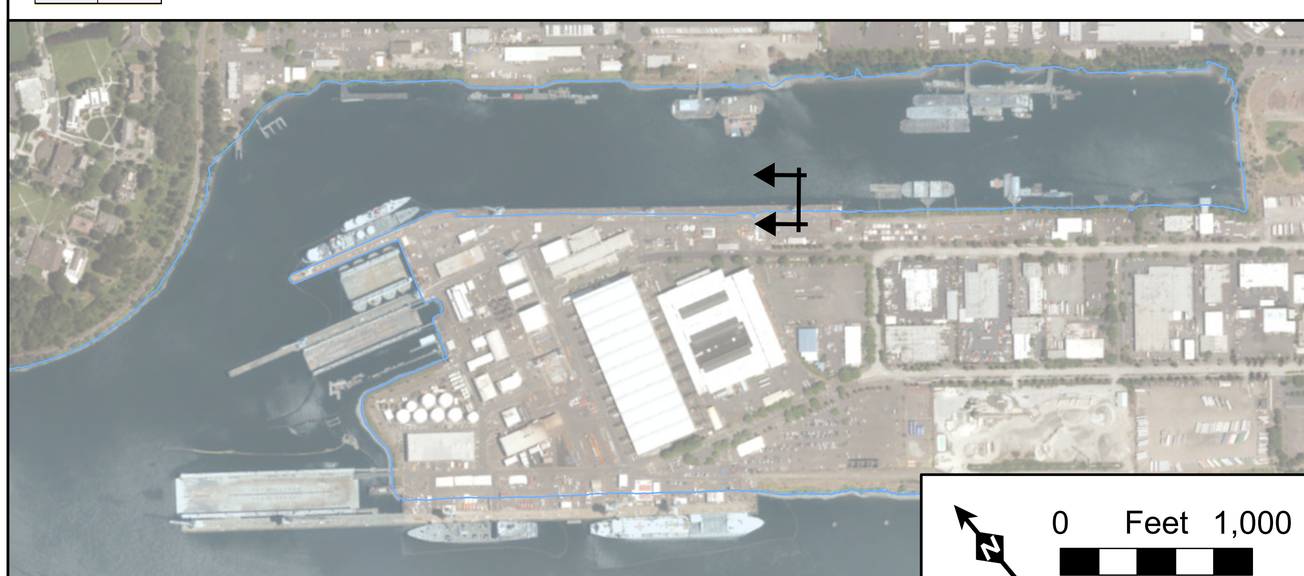
Willamette River Elevation

- Water

0ft 100ft

ABBREVIATIONS

CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water



Notes:

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4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

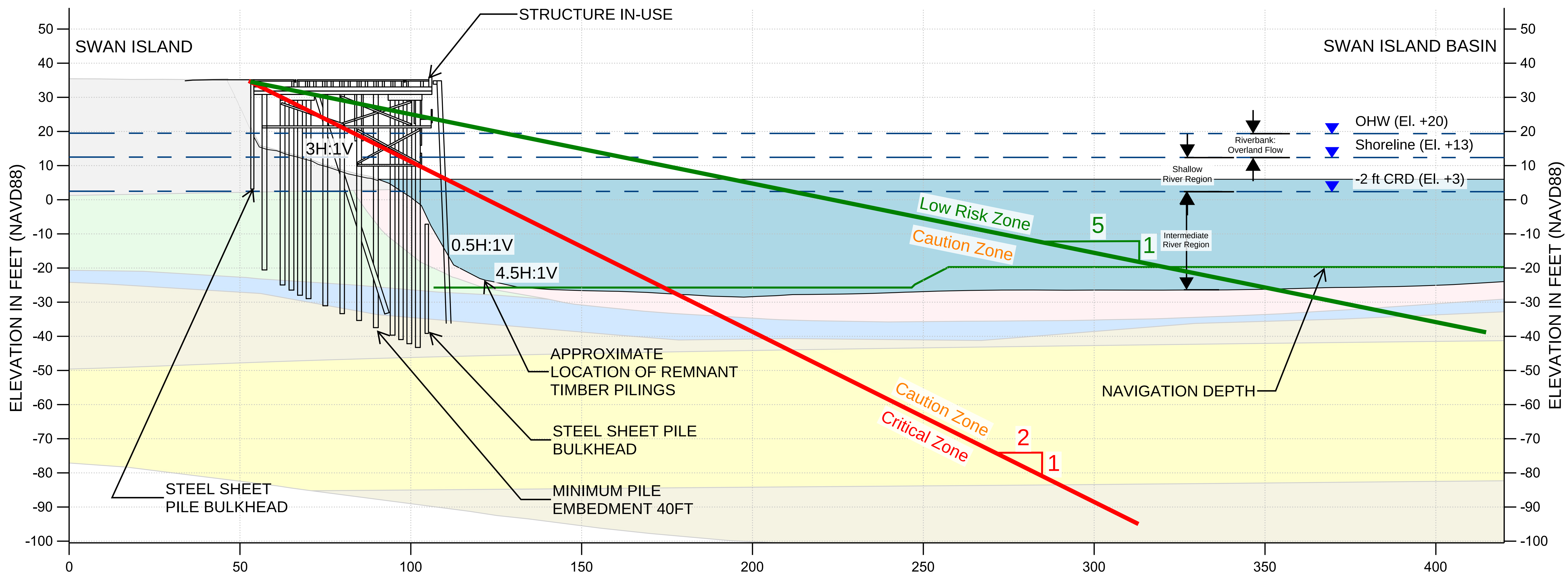
Figure 6-16

Berth 305 Cross-Section

Property ID: R543777

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units

- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Willamette River Elevation

- Water

0ft 100ft

ABBREVIATIONS
CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
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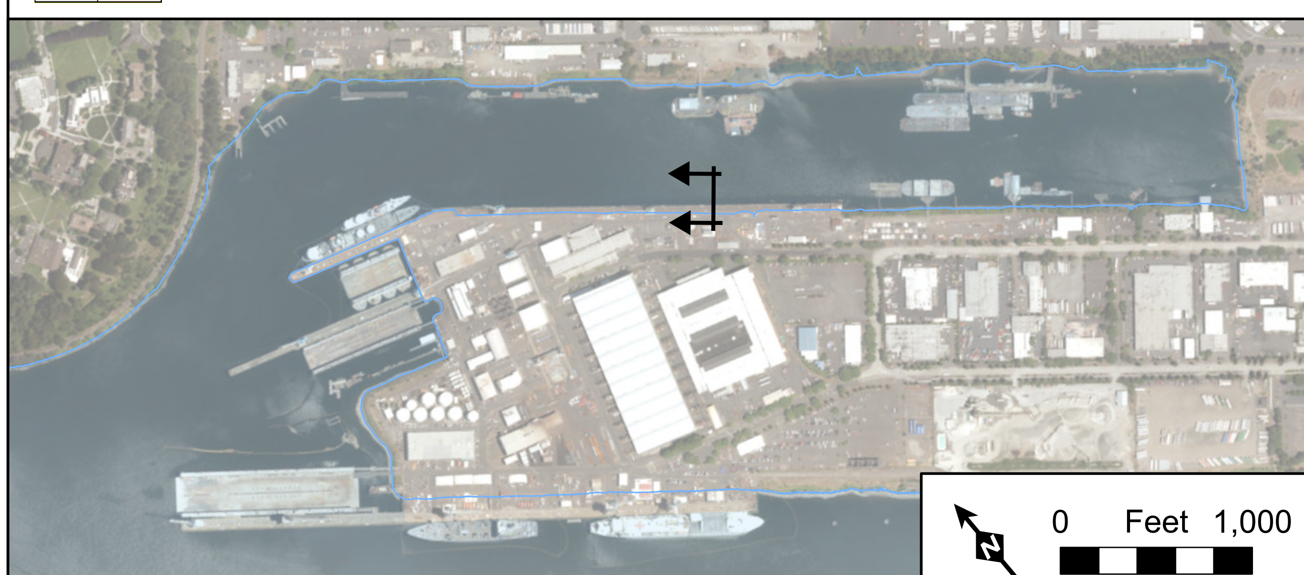
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water



Notes:

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4. Riverbank stability to be evaluated based on chosen remedial actions.
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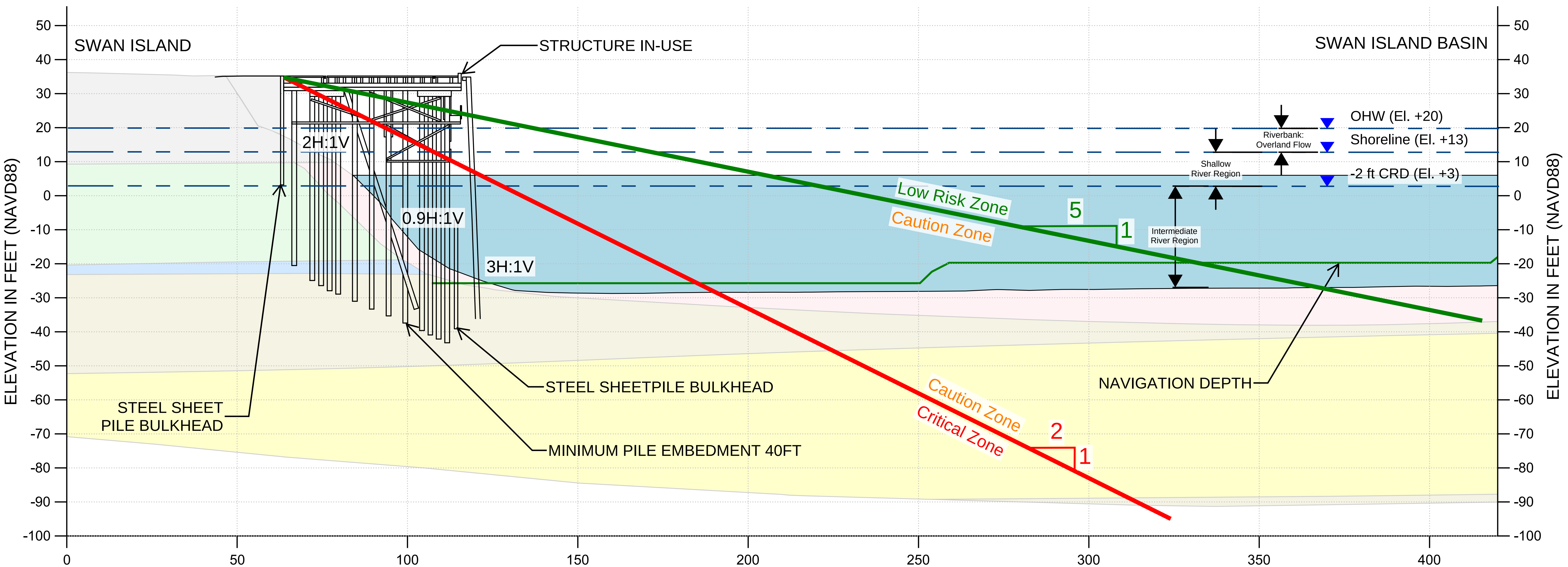
Figure 6-17

Berth 304 Cross-Section

Property ID: R543777

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units

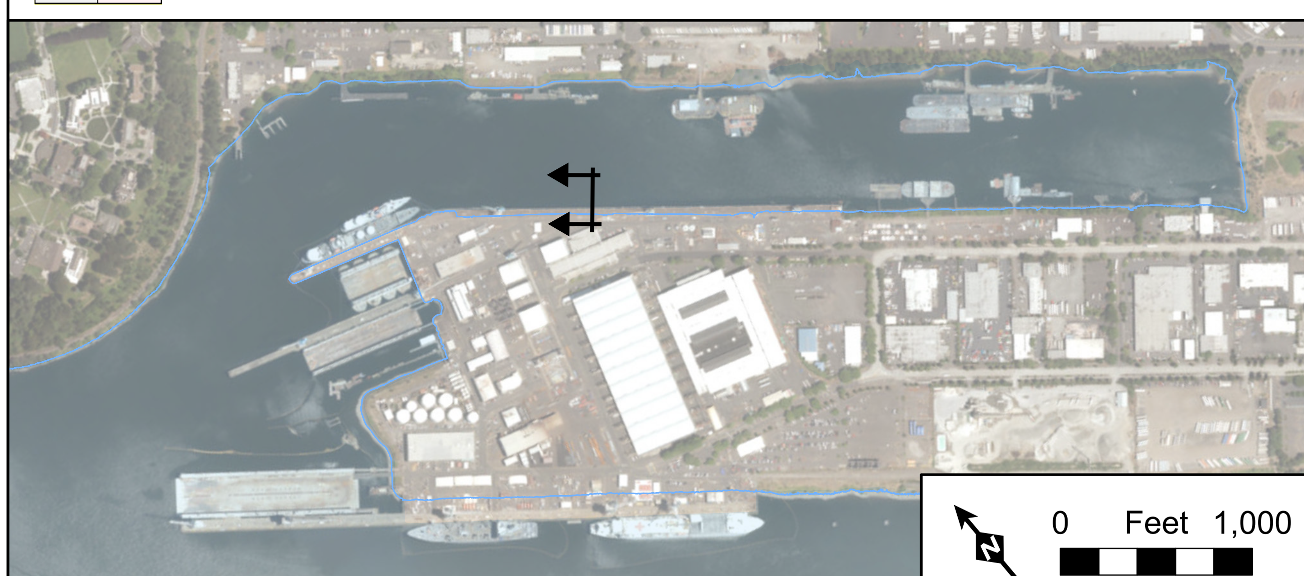
- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Willamette River Elevation

- Water

0ft 100ft

ABBREVIATIONS
CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water



Notes:

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4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

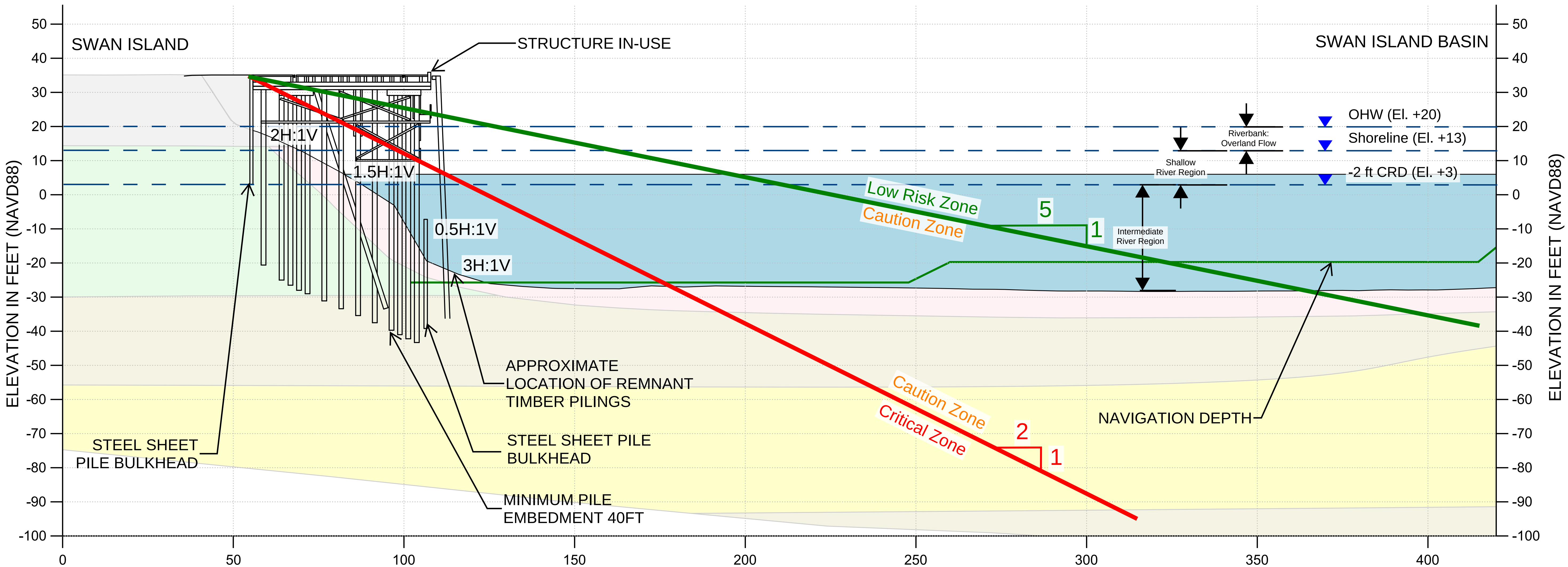
Figure 6-18

Berth 303 Cross-Section

Property ID: R543777

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units

- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Willamette River Elevation

- Water

0ft 100ft

ABBREVIATIONS
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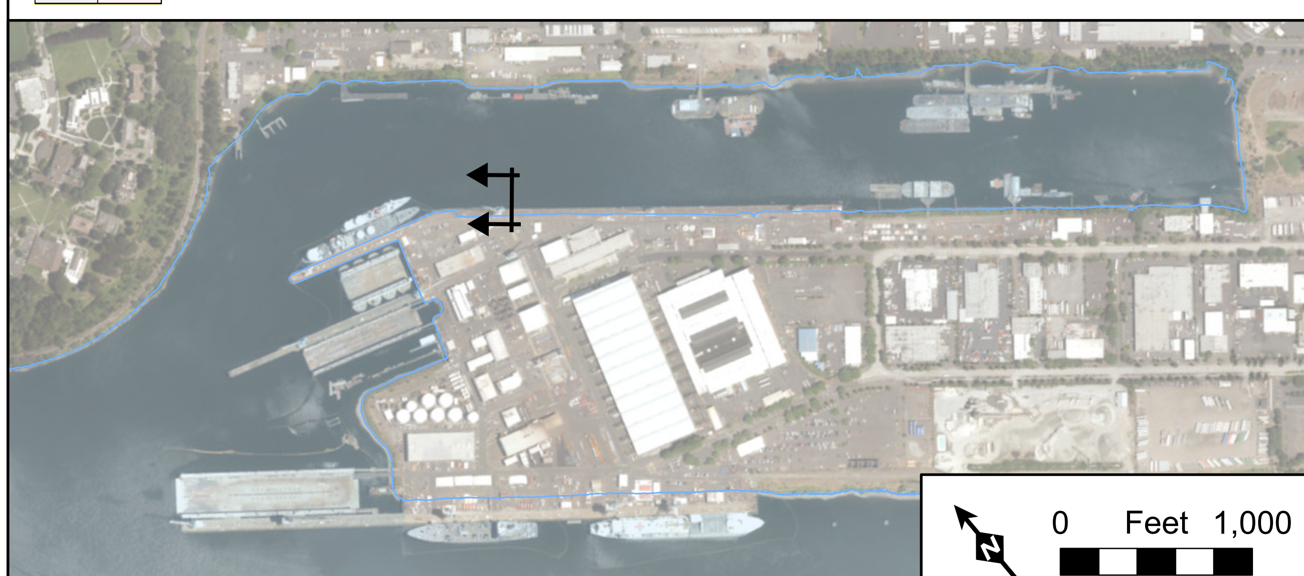
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water



Notes:

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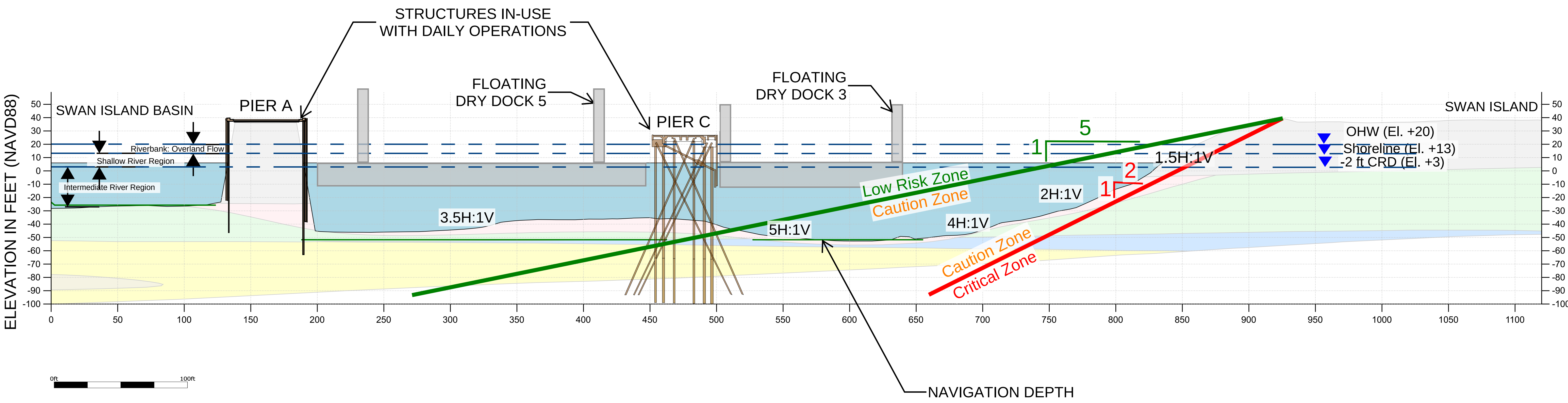
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

Figure 6-19
Berth 302 Cross-Section

Property ID: R543777

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units
- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Willamette River Elevation
- Water

ABBREVIATIONS
CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
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H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water

Notes:

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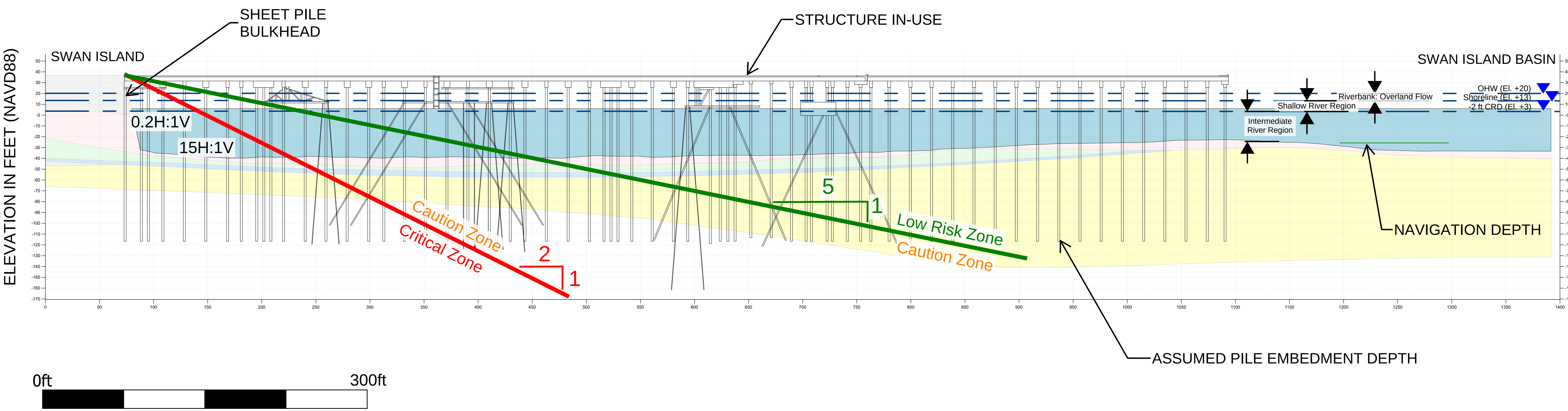
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

Figure 6-20
Pier A and Pier C Cross-Section

Property ID: R543777

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units

- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Columbia River Elevation

- Water

ABBREVIATIONS

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OHW – Ordinary High Water

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4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

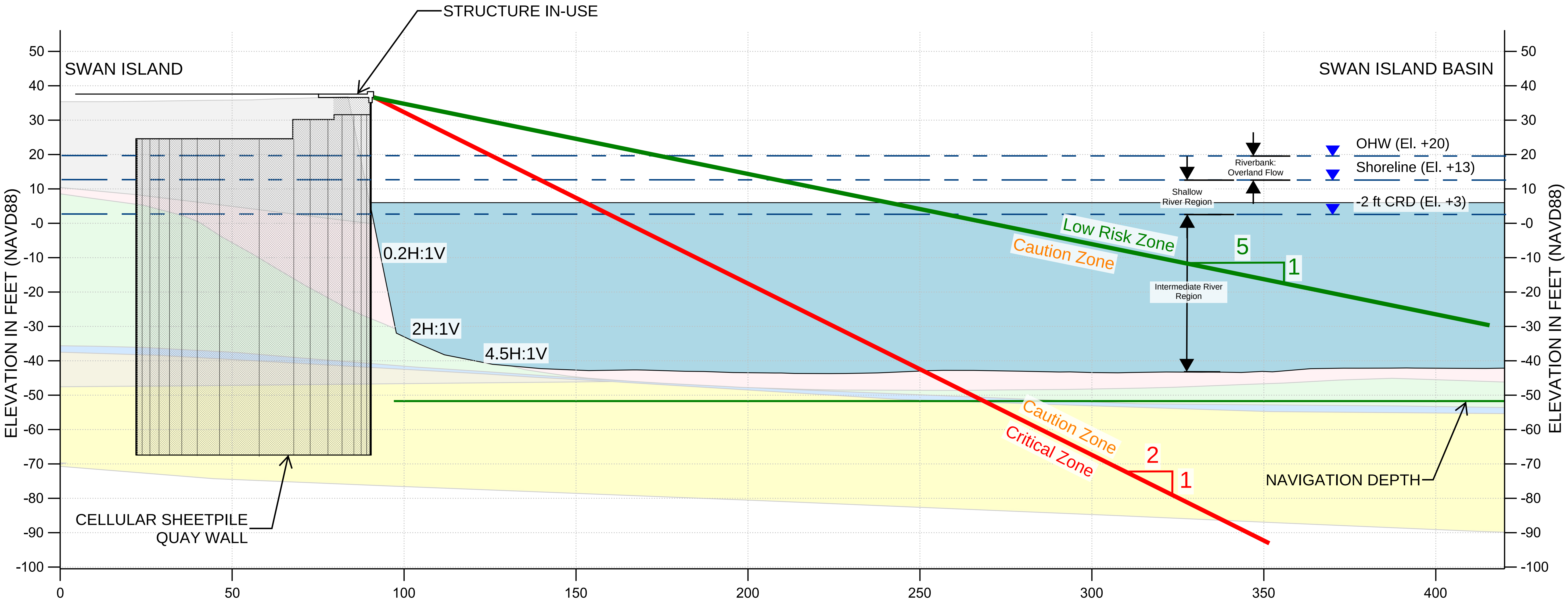
Figure 6-21

Pier C Cross-Section

Property ID: R543777

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units

Clay (Native)

Sand (Native)

Silt (Native)

Non-native material

Willamette River Elevation

Water

0ft 100ft

ABBREVIATIONS

CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)

El. – Elevation

H:V – Horizontal to Vertical Slope

NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)

OHW – Ordinary High Water

Notes:

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4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

Figure 6-22

Quay Wall Dry Dock 5 Cross-Section

Property ID: R543777

Prepared on: 4/8/2024

Basis of Design Report

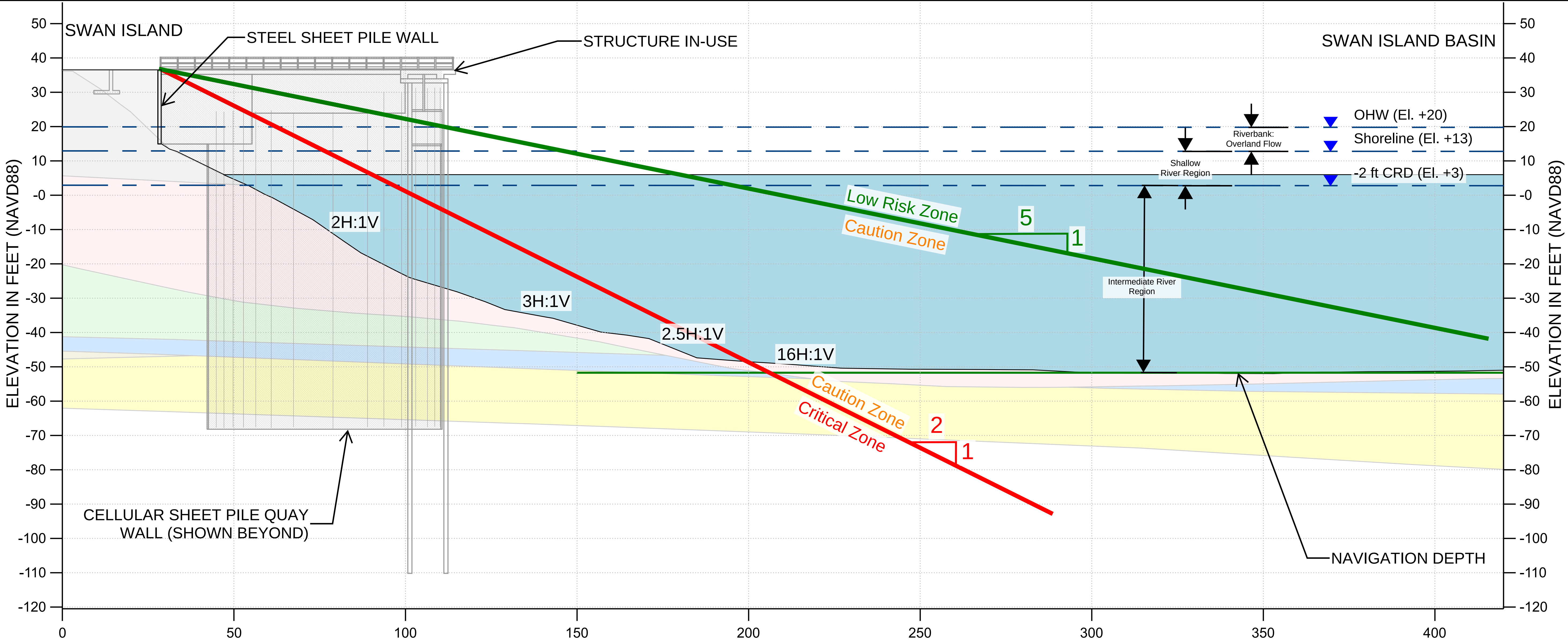
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP

HGL

MOTT MACDONALD

BRIDGEWATER GROUP



Interpreted Geologic Units

- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Columbia River Elevation

- Water

0ft 100ft

ABBREVIATIONS

CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water

Notes:

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2. For discussion purposes only, not for construction.
3. Existing structure to be evaluated based on chosen remedial actions near and beneath the structure.
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

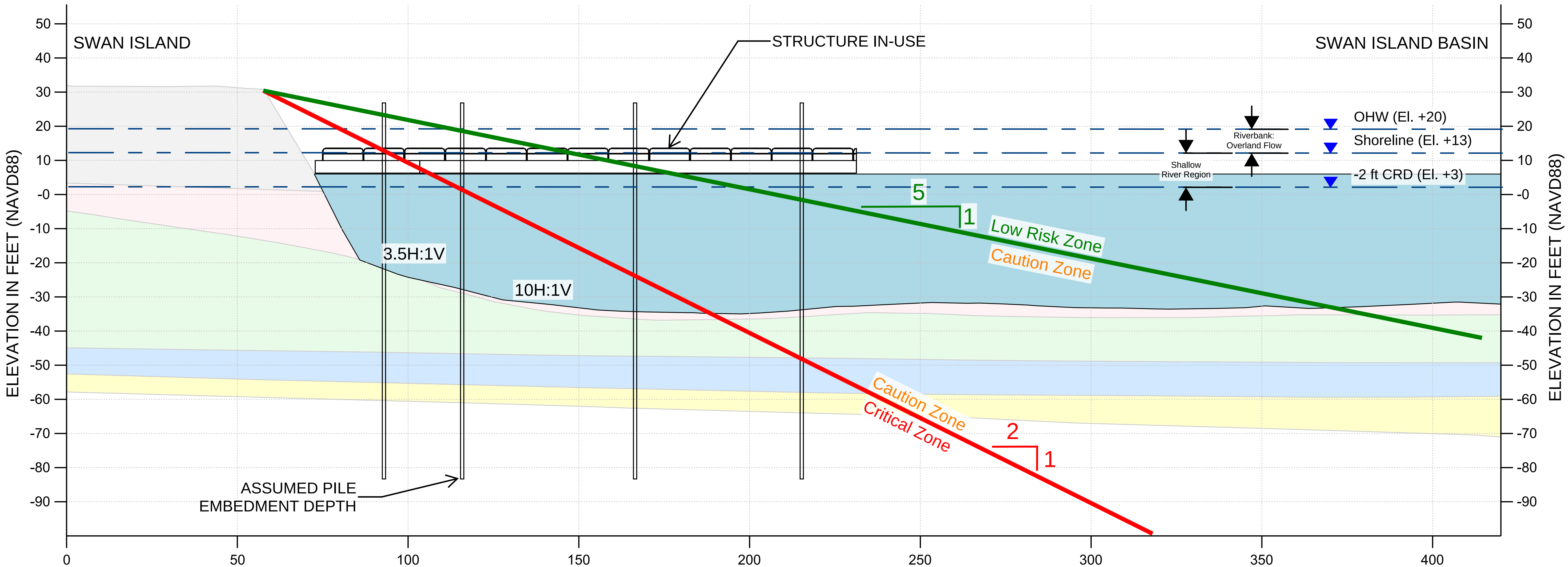
Figure 6-23

Quay Wall Dry Dock 3 Cross-Section

Property ID: R543777

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units

- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Willamette River Elevation

- Water

0ft 100ft

ABBREVIATIONS

CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water

Notes:

1. Structure location and dimensions are approximate and for illustration purposes only.
2. For discussion purposes only, not for construction.
3. Existing structure to be evaluated based on chosen remedial actions near and beneath the structure.
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

Figure 6-24

SCC Floating Dock 1 Cross-Section

Property ID: R543777

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
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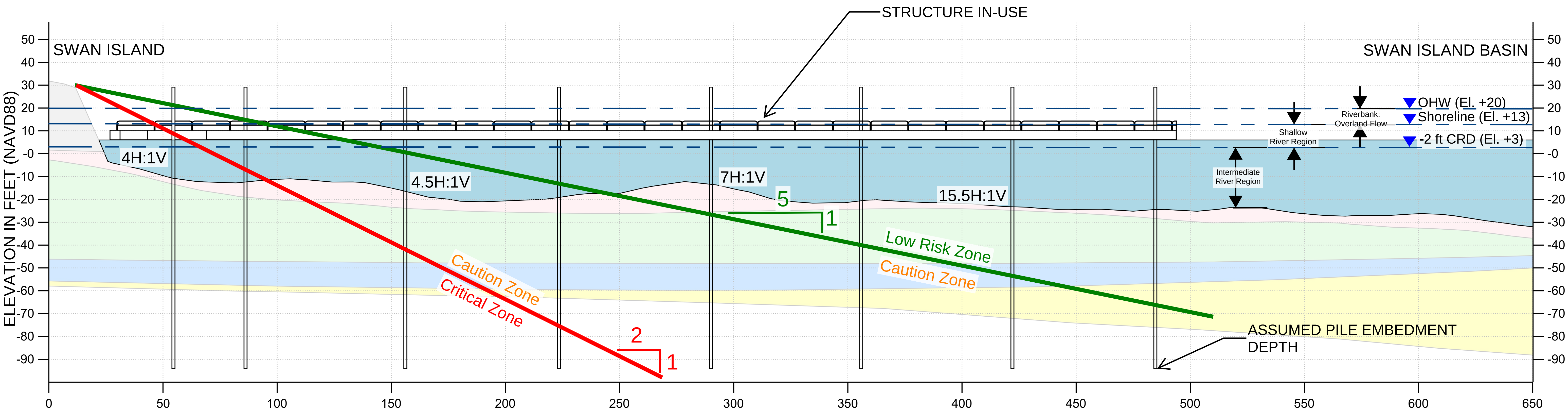
BRIDGEWATER GROUP



Interpreted Geologic Units

- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Willamette River Elevation

- Water

0ft 100ft

ABBREVIATIONS

CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
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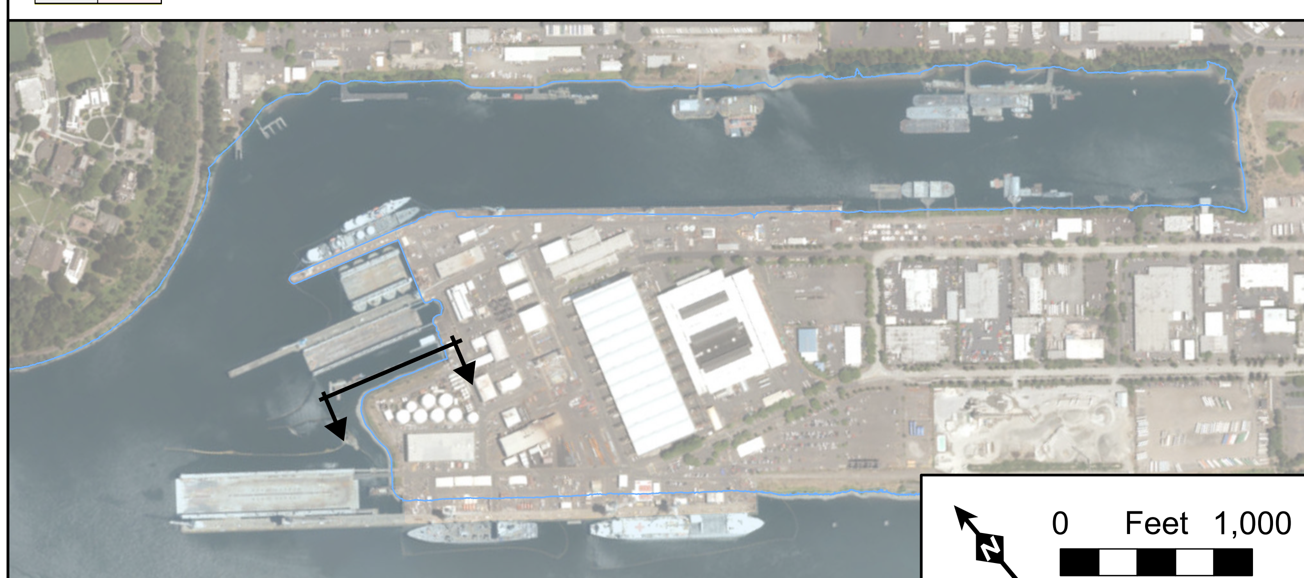

Notes:

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3. Existing structure to be evaluated based on chosen remedial actions near and beneath the structure.
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

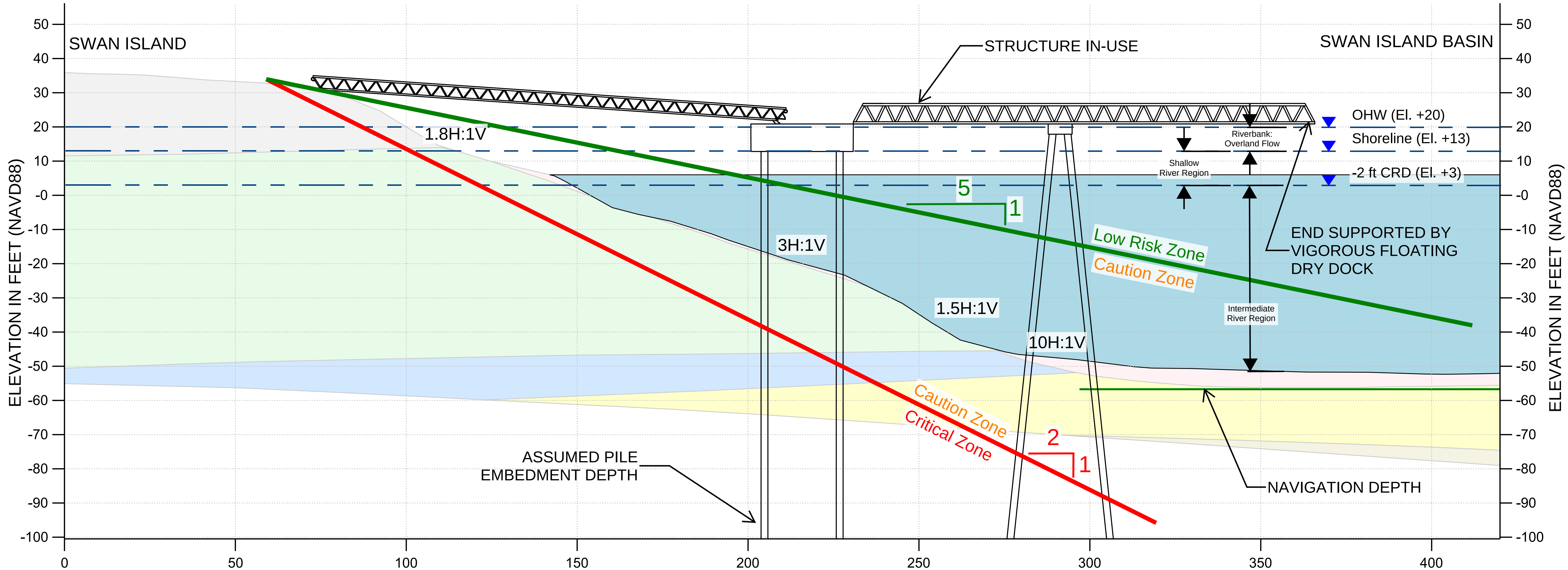
Figure 6-25

SCC Floating Dock 2 Cross-Section

Property ID: R543777

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

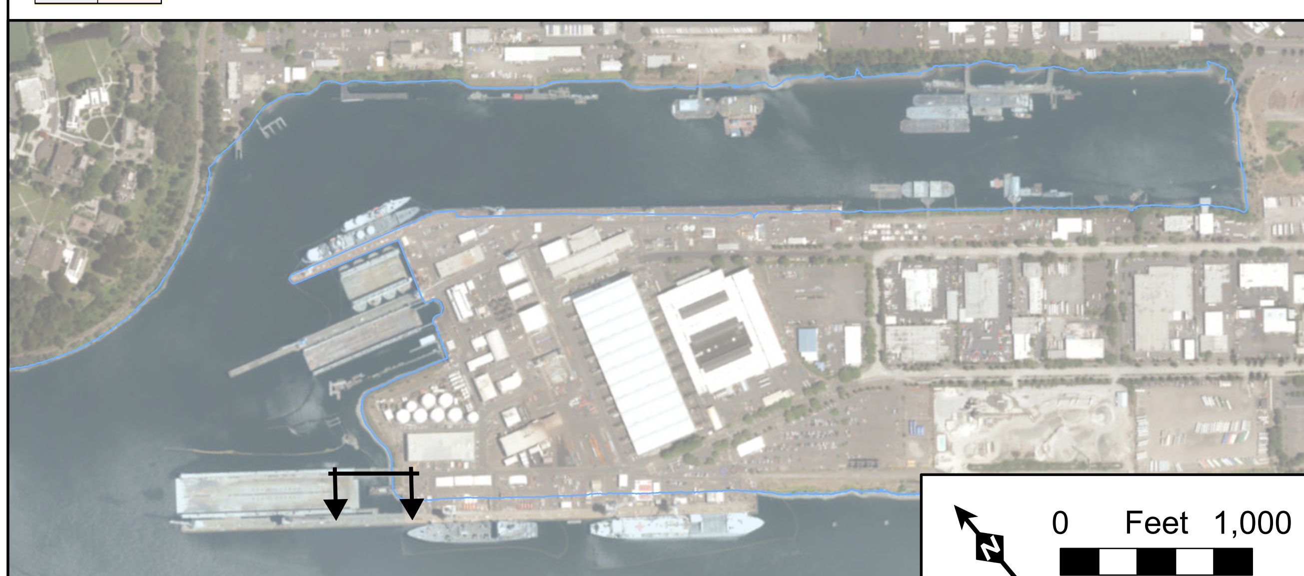
PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units
- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Willamette River Elevation
- Water

ABBREVIATIONS
CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water



Notes:

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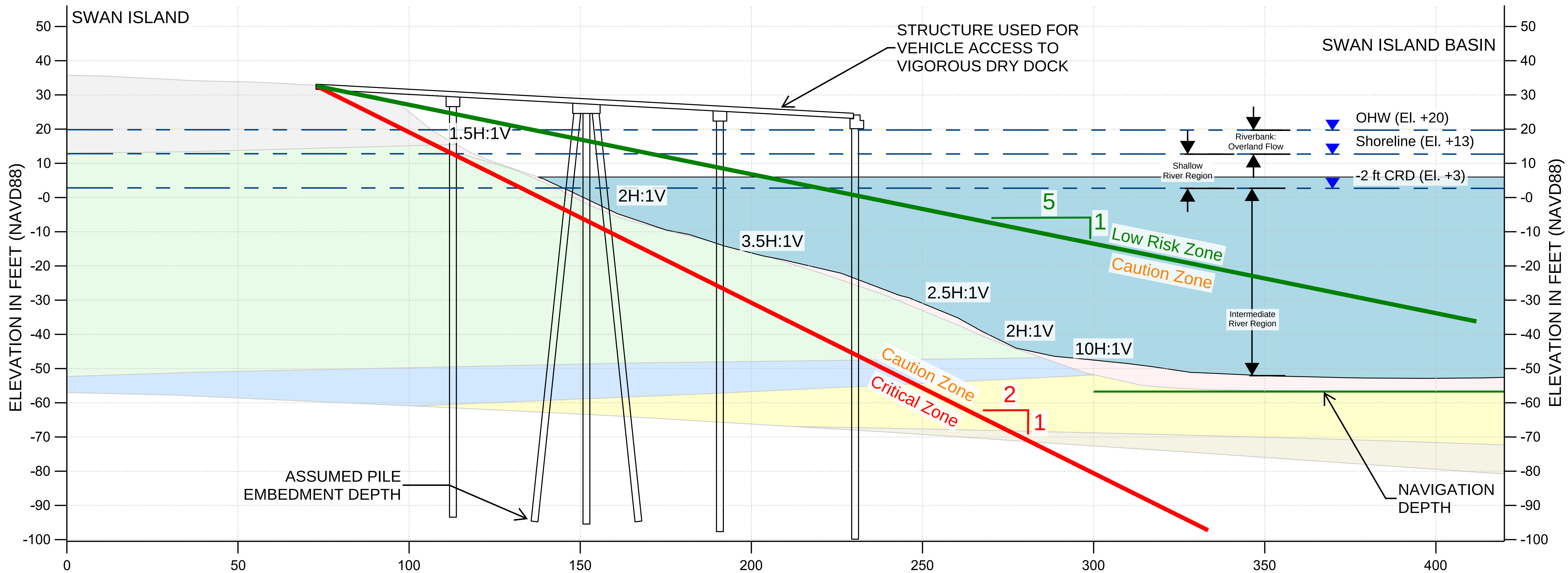
2. For discussion purposes only, not for construction.
3. Existing structure to be evaluated based on chosen remedial actions near and beneath the structure.
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

Figure 6-26
East Pier Cross-Section

Property ID: R543777

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP



Interpreted Geologic Units

- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Willamette River Elevation

- Water

0ft 100ft

ABBREVIATIONS

CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water

Notes:

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4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

Figure 6-27

West Pier Cross-Section

Property ID: R543777

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Basis of Design Report
Swan Island Basin Remedial Design Group

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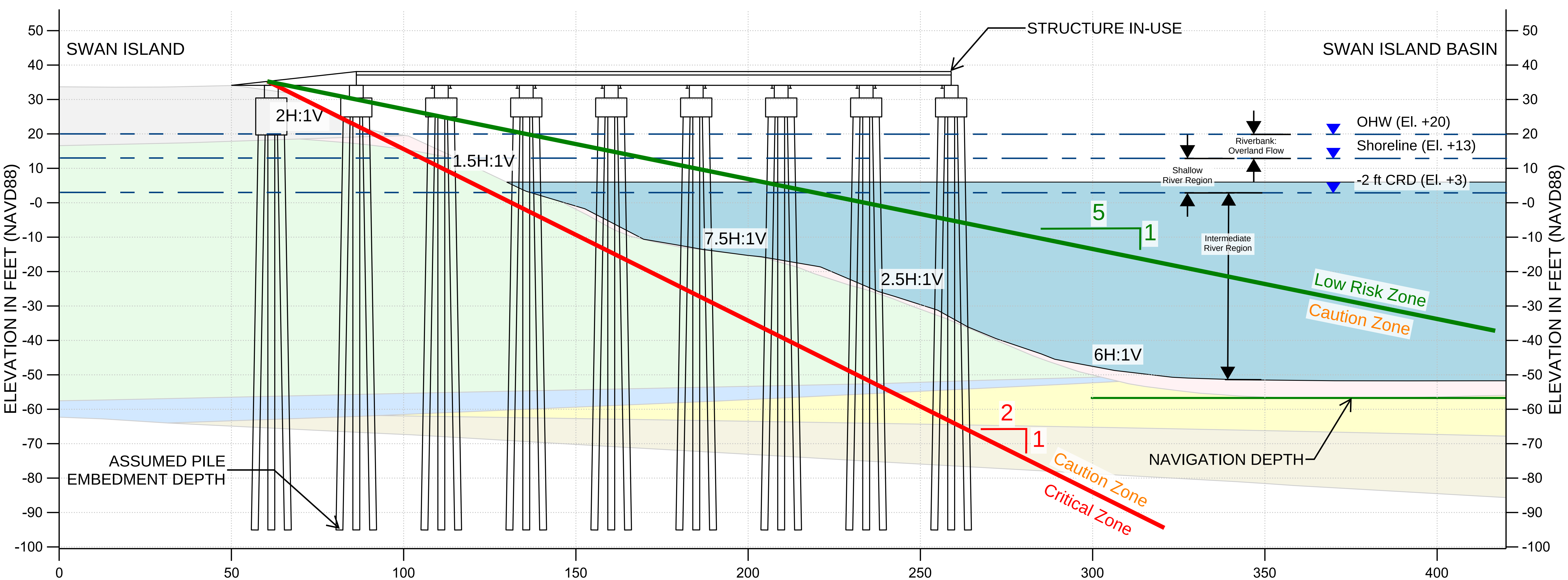


Interpreted Geologic Units

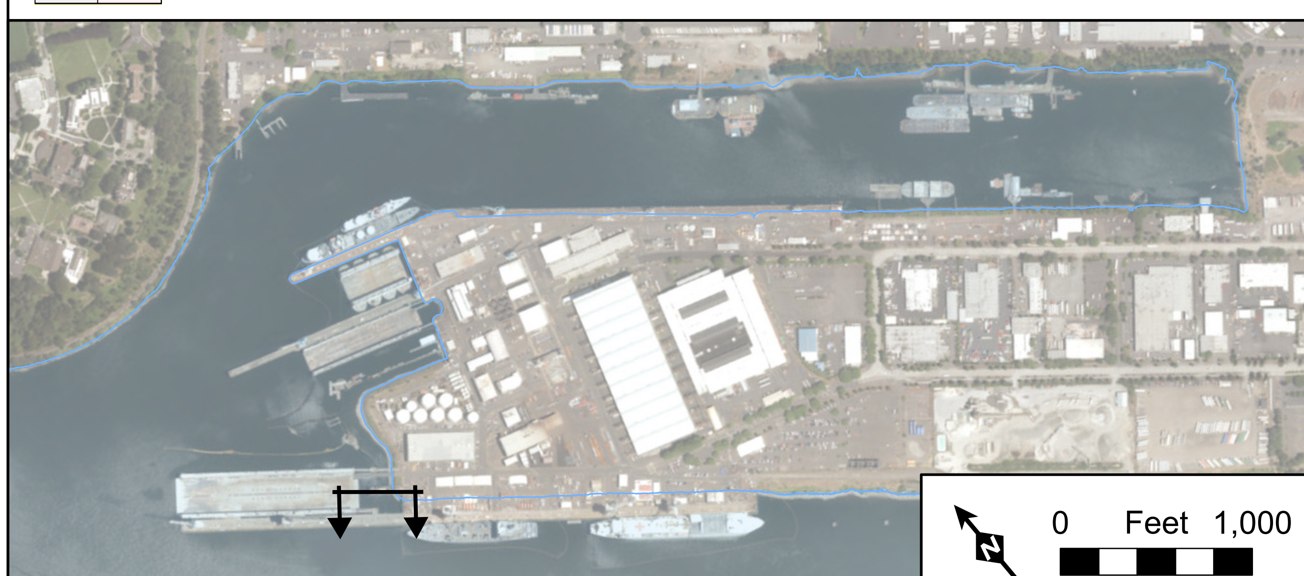
- Clay (Native)
- Sand (Native)
- Silt (Native)
- Non-native material

Willamette River Elevation

- Water

0ft 100ft

ABBREVIATIONS
CRD – Columbia River Datum (0' CRD = 5.28' NAVD88)
El. – Elevation
H:V – Horizontal to Vertical Slope
NAVD88 – North American Vertical Datum of1988 (0' NAVD88 = -5.28' CRD)
OHW – Ordinary High Water



Notes:

1. Structure location and dimensions are approximate and for illustration purposes only.
2. For discussion purposes only, not for construction.
3. Existing structure to be evaluated based on chosen remedial actions near and beneath the structure.
4. Riverbank stability to be evaluated based on chosen remedial actions.
5. Interpreted Geologic Units are interpreted from the Geotechnical Data Report, Revision 0 (July 2023), Contract DT2002.

Figure 6-28
Demo Pier Cross-Section

Property ID: R543777

Prepared on: 4/8/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

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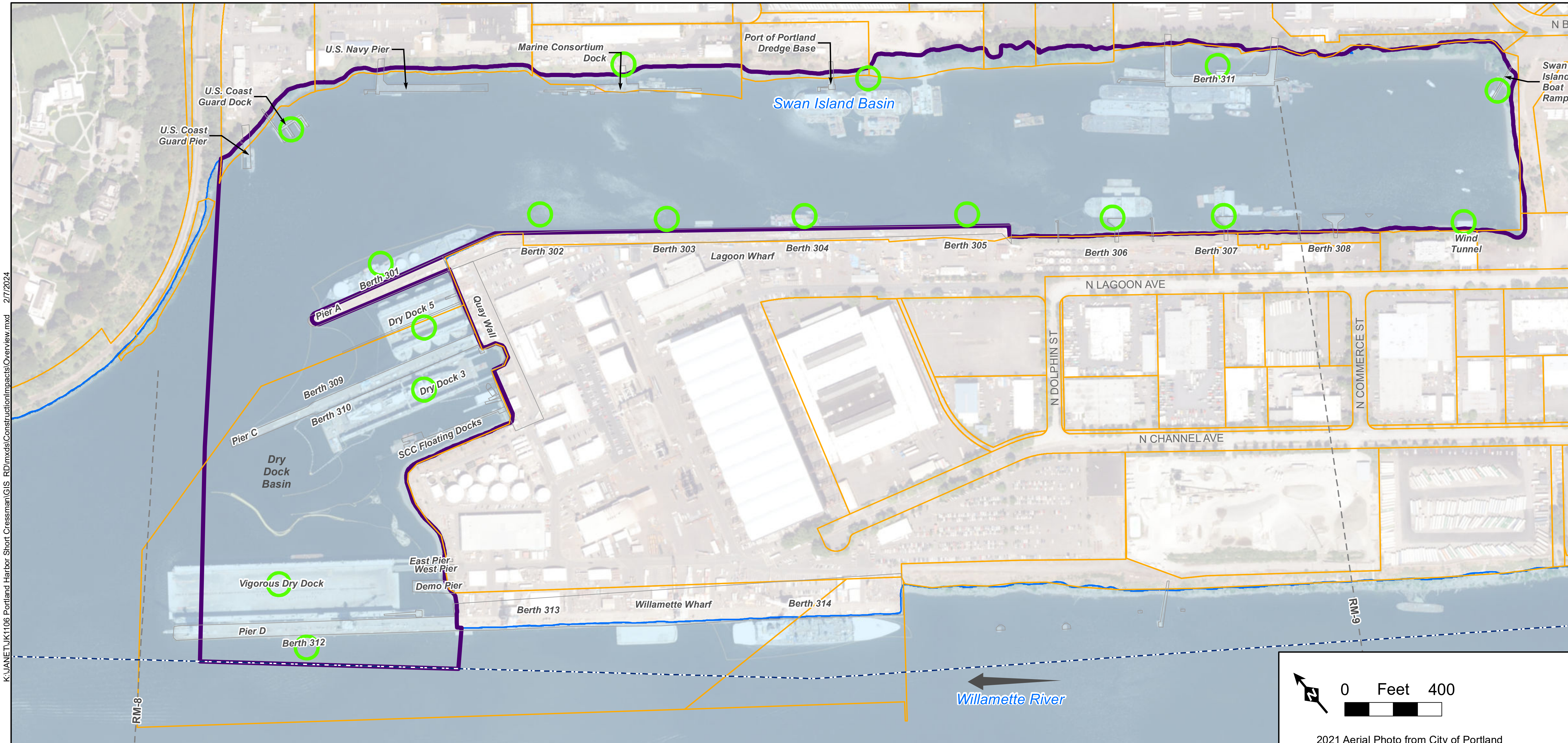
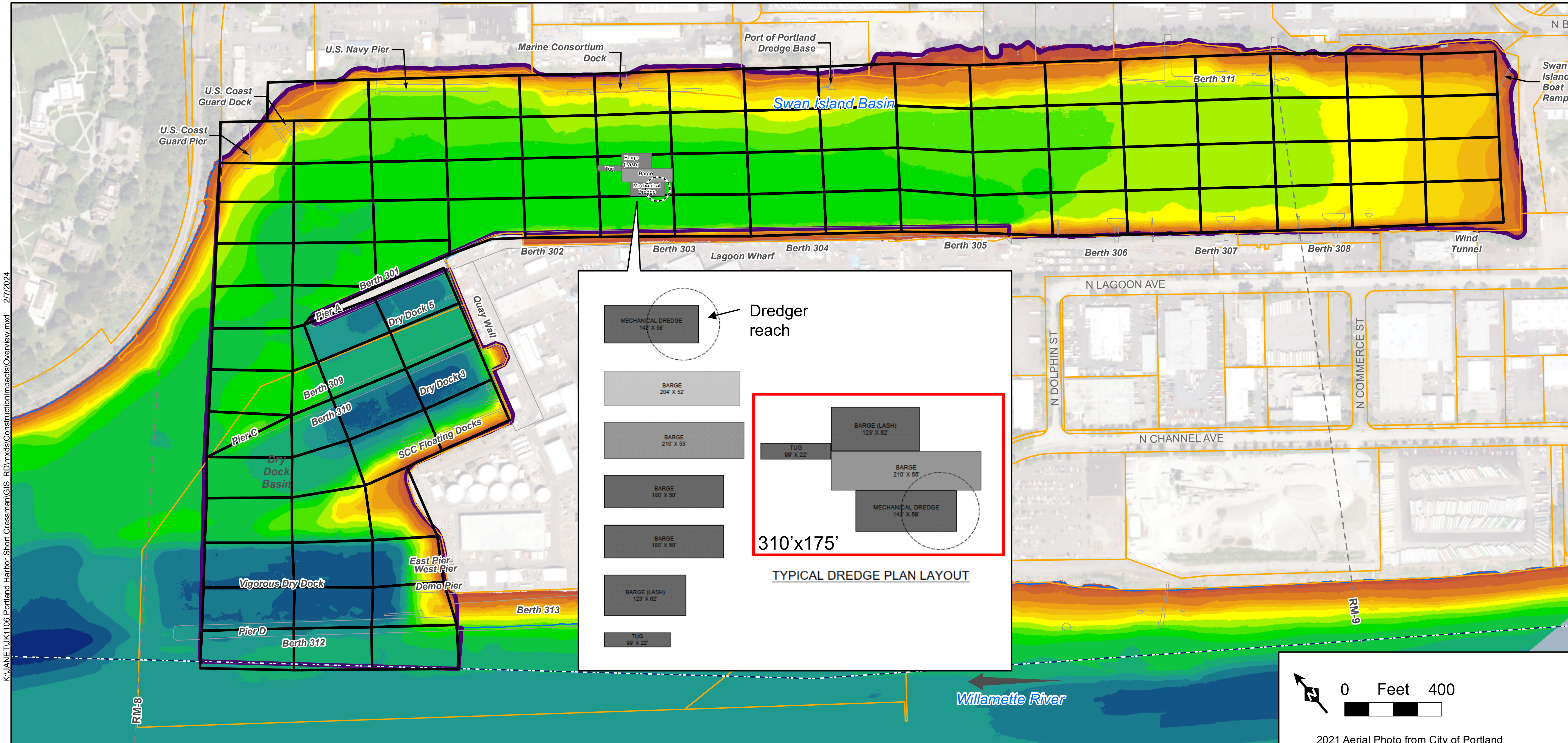


Potentially Impacted Facilities
River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

Notes:
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

Figure 6-29
Existing Facilities Potentially Impacted by RA Activities

Prepared on: 2/7/2024
Basis of Design Report
Swan Island Basin Remedial Design Group



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- River Mile (RM)
- Swan Island Sediment Decision Unit (SDU)
- Federal Navigation Channel (USACE, 2020)
- Docks and Structures
- Tax Lot Boundary
- Ordinary High Water (City of Portland, 2013)
- Construction Grid
- River Flow Direction

Elevation in Feet CRD
- 10.1 - 15
- 5.1 - 10
- 0.1 - 5
- -4.9 - 0
- -9.9 - -5
- -14.9 - -10
- -19.9 - -15
- -24.9 - -20
- -29.9 - -25
- -34.9 - -30
- -39.9 - -35
- -44.9 - -40
- -49.9 - -45
- -54.9 - -50
- -59.9 - -55
- -62.7 - -60

Notes:
CRD – Columbia River Datum
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

Figure 6-30
Construction Grid Layout

Prepared on: 2/7/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

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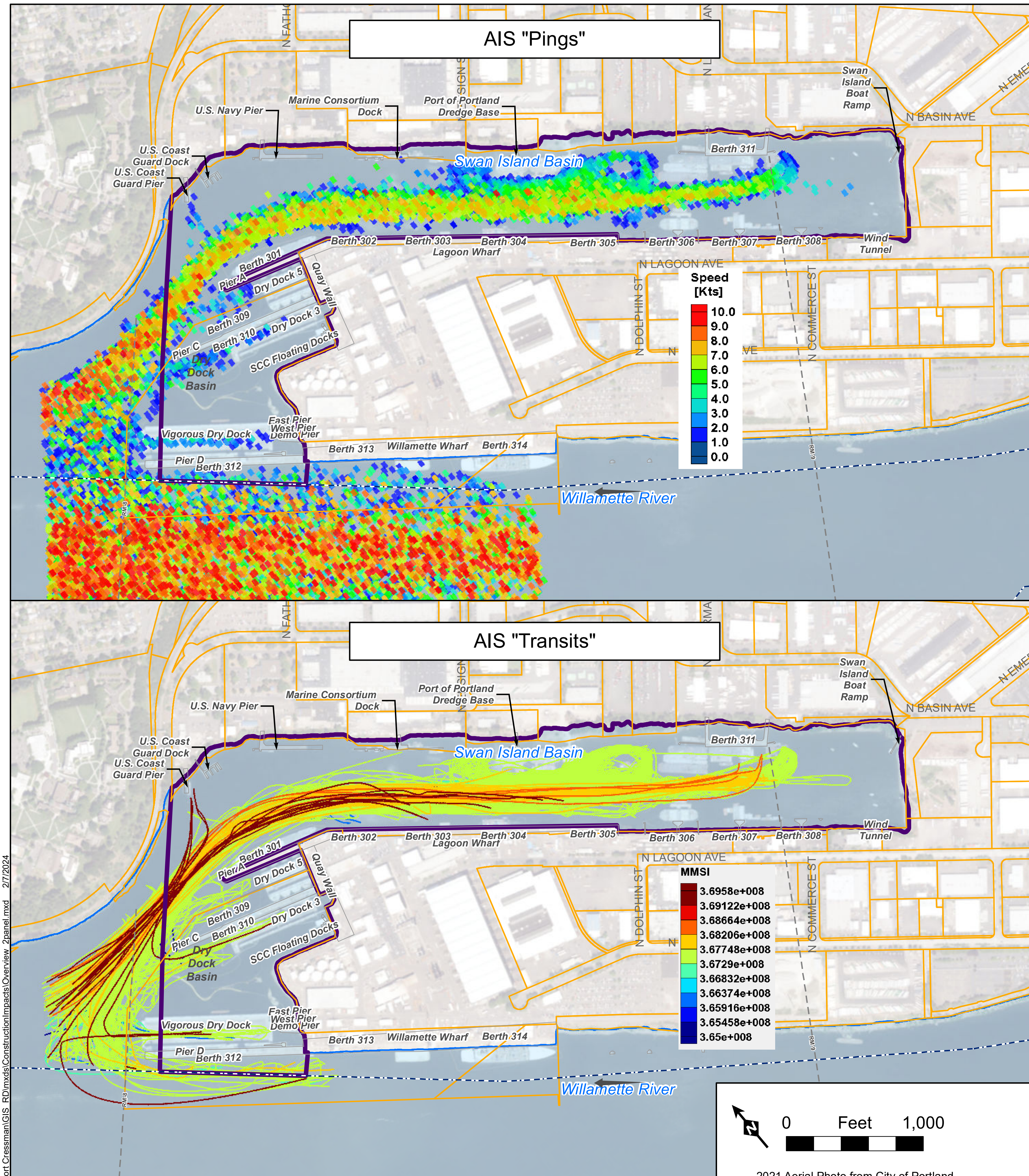

River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

Notes:
AIS – Automatic Identification System
kts – knots
MMS – Maritime Mobile Service Identity Number
USACE – U.S. Army Corps of Engineers

Figure 6-31
AIS Pings/AIS Transits

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Basis of Design Report
Swan Island Basin Remedial Design Group

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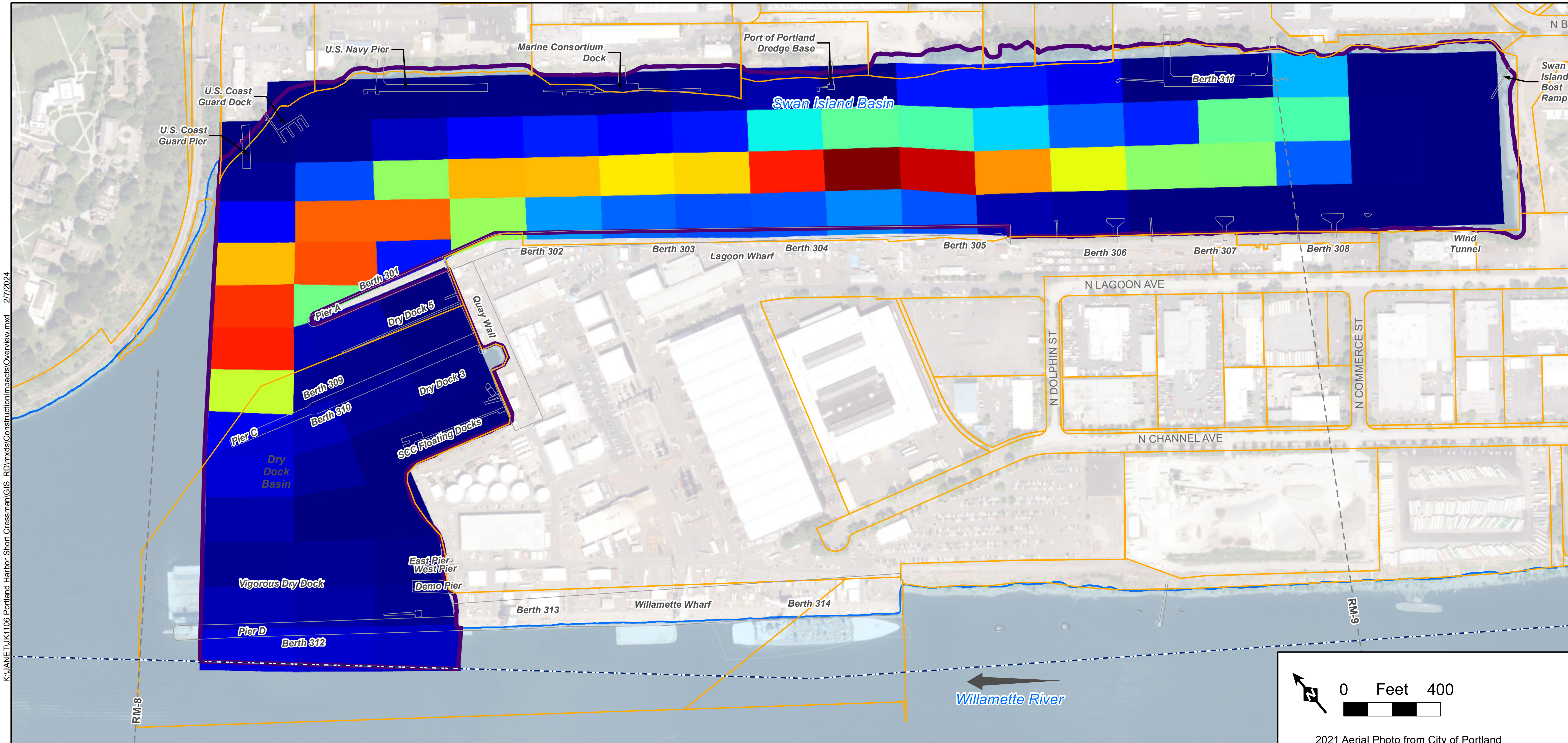

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- River Mile (RM)
- Swan Island Sediment Decision Unit (SDU)
- Federal Navigation Channel (USACE, 2020)
- Docks and Structures
- Tax Lot Boundary
- Ordinary High Water (City of Portland, 2013)
- River Flow Direction

Notes:
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

Figure 6-32

Potential Conflicts for All Transits in Swan Island Basin

Prepared on: 2/7/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

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APPENDICES

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APPENDIX A
CAP EVALUATION

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APPENDIX A - CAP EVALUATION - REVISION 0
REMEDIAL DESIGN SERVICES, SWAN ISLAND BASIN PROJECT AREA
CERCLA DOCKET NO. 10-2021-001
PORTLAND HARBOR SUPERFUND SITE
PORTLAND, MULTNOMAH COUNTY, OREGON

APPENDIX A - CAP EVALUATION

This Appendix to the Basis of Design Report (BODR) presents a conceptual cap evaluation used for the Remedial Design (RD) conducted for the Swan Island Basin (SIB) Project Area within the Portland Harbor Superfund Site (PHSS) in Portland, Multnomah County, Oregon. The HydroGeoLogic, Inc. (HGL) team performed the work on behalf of the SIB RD Group based on the requirements of the PHSS Record of Decision (ROD) (U.S. Environmental Protection Agency [EPA], 2017) and the Administrative Settlement Agreement and Order on Consent (EPA, 2021a). The data used in this cap evaluation were collected in accordance with the final Pre-Design Investigation (PDI) Work Plan, which the EPA approved in May 2022 (HGL, 2022), and were reported in the PDI Evaluation Report (ER) (HGL, 2024).

The objective of this cap evaluation is to provide a preliminary evaluation of chemical criteria and physical constraints to evaluate a conceptual cap that is protective of human health and the environment. This evaluation will help with determining whether capping is a viable remedial approach for SIB. Information from this cap evaluation will be used in the future refinement of the capping assessment during the Draft 50% RD.

Cap evaluation includes chemical isolation and physical considerations. Section 1 discusses capping as a remedial approach. Section 2 describes the evaluation of the chemical isolation component considerations used in this cap evaluation. Section 3 discusses the physical considerations used in this cap evaluation including cap footprint, erosion protection layer for the engineered cap, and geotechnical factors. Section 4 outlines additional considerations to include work around structures, capping monitoring, capping operation and maintenance, design life, and consistency with anticipated and in-river uses. Section 5 summarizes the findings of this cap evaluation that will be utilized in the development of the RD.

1.0 CAPPING AS A REMEDIAL APPROACH

Capping is a remedial approach involving the placement of clean covering or isolating material to cover and separate subaqueous contaminated sediment from the water column to mitigate risks posed by contaminated sediments to human health and the environment. The material used in capping may consist of layers of sand, sediments, and/or other materials. Capping creates a physical barrier between contaminated sediments and benthic organisms populating the top sediment layer; reduces contaminant fluxes due to organism-induced mixing of contaminated sediments (bioturbation); stabilizes contaminated sediments to prevent resuspension during high-flow conditions; and provides resistance to the transport processes that result in chemical release from the sediments (Lampert and Reible, 2009). In situ capping refers to the placement of the cap

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703-478-5186

at the contaminated site, while ex situ capping, which is not being considered for the SIB SMA, refers to the capping of contaminated sediment dredged and moved to a separate location (Randall and Chattopadhyay, 2013). Sand or coarse media is often used as a cap layer, which facilitates in situ placement of the cap. Because contaminants are often associated with fine-grained particles, contaminated sediments often have high water content, low load-bearing capacity, and low shear strength, which is a concern with regards to cap displacement or resuspension that needs to be addressed as part of this design (Reible, 2008). A reactive cap incorporates sorbent material (such as granular activated carbon [GAC]) within the capping material and relies on the sorptive properties of contaminants to slow down the contaminant migration through the cap by accumulation within the clean cap layer (Lampert and Reible, 2009).

As summarized in Processes, Assessment and Remediation of Contaminated Sediments (Reible, 2014), capping contaminated sediments following dredging operations and capping dredged material has been a common practice by the U.S. Army Corps of Engineers (USACE) since the 1970s. Field studies including sediment coring were performed on these early USACE sites to evaluate long-term effects of caps on contaminant levels. Those studies revealed sharp gradients in concentration between the underlying material and the caps. However, the analysis was based on bulk solids and was inherently biased due to differences in partitioning between the sediment and sand. The application of sand and sediment caps as a remediation technology for contaminated sediments was subsequently investigated. Thibodeaux et al. (1991) proposed using capping with clean sediments to create a diffusive barrier for reducing the concentrations and fluxes from sediments contaminated with polychlorinated biphenyls (PCBs). Wang et al. (1991) found that a layer of clean sediment successfully reduced concentrations of 2,4,6-trichlorophenol. Later laboratory studies used a sorption-diffusion model to predict the observed behavior (Thoma et al., 1993). Based on initial successes, other studies were employed using clean sands and other "active" materials that attempted to sequester or enhance degradation of the contaminants (Reible, 2014). More recently, capping has been used on a variety of sites such as Aberdeen Proving Ground, Anacostia River, Barge Canal, Bellingham Bay, Bremerton Naval Complex (OU B), Callahan Mining, Commencement Bay, Detroit River, Eagle (East) Harbor, Fox River & Green Bay, Galaxy/Spectron, Grasse River, Hudson River, Lower Duwamish, McCormick & Baxter Site on Willamette River, Penobscot River, etc. (ITRC, 2023).

1.1. CAPPING DESIGN EVALUATION

This engineered cap design evaluation was performed in accordance with the following cap design guidance documents:

- *Contaminated Sediments Remediation: Remedy Selection for Contaminated Sediments* (CS-2) (ITRC, 2014)
- *Sediment Cap Chemical Isolation Guidance* (SD-1) (ITRC, 2023)
- *Guidance for Subaqueous Dredged Material Capping* (Palermo et al., 1998a)

Generally, caps are designed to:

- Prevent resuspension and transport of sediment contaminants through processes such as advection, dispersion/diffusion, and surface exchange (stabilization);

- Attenuate and/or prevent migration of contaminants in porewater (chemical isolation); and
- Prevent benthic communities from direct contact with underlying contaminated sediments (bioturbation) (ITRC, 2023).

Geotechnical analysis is included in this cap evaluation to assess the stability of an engineered cap against bearing failure, settlement, sliding or slope displacement, and both cap and sediment material migration or mixing. Evaluation of seismic risk was also considered.

1.2. CAPPING DESIGN CRITERIA

Capping design criteria were defined in ROD Section 14.2.9.1 (EPA, 2017) and are applicable to the entire PHSS, including general applicability to the SIB. ROD design criteria are further described below.

- Caps designed to consider the following elements:
    - Sufficient chemical isolation layer to reliably contain underlying contamination;
    - Use of reactive material to contain contamination to meet remedial action objectives;
    - Use of reactive material to prevent contamination migration through the cap, accounting for the degrees of upland source control;
    - Potential for adverse impacts to the floodway due to flood rise;
    - Ability of cap to withstand more frequent floods with higher peak flows anticipated to be more common with climate change;
    - Logistics of the placement of caps below or adjacent to structures;
    - The presence of debris that could hinder cap performance;
    - The slope of the sediment bed;
    - Consistency with anticipated land and in-river uses; and
    - Appropriate earthquake design elements for contingency level events.
- Caps constructed to minimize adverse effects on the in-river and riparian habitat, including the loss of shallow water habitat;
- Caps constructed with suitable habitat materials, where applicable;
- Caps constructed on sediment bed that can support the cap during placement;
- Caps constructed with sufficient armor material to remain in place when subject to erosive forces from wind-and vessel-generated waves, river current; and propeller wash (propeller [prop] wash); and
- Where the cap is installed within the navigation channel and future maintenance dredge areas, verifying that the cap is compatible with current and anticipated waterway use and consideration of the current and authorized channel depth, the potential for an increase to the currently authorized channel depth, future navigation and maintenance dredging, and an appropriate buffer depth to ensure the integrity of the cap. The U.S. Army Corps of

Engineers (USACE) maintains the navigation channel, which does not extend into the SIB. Future maintenance dredging areas are discussed in Section 2.6.3 of the BODR.

1.3. CAPPING DESIGN PERFORMANCE STANDARDS

Caps will be designed to achieve suitable chemical isolation that is protective of human health and the environment, which was evaluated using cleanup levels (CULs) as a performance standard. The targeted design life, or the time period over which the cap is designed to meet the performance standards for contaminants of concern (COCs), is 100 years (EPA, 2021b). The 100-year design life selected is a widely accepted design life for caps (ITRC, 2023), as well as design life used for representative site and capping options modeling as identified in the ROD Section 6.5.1 (EPA, 2017).

The ROD Errata #2 Table 17 (EPA, 2020) provides applicable CULs, which are summarized for modeled contaminants in Table 1-1. The analytes 1,2,3,4,7,8-HxCDF, 1,2,3,7,8-PeCDD, 2,3,4,7,8 PeCDF, and 2,3,7,8-TCDF do not have surface water or groundwater CULs; therefore, indicator surface water concentrations were derived from the 2,3,7,8-TCDD surface water CUL based on their respective Toxic Equivalency Factor from Table 17 CULs for 2,3,7,8-TCDD (EPA, 2017).

2.0 CHEMICAL ISOLATION LAYER CONSIDERATIONS

Based on Appendix L of PDI ER (HGL, 2024), the refined sediment management area (SMA) contains 1,419,000 cubic yards of in situ sediments exceeding remedial action levels (RALs)/Practical Quantitation Limits (PQLs) and PTW thresholds for ROD Table 21 COCs. Per the ROD Section 10, SMAs were identified as areas where containment or removal technologies were considered to immediately reduce risks upon implementation (EPA, 2017). As a result, capping is evaluated as a containment remedial technology in this section.

Chemical isolation layer components were evaluated using a modeling tool in order to design a cap that effectively contains underlying contamination to meet remedial action objectives established in the ROD. The modeling analyses were used to evaluate cap characteristics (e.g., thickness, composition) and the quantity of reactive amendment required to control the migration of contaminants under fate and transport mechanisms such as advection, diffusion, dispersion, biodegradation, and bioturbation. The modeling was performed in accordance with the ROD (EPA, 2017), Remedial Design Guidelines and Considerations (RDGC; EPA, 2021b), EPA (Palermo et al. 1998a) and Sediment Cap Chemical Isolation Guidance (SD-1) (ITRC, 2023). This section includes details regarding the inputs used in modeling efforts conducted using CapSim, including site-specific concentrations and chemical, sediment, and cap material characteristics.

The purpose of this evaluation is to provide proof of concept of capping as an effective containment technology. This evaluation contains the most conservative input parameters with the intention of demonstrating that if the capping is effective in this most conservative scenario, it is also effective for each individual area-specific scenario. Development of various capping designs for area-specific parameters will be completed during RD. One-dimensional chemical mass transport modeling was performed to develop a conceptual-level chemical isolation layer design for an engineered sand cap included in remedial alternatives. The engineered sand cap modeling was performed using CapSim Version 4.2 modeling software (Shen et al, 2018; Reible, 2023) and following Sediment Cap Chemical Isolation Guidance (SD 1) guidance (ITRC, 2023). CapSim modeling evaluated the effectiveness of the cap in maintaining solid and porewater concentrations below sediment and surface water CULs, respectively. This evaluation was completed at 30 centimeters (cm) below the top of the cap. The evaluation was for the 100 year design life (EPA, 2021b).

2.1. CAPSIM MODELING SOFTWARE

The CapSim modeling software was utilized to analyze fate and transport of contaminants in sediments and caps (Shen et al, 2018; ITRC, 2023). CapSim simulates contaminant transport and reaction through sediment and caps for the purposes of assessing natural recovery processes and supporting cap and in situ treatment design. CapSim simulates fate and transport processes in both the porewater and solid phases based on porewater concentrations of contaminants. CapSim can also be used to model conditions that affect contaminants, including advection, diffusion, hydrodynamic dispersion, bioturbation, consolidation, benthic exchange, deposition, multispecies reaction, sorption, and desorption. The governing numerical equation for the model is a mass conservation equation for a one-dimensional stratified system composed of multiple layers with various physical and chemical properties. The model simulates all layers as saturated porous media with the solid particles as immobile except near the surface where particles can move due to bioturbation, erosion, deposition, or consolidation (Shen et al, 2018; ITRC, 2023).

2.2. CHEMICAL TRANSPORT MODELING APPROACH

The CapSim modeling software was used to predict the mobility and partitioning of COCs. The analytical model was applied using site-specific characteristics to simulate the effectiveness of an engineered cap in reliably containing the flux of COCs into surface sediments. Reliable containment is defined in the PHSS Feasibility Study (FS) as having a contaminant concentration in the sediment cap porewater just below the sediment cap-surface water interface that meets regulatory levels for a period of 100 years (EPA, 2016). Based on the RDGC, the "results of the cap modeling should confirm that the cap can keep COC concentrations in the top 30 cm of the sediments and in associated porewater below the cleanup levels for the design period of 100 years" (EPA, 2021b). The applicable regulatory levels are detailed in Tables 17 and 21 of the ROD Errata #2 and Errata #3, respectively (EPA, 2020 and 2022) and summarized in Table 1-1. The methods and assumptions described below were used to provide an initial, conservative assessment of the cap characteristics and reactive amendments required to reliably contain the migration of contaminants for a 100-year period. Area-specific analysis of cap design will be completed during the Draft 50% RD.

The CapSim modeling software also predicted the reliable time for containment of sediment and porewater (as surface water) concentrations below CULs at the top surface of the chemical isolation layer for 37 individual contaminants and 3 COC summations (total carcinogenic polycyclic aromatic hydrocarbons [cPAHs], total polycyclic aromatic hydrocarbons [PAHs], and total polychlorinated biphenyls [PCBs]). The analytes included in this evaluation are based on the Focused COCs and Additional Contaminants included in Table 21 of the ROD Errata #3 (EPA, 2022). Individual cPAHs and PAHs for which sediment data was available were modeled and summed over the model run time as another point of evaluation for Total cPAHs and Total PAHs.

In addition to Total PCBs, 9 individual PCB congeners with high concentrations relative to other congeners detected within the SMA were modeled. These were additionally summed over the model run time, however, as the nine congeners do not represent all PCB detections, their summation analogue provides a more qualitative indicator of COC migration. Time-to-breakthrough is defined as the time elapsed between cap installation and the first occurrence of a COC porewater or total solid concentration (the concentration of contaminant on all solids present at the depth of interest in contaminant mass per mass dry solids) equaling or surpassing the relevant CUL at the depth of interest. The cap performance detailed in Section 2.4 is reported as the time-to-breakthrough. Cap scenarios that did not experience breakthrough within the modeled 100-year design life are reported to have a time-to-breakthrough of more than 100 years.

The model input parameters were based on site-specific data, where available, or literature values for comparable conditions. All chemical concentrations and 13 percent of capping material and sediment process input parameters were site-specific values. Site-specific input parameters were supplemented by typical modeling values or available literature values for chemical and material properties where needed. Sensitivity testing was performed to confirm that selected literature values produced a conservative cap design, as detailed in Section 2.5.

The following four conceptual chemical isolation layer cap design alternatives were modeled.

Cap alternatives with erosion protection layer (EPL):

- **Cap Alternative 1:** 2 feet (ft) (60 cm[1]) of unamended sand with overlying 2 ft (60 cm) erosion protection layer, and
- **Cap Alternative 2:** 4.33 inches (11 cm) of GAC-amended sand with overlying 2 ft (60 cm) erosion protection layer.

Cap alternatives without EPL[2]:

- **Cap Alternative 3:** 3 ft (90 cm) of unamended sand (2 ft [60 cm] unamended sand for CIL with overlying 1 ft [30 cm] unamended sand for bioturbation layer), and
- **Cap Alternative 4:** 4.33 inches (11 cm) of GAC-amended sand with overlying 1 ft (30 cm) unamended sand layer as a bioturbation layer.

The point of compliance was selected to be at the top surface of the chemical isolation layer (60 cm [2ft]) for cap alternatives 1 and 2, and 1 ft (30 cm) below the cap top surface for cap alternatives 3 and 4) based on the RDGC requirement to evaluate a cap's ability to contain COC concentrations

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[1] CapSim uses metric measurements, while the rest of this BODR uses imperial measurements. As a result, this appendix contains rounded metric measurements in parenthesis, with converted imperial measurements in front of the parenthesis to remain consistent with other sections of this BODR. Tables and Attachment A related to CapSim modeling are all in metric measurements due to being related to CapSim input and output parameters.

[2] Cap Alternatives 3 and 4 included an additional 1 ft (30 cm) of unamended sand (Sand Layer). Unamended sand was chosen as a cost-efficient approach to evaluate that the chemical isolation layer cap can keep COC concentrations in the top 1 ft (30 cm) of the sediment and associated porewater below cleanup levels for the design period of 100 years per RDGC Section 5.2.6 (EPA, 2021b). This 1 ft (30 cm) also include a conservative bioturbation layer thickness of 7.87 inches (20 cm). All four alternatives were evaluated at the CPP for a conservative performance estimate in accordance with RDGC (EPA, 2021b) and comparability of alternative results.

below cleanup levels in the top 1 ft (30 cm) of the sediments and in associated porewater, and to ensure consistency in evaluation between the cap alternatives. These 12 inches (30 cm) include a conservative estimate of the thickness of the modeled depth of bioturbation reported in the ROD of 7.87 inches (20 cm) (EPA, 2017). See Section 2.3.6 for further discussion on bioturbation. Because the point of compliance was 2 ft (60 cm) or 1 ft (30 cm) below the top of the cap and surface water interface, it is very likely outside of the influence of bioturbation and therefore represents a conservative estimate of reliable containment.

Figure 2-1 illustrates the four conceptual chemical isolation layer cap design alternatives. modeled.

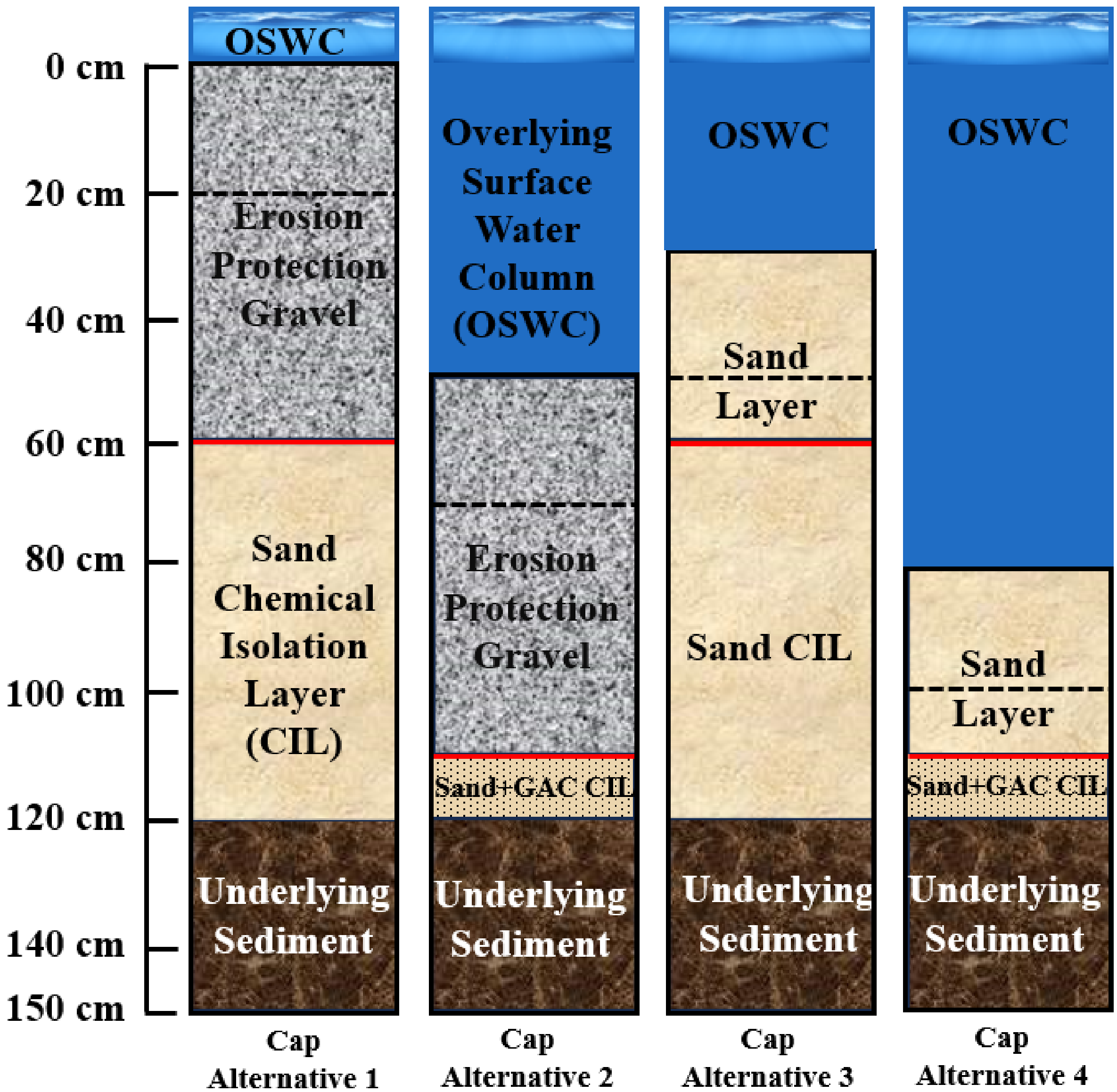

Figure 2-1. Depictions of Cap Alternatives 1 through 4.

The red line represents the depth at which the cap performance was evaluated, also referred to as the cap performance point (CPP). CPP was determined as the top of the chemical isolation layer. The dashed line represents the presumed maximum depth of bioturbation. Materials above and below the dashed line are the same. The layer thickness is in cm.

2.3. MODEL INPUTS

Input parameters were based on site-specific data when available, such as upwelling velocities and sediment COC concentrations, along with information from scientific literature, including inputs from other regional CapSim applications (Tables 2-1 and 2-2). Conservative estimates were utilized throughout this cap evaluation that may have compounding effects and result in a very high safety factor incorporated into the design evaluated. Area-specific cap design, conducted during the RD, may include area-specific inputs that are less conservative to optimize cost while maintaining the effectiveness of the remedial cap. Details on the development of the various model input parameters are provided in the following sections.

Since the intent of this capping evaluation was to evaluate capping as a remedial approach to be used in the RD, a conservative approach was taken to evaluate if capping would be able to contain the contamination in the "worst-case scenario" observed on site. To evaluate the most conservative cap design, a “worst-case” scenario was used by evaluating 95th percentile of the observed sediment concentrations across the SIB. The 95th percentile was used instead of maximum concentration encountered on site to evaluate representative site-wide conditions that are not impacted by potential maximum concentration outliers that would cause overly conservative cap design. Per ITRC’s *Sediment Cap Isolation* guidance: "*Capping is an areal remedy; therefore, using a 95% UCL of the mean is suggested and considered to be appropriately conservative*." (ITRC, 2023). In the absence of measured porewater concentrations, the associated equilibrium porewater concentrations were calculated within CapSim and used as the initial underlying sediment porewater concentration, consistent with the same guidance.

2.3.1. Native Sediment and Thickness of Model Domain

The underlying sediment was assumed to be composed primarily of clayey-silt based on observations noted in the Appendix A of the PDI ER (HGL, 2024). In anticipation of dredging or removal prior to cap installation, the total organic carbon (TOC) results of subsurface sediment (deeper than 15.8 inches [40 cm]) core samples presented in Appendix I of the *Head of Swan Island Lagoon Field Sampling Data Report* (Pacific Groundwater Group, 2019) were averaged. From those subsurface core samples, the TOC of sample G-9.15-0 to 18-102418, which was composed of 95.5 percent sand, was used to select the native sand fraction organic carbon (f_{OC}) of 0.62 percent. This native sand f_{OC} and the average percentage of sand per core sample were used to adjust the overall average TOC to a TOC for site-specific clayey-silt, 35,530 milligrams per kilogram (3.553 percent f_{OC}). Sediment thickness was modeled as 1 foot (ft) (30 cm), consistent with ROD Section 6.5.2 and ITRC guidance (EPA, 2017; ITRC, 2023).

2.3.2. Initial Sediment and Porewater Concentrations

The 95th percentile surface or subsurface sediment concentrations from the historical and PDI sediment data set for each of the 37 individual contaminants and 3 COC summations were selected within the area of each modeled scenario (HGL, 2024). These concentrations were assigned uniformly throughout the modeled sediment thickness. The initial sediment concentrations are included in Table 2-3. Table 2-3 also includes the equivalent porewater concentration that would result from equilibrium phase partitioning using the assumed partitioning coefficients (Table 2-1) and f_{OC} of the existing sediment. These model-calculated porewater concentrations were also used as the bottom boundary concentrations and provided a constant supply of contamination, without depletion through time.

2.3.3. Darcy Velocity

The upwelling velocity is based on a steady, uniform Darcy velocity across the basin. The highest 50-hour maximum specific discharge, presented in the Appendix B of PDI ER (HGL, 2024), was converted to units of 158.3 inches per year or 402 cm per year and rounded up to the next whole number for use within CapSim.

2.3.4. Partition Coefficients

All chemical partition coefficients were gathered from scientific literature (Table 2-1). The linear sorption model was applied to the sediment, sand, and erosion protection materials, while Freundlich sorption isotherm was applied to the GAC amendment. The linear sorption model is a widely accepted model for sorption of hydrophobic organic compounds onto sediments (Karickhoff et al., 1979) as follows:

$$K_d = K_{oc} * f_{oc}$$

Where K_d is a constant related to the organic carbon normalized partitioning coefficient, K_{OC} is organic carbon normalized partition coefficient, and f_{OC} is fraction of organic carbon primarily responsible for accumulation of contaminates to sediments (Goring CA, 1962; Reible, 2014).

The Freundlich sorption isotherm is frequently used to predict particle concentrations (q) from porewater concentrations (C) for activated carbon. The relation is as follows:

$$q = K_f * C^{1/n}$$

Where K_f is the adsorption capacity at unit concentration and 1/n (N) is the adsorption intensity (Reible, 2014).

In the amended cap layer models, it was assumed that GAC and clean sand were evenly mixed within the chemical isolation layer and the above sorption isotherms applied to their respective particles in the mixture.

The organic carbon partition coefficients, KOC, and sources for each are presented in Table 2-1. For DDx (comprising DDD, DDE, and DDT); PCDDs/PCDFs; and naphthalene, K_{OC} values were available from multiple sources. The minimum, maximum, and average K_{OC} were each modeled and the value that resulted in the highest porewater and total solid concentrations near the surface of the cap was retained. In the cases where the same K_{OC} value did not result in both the highest porewater and total solid concentrations, judgement was employed to select the value that would be the most conservative across media.

The K_f values and sources for each are presented in Table 2-1. For each COC, K_f and 1/n (N) values originated from the same source. To ensure a conservative cap evaluation during preliminary Table 21 COC modeling, K_f values for DDx (comprising DDD, DDE, and DDT); dioxins/furans; and naphthalene were modified by a factor of $10^{\pm1}$ to create high, medium, and low alternatives. These were each modeled and, as with KOC, the K_f that resulted in the highest porewater and total solid concentrations near the surface of the cap was retained. Based on the consistent results of this sensitivity testing, the K_f used in later modeling for each COC was the scientific literature value reduced by a factor of 10 ($K_f \cdot 10^{-1}$). The Freundlich adsorption intensity exponent was not modified.

2.3.5. Fraction Organic Carbon in Capping Materials

The fraction organic carbon in the isolation layer sand was not available from nearby materials suppliers. Other regional remediation projects assumed the capping material to have between 0.05 percent and 2.0 percent f_{OC}. The Former Portland Gas Manufacturing Site (Anchor QEA, 2020) and the Crawford Street Site (GeoEngineers, 2022), both in Portland, Oregon, are among several projects that assumed the sand to have an fOC of 0.1 percent for CapSim modeling as it "represents the lower end of the range for dredged Columbia River sand" (GeoEngineers, 2022).

In all modeling scenarios, the sand present in the chemical isolation layer was assumed to have a f_{OC} of 0.1 percent. Sensitivity testing assuming a sand f_{OC} of 0.05 percent as a low organic carbon condition was additionally completed, as detailed in Section 2.5.6.

The modeled erosion protection layer in Cap Alternatives 1 and 2 was assumed to be composed of gravel with a f_{OC} of 0.0 percent as this layer is not intended to provide chemical sequestration. The GAC amendment to the chemical isolation layer is assumed to have a f_{OC} of 100 percent, which is the CapSim default for the material (Reible, 2023).

2.3.6. Bioturbation and Benthic Boundary Layer Condition

Bioturbation is a mixing process that affects both the porewater and solids and is caused by benthic organism activities. Bioturbation accounts for biological activities such as burrowing, sediment ingestion, and bioirrigation as benthic organisms flush their burrows with overlying water (ITRC, 2023). Bioturbation enhances particle mixing in the biologically active zone and exchange of dissolved substances between the porewater and overlying surface water (ITRC, 2023). This zone is typically limited to near surface (5 to 15 cm below sediment-surface water interface) (Reible, 2014). The feeding habits of benthic organisms may lead to uptake of contaminants. For this reason, caps at SIB will be designed with intent to contain contaminants below the zone where bioturbation occurs, also known as bioturbation layer or biologically active zone. Per ROD Section 14.2, "The biologically active zone of the Site that supports benthic communities is in the 'shallow' sediment (less than 38 cm deep) and is generally 10 to 20 cm deep, based on sediment profiling imaging data" (EPA, 2017). In this zone, the physical and chemical characteristics, such as organic carbon and redox conditions, may be significantly different as compared to underlying sediment (Shen, 2017). In addition to designing a cap that would minimize risk of exposure of benthic organisms to contaminants in sediment and porewater, cap evaluation simulations also modeled bioturbation using a conservative bioturbation layer thickness of 20 cm. The bioturbation modeling approach was incorporated in CapSim assuming the mixing process is random, and the bioturbation flux is a Fickian diffusion process[3] for both the free molecular (porewater) and the sediment-associated contaminant (Shen, 2017; Shen et al, 2018).

Following CapSim recommendations (Reible, 2023), the mass transfer benthic boundary condition type was used for modeling. To ensure conservative near-surface concentrations, the mass transfer coefficient was set to 0.1 cm per hour (876 cm/year) for all COCs. Sensitivity testing was performed on the mass transfer coefficient (Section 2.5.14) and the difference in resulting porewater concentrations was found to decrease with increasing depth. At the depth of interest, the difference between mass transfer coefficients is negligible.

In addition to evaluating the impact of bioturbation on contaminant fate and transport through the cap, cap evaluation efforts included additional consideration of protection of the benthic community or aquatic life. To achieve this, the cap design was evaluated at CPP, which was beneath the conservative benthic boundary of 20 cm below sediment-surface water interface. This evaluation at CPP was done with the intent of implementing a cap that would contain contamination below the bioturbation layer to mitigate the risk of benthic organisms coming into contact with underlying contaminated sediments (ITRC, 2023).

During the Draft 50% RD, additional consideration will be taken to consider the substrate needed to support or enhance the existing or desired benthic community. Cap design may also consider the potential for short-term impacts to the benthic community from the amendment dose. Cap design will also consider the option to promote ecosystem recovery to the extent practicable, in addition to protection from chemical contaminant impacts (ITRC, 2023).

2.3.7. Model Input Summary

All chemical properties and partitioning coefficients are presented in Table 2-1. The non-chemical specific model input parameters are presented in Table 2-2. This table is divided into sections that are specific to the sediment or capping materials and those that are general system parameters.

2.4. RESULTS OF CAP MODELING EVALUATION

The results of the cap chemical transport modeling indicate that chemical isolation layer comprising 11 cm of 5.0 percent GAC-amended sand is predicted to reliably contain the flux of COCs into overlying cap layer and water column. This conclusion is applicable regardless of whether erosion protection gravel or sand layers are placed on top of the chemical isolation layer (Cap Alternatives 2 and 4). This conclusion also applies to all concentration-based scenarios that were sensitivity tested (Section 2.5.1). The time-to-breakthrough for each modeled scenario are available in Table 2-4. The efficacy of the GAC amendments in this modeling effort were driven by Total PAHs surpassing its sediment CUL. The time-to-breakthrough for each modeled scenario

[3] The Fickian diffusion process is diffusion driven by concentration gradient (e.g., flux moves from areas with high concentration into areas of low concentration).

for the unamended cap (Cap Alternatives 1 and 3) alternatives are available in Table 2-5. According to modeling results, unamended sand caps are insufficient for containing the flux of COCs into surface sediments for any contaminated sediment within the SIB SMA. The time-to-breakthrough was primarily driven by Total PCBs, dioxins and furans, particularly 2,3,4,7,8-PeCDF, 2,3,7,8-TCDF, and 2,3,7,8-TCDD, as well as DDT.

2.5. SENSITIVITY ANALYSES

Several of the model input parameters have uncertainty or variability associated with them, such as initial COC concentrations, material fOC and sorption parameters, groundwater upwelling velocity, sand cap thickness, and temporal and spatial discretization.

Unless otherwise noted, the sensitivity analyses were performed for the whole basin scenario (Section 2.5.2) using a 1.97-inch (5-cm) thick sand cap amended with 1.0 percent GAC by weight and topped with 1 ft (30 cm) of clean sand (1.97-inch [5-cm] version of Cap Alternative 4) with an upwelling velocity of 31.89 inches/year (81 cm/year), which is equal to the highest 50-hour average specific discharge presented in the Appendix B of the PDI ER (HGL, 2024). The reported percentage change in time-to-breakthrough or of input parameter values is the Relative Percent Difference (RPD)[4]. A list of completed sensitivity analyses and the resulting differences in time-to-breakthrough are detailed in Table 2-6.

2.5.1. Initial COC Concentrations

Three conceptual scenarios were modeled to understand the potential range of necessary cap compositions and amendments based on changes in initial COC concentrations. The assumptions regarding infinite supply, no degradation, and uniform concentration throughout the sediment profile provide a safety factor for the design.

The initial and bottom boundary concentrations for each scenario are listed in Table 2-3.

- **Initial Scenario (Section 2.3.2) –** Whole Basin: Representative of sediment with the 'worst-case' sediment-wide concentrations to understand the upper range of potential cap amendments. Initial sediment concentrations were set to the 95th percentile of the observed sediment concentrations across the SIB. 95th percentile was used instead of maximum concentration to evaluate representative site-wide conditions that are not impacted by maximum concentration outliers. In the absence of measured porewater concentrations, the associated equilibrium porewater concentrations were calculated within CapSim and used as the initial underlying sediment porewater concentration, consistent with ITRC guidance (ITRC, 2023).
- **Alternative Scenario 1 –** Low concentration: To better understand the difference between compliance with sediment CULs as compared to porewater CULs, and to explore the minimum requirements of a sediment cap designed for cleanup, initial sediment concentrations were set to the ROD Table 17 sediment CULs (EPA, 2017 and 2020). The associated equilibrium porewater concentrations were calculated within CapSim and

[4] RPD is the ratio of the absolute difference between two values to the average of the two values, calculated as a percentage [$(absolute\ difference\ /\ average) * 100$].

used as the bottom boundary concentration, consistent with ITRC (ITRC, 2023) guidance. For contaminants with only surface water CULs, the surface water CULs were used instead, and the sediment concentrations were calculated within CapSim. Contaminants with neither sediment nor surface water CULs were not modeled in this scenario. The reasoning for inclusion of each contaminant has been expanded upon in Section 2.3.2. Some individual PAHs and all individual PCBs do not have CULs but were summed over the 100-yr period and evaluated against the Total PAH and Total PCB CULs.

- **Alternative Scenario 2 –** End of Basin: This scenario focuses on the end of the basin, defined by grid cell columns 24 and higher (Figure 2-2). This area of the basin experiences less vessel traffic and has a deeper vertical extent of contamination than other areas within the SMA; therefore, the area has higher potential to be capped, although area-specific analysis will be completed during RD. Initial sediment concentrations were set to the 95th percentile observed sediment concentrations in this area of the SIB (HGL, 2024). In the absence of measured porewater concentrations, the associated equilibrium porewater concentrations were calculated within CapSim and used as the bottom boundary concentration, consistent with ITRC guidance (ITRC, 2023).

Alternative Scenarios 1 and 2 were reliably contained for 100 years by a 4.33 in (11 cm) sand cap amended with 5.0 percent GAC by weight, when topped by either erosion protection (Cap Alternative 2) or clean sand (Cap Alternative 4) when assuming area-specific highest 50-hour maximum specific discharge. The individual PAHs with resulting total solid concentrations that most directly determine the time-to-breakthrough of Cap Alternatives 2 and 4 in the Whole Basin initial scenario, 1-methylnaphthalene and 2-methylnaphthalene, do not have Table 17 CULs and either were not detected, or were detected at lower concentrations, in samples from the end of basin area. The zero or reduced concentrations for Alternative Scenario 2 were reflected in the modeled initial and bottom boundary concentrations (Table 2-3), and the resulting Total PAH concentration did not surpass sediment CULs within the modeled design life.

2.5.2. Whole Basin Analysis

Sediment COC concentrations at the 95th percentile observed concentrations from within the whole SIB are reliably contained for 100 years by a 4.33-inch (11-cm) sand cap amended with 5.0 percent GAC by weight, when topped by either erosion protection (Cap Alternative 2) or clean sand (Cap Alternative 4). Modeling the 4.33-inch (11-cm) sand cap amended with 1.0 percent GAC by weight and an upwelling velocity of 402 cm/year, the reliable containment time is 24 years for Cap Alternatives 2 and 4. When modeling the same cap with an upwelling velocity of 31.9 inches/year (81 cm/year), which is the basis of comparison for the sensitivity analyses, the reliable containment time is 48 years for Cap Alternatives 2 and 4.

2.5.3. Capping of Low Concentration Sediments

Modeling indicates that initial low concentration (“clean”) sediment COC concentrations at the sediment CULs partition under equilibrium conditions to porewater concentrations in excess of the surface water CULs for Total cPAHs, Total PCBs, DDD, DDE, DDT, 1,2,3,7,8-PeCDD, 2,3,4,7,8-PeCDF, 2,3,7,8-TCDD, and 2,3,7,8-TCDF. When modeling with an upwelling velocity of 402 cm/year, the reliable containment time at the top surface of the chemical isolation layer, driven by naphthalene, Total PCBs, and DDT porewater concentrations, is as follows:

- 4 years for Cap Alternative 1, 2 ft (60 cm) unamended sand with overlying 2 ft (60 cm) erosion protection layer; and
- 4 years for Cap Alternative 3, 3 ft (90 cm) unamended sand.

When modeling with an upwelling velocity of 31.89 inches/year (81 cm/year), the reliable containment time at the top surface of the chemical isolation layer is as follows:

- 18 years for Cap Alternative 1, 2 ft (60 cm) unamended sand with overlying 2 ft (60 cm) erosion protection layer; and
- 18 years for Cap Alternative 3, 3 ft (90 cm) unamended sand.

The low concentration sediment was effectively contained for the 100-year design life at the depth of interest by Cap Alternatives 2 (4.33-inch [11-cm] GAC-amended sand with overlying 2 ft (60 cm) erosion protection layer) and 4 (4.33-inch [11-cm] GAC-amended sand with overlying 1 ft [30 cm] sand layer) with GAC amendments of 1.0 percent and 5.0 percent.

These modeling findings show that even areas of SIB that are at the sediment CULs will require amended capping to achieve the more stringent porewater CULs; therefore, the remaining results discussion focus on Cap Alternatives 2 and 4.

2.5.4. Groundwater Upwelling Velocity

Appendix B of the PDI ER (HGL, 2024) reported measurements of 50-hour maximum specific discharges from 0.1 inches/day (0.264 cm/day or 96.4 cm/year) at Station 8D to 0.433 inches/day (1.1 cm/day or 402 cm/year) at Station 10A[5]. Section 2.4 reports the findings of modeling Cap Alternative 4 with an 11 cm chemical isolation layer using the highest 50-hour maximum specific discharge from Station 10A. When modeling Cap Alternative 4 with 1.0 percent GAC by weight as a 5 cm chemical isolation layer and using the highest 50-hour maximum specific discharge from Station 10A, the time-to-breakthrough is 10 years.

Measured 50-hour average specific discharges from -0.001 cm/day (negative value indicating recharge that equals -0.144 inches/year [-0.365 cm/year]) at Station 1D to 0.087 inches/day (0.22 cm/day or 80.3 cm/year[5]) at Station 10A. The average 50-hour average specific discharge across all 21 stations is 0.025 inches/day (0.064 cm/day or 23.5 cm/year). As a sensitivity analyses, the whole basin scenario was modeled using the highest 50-hour average specific discharge measured at Station 10A (rounded up to 81 cm/year) and the average 50-hour average specific discharge (rounded up to 24 cm/year) (PDI ER, 2024). The time-to-breakthrough for the 1.97-inch (5-cm) chemical isolation layer increased from 10 to 48 years (131 percent) and 100+ years (164+ percent) respectively.

[5] Values used in CapSim modeling were rounded up during conversions, so a more conservative value of 158.3 inches/year (402 cm/year) was used in modeling efforts.

The SIB SMA is subject to tidal influence, which was modeled using a diurnal oscillation period with variable magnitudes based on the recorded 50-hour maximum specific discharge values. The highest 50-hour maximum specific discharge was 0.433 inches/day (1.1 cm/day, rounded up to 402 cm/year) observed at Station 10A, which could be used in a conservative model with an oscillating upwelling velocity of 31.9±122 inches/year (81±310 cm/year). For the high concentration whole basin scenario under these assumptions, the time-to-breakthrough for Cap Alternative 4 with 1.0 percent GAC by weight is reduced from 48 to 42 years, a reduction in reliable containment time of 13.3 percent.

2.5.5. Impact of Dredging

The potential impact of dredging was evaluated for the End of Basin alternative scenario 2 discussed above. In this scenario (also referred to as Alternative Scenario 3), cap evaluation was completed for the End of Basin concentrations following 3 ft (91 cm) dredge. This scenario aides in conceptual understanding of the impact of a moderate surface dredge on cap performance. Initial sediment concentrations were set to the 95th percentile observed sediment concentrations in the end of basin area of the SIB that have an upper depth of 3 ft or deeper. In the absence of measured porewater concentrations, the associated equilibrium porewater concentrations were calculated within CapSim and used as the bottom boundary concentration, consistent with ITRC (2023) guidance. The area-specific highest 50-hour maximum specific discharge used in Alternative Scenarios 2 and 3 was recorded at Station 2D (0.32 inches/day [0.808 cm/day, which equals 295 cm/year]).

The end of basin, with and without dredging (Alternatives Scenarios 2 and 3), are both reliably contained for 100 years by a 4.33-inch (11-cm) thick sand cap amended with 1.0 percent or 5.0 percent GAC by weight[6] (Cap Alternatives 2 and 4).

2.5.6. Material f_{OC}

The f_{OC} of the sand in the chemical isolation layer and the gravel in the erosion protection layer was conservatively assumed from relevant scientific literature values. As a sensitivity analysis, the time-to-breakthrough was determined for a low organic carbon (0.05 percent f_{OC}) sand condition in Cap Alternative 4 amended with 1.0 percent and 5.0 percent GAC by weight for the whole basin initial scenario. The time-to-breakthrough was not impacted by the change in sand f_{OC}, as the relative change in sorptive capacity is minimal compared to the available GAC. This sensitivity test was also performed for unamended Cap Alternative 3 to quantify the impact of sand f_{OC} when sand alone is providing chemical sequestration. The time-to-breakthrough in total solid was reduced from 27 to 21 years, a reduction of 25 percent. These results are reported in Tables 2-4 and 2-5 alongside the results for the 0.1 percent f_{OC} sand and modeling used the highest 50-hour maximum specific discharge.

[6] During area-specific remedial design in the RD, parameters such as foc of the sand and percentage of the amendments will need to be verified by the supplier. Percentage of GAC used here is strictly for modeling purposes to be able to complete sensitivity testing and obtain meaningful differences in measurements. Field application rates will be higher.

Any innate f_{OC} that is present in the sand or gravel in excess of the modeling assumptions at the time of cap construction or acquired by the capping materials due to normal life-cycle activities of benthic organisms will increase the potential for COC adsorption by the capping materials and extend the reliable containment time.

2.5.7. GAC Amendment Percentage

The weight percentage of the GAC amendment in the amended caps that were modeled (Cap Alternatives 2 and 4) was assumed to be 5.0 percent by weight for constructability. Natural inconsistencies in mixing have the potential to increase or reduce the GAC percentage present in areas of an amended cap. As a sensitivity test, all concentration-based scenarios were additionally modeled assuming a GAC amendment of 1.0 percent by weight. These results are presented alongside the 5.0 percent GAC by weight results in Table 2-4. The time-to-breakthrough for the whole basin (Initial Scenario) when modeled with 1.0 percent GAC by weight and the highest 50-hour maximum specific discharge (158 inches/year [402 cm/year]) was 24 years, a reduction in reliable containment time of 123 percent.

2.5.8. Chemical Isolation Layer Thickness

For ease of comparison across sensitivity scenarios, the thickness of the amended chemical isolation layers were assumed to be 1.97 inches (5 cm). Chemical isolation layer thickness for Cap Alternative 4 was additionally varied to 0.98 inches (2.5 cm) and 3.94 inches (10 cm) to understand the potential impact of cap application variability. Reducing the isolation layer thickness to 0.99 inches (2.5 cm) decreased the time-to-breakthrough of the cap to 21 years, a reduction in reliable containment time of 78.3 percent. Similarly, increasing the isolation layer thickness to 3.94 inches (10 cm) increased the time-to-breakthrough to 99 years, an increase in reliable containment time of 69.4 percent.

Sensitivity analysis was also performed for low concentrations (Alternative Scenario 1) using Cap Alternative 3, unamended sand without the erosion protection layer, to determine the necessary cap thickness to achieve reliable containment of sediment CULs without GAC amendments. Modeling using an upwelling velocity of 31.9 inches/year (81 cm/year) suggests that the cap thickness required for a 0.1 percent f_{OC} unamended sand cap to increase time-to-breakthrough from 15 years to 100 years at the CPP is 109 inches (270 cm), a 70.9-inch (180-cm) increase in total cap thickness from Cap Alternative 3 as described in Section 2.2. Using the higher upwelling velocity of 158 inches/year (402 cm/year) suggests that the required chemical isolation layer thickness to achieve a 100-year time-to-breakthrough at the CPP is 419 inches (1,065 cm), a 384-inch (975-cm) increase in total cap thickness from Cap Alternative 3 as described in Section 2.2

2.5.9. Sorption Parameters

The derivation of the conservative organic carbon and Freundlich sorption parameters that were used in modeling is described in Section 2.3.4. ITRC guidance states that "If site-specific testing is not conducted, literature values may be used, although isotherms derived from the literature may not account for particle size differences (e.g., GAC vs. PAC), competition of sorption sites for the full suite of chemicals present in the sediment porewater at a site, the potential for fouling or dechlorination and the formation and precipitation of metal sulfides, or the competitive effects of

NOM. It may be appropriate to reduce the sorptive capacity of activated carbon by a factor of 2 to 5 to account for the effects of NOM" (ITRC, 2023). As a sensitivity analysis, the K_f values were increased by a factor of five times over the base model values (i.e., to one-half the literature K_f values) for all modeled COCs. The model proved to be very sensitive to the change in sorption parameters, as the time-to-breakthrough increased from 48 to 100+ years, a 70.3+ percent increase in reliable containment time.

2.5.10. Spatial Discretization

CapSim guidance suggests using a uniform number of grid cells in each layer. For this initial modeling, 20 grid cells per layer were selected. Sensitivity testing was completed by using 30, 40, and 60 grid cells per layer. The thinner step size discretization resulted in lower individual COC concentrations near the sediment cap-water interface but did not impact the modeled reliable containment time.

2.5.11. Outlier Influence

As described in Section 2.3.2, the 95th percentile sediment concentrations were used for modeling to mitigate undue influence from outliers. The whole basin (Initial Scenario) scenario was additionally modeled using the maximum observed sediment concentrations as the initial sediment and bottom boundary concentrations. The RPD of modeled sediment concentrations ranged from 98.2 percent (benzo(e)pyrene: increased to 880 µg/kg from 300.5 µg/kg) to 194.9 percent (DDD: increased to 1000 µg/kg from 13 µg/kg). When modeling with the maximum observed concentrations the time-to-breakthrough was reduced from 48 years to 9 years, a decrease in reliable containment time of 136.8 percent.

2.5.12. Cap Performance Point

The cap performance point (CPP) for Cap Alternative 4 was chosen to be 1 ft (30 cm) based on ITRC guidance. Porewater and total solid concentrations were additionally evaluated at the estimated maximum depth of benthic activity, 7.87 inches (20 cm), to evaluate the protection to burrowing organisms provided by the cap. The overlying 0.1 percent f_{OC} sand layer has much less sorptive capacity than the GAC-amended chemical isolation layer it tops. The GAC-amended chemical isolation layer had substantially lower predicted porewater and anticipated total concentrations. At a depth of 30 cm, Cap Alternative 4 with 1.0 percent GAC in the initial whole basin scenario, exceeded based on the total solids concentrations. Evaluating COC concentrations closer to the cap and surface water interface extended the time-to-breakthrough from 48 years to 100+ years, an increase in reliable containment time of 70.3 percent.

2.5.13. Hydrodynamic Dispersivity

CapSim guidance describes dispersivity as being "largely associated with the length scale of heterogeneities in the sediment layers" and suggests setting the value to 5-10 percent of the travel path of groundwater flow. In all cap alternatives and initial concentration scenarios, the dispersivity in each layer was set to be 10 percent of the layer thickness (Table 2-2). In layers thinner than 3.94 inches (10 cm), it is suggested to set the dispersivity to 0.39 inches (1 cm) as a conservative approximation, which equates to 20 percent of the 1.97-inch (5-cm) amended chemical isolation layer thickness used for sensitivity analysis. Cap Alternative 4 was modeled with the dispersivity of the chemical isolation layer set to 0.39 inches (1 cm), and the dispersivity of the sediment and sand layers remained at 10 percent of the layer thickness (3 cm). Under these assumptions, the time-to-breakthrough was reduced from 48 to 42 years, a reduction in reliable containment time of 13.3 percent.

2.5.14. Mass Transfer Coefficient

To ensure conservative near-surface concentrations, the mass transfer coefficient was set to 0.04 inches/hour (0.1 cm/hour or 876 cm/year) for all COCs. CapSim guidance (Reible, 2023) suggests a mass transfer coefficient on the order of 0.39 inches/hour (1 cm/hour or 8760 cm/year). Sensitivity testing was conducted using a mass transfer coefficient of 0.2 inches/hour (0.5 cm/hour or 4,380 cm/year) and the difference in resulting concentrations was found to decrease with increasing depth. The reliable containment time was unaffected.

At the CPP (1 ft [30 cm] below the sediment cap-water interface), eight of the modeled COC sediment concentrations, and none of the porewater concentrations, had non-zero changes with RPD values ranging from 91.0 percent (naphthalene: decreased to 4.01E-14 µg/kg from 1.07E-13 µg/kg) to 200.0 percent (Chrysene: increased to 1.28E-09 µg/kg from 0 µg/kg). At a depth of 5.9 inches (15 cm) below the sediment cap-water interface, there were four sediment and porewater concentrations that had non-zero changes with RPD values ranging from 0.17 percent (phenanthrene in total solid: decreased from 5.77E-13 µg/kg to 5.76E-13 µg/kg) to 0.70 percent (beta-chloronaphthalene in porewater: decreased to 143 µg/kg from 144 µg/kg). At a depth of 1.18 inches (3 cm) below the sediment cap-water interface, there were six sediment and porewater concentrations that had non-zero changes with RPD values ranging from 0.38 percent (benzo(g,h,i)perylene in total solid: increased to 2.66E-08 µg/kg from 0 µg/kg) to 8.0 percent (beta-chloronaphthalene in porewater: decreased to 68.4 µg/kg from 74.1 µg/kg).

2.5.15. Bottom Conditions

The bottom boundary condition type was conservatively assumed to be a fixed concentration. The flux-matching bottom boundary condition is commonly used to model advective, reactive transport (Reible, 2023). Sensitivity testing using the Flux Matching bottom boundary condition type did not result in a change in time-to-breakthrough, nor did it result in any differences in COC concentrations at the CPP.

2.5.16. Underlying Sediment Thickness

Sediment thickness was modeled as 1 ft (30 cm), consistent with ITRC guidance (ITRC, 2023). As a sensitivity test, sediment thickness was modeled as 47.2 inches (120 cm). At the CPP, there were four porewater concentrations and eight sediment concentrations with non-zero RPD values ranging from 0.13 percent (Total PAHs in porewater: decreased from 794 µg/kg to 793 µg/kg) to 200.0 percent (fluoranthene in total solid: increased from 1.56E-10 µg/kg to 8.55E-05 µg/kg). The increase in the underlying sediment thickness did not impact the modeled reliable containment time.

2.5.17. Dissolved Organic Carbon in Overlying Water

The overlying water was assumed to have a dissolved organic carbon (DOC) concentration of 1.0 mg/L. Sensitivity analysis was performed with a water DOC of 8.0 mg/L. The higher water DOC did not result in changes in porewater concentrations or in the modeled reliable containment time. The RPD values of the non-zero changes in total solids concentrations at the CPP ranged from 2.10 percent (pyrene: increased from 7.07E-16 µg/kg to 7.22E-16 µg/kg) to 200.0 percent (fluoranthene: decreased from 1.56E-10 µg/kg to 9.82E-05 µg/kg).

2.5.18. Time Step

The time step used for the modeling results reported in Section 2.4 was the default value of 0.1 years. To test the sensitivity of the model to more continuous evaluation, the time step was shortened to 0.01 years. The shorter time steps did not impact the modeled reliable containment time. There were non-zero RPD differences for 10 total solid concentrations, ranging from 4.87 percent to 200.0 percent with an average of 180.4 percent, and for five porewater concentrations, ranging from 0.13 percent to 200.0 percent with an average of 41.0 percent.

2.5.19. Absolute Model Error Tolerance

The absolute model error tolerance used for the modeling results reported in Section 2.4 was the default value of 1E-8 µg/L. Reible (2023) suggests reducing the error tolerance in the iterative solver when working with nonlinear systems to ensure the results do not change significantly. Sensitivity testing using an absolute error tolerance of 1E-10 did not result in a change in time-to-breakthrough, nor did it result in any differences in COC concentrations at the CPP.

3.0 PHYSICAL DESIGN CONSIDERATIONS

Physical design considerations that pertain to cap evaluation include geotechnical (Section 3.1) and erosion protection layer (Section 3.2) factors. An erosion protection layer may be needed to prevent damage to cap placements. Consideration of geotechnical factors is needed for evaluation of cap stability.

3.1. GEOTECHNICAL CONSIDERATIONS

Geotechnical factors were considered as they pertain to capping design and the underlying sediment. Geotechnical considerations are important in capping because contaminated sediments are typically fine-grained and may have high water contents and low shear strengths (Palermo et al., 1998a). Geotechnical considerations for this cap evaluation included bearing capacity, consolidation, slope stability, liquefaction, and filter design. The objective of this evaluation is to assess the stability of an engineered cap against bearing failure, settlement, sliding or slope displacement, and both cap and sediment material migration or mixing. Geotechnical analysis was driven by chemical isolation and erosion protection layer hypothetical alternatives. Conceptual cap design alternatives identified in Section 2.2 were evaluated to identify relevant geotechnical risks and potential cap failure modes. Representative sections were developed based on the conceptual cap alternatives and evaluated to identify relevant geotechnical risks and potential cap failure modes. Based on the evaluation of the geotechnical alternative listed above, the potential risks and failure modes identified included bearing failure, differential and total settlement, liquefaction susceptibility, slope stability, and material migration.

3.1.1. Requirements

The geotechnical evaluation was performed following the methods described in the PDI Work Plan (HGL, 2022); *Remedial Design Guidelines and Considerations (EPA, 2021b); and Guidance for In-Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al., 1998b). Geotechnical considerations evaluated for cap stability included:

- Representative section development and identification of risks and failure modes,
- Bearing capacity analysis,
- Settlement analysis,
- Filter design analysis,
- Evaluation of potential liquefaction susceptibility, and
- Static and pseudo-static slope stability analysis.

The geotechnical evaluations also included seismic effects, proximity to steep riverbanks and shoreline structures, and geotechnical considerations related to the sediments below the cap and surface preparation prior to cap placement. Detailed capping evaluations in different locations around the basin, including at individual structures and existing slopes, will be developed during RD.

3.1.2. Bearing Capacity

Bearing capacity of near surface sediment material was evaluated using methods described in *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al., 1998b).

An allowable cap thickness was estimated based on an undrained analysis, considering local shear failure for a cap load applied at the ground surface (zero foundation embedment). The analysis is based on a constant value of undrained shear strength and a safety factor of 3. Soil parameters used in the analysis included an undrained shear strength value of 250 pounds per square ft (based on in-water unconsolidated undrained triaxial test results within 3.5 ft [1 meter] of the mudline), a total unit weight of 115 pounds per cubic ft (pcf) for the clean sand portion of the cap, and a total unit weight of 140 pcf for the erosion protection layer (the effective unit weights when submerged are 53 and 78 pcf, respectively). Unit weights were estimated based on the anticipated cap and erosion protection material types as well as published correlations for cohesionless soils (Bowles, 1977).

Based on this analysis, the estimated maximum allowable cap thicknesses for the aggregate cap unit weights associated with the geotechnical alternatives are as follows:

- The maximum allowable cap thickness for Geotechnical Alternative 1 (2 ft [60 cm] of clean sand topped with 2 ft [60 cm] of erosion protection, effective unit weight: 65.1 pcf) is 4.4 ft;

- The maximum allowable cap thickness for Geotechnical Alternative 2 (4.33 inches [11 cm] of clean sand evenly mixed with GAC topped with 2 ft [60 cm] of erosion protection, effective unit weight: 73.7 pcf) is 3.9 ft;
- The maximum allowable cap thickness for Geotechnical Alternative 3 (3 ft [90 cm] of clean sand, effective unit weight: 52.6 pcf) is 5.4 ft; and
- The maximum allowable cap thickness for Alternative 4 (1 ft [30 cm] of clean sand and 4.33 inches [11 cm] of clean sand evenly mixed with GAC, effective unit weight: 52.6 pcf) is 5.4 ft.

3.1.3. Liquefaction Susceptibility

The liquefaction susceptibility was evaluated using a cone penetration test (CPT)-based liquefaction triggering assessment (Boulanger and Idriss, 2014) and the commercially available software CLiq Version 3.3.2.9 by GeoLogismiki. The analysis was based on sand-like behavior only (classic cyclic liquefaction); clay-like behavior (cyclic softening of clays and plastic silts) was not considered in the analysis. Seismic design parameters were based on the 2018 Conterminous U.S. National Seismic Hazard Map and a return period of 10 percent probability in 50 years (475 years). A peak ground acceleration of 0.234 g and moment magnitude of 9.08 (Mw) were used in the liquefaction triggering analysis. The CPT and groundwater data utilized to perform the liquefaction triggering assessment are presented in the *Geotechnical Data Report* (Appendix F of the PDI ER [HGL, 2024]).

Based on liquefaction susceptibility analysis (Figure 3-1), estimated CPT seismic settlement ranged from 3.3 to 15.8 inches (8.3 to 40 cm), with the maximum estimated seismic settlement of 15.7 inches (40 cm) observed at sCPTW-11.

3.1.4. Settlement Analysis

A differential and total consolidation settlement analysis was based on multiple cap alternatives. Consolidation settlement was evaluated using Settle3 by Rocscience, a soil settlement and consolidation analysis software. The 3D stress distributions were computed using Boussinesq and Westergaard computation methods. Uniform polygonal loads were used for Geotechnical Alternatives 1 and 2, applied in a single stage. One-dimensional consolidation test results for in-water geotechnical samples were used. A uniform pre-capping dredge depth of 4 feet (120 cm) was considered during analysis of each cap alternative. Additional settlement evaluations, based on a refined understanding of anticipated pre-capping dredge depths at various locations within the basin, will be performed during RD. Existing sediments were assumed to have an effective unit weight of 28 pcf.

Based on settlement analysis, the following conclusions were made for each geotechnical alternative considered:

- Estimated cap load for Geotechnical Alternative 1 (2 ft [60 cm] of clean sand topped with 2 ft [60 cm] of erosion protection) is 0.15 kilopound per square ft (ksf). Total predicted consolidation settlement ranged from 0.2 inches (0.5 cm) to 7.2 inches (18.3 cm), which represents the maximum predicted consolidation settlement (based on Boussinesq stress distribution) found for the SIB (Figure 3-2);

- Estimated cap load for Geotechnical Alternative 2 (4.33 inches [11 cm] of clean sand evenly mixed with GAC topped with 2 ft [60 cm] of erosion protection) is 0.06 ksf. Total predicted consolidation settlement is estimated to be up to 4.3 inches (11 cm , Figure 3-3);
- Estimated cap load for Geotechnical Alternative 3 (3 ft [90 cm] of clean sand) is 0.05 ksf. Total predicted consolidation settlement is estimated to be up to approximately 4 inches (10 cm); and
- Estimated cap load for Geotechnical Alternative 4 (1 ft [30 cm] of clean sand and 4.33 inches [11 cm] of clean sand evenly mixed with GAC) was -0.04 ksf, indicating a net load reduction. Settlement estimates were not performed due to the net load reduction following Alternative 4 dredging and capping.

3.1.5. Filter Design

A preliminary evaluation of grain size compatibility between cap materials and native sediment was completed with respect to the potential for vertical migration of both sediment and cap materials. Filter design was evaluated based on Gradation Design of Sand and Gravel Filters (USDA, 2017). Sediment soils evaluated included elastic silt (MH) from BW-15 (sample #2 at 3 ft [90 cm]), which is representative of the controlling material type with respect to grain size compatibility between cap materials and native sediment. Sand cap material was based on Oregon Department of Transportation (ODOT) fine concrete aggregate (based on Table 02690-5). The erosion protection material (gravel) evaluated was based on ODOT coarse concrete aggregate (ODOT, 2021), which is comprised primarily of aggregates with a nominal size of less than 1 inch, and greater than the aperture of a #4 sieve. The materials evaluated for the filter design are consistent with erosion protection requirements described in Section 3.2.

A preliminary evaluation of grain size compatibility indicated the anticipated cap material types adequately limit the potential of vertical migration of both sediment and cap materials. Potential sand cap and erosion protection material gradations should be generally consistent with the corresponding ODOT gradations. The potential for vertical migration may be determined in RD using guidance developed for the design of sand and gravel filters (USDA, 2017).

The use of filter fabric (geotextile) in cap design was considered. Although it is not likely to be feasible site-wide due to the time and challenges with placement, it is still maintained as a consideration for challenging areas that will need special consideration in RD. Filter fabric may be required to prevent differential movement during placement, although, the analysis of all results available to date indicates that vertical sediment migration can be adequately limited without the use of filter fabric for even the most conservative scenarios.

3.1.6. Slope Stability and Seismic Evaluation Analyses

Cap slope stability was evaluated with 2D limit-equilibrium analysis using Slide2 by Rocscience. A static analysis based on a minimum safety factor of 1.5 was completed, in addition to pseudo-static (non-liquefied) analysis based on a minimum safety factor of 1.0. The potential for liquefaction-induced flow failure was evaluated using conventional limit equilibrium slope stability analyses and residual undrained shear strength parameters for the liquefied cap material (analysis decoupled from all seismic inertial forces). The 2D limit-equilibrium analysis results were checked against infinite slope chart solutions for general agreement.

A horizontal seismic coefficient of 0.12 was used in pseudo-static stability analyses. The horizontal seismic coefficient was estimated as a half of the mapped peak ground acceleration of 0.234 g (2018 Conterminous U.S. National Seismic Hazard Map) for a 10 percent probability in 50 years (475-year) return period.

Based on slope stability analysis, the static safety factor of a 1.2-meter sand cap at a 25-degree slope is approximately 1.6 (Figure 3-4). Based on an infinite slope chart solution, the static safety factor for a 1.2-meter sand cap at a 22-degree slope is 1.5. The pseudo-static safety factor for a 1.2-meter sand cap at a 25-degree slope is approximately 1.0 (Figure 3-5). The safety factor against liquefaction-induced flow failure for a 1.2-meter sand cap at a 25-degree slope is approximately 1.3 (Figure 3-6).

Preliminary cap design should be based on slope gradients of 2.5 horizontal to 1 vertical (±22 degrees) or flatter. Detailed cap stability evaluations will be performed during RD to determine final cap slopes and configurations.

3.2. EROSION PROTECTION LAYER CONSIDERATIONS

Erosive forces may impact stability of the cap; therefore, an erosion protection layer may be needed in some areas to prevent short-term and long-term damage to the cap's chemical isolation layer (Palermo et al., 1998a; ITRC, 2023). An assessment of the erosive forces (natural and anthropogenic) was completed to determine the characteristics of the erosion protection layer potentially needed to prevent erosion of the cap, including layer thickness and material size. The erosion protection layer design considered the magnitude and probability of occurrence of relatively extreme erosive forces estimated at the capping site (Palermo et al., 1998b). The erosive forces evaluated included wind- and vessel-generated waves, prop wash, river currents during a 100-year flood, stormwater outfall discharges, rainfall runoff, and Dry Dock activities. The following sections summarize the evaluation of each erosive force and its implications for erosion protection layer design.

3.2.1. Currents in the SIB

Erosive forces created by river currents during a 100-year flood were evaluated to design the appropriate erosion protection layer thickness and utilize appropriate material size.

Numerical modeling of river flow and tides was conducted using the 3D hydrodynamic model Delft3D-FLOW for high-flow and low-flow events (Deltares, 2023a and 2023b). The numerical model solves the motion and continuity equation derived from the 3D Navier-Stokes equation for incompressible free surface flow. Time integration was performed using a first order implicit scheme. Delft3D-FLOW was selected for the analysis based on its accurate 3D simulation of hydrodynamics and robustness.

For the cap evaluation, the hydrodynamic model consisted of a large-scale model for boundary forcing, and a nested model to resolve the finer-scale processes in the SIB. The global domain

(Figure 3-7, bottom left) included the Willamette River, Columbia River, and Multnomah Channel and was created using the Delft3D Flexible Mesh module using a combination of unstructured elements (both triangular and quadrilateral). To better resolve processes at the project site, a nested Delft3D 4 model was created using a detailed structured/curvilinear grid encompassing the SIB and its geographic context. Nested model boundary conditions were taken from the results of the large-scale model. The large-scale model (Flexible Mesh) included 19,000 elements, with element sizes ranging from 250 meters to 15 meters. The nested model (structured/curvilinear) included 12,000 elements, with element sizes ranging from 45 meters to 15 meters.

Both hydrodynamic models were evaluated in 3D with a vertical grid defined by a sigma coordinate approach. In a sigma coordinate approach, the number of vertical elements is composed of a fixed number of layers assigned a fraction of the water column; the cell size and cell center coordinates change as function of depth during the simulation. For both models, five layers were chosen to resolve vertical stratification.

Model grid bathymetry was compiled from several data sources, including the following:

- HGL Survey within SIB (PDI ER Appendix E; HGL, 2024);
- USACE Navigation Survey of Willamette River (USACE, 2022);
- David Evans Associates Survey of Willamette River (David Evans Associates, 2018);
- Vigor Survey of Portland Facilities (eTrac, 2018);
- National Oceanic and Atmospheric Administration (NOAA) Lower Columbia River DEM (USACE, 2010); and
- Oregon LiDAR Consortium (OLC) – Oregon LiDAR for upland areas (OLC, 2014).

Where there was overlap between multiple datasets, priority was given to the most recent data.

The large-scale model included six upstream discharge boundaries and one downstream elevation boundary. The upstream large-scale model boundaries were based on locations of dams (Bonneville Dam and Willamette Falls) located in the Columbia River and Willamette River, respectively. Discharge at Columbia River was developed using historical Bonneville Dam flow data from USACE. U.S. Geological Survey (USGS) Station 14142800 Beaver Creek (USGS, 2023a) and USGS Station 14142500 Sandy River (USGS, 2023b) data were used to develop the other discharges along the Columbia River.

Flow data from USGS Station 14211010 Clackamas River (USGS, 2023c); USGS Station 14211315 Tryon Creek (USGS, 2023d); and USGS Station 14211550 Johnson Creek (USGS, 2023e) were used to develop discharges for tributaries along the Willamette River. Discharge at Willamette Falls was developed using the difference between historical flow data from USGS Station 14211720 Willamette River (USGS, 2023f) and the sum of discharges from Willamette River tributaries (no direct flow measurements at Willamette Falls are available).

The downstream boundary of the large-scale model is located at the NOAA gage station at St. Helens, where historical water surface elevation data are available. Historical winds measured at Portland Airport were used as input to the model in all simulations using spatially constant but temporally varying wind speed and direction (Meteostat, 2023).

The large-scale model was validated using measured water levels at USGS Station 14211720 Willamette River, also referred to as Morrison Street Bridge Portland and Morrison Street (USGS, 2023a). The water level validation at Morrison Street showed excellent correlation for a range of various Willamette River flow periods including low flow, medium flow, and higher flow. As seen on Figure 3-7, coefficient of determination exceeded 0.90 for low-flow conditions, 0.99 for high-flow conditions, and 0.99 for the validation period.

The nested/structured Delft3D model was validated using multiple velocity datasets. Acoustic doppler current profiler (ADCP) data, reported in the *Hydrodynamics and Sediment Dynamics Surveys Report* (Appendix I of the PDI ER; HGL, 2024), were used to validate the model for the SIB. ADCP1 was deployed during Deployment 1 from February 21 to April 1, 2022 (38 days of data collected), whereas ADCP2 collected data for a full 2-month duration (Figure 3-8). The combination of extremely low turbidity and extremely low water velocities resulted in moderate levels of noise that required further processing and filtering of the raw data. Overall, ADCPs measured very low velocities (less than 0.1 ft per second), which demonstrated very little exchange/influence between the SIB and the Willamette River. The Delft3D model also predicts extremely low velocities in the SIB (less than 0.1 ft per second [0.03 meters per second]).

ADCP data were also collected at River Miles 1.4 through 2.8 in 2017 and 2018 at two locations (North Platform and South Platform) downstream of the Multnomah Channel confluence in the Willamette River. The North Platform was located at River Mile 1.4 and was used for validation of the large-scale hydrodynamic model. No validation of the nested hydrodynamic model was performed here because it is outside the nested model domain; however, results between the large-scale and nested model at a location in the nested domain nearest River Mile 1.4 were consistent. Figure 3-9 shows validation during the Winter Deployment at the North Platform. The nested model validation was successful, with coefficients of determination ranging from 0.85 to 0.93 at different vertical levels in the water column.

Flood modeling was performed using the nested Delft3D model. Results were verified to be consistent with the validated large-scale unstructured model. For the purposes of cap erosion protection evaluation, the nested model simulated 100-year flood event conditions provided by the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FEMA, 2010). A constant discharge of 380,000 cubic ft per second (cfs) was used as the upstream boundary condition with a constant water level of 9.45 meters (31 ft) North American Vertical Datum of 1988 (NAVD88) used as the downstream boundary condition. The downstream boundary water level was taken from the results of the Corrected Effective Model (CDM Smith, 2022). Bed shear stresses were extracted from the model results. Figure 3-10 shows maximum depth-averaged velocity and Figure 3-11 shows maximum bed shear stresses. Results indicate that bed shear stresses from river currents are small and likely do not govern erosion protection design anywhere in the SIB.

3.2.2. Wind-Waves

Wind-waves are generated by winds blowing over the water surface. The Simulating Waves Nearshore (SWAN) model (Delft, 2012) was used to predict wave conditions generated by winds during a 100-year storm from all directions. SWAN predicts random, short-crested wind-generated waves in coastal regions and inland waters from given wind, water depth, and current conditions. The model domain consisted of a structured uniform 2-meter grid. The 100-year wind speeds were taken from the FS Table C-1 (EPA, 2016). Table 3-1 lists 100-year wind directions and speeds used in SWAN modeling efforts (EPA, 2016). Simulations were performed at water levels corresponding to mean low water (MLW) and ordinary high water (OHW) elevations.

Wave conditions were extracted at transects around the SIB with spacing of 30.5 meters (100 ft). Wave runup velocities on the slopes were computed using the SWASH model (Delft, 2018). Maximum bottom velocities during the storm event were extracted at each transect. Shear stresses were computed using the maximum velocity on the slope and quadratic bed friction formulation with drag coefficient based on a Manning's roughness coefficient of 0.02. The areas between MLW and OHW are anticipated to have similar bed shear stresses as those computed at MLW and OHW; therefore, the shear stress is shown as a constant value on the slope between elevations at each transect.

Significant wave heights reaching 1.1 ft (33.5 cm) were observed near the head of the basin (Figure 3-12). The largest significant wave heights reach 1.6 ft (48.8 cm) near the mouth of the basin. Bed shear stresses of up to 50 Pascals (Pa) were observed on the slopes, indicating that more robust erosion protection will be required on steeper slopes (Figure 3-13). Slopes/banks will be further evaluated using coastal engineering methods and consideration of suitable habitat materials during Draft 50% RD.

Vessel wakes were measured in the SIB; however, they were found to be similar in nature to wind-waves and smaller in height. This is anticipated because vessel traffic moves relatively slowly in the SIB. Since wind-waves control the design of the erosion protection layer in shallow water, vessel wakes were not further evaluated in erosion protection design.

3.2.3. Propeller Wash

High-frequency (30-second) Automatic Information System (AIS) data collection was commissioned for the SIB and a portion of the river surrounding the SIB for the 3 months from February 21 to May 27, 2022 (HGL, 2024). The data points are shown in Figure 3-14 (top left). The majority of the transits within SIB were made by tugs (Figure 3-14, bottom left). For prop wash analysis, AIS pings were separated into passing events (vessel tracks) based on unique Maritime Mobile Service Identity (MMSI) voyage numbers. Events with speeds below 1 knot were not considered. For each event, the data points were splined to provide a smooth and continuous vessel track at 1-meter intervals (Figure 3-14, top right).

Prop wash was simulated for each transit using the 3D empirical Dutch Method (PIANC, 2015), as demonstrated in Figure 3-14 (bottom left). The prop wash and bottom velocities were computed while vessels progressed along the routes observed in the AIS data. Applied power used for computing prop wash velocities by each vessel was prescribed per the FS Table C-18 recommendations for design (EPA, 2016). The high applied power values result in a more conservative prop wash bottom velocity estimate considering the SIB site conditions. At the SIB, vessels are expected to move at slower velocities and thus cause less prop wash. Propeller diameters were estimated based on vessel type and vessel size using industry data. No alternative propulsion systems were considered in the analysis.

Bottom velocity was computed on the riverbed (unified elevation model) with time-varying river water levels at every 1 meter along each passing route. Bottom velocities were computed on the riverbed using the Unified Elevation Model. The Unified Elevation Model is a seamless 1-ft by 1-ft elevation grid in feet relative to NAVD88. Source elevation data was prioritized by date, with newer data being included where datasets overlapped. The in-water data sources included multibeam bathymetry from 2022, 2018, and 2015. In the above-water areas, data sources included Mobile Terrestrial LiDAR collected by eTrac in 2022, as well as LiDAR from the City of Portland collected in 2019. The 2022 eTrac LiDAR was refined to remove structures (e.g., timber piles) and was primarily used for areas under wharves (Lagoon Wharf and Willamette Wharf). Manual methods were used to remove the wharf structures and interpolation was used to create a seamless elevation dataset in these areas. A polygon representing the boundary where the 2019 bare earth Lidar was returning valid ground values was used to restrict the use of this dataset to areas with actual bare earth returns. At Pier A and the Quay Wall, data from 2019 Lidar First Return dataset was used after manual refinement to remove surface structures. Finally, the 2019 bare earth LiDAR from the City of Portland was used to fill in the upland areas. The remaining relatively small areas between the above-water data and the below-water data were filled by linear interpolation to create a seamless elevation dataset. Figures 3-14 and 3-15 show the Unified Elevation Model elevations, and locations where each elevation data source was applied, respectively.

Bed shear stress was computed using near-bed velocity and shear stress as a function of tow parameters (Maynord, 2000). An example bed shear stress calculation is shown for a single vessel position in Figure 3-16 (bottom right). Results show that prop wash maximum bed shear stresses reach approximately 10 to 15 Pa and are focused in the main navigation areas in the SIB (deeper water, see Figure 3-17). Results indicate that shear stresses from prop wash would require relatively modest armor protection (e.g., coarse sand or gravel).

3.2.4. Dry Dock Activities

Dry Dock operations were discussed with operations staff at Shipyard Commerce Center prior to the analysis and the erosion protection assessment was performed in accordance with documented shipyard practices (Appendix K of PDI ER; HGL, 2024). Dry Dock operations that may generate bottom velocities consist of (1) lowering and raising the Dry Dock, and (2) ballast water intake and discharge. Lowering and raising Dry Dock (hull movement displacing water) was analyzed only in the unladen configuration (no vessel inside) because the dry dock raises and lowers much faster, resulting in higher bottom velocities. Lowering and raising of the dry docks with vessels inside was not evaluated because it typically occurs over 4 to 5 hours and would not generate bottom velocities of concern. Ballast water intake/discharge (localized water jets) was analyzed because it can impact the side slopes of the dredge cut or bulkheads and can interact with other dry docks to create zones of accelerated flow.

Computational Fluid Dynamics (CFD) modeling was performed to evaluate bed shear stresses from both types of dry dock operations. CFD model input parameters included bathymetry created from the unified elevation model. For simulations evaluating lowering and rising of dry dock, mesh resolution typically ranged from 0.5 meter along the dredge cut slopes and near the bed to 3 meters at the distant corners of the model domain. For simulations evaluating ballast water intake and discharge, higher-resolution mesh blocks were used to resolve the water jets (resolution as high as 3.93 inches [10 cm]). Figure 3-18 (top right, bottom right) shows, as an example, the model setup for Dry Dock 3 and typical ballast water discharge simulation results.

Lowering of unladen Vigorous Dry Dock was simulated over a 90-minute period. Lowering of unladen Dry Dock 3 was simulated over a 40-minute period. Lowering and raising of unladen Dry Dock 5 was simulated over a 2-hour period and included the presence of Dry Dock 3.

Dewatering (raising) of Vigorous Dry Dock was simulated using 10 discharge jets with a 0.5-meter diameter on both port and starboard sides. Discharge was 13,000 gallons per minute (gpm) at each port. Dewatering (raising) of Dry Dock 3 was simulated using 12 discharge jets with a 0.5-meter diameter on both port and starboard side. Discharge was 8,400 gpm at each port. When Dry Dock 5 is in the lowered position, the discharge jets on the starboard side of Dry Dock 3 may cause flow acceleration under Dry Dock 5 (if in the lowered position). Dewatering (raising) of Dry Dock 5 was simulated using 8 discharge jets with flows of 16,500 gpm each, with a 0.6-meter diameter. Discharge jets on the pontoon are directed at the Quay Wall, travel downwards, and interact with the riverbed, potentially mobilizing sediment.

For the dry dock lowering and raising simulations, hull movements displacing water produced relatively low velocities due to dry dock movements occurring over long time periods. Modest currents were generated at the slopes of the dredge cut. Figure 3-18 (left) shows peak bed shear stresses from all simulations performed, for all dry docks. Peak shear stress of up to 0.25 Pa was produced due to lowering of Dry Dock 3 and Vigorous Dry Dock. Lowering Dry Dock 5 caused negligible bed shear stress. In these areas, only affected by dry dock hull movements, erosion protection may not be required if the chemical layer consists of medium-to-coarse sand.

Ballast water intake/discharge jets may impact the slopes of the dredge cuts and bulkheads and could also interact with other dry docks if they are in the lowered position. Dewatering jets cause peak bed shear stress of 0.60 Pa at Dry Dock 5 where they impinge upon the Quay Wall, but much lower elsewhere. Peak bed shear of 0.45 Pa was observed on the south side of Vigorous Dry Dock (outside the dredge cut). Peak bed shear stress of 0.16 Pa was observed on the north side of Dry Dock 3. Coarse to very coarse sand is likely to provide sufficient cap erosion protection based on bed shear stresses induced by dewatering jets. Inside the dredge cuts themselves, where maintenance dredging is likely to take place, no erosion protection layer is likely required (pending material specification for the chemical isolation layer).

3.2.5. Outfalls

Erosion protection requirements around outfalls are the most robust of any location in the SIB. During peak rainfalls, outfall discharges result in large water velocities and bed shear stresses, which are presently resisted by riprap and/or concrete headwalls surrounding the outfalls. Discharges were estimated using the Pacific Coast Stormwater Management Manual (PCSWMM) stormwater system model (advanced modeling software for EPA SWMM 5 stormwater, wastewater, and watershed systems) created to represent the City of Portland outfalls. Outfall discharges were simulated with a CFD model for time periods with high discharge and low water level (worst-case velocities).

The 100-year design outfall flow rates were developed using a PCSWMM water management model of the SIB stormwater system and catchment basin. Inputs used included a 100-year, 24 hour rainfall of 4.5 inches (per NOAA Precipitation Atlas Volume 2) and a recommended Type1 rainfall distribution (per Natural Resources Conservation Service TR-55).

A CFD model was developed with M-1, M-2, M-3, S-1, S-2 100-year outfall flow rates ranging from 38 to 135 cfs, including 134 cfs, 135 cfs, 118 cfs, 38 cfs, and 46 cfs, respectively. The CFD model simulated discharges at a conservative low river water level of 0 meters (0 ft) Columbia River Datum. The CFD model incorporated topography/bathymetry from the unified elevation model, with outfalls inserted at the actual location/orientations including real geometry and existing wing walls/aprons. Additional inputs factored into modeling, including invert elevations taken from city drawings, as well as pipe diameter, slope, and material. The CFD model used grid cell sizes of 0.1 meter at city outfalls S-1/S-2 and 0.15 meter at city outfalls M-1, M-2, and M-3.

Figure 3-19 shows the maximum bed shear stresses predicted in the CFD model for all five city outfalls. Maximum resulting bed shear stresses were extracted from the 60-second CFD simulations of each outfall scenario (no ambient currents/waves/winds included in CFD). As a result of outfall modeling efforts, peak shear stresses of up to 60 Pa were identified. Shear stresses associated with stormwater outfalls confirm that heavier, more robust protection is needed near the outfalls. Outfall erosion protection design and the potential impact on habitat will be evaluated in the habitat impact evaluation.

3.2.6. Rainfall Runoff

Bed shear stresses due to rainfall runoff were evaluated using the MORPHO model (Kivva et al, 2006). MORPHO is a 2D model that simulates depth-averaged surface water flow, sediment transport, and bottom-change morphology in the near-shore zone. The maximum 5-minute interval rainfall rate from 2018 to 2022 (2.64 inches per hour [6.7 cm per hour]) was used in the simulations. Additional assumptions used in the model included no infiltration; no canopy/ground cover; no flow diversion incorporated (i.e., curbs, swales, drains, straw bales, etc.); and Manning's roughness coefficient of 0.03 for all surfaces.

Peak bed shear stresses induced by rainfall were modest (Figure 6-1), even under peak rainfall intensity. Based on results of the rainfall runoff modeling, rainfall runoff can cause downslope movement of finer material but will likely not govern any slope erosion protection requirements (wind-waves and overall slope stability will likely govern design of erosion protection).

3.2.7. Stable Material Sizes

Peak bed shear stresses (Figure 6-2) from each hydrodynamic process were overlaid onto a 1 meter grid, and maximum values were taken from each process to identify stable grain sizes. Stable particle classifications were identified using Table 7 in USGS Scientific Investigations Report 2008–5093 (USGS, 2008). For each particle classification, maximum particle diameters were conservatively assigned to peak bed shear stresses across the SIB. Figure 6-3 illustrates the stable bed material sizes.

The largest bed shear stresses were found on banks and slopes surrounding the outfalls. The second largest material requirements are on the submerged slopes and riverbanks, due to exposure to storm waves. In both of these areas, specialized considerations are necessary and erosion protection material sizes will be generated during RD. In most of the SIB, gravel (“coarse,” “very coarse,” [Berenbrock et al, 2008]) is large enough to provide static material stability against erosion. In limited quiescent areas, it is likely that medium-to-coarse sand used for the chemical isolation layer will be generally stable (i.e., no erosion protection layer may be required).

3.2.8. Material Availability

Material availability and costs will be discussed in detail in the cost analysis. However, preliminary material availability efforts have been completed assuming a hypothetical need of 420,000 cubic yards of both sand and gravel (2 ft [60 cm] chemical isolation layer and 2 ft [60 cm] erosion protection layer, both applied sitewide). Local rock quarries were surveyed to assess the feasibility of the conservative volume of capping material that may be needed. Information requested included feasibility of producing and delivering large volumes of material, transportation logistics, lead time required for material, and source material information.

The survey of local suppliers concluded:

- For the volume of material required, more than one supplier will likely be needed;
- Suppliers may need to accommodate multiple ongoing projects planned in the Central Harbor area of Portland that are requiring or will require large volumes of material;
- The estimated volume represents a large portion of yearly production quantity for some suppliers;
- Different suppliers may be needed for gravel and sand;
- Lead times for estimated quantity is approaching up to 1 year;
- Transportation is quarry-dependent; some have availability to barge locally; and
- Most quarries do not provide organic carbon concentrations for material. Organic carbon content of interest for chemical isolation layer design will require on-site sampling and testing for the project.

4.0 OTHER CAPPING CONSIDERATIONS

In addition to chemical isolation layer and physical design considerations, there are additional considerations with cap placement. These considerations include structures, debris, and flood rise and navigation, consistency with anticipated land and in-river uses land, capping monitoring and maintenance, and design life.

4.1. WORK AROUND STRUCTURES

For structures that are permanent and functional, placement of cap around them may be challenging and limited, and the ability to effectively place a cap will have to be closely examined in the Draft 50% RD.

4.2. CAPPING MONITORING

Cap monitoring will be performed in accordance with Section 10.1.1.9 of the ROD to include baseline porewater sampling, short-term monitoring until Remedial Action performance goals and CULs are met, and long-term monitoring during statutory Five-Year Reviews until unlimited use/exposure for the PHSS is achieved (EPA, 2017). Monitoring performed may result in operation and maintenance activities based on potential damage to the cap. Additional considerations for cap monitoring needs will be identified in the Draft 50% RD.

4.3. CAPPING OPERATION AND MAINTENANCE

Additional considerations for cap monitoring and additional potential maintenance are summarized in BODR Section 9. Damage to the cap from flooding, seismic events, prop wash, etc. is discussed as an O&M concern Additional considerations and potential maintenance needs will be identified in the Draft 50% RD.

4.4. DESIGN LIFE

This cap was designed for 100-year performance. Continued monitoring results can be used to compare performance encountered against the design predicted in this evaluation. At 100 years, a re-evaluation of cap performance should be completed to evaluate if the existing remedy is still protective of human health and the environment for areas that were capped or dredged and capped. If the outcome of that evaluation concludes that additional work is needed, effort should be taken to re-evaluate COC concentrations at the top layer and implement the most applicable available remedial design at the time of the evaluation.

4.5. CONSISTENCY WITH ANTICIPATED LAND AND IN-RIVER USES

As indicated in PDI ER, current land uses within and adjacent to the SIB Project Area consist of light and heavy industrial uses and limited commercial uses. SIB is an active navigable industrial waterway, and the shoreline hosts many structures supporting light and heavy industrial activities (HGL, 2024). The waterway within the SIB Project Area currently supports commercial/industrial, recreational, and government vessel traffic related to the ongoing uses of the shoreline. Shoreline facilities support light and heavy industrial uses, vessel mooring, U.S. Coast Guard (USCG) operations, U.S. Navy operations, and public access (HGL, 2024). As seen in Section 2.6 of BODR, the anticipated future use for existing SIB Project Area facilities is the same as the current use. As a result, the cap is designed with anticipated future use as well so that the cap is not destroyed or damaged by those uses. If future land use changes, RD would have to be re-evaluated to help maintain cap effectiveness aligned with that change.

5.0 SUMMARY OF CAP DESIGN CONSIDERATIONS

This section summarizes findings from chemical isolation layer, erosion protection layer, and geotechnical considerations. The following conclusions were made based on chemical isolation considerations:

- Analysis shows that cap alternatives amended with 5.0 percent GAC are protective sitewide for the duration of the design life (100 years);
- Nine of the COCs, when modeled at the sediment CULs, would partition under equilibrium conditions to porewater at concentrations exceeding the surface water CULs by one to three orders of magnitude. To address this consideration, modeling efforts suggest that sediment concentrations at the sediment CUL would require remediation to prevent porewater migration into overlaying water column at concentrations exceeding surface water CULs. Upon further examination of remedial options, unamended 3 ft (90 cm) sand cap time-to-breakthrough at the CPP would occur 15 (Cap Alternative 3) to 18 (Cap Alternative 1) years after cap installation. As a result, these sediments at CUL COC concentration would have to be remediated by placing a GAC-amended cap to keep porewater concentrations below the surface water CULs;
- Results of modeling suggest that an addition of 5.0 percent GAC by weight will be sufficient for COC chemical isolation for a 100-year time-to-breakthrough in a 4.33-inch (11-cm) amended sand cap with overlying 2 ft (60 cm) of erosion protection (Cap Alternative 2) or with a 1.97-inch (5-cm) amended sand cap with overlying 1 ft (30 cm) of clean sand (Cap Alternative 4);
- Calculated Total PAH concentrations in total solids is the primary driver of amended cap time-to-breakthrough, particularly 1-methylnaphthalene and 2-methylnaphthalene;
- Calculated porewater concentrations of Total PCB, 2,3,4,7,8 PeCDF, 2,3,7,8-TCDD, and DDT are the primary drivers of unamended cap breakthrough at the CPP well before the desired 100-year design life; and
- Further refinement of the SIB SMA sub-areas in the RD will enable cap recommendations that are more tailored to specific chemical isolation, erosion protection, and geotechnical consideration requirements.

The following conclusions were made based on erosion protection considerations:

- The majority of the SIB SMA can be capped with relatively cost-efficient EPL material (gravel) in a single-layer approach as compared to armor and bedding layer) directly above chemical isolation layer containing medium or coarse sand;
- Gravel sizes from “medium” to “very coarse” (Berenbrock et al, 2008) are feasible for use in various locations throughout the SIB SMA;
- Gravel armor layer allows for convenient and efficient placement, which reduces the overall cost of the remedy; and
- Armor layer requirements are fairly minimal except on steeper slopes and near outfalls, where material will be larger than gravel.

Variations in armoring size within the site-specific areas will be further evaluated in the Draft 50% RD.

The following conclusions were made based on the geotechnical considerations:

- Cap designs all have a safety factor of at least 3 against bearing failure (based on near surface in situ sediment shear strengths);
- Predicted consolidation settlement of sediment material under anticipated cap loads and liquefaction-induced settlement magnitudes are variable across the basin;
- Detailed analysis will be required during RD to assess the potential for differential settlement;
- A preliminary evaluation of grain size compatibility indicates the anticipated cap material types adequately limit the potential of vertical migration of both sediment and cap materials;
- Preliminary slope stability analysis indicates minimum required factors of safety are met for submerged cap slopes at gradients of up to 2.5 horizontal to 1 vertical (±22 degrees);
- Detailed analysis will be completed next to assess cap stability on emergent slopes basin wide; and
- Detailed analysis will be completed next in different locations around the basin, including cap placement around and under individual structures.

Area-specific cap design incorporating these considerations will be performed during Draft 50% RD.

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Table 1-1
Sediment and Surface Water Criteria for Modeled COCs
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Chemicals Analyzed	Sediment			Surface Water
	RAL (µg/kg)	PTW (µg/kg)	CUL (µg/kg)	CUL (µg/L)
DDD	160	7,050	114	3.10E-05
DDE			50	1.80E-05
DDT			246.0	2.20E-05
1,2,3,4,7,8-HxCDF	-	0.4	0.0004	5.10E-09^
1,2,3,7,8-PeCDD	0.0008	0.01	0.0002	5.10E-10^
2,3,4,7,8-PeCDF	0.2	0.2	0.0003	1.70E-09^
2,3,7,8-TCDD	0.0006	0.01	0.0002	5.10E-10
2,3,7,8-TCDF	-	0.6	0.000407	5.10E-09^
Total PCBs	75	200	9	6.40E-06
PCB-44	-	-	-	-
PCB-99	-	-	-	-
PCB-141	-	-	-	-
PCB-153	-	-	-	-
PCB-174	-	-	-	-
PCB-177	-	-	-	-
PCB-180	-	-	-	-
PCB-183	-	-	-	-
PCB-199	-	-	-	-
cPAHS [B(a)P Eq.]	-	774,000	85	0.00012
Benzo(a)anthracene	-	-	-	0.0012
Benzo(a)pyrene	-	-	-	0.00012
Benzo(b)fluoranthene	-	-	-	0.0012
Benzo(k) fluoranthene	-	-	-	0.0013
Chrysene	-	-	-	0.0013
Dibenz(a,h) anthracene	-	-	-	0.00012
Indeno(1,2,3-cd) pyrene	-	-	-	0.0012
Total PAHs	30,000	-	23,000	-
1-Methylnaphthalene	-	-	-	-
2-Methylnaphthalene	-	-	-	-
Acenaphthene	-	-	-	23$
Acenaphthylene	-	-	-	-
Anthracene	-	-	-	0.73$
Benzo(e)pyrene		-	-	
Benzo(g,h,i)perylene	-	-	-	0.4$
Beta-chloronaphthalene	-	-	-	-
Fluoranthene	-	-	-	6.2$
Fluorene	-	-	-	3.9$
Naphthalene	-	>140,000	-	12
Phenanthrene	-	-	-	6.3$
Pyrene	-	-	-	10$

Notes:

$ Groundwater cleanup levels from Table 17 used in lieu of surface water

^ Surface water cleanup levels TEF-adjuted 2,3,7,8-TCDD eq.

> = greatear than

B(a)P = benzo(a)pyrene

COC = contaminant of concern

cPAHs = carcinogenic polycyclic aromatic hydrocarbons

CUL = cleanup level

DDD = dichlorodiphenyldichloroethane

DDE = dichlorodiphenyldichloroethylene

DDT = dichlorodiphenyltrichloroethane

DDx = DDD + DDE + DDT

Eq. = equivalents

HxCDF = hexachlorodibenzofuran

N/A = not applicable

PAHs = polycyclic aromatic hydrocarbons

PCBs = polychlorinated biphenyls

PeCDD = pentachlorodibenzo-p-dioxin

PeCDF = pentachlorodibenzofuran

PTW = principal threat waste

RAL = remedial action level

TCDD = tetrachlorodibenzo-p-dioxin

TCDF = tetrachlorodibenzofuran

μg/kg = micrograms per kilogram

μg/L = micrograms per liter

μg/L = micrograms per liter

Table 2-1
Chemical Properties and Partitioning Coefficients for Modeled COCs
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Modeled COCs			Molecular Weight	Diffusivity in Water, D_w[b] [cm^2/s]	Log K_{oc}[c] [log(L/kg)]	Log K_{doc}[d] [log(L/kg)]	K_F[e] [$\mu g/kg/(\mu g/L)^N$]	Log K_F[e] [$\log(\mu g/kg/(\mu g/L)^N)$]	N^e
Dioxins/Furans	Individual Dioxins/Furans	1,2,3,4,7,8-HxCDF	374.9	4.23E-06	7.4	6.86	6.310E+06	6.80	0.61
		1,2,3,7,8-PeCDD	356.0	4.16E-06	6.6	6.31	1.259E+06	6.10	0.61
		2,3,4,7,8-PeCDF	340.0	8.00E-06	5.15	6.23	1.995E+06	6.30	0.61
		2,3,7,8-TCDF	305.98	4.85E-06	5.18	5.44	6.310E+05	5.80	0.61
	Total Dioxins/Furans	2,3,7,8-TCDD Eq.	322.0	5.10E-05	5.4	5.65	3.981E+05	5.60	0.61
PAHs	cPAHs	Benzo(a)anthracene	228.3	9.00E-06	5.55	4.95	6.830E+05	5.83	0.5
		Benzo(a)pyrene	252.32	9.00E-06	5.77	5.65	1.610E+05	5.21	0.44
		Benzo(b)fluoranthene	252.31	5.56E-06	6.08	5.65	4.420E+06	6.65	0.37
		Benzo(k)fluoranthene	252.31	5.56E-06	6.09	5.65	3.550E+05	5.55	0.57
		Chrysene	228.3	6.21E-06	5.49	4.95	3.030E+06	6.48	0.458
		Dibenz(a,h)anthracene	278.36	5.18E-06	6.28	6.35	3.900E+05	5.59	0.75
		Indeno(1,2,3-cd)pyrene	276.33	5.66E-06	6.54	6.35	1.995E+07	7.30	0.82
	Total cPAHs[a]		252.32	9.00E-06	5.77	5.65	1.610E+05	5.21	0.44
	PAHs	1-Methylnaphthalene	142.2	7.80E-06	3.4	4.59	2.010E+06	6.30	0.43
		2-Methylnaphthalene	142.2	7.80E-06	3.4	4.78	2.010E+06	6.30	0.43
		Acenaphthene	154.21	7.69E-06	3.6	3.34	2.660E+06	6.42	0.457
		Acenaphthylene	152.2	6.98E-06	3.7	3.09	3.303E+06	6.52	0.302
		Anthracene	178.23	7.74E-06	4.37	3.56	4.560E+05	5.66	0.62
		Benzo(g,h,i)perylene	276.34	5.23E-06	6.29	6.35	1.070E+03	3.03	0.37
		Benzo(e)pyrene	252.32	5.49E-06	6.25	6.35	2.512E+07	7.40	0.82
		Beta-chloronaphthalene	162.61	8.79E-06	3.39	3.00	2.800E+04	4.45	0.46
		Fluoranthene	202.25	6.35E-06	4.69	4.26	2.300E+06	6.36	0.341
		Fluorene	166.22	7.88E-06	3.96	3.18	1.040E+06	6.02	0.604
		Naphthalene	128.18	7.50E-06	3.3	2.18	7.250E+05	5.86	0.43
		Phenanthrene	178.24	7.47E-06	4.22	3.56	5.129E+07	7.71	1.11
		Pyrene	202.26	7.24E-06	4.58	4.26	2.000E+06	6.30	0.386
	Total PAHs[a]		213.0	6.52E-06	5.4	4.40	1.450E+06	6.16	0.47
DDx	DDD		320.04	4.76E-06	5.51	4.78	1.995E+07	7.30	0.73
	DDE		318.02	5.87E-06	5.64	4.91	3.162E+07	7.50	0.69
	DDT		354.48	4.95E-06	5.14	5.70	1.020E+06	6.01	0.5
PCBs	Individual PCBs	PCB-44	291.99	5.38E-06	4.92	3.58	3.981E+07	7.60	0.92
		PCB-99	326.43	5.19E-06	5.46	4.04	5.012E+06	6.70	0.71
		PCB-141	360.88	5.03E-06	5.82	4.34	1.995E+08	8.30	0.95
		PCB-153	360.88	5.03E-06	5.9	4.41	2.512E+07	7.40	0.72
		PCB-174	395.32	4.89E-06	6.06	4.55	2.512E+07	7.40	0.71
		PCB-177	395.32	4.89E-06	6.03	4.53	3.802E+06	6.58	0.69
		PCB-180	395.32	4.88E-06	6.27	4.73	1.259E+08	8.10	0.82
		PCB-183	395.32	4.88E-06	6.13	4.61	1.995E+07	7.30	0.69
		PCB-199	429.77	4.75E-06	6.13	4.61	1.000E+07	7.00	0.7
	Total PCBs[a]		376.0	5.23E-06	5.28	3.81	2.100E+07	7.32	0.812

Notes:

a. Model inputs for Total PAHs and Total PCBs are based on the average values (specific sources noted in parameter-specific note). Total cPAHs is based on Benzo(a)pyrene.

b. Diffisivities were sourced from (Addeck et al., 2014) for HxCDF and TCDF; (GeoEnginers, 2022) for PeCDD; (Gilkinson, 1999) for PeCDF; (Addeck et al., 2012) for TCDD; (New Mexico Environment Department, 2021) for 1-Methylnaphthalene, 2-Methylnaphthalene, Beta-chloronaphthalene, Phenanthrene; (Division of Spill Prevention and Response Contaminated Sites Program, 2018) for Acenaphthylene and Benzo(g,h,i)perylene; (EPA, 1996)for B(a)P, Fluorene, Naphthalene, DDD, DDE, DDT; and the CapSim defaults for all Individual cPAHs and PCBs, Acenaphthene, Anthracene, Benzo(e)pyrene, Fluoranthene, Pyrene, Total PAHs, Total PCBs.

c. Log K_{oc} were sourced from: (Addeck et al, 2014) for HxCDF and TCDF; (Götz et al, 1994) for PeCDD; PubChem website for PeCDF; CLARC data tables for TCDD; Portland Harbor RI/FS Table D7-1 for B(a)P; (New Mexico Environment Department, 2021) for 1-Methylnaphthalene, 2-Methylnaphthalene, Beta-chloronaphthalene, Fluorene, and Phenanthrene; (Division of Spill Prevention and Response Contaminated Sites Program, 2018) for Acenaphthylene, Benzo(g,h,i)perylene; Superfund Technical Background Document for Naphthalene; and the CapSim Defaults (Shen et al, 2018) for all Individual cPAHs and PCBs, Acenaphthene, Anthracene, Benzo(e)pyrene, Fluoranthene, Pyrene, DDT. Log K_{oc} for DDD, DDE, Total PAHs, and Total PCBs are the average of multiple sources including (EPA, 2023) for DDD, DDE, and Total PCBs, (GeoEngineers, 2022) for Total PAHs, and Total PCBs, (NJDEP, 2014) for DDD, DDE, Total PAHs, Total PCB), CLARC data tables for DDD, DDE, and Total PCBs), and CapSim Defaults for DDD, and DDE; and (EPA, 2003) for total PAHs.

d. Log K_{doc} were sourced from: The Louis Berger Group (2014) and the Burkhard method for HxCDF, TCDF; The Louis Berger Group (2014) and estimating method $K_{doc} = K_{ow}/10$ for PeCDF, TCDD; Meador et al. (1995) and estimating method $K_{doc} = K_{ow}/10$ for 1-Methylnaphthalene, 2-Methylnaphthalene; Mabey et al. (1982) for Beta-chloronaphthalene; GeoEngineers (2022) for PeCDD, Total PAHs, Total PCBs; CapSim reference documents for Acenaphthylene, Fluorene, Phenanthrene; and the CapSim Defaults for all Individual cPAHs and PCBs, Acenaphthene, Anthracene, Benzo(e)pyrene, Fluoranthene, Pyrene, Naphthalene, DDD, DDE, DDT.

e. K_F, Log K_F, and N values were sourced from: Cornelissen et al. (2008) for HxCDF PeCDD, PeCDF, TCDF, TCDD; CapSim Defaults for B(a)P, Benzo(k)fluoranthene, Benzo(a)anthracene, Chrysene, DDT, all individual PCBs; Walters and Luthy (1984) for Acenaphthene, Acenaphtylene, Anthracene, Fluorene, Fluoranthene, Naphthalene, Pyrene; USEPA (1980) for Benzo(g,h,i)perylene, Beta-chloronaphthalene; (Kupryianchyk et al., 2012) for Indeno(1,2,3-cd)pyrene, Benzo(e)pyrene; GeoEngineers (2022) for 1-Methylnaphthalene, 2-Methylnaphthalene; Gomez-Eyles et al. (2013) for all individual PCBs, Phenanthrene, DDD, DDE. The values for Total PAHs were averaged across CapSim Defaults for individual PAHs. The values for Total PCBs were averaged across the sources: Gomez-Eyles et al. (2013), CapSim Defaults, and McDonough et al. (2008).

μg/kg = micrograms per kilogram
μg/L = micrograms per liter
cm = centimeter
cm^2 = centimeters squared
COC = contaminant of concern
K_{oc} = organic carbon-water partition coefficient
K_{doc} = dissolved organic carbon-water partition coefficient
K_F = Freundlich partition coefficient
B(a)P = benzo(a)pyrene
cPAHs = carcinogenic polycyclic aromatic hydrocarbons
Eq. = equivalents
HxCDF = hexachlorodibenzofuran
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyls
PeCDD = pentachlorodibenzo-p-dioxin
PeCDF = pentachlorodibenzofuran
TCDD = tetrachlorodibenzo-p-dioxin
TCDF = tetrachlorodibenzofuran

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Table 2-2
CapSim Model Input Parameters
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Parameter		Units	Value	Site-Specific	Notes
Underlying Sediment					
Thickness	h_{sed}	cm	30	N/A	Selected largest value in range of sediment thicknesses suggested by ITRC, 2023
Porosity	f_{sed}		0.449	No	Table 3.2 Total Porosity values assuming an even mixture of fine and coarse sand (Yu et al.,1993) and the average clay, silt, and sand content in cores D-8.90, E-9.02, and D-9.09 in the Head of Swan Island Lagoon FSDR (2019) Appendix I
Bulk Density	r_{sed}	g/cm^3	1.28	No	Table 2.1 assuming the average clay, silt, and sand content in cores D-8.90, E-9.02, and D-9.09 in the Head of Swan Island Lagoon FSDR (2019) Appendix I (Yu et al, 1993)
Total Organic Carbon	f_{ocsed}	%	3.553	Yes	From Total Organic Carbon results for core samples deeper than 40cm in the Head of Swan Island Lagoon FSDR (2019) Appendix I, and assuming based on those results that the native sand f_{oc} is 0.62%, values were derived for a predominately silt sediment
Fraction Organic Carbon	f_{ocsed}		0.03553		
Particle Size		mm	0.06	No	CapSim default
Permeability		cm^2	6.0E-08	No	Kozeny & Carman calculation completed within CapSim
Sorption Isotherm			Linear: $K_{oc}f_{oc}$	N/A	CapSim default
Capping Sand					
Porosity	f_{sand}		0.32	No	Table 3.2 Effective Porosity for medium sand (Yu et al, 1993).
Bulk Density	r_{sand}	g/cm^3	1.6	No	Regularly cited bulk density for dry sand
Total Organic Carbon	$f_{tocsand}$	%	0.1	Yes	Mode of regionally tested and assumed sand cap f_{oc} including the following sites: Former Portland Gas Manufacturing Site (Anchor QEA, 2020), Crawford Street BODR (GeoEngineers, 2022), Pacific Gas & Electric Pier 39 (Haley & Aldrich, 2020), Quendall Terminals Site FS (Aspect & Arcadis, 2013)
Fraction Organic Carbon	f_{ocsand}		0.001		
Particle Size		mm	1.2125	No	Table 3-1 median of United Soil Classification System range of medium sand (0.425-2.0mm) (USDA, 2012)
Permeability		cm^2	5.8E-06	No	Kozeny & Carman calculation completed within CapSim
Sorption Isotherm			Linear: $K_{oc}f_{oc}$	N/A	CapSim default
Activated Carbon					
Porosity	f_{ac}		0.6	No	CapSim default
Bulk Density	r_{ac}	g/cm^3	0.4	No	CapSim default
Total Organic Carbon	f_{tocac}	%	100	No	CapSim default
Fraction Organic Carbon	f_{ocac}		1.0		
Particle Size		mm	0.5	No	CapSim default
Permeability		cm^2	1.9E-05	No	Kozeny & Carman calculation completed within CapSim
Sorption Isotherm			Freundlich	N/A	CapSim default

Table 2-2 (continued)
CapSim Model Input Parameters
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Parameter		Units	Value	Site-Specific	Notes
Erosion Protection Material					
Thickness	h_{ep}	cm	60	N/A	A 60 cm erosion protection layer is only included in cap alternatives 1 and 2
Porosity	f_{ep}		0.3	No	Yu et al. (1993) Table 3.2 Total Porosity average of range for coarse gravel
Bulk Density	r_{ep}	g/cm^3	1.8	No	From Table 2 from Sakr et al. (2016)
Total Organic Carbon	f_{tocep}	%	0	No	Assumed 0% organic carbon for clean gravel to remove possibility for chemical adsorption in the erosion protection layer
Fraction Organic Carbon	f_{ocep}		0.0		
Particle Size		mm	39.624	No	Mean equivalent diameter based on a distribution for type 2 bedding stone (10% = 0.6", 40% = 1.5", 50% = 1.8")
Permeability		cm^2	4.8E-03	No	Kozeny & Carman calculation completed within CapSim
Sorption Isotherm			Linear: $K_{oc}f_{oc}$	N/A	CapSim default
General Input					
Darcy Velocity		cm/year	402/81/295	Yes	Steady flow upwelling assumed. The value for the main evaluation used was 402 cm/year, consistent with the maximum porewater upwelling recorded during the Porewater Upwelling Study and reported in Appendix B of the PDI ER (HGL, 2024). Additional values were used in sensitivity analyses, and included 81 cm/year which was the highest 50-hour average specific discharge from the same study. Additionally, 25 cm/year was used for End of Basin sensitivity scenarios and is the highest 50-hour maximum specific discharge within the End of Basin area from the July 2023 upwelling study (HGL, 2024).
Hyporheic Exchange			None	N/A	Assumed
Erosion			None	N/A	Assumed
Bioturbation		cm	20	Yes	Uniform bioturbation within modeled depth with particle size impact. Depth estimated is the high end of the estimated range reported in Portland Harbor RI/FS Appendix D (EPA, 2016)
Particle Biodiffusion Coefficient		$cm^2/year$	8.74	No	Selected average literature values (Reible 2014, Sections 2.3.2 and 2.3.3)
Pore Water Biodiffusion Coefficient		$cm^2/year$	173	No	
Maximum Consolidation Depth		cm	20.0	No	Assumed
Time to 90% Consolidation		year	5	No	Assumed
Ionic Activity			None	N/A	Assumed
Deposition			None	N/A	Conservatively assumed no sediment deposition
Decay			None	N/A	Conservatively assumed no contaminant decay

Table 2-2 (continued)
CapSim Model Input Parameters
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Parameter		Units	Value	Site-Specific	Notes
Depth of Interest		cm	30 / 60	No	For all cap alternatives, time to breakthrough was evaluated at the top boundary of the chemical isolation layer. When erosion protection was present (Cap Alternatives 1 and 2), breakthrough was evaluated at the interface of the chemical isolation and erosion protection layers (60 cm). When erosion protection was not present (Cap Alternatives 3 and 4), breakthrough was evaluated at the interface of the chemical isolation and sand layers (30 cm).
Number of Grids per Layer			20	N/A	CapSim guidance documents recommends using a uniform number of grid cells in each layer (Reible, 2022). Fewer grid cells per layer is more conservative.
Time Step Size		year	0.1	N/A	CapSim default
Hydrodynamic Dispersivity		%	10	N/A	CapSim guidance documents recommend 10% of layer thickness (Reible, 2022)
Dissolved organic matter concentration		mg/L	0.0	No	Assumed
Boundary Conditions					
Benthic Boundary Condition Type			Mass Transfer	N/A	CapSim guidance documents recommendation for evaluating cap breakthrough (Reible, 2022)
Water Dissolved Organic Matter		mg/L	1.0	No	Assumed
Water Concentration		µg/L	1.0E-25	No	Assumed value close to 0
Mass Transfer Coefficient		cm/year	876	No	Equivalent to 0.1 cm/hr, which falls within EPA recommendation of using a mass transfer coefficient less than 0.5 cm/hr.
Bottom Boundary Condition Type			Fixed Concentration	N/A	Conservatively assumed constant supply of contaminants
Bottom Concentration		µg/L	Variable	N/A	See Table 1-4 for boundary concentrations for each modeled scenario

Table 2-2
Sources referenced are listed in the references section of the BODR.
% = percent
BODR = basis of design report
cm = centimeter
cm/hr = centimeter per hour
cm/year = centimeter per year
cm^2 = centimeter squared
cm^2/year = centimeter squared per year
g/cm^3 = grams per meter cubic
mg/L = milligrams per liter
mm = millimeter
N/A = not applicable
μg/L = micrograms per liter

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Table 2-3
Chemical Concentrations for Modeled COCs
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Modeling Scenario	Initial Scenario - Whole Basin		Alternative Scenario 1 - Cleanup Levels			Alternative Scenario 2 - End of Basin		Alternative Scenario 3 - End of Basin Following 3ft Dredge	
COC	Csed (µg/kg)	Calc Cpw (µg/L)	Csed (µg/kg)	Cpw (µg/L)	Source C	Csed (µg/kg)	Calc Cpw (µg/L)	Csed (µg/kg)	Calc Cpw (µg/L)
DDD	13	0.00113	114	0.00992	Sediment CUL	7.4	0.000644	7.07	0.000615
DDE	12	0.000774	50	0.00322	Sediment CUL	8.4	0.000542	8.89	0.000573
DDT	43.3	0.00883	246	0.0502	Sediment CUL	14	0.00286	5.50	0.00112
1,2,3,4,7,8-HxCDF	0.03	3.36E-08	0.0004	4.48E-10	Sediment CUL	0.0206	2.31E-08	0.0205	2.30E-08
1,2,3,7,8-PeCDD	0.00518	3.66E-08	0.0002	1.41E-09	Sediment CUL	0.0049	3.46E-08	0.00535	3.78E-08
2,3,4,7,8-PeCDF	0.0111	2.21E-06	0.0003	5.98E-08	Sediment CUL	0.0114	2.27E-06	0.0117	2.33E-06
2,3,7,8-TCDD	0.0367	4.11E-06	0.0002	2.24E-08	Sediment CUL	0.032	3.59E-06	0.0357	4.00E-06
2,3,7,8-TCDF	0.006598	1.23E-06	0.000407	7.57E-08	Sediment CUL	0.00591	1.10E-06	0.005969	1.11E-06
Total PCBs	1,284	0.1897	9	0.00133	Total PCB Sediment CUL	625	0.0923	688	0.1016
PCB-44	35.8	0.0121	9	0.00305	Total PCB Sediment CUL	10.7	0.00361	5.17	0.00175
PCB-99	50.9	0.00497	9	0.000878	Total PCB Sediment CUL	14.0	0.00136	7.55	0.000737
PCB-141	14.9	0.000634	9	0.000383	Total PCB Sediment CUL	5.62	0.000239	3.26	0.000139
PCB-153	73.9	0.00262	9	0.000319	Total PCB Sediment CUL	34.5	0.00122	18.6	0.000657
PCB-174	21.6	0.000354	9	0.000221	Total PCB Sediment CUL	11.5	0.000282	5.80	0.000142
PCB-177	13.5	0.000354	9	0.000236	Total PCB Sediment CUL	7.43	0.000195	3.88	0.000102
PCB-180	47.3	0.000715	9	0.000136	Total PCB Sediment CUL	21.5	0.000325	13.2	0.000200
PCB-183	17.5	0.000365	9	0.000188	Total PCB Sediment CUL	8.36	0.000175	3.36	7.00E-05
PCB-199	16.8	0.000351	9	0.000188	Total PCB Sediment CUL	2.6	5.43E-05	3.36	7.02E-05
cPAHs [B(a)P Eq.]	692	0.0331	85	0.00406	Sediment CUL	477	0.0228	409	0.0196
Benzo(a)anthracene	700	0.0555	15	0.0012	Surface Water CUL	360	0.0286	224	0.0177
Benzo(a)pyrene	584	0.0279	2.51	0.00012	Surface Water CUL	368	0.0176	294	0.0141
Benzo(b)fluoranthene	860	0.0201	51.3	0.0012	Surface Water CUL	428	0.0100	317	0.00742
Benzo(k)fluoranthene	473	0.0108	56.8	0.0013	Surface Water CUL	199	0.00455	120	0.00275
Chrysene	738	0.0672	14.3	0.0013	Surface Water CUL	474	0.0431	312	0.0284
Dibenz(a,h) anthracene	113	0.00167	8.12	0.00012	Surface Water CUL	58.3	0.000860	38	0.000561
Indeno(1,2,3-cd) pyrene	430	0.00349	148	0.0012	Surface Water CUL	251.6	0.00204	215	0.00174
Total PAHs	8,510	0.954	23,000	2.58	Sediment CUL	5,468	0.613	3,930	0.440
1-Methylnaphthalene	133	375	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2-Methylnaphthalene	110	310	N/A	N/A	N/A	92.4	1.04	94.7	1.06
Acenaphthene	306	2.16	3,250	23	Surface Water CUL	110	0.778	89.0	0.629
Acenaphthylene	87	0.489	N/A	N/A	N/A	63.6	0.357	56.0	0.314
Anthracene	425	0.511	608	0.73	Surface Water CUL	160	0.192	140	0.168
Benzo(e)pyrene	301	0.00476	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 2-3 (continued)
Chemical Concentrations for Modeled COCs
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Modeling Scenario	Initial Scenario - Whole Basin		Alternative Scenario 1 - Cleanup Levels			Alternative Scenario 2 - End of Basin		Alternative Scenario 3 - End of Basin Following 3ft Dredge	
COC	Csed (µg/kg)	Calc Cpw (µg/L)	Csed (µg/kg)	Cpw (µg/L)	Source C	Csed (µg/kg)	Calc Cpw (µg/L)	Csed (µg/kg)	Calc Cpw (µg/L)
Benzo(g,h,i)perylene	380	0.00549	27,700	0.4	Surface Water CUL	265	0.00383	240	0.00346
Beta-chloronaphthalene	54	152	N/A	N/A	N/A	43.8	0.502	12.4	0.142
Fluoranthene	1,694	0.974	10,800	6.2	Surface Water CUL	1,100	0.632	655	0.376
Fluorene	340	1.26	1,051	3.9	Surface Water CUL	140	0.432	120	0.370
Naphthalene	190	2.68	851	12	Surface Water CUL	190	2.68	206	2.91
Phenanthrene	1,855	3.15	3,715	6.3	Surface Water CUL	848	1.44	598	1.01
Pyrene	1,545	1.14	13,500	10	Surface Water CUL	1,100	0.814	743	0.550

Notes:

µg/kg = micrograms per kilogram
µg/L = micrograms per liter
C = concentration
Csed = sediment concentration
Cpw = porewater concentration
Calc = calculated
COC = contaminant of concern
B(a)P = benzo(a)pyrene
cPAHs = carcinogenic polycyclic aromatic hydrocarbons
DDx = DDD + DDE + DDT
DDD = dichlorodiphenyldichloroethane
DDE = dichlorodiphenyldichloroethylene
DDT = dichlorodiphenyltrichloroethane
Eq. = equivalents
ft = feet
HxCDF = hexachlorodibenzofuran
N/A = not applicable
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyls
PeCDD = pentachlorodibenzo-p-dioxin
PeCDF = pentachlorodibenzofuran
TCDD = tetrachlorodibenzo-p-dioxin
TCDF = tetrachlorodibenzofuran

Table 2-4
Time-to-Breakthrough Results of Amended Cap Modeling
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Initial Sediment Concentration Scenario	% GAC by Weight	Darcy Velocity (cm/year)	With Erosion Protection Layer (Alternative 2) Time-to-Breakthrough		Without Erosion Protection Layer (Alternative 4) Time-to-Breakthrough		Material f_{OC} Sensitivity Test Alternative 4: 0.05% f_{OC} Sand Time-to-Breakthrough	
			Total Solid	Porewater	Total Solid	Porewater	Total Solid	Porewater
Initial Scenario - Whole Basin	5.0%	402	100+	100+	100+	100+	100+	100+
Alternative Scenario 1 - Low Concentration		402	100+	100+	100+	100+	-	-
Alternative Scenario 2 - End of Basin		295	100+	100+	100+	100+	-	-
Alternative Scenario 3 - End of Basin Following 3 ft Dredge		295	100+	100+	100+	100+	-	-
Initial Scenario - Whole Basin	1.0%	402	24	100+	24	100+	24	100+
Alternative Scenario 1 - Low Concentration		402	100+	100+	100+	100+	-	-
Alternative Scenario 2 - End of Basin		295	100+	100+	100+	100+	-	-
Alternative Scenario 3 - End of Basin Following 3 ft Dredge		295	100+	100+	100+	100+	-	-

Notes:
100+ = time-to-breakthrough exceeds 100 years
% = percent
cm = centimeter
cm/year = centimeter per year
CPP = cap performance point
CUL = cleanup level
foc = fraction of organic carbon
ft = feet
GAC = granular activated carbon
Time-to-breakthrough is defined as the time elapsed between cap installation and the first occurrence of a COC porewater or total solid concentration (the concentration of contaminant on all solids present at the depth of interest in contaminant mass per mass dry solids) equaling or surpassing the relevant CUL at the CPP.

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Table 2-5
Time-to-Breakthrough Results of Unamended Cap Modeling
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Initial Sediment Concentration Scenario	Darcy Velocity (cm/year)	With Erosion Protection Layer (Alternative 1) Time-to-Breakthrough		Without Erosion Protection Layer (Alternative 3) Time-to-Breakthrough		Material f_{OC} Sensitivity Test Alternative 3: 0.05% f_{OC} Sand Time-to-Breakthrough	
		Total Solid	Porewater	Total Solid	Porewater	Total Solid	Porewater
Initial Scenario - Whole Basin	391	28	4	27	3	21	2
Alternative Scenario 1 - Low Concentration	391	42	4	47	4	-	-
Alternative Scenario 2 - End of Basin	295	45	6	45	6	-	-

Notes:
100+ = time-to-breakthrough exceeds 100 years
% = percent
cm = centimeter
cm/year = centimeter per year
foc = fraction of organic carbon
Time-to-breakthrough is defined as the time elapsed between cap installation and the first occurrence of a COC porewater or total solid concentration (the concentration of contaminant on all solids present at the depth of interest in contaminant mass per mass dry solids) equaling or surpassing the relevant CUL at the depth of interest.

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Table 2-6
Cap Modeling Input Parameters Sensitivity Analyses
Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Sensitivity Analysis	Base Case Scenario		Sensitivity Analysis Scenario		Time-to-Breakthrough RPD (%)
	Parameter Value	Time-to-Breakthrough	Parameter Value	Time-to-Breakthrough	
Unamended Isolation Layer Thickness	60 cm	15	270 cm	100+	147.8
Outlier Impact	95th Percentile	48	Maximum Concentration	9	136.8
Amended Isolation Layer Thickness	5 cm	48	2.5 cm	21	78.3
			10 cm	99	69.4
Freundlich Coefficients	Literature Kf ÷ 10	48	Literature Kf ÷ 2	100+	70.3
GAC Amendment (Darcy: 402 cm/year)	5% GAC	100+	1% GAC	24	122.6
Initial COC Concentrations (Darcy: 402/295 cm/year)	Whole Basin	24	Low Concentration (Alternative 1)	100+	122.6
			End of Basin (Alternative 2)	100+	122.6
			End of Basin + Dredge (Alternative 3)	100+	122.6
Cap Performance Point (CPP)	30 cm	48	20 cm	100+	70.3
Upwelling Velocity	81 cm/year	48	24 cm/year	100+	70.3
			81± 310 cm/year	42	13.3
Material f_{OC} (Darcy: 402 cm/year)	0.1% - Cap 3	3	0.05% - Cap 3	2	40.0
	0.1% - Cap 4	24	0.05% - Cap 4	24	0.0
Hydrodynamic Dispersivity of Isolation Layer	10% (0.5 cm)	48	20% (1.0 cm)	42	13.3
Absolute Error Tolerance	1.00E-08	48	1.00E-10	48	0.0
Benthic Mass Transfer Coefficient	0.1 cm/hr	48	0.5 cm/hr	48	0.0
Benthic Boundary Condition Type	Fixed Concentration	48	Flux-Matching	48	0.0
Sediment Thickness	30 cm	48	120 cm	48	0.0
Spatial Discretization	20 grids	48	30 grids	48	0.0
			40 grids	48	0.0
			60 grids	48	0.0
Surface Water DOC	1 mg/L	48	8 mg/L	48	0.0

Table 2-6 (continued)

Cap Modeling Input Parameters Sensitivity Analyses

Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Sensitivity Analysis	Base Case Scenario		Sensitivity Analysis Scenario		Time-to-Breakthrough RPD (%)
	Parameter Value	Time-to-Breakthrough	Parameter Value	Time-to-Breakthrough	
Time Step	0.1 year	48	0.01 year	48	0.0

Notes:

% = percent

cm = centimeter

cm/hr = centimeter per hour

cm/year = centimeter per year

f_{oc} = fraction organic carbon

GAC = granular activated carbon

mg/L = milligrams per liter

RPD = relative percent difference [*(absolute difference / average)* · *100*]

Table 3-1

100-year Wind Speed by Direction

Appendix A - Cap Evaluation; Swan Island Basin Project Area, Portland, Oregon

Wind Direction (degrees True North)	Wind Speed (mph)
0 – 30	30
31 – 60	37
61 – 90	56
91 – 120	59
121 – 150	40
151 – 180	69
181 – 210	69
211 – 240	60
241 – 270	47
271 – 300	39
301 – 330	38
331 – 360	37

Notes:

100-yr wind speeds were taken from the Portland Harbor Feasibility Study RI/FS Table C-1 (EPA, 2016).

mph = miles per hour

Reference:

EPA, 2016. Portland Harbor RI/FS Appendix D: Supporting Information for Alternative Development (Feasibility Study No. 840007; Portland Harbor RI/FS). at URL https://semspub.epa.gov/work/10/840007.pdf.

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FIGURES

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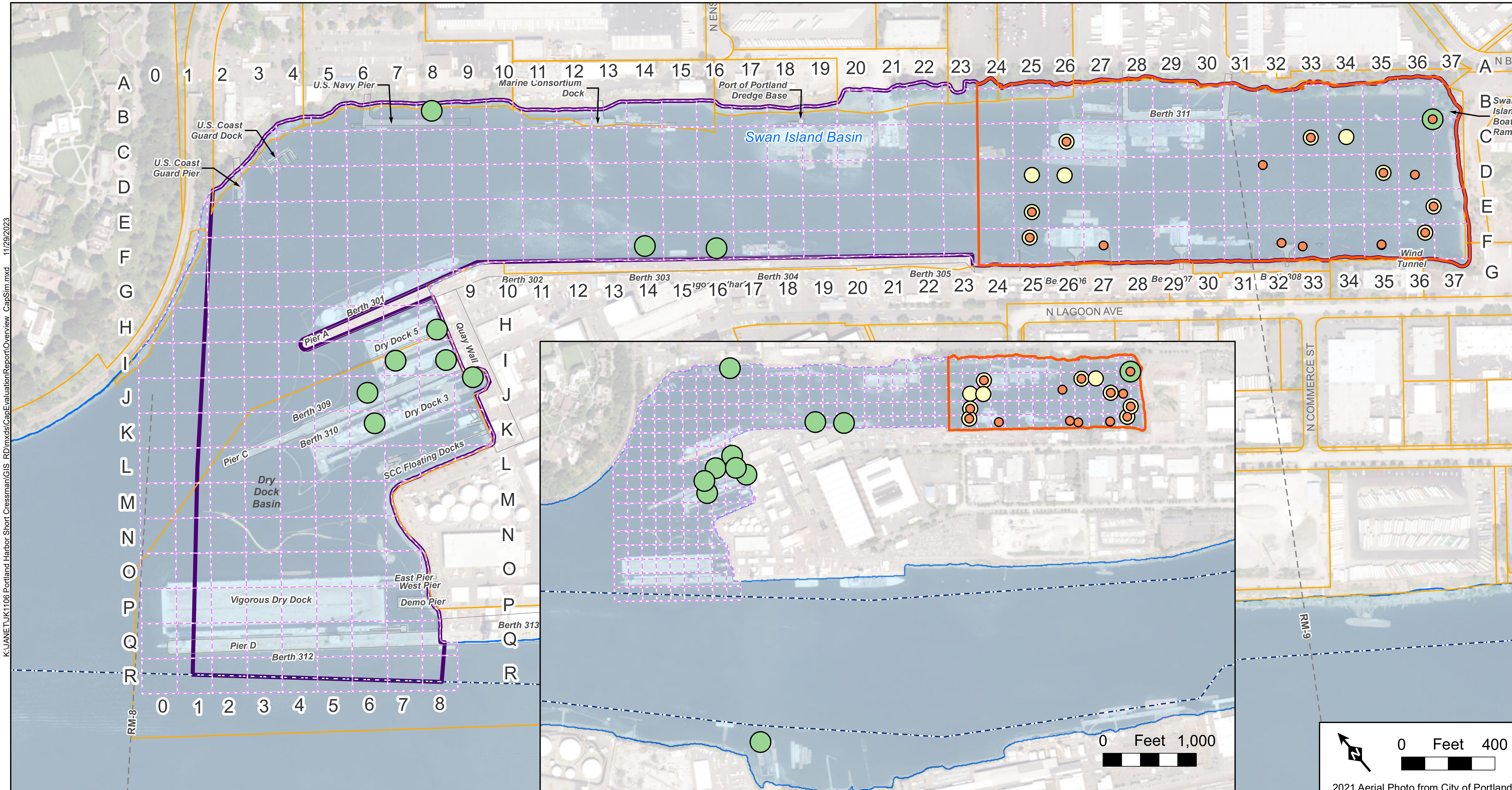

Project Area Grid
River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

End of Basin

Modeled Sample Locations
- End Basin
- End Basin 3-foot Dredge
- Whole Basin

Notes:
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

Figure 2-2
CapSim Model Overview

Date Prepared: 11/29/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP HGL MOTT MACDONALD BRIDGEWATER GROUP

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◐ Cone Penetration Test
◐ Seismic Cone Penetration Test
River Mile (RM)
Federal Navigation Channel (USACE, 2020)
River Flow Direction

Liquefaction Induced Settlement
- less than 4 inches
- 4 to 7 inches
- 7 to 10 inches
- 10 to 13 inches
- greater than 13 inches

Note:
CPT - cone penetration test
sCPT - seismic cone penetration test
HGL - HydroGeoLogic
MM - Mott MacDonald
RM - River Mile
SIB - Swan Island Basin
USACE - U.S. Army Corps of Engineers

Figure 3-1
Liquefaction Induced Settlement SIB

Date Prepared: 5/2/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

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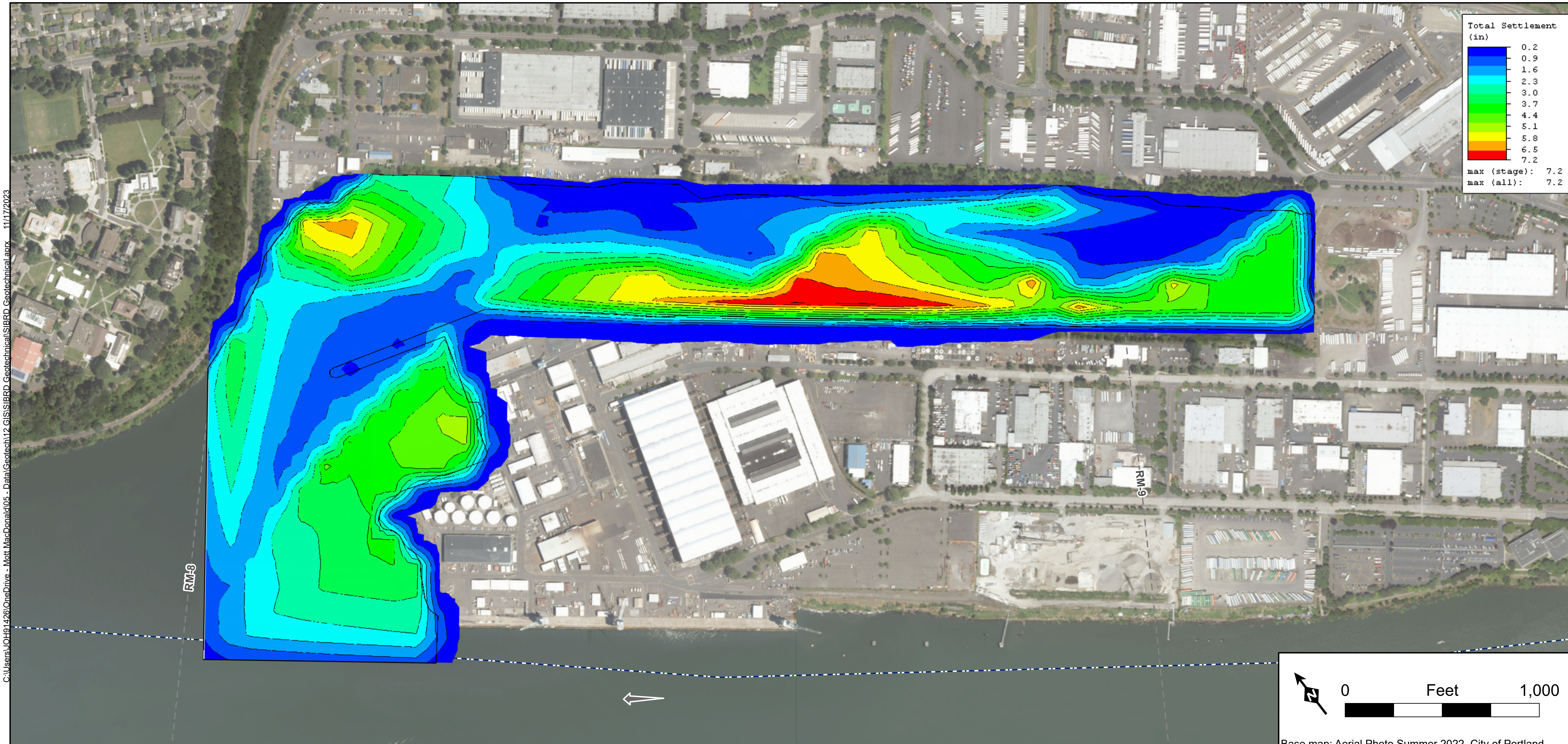

River Mile (RM)

Federal Navigation Channel (USACE, 2020)

River Flow Direction

Note:
CPT - cone penetration test
sCPT - seismic cone penetration test
HGL - HydroGeoLogic
in. - inch
max - maximum
MM - Mott MacDonald
RM - River Mile
SIB - Swan Island Basin
USACE - U.S. Army Corps of Engineers

Figure 3-2

Estimated Consolidation Settlement Hypothetical Cap Alternative 1 SIB

Date Prepared: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

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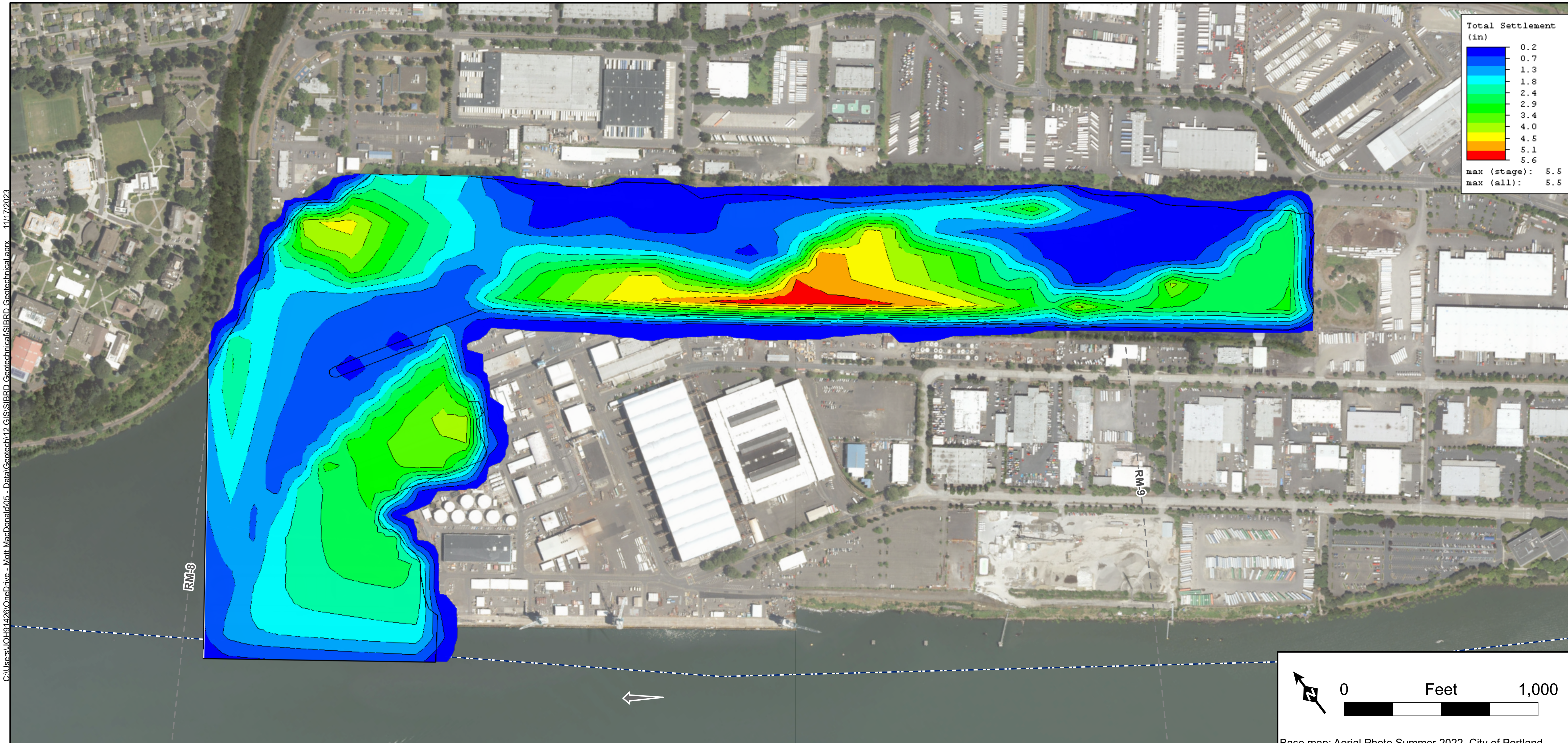

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River Mile (RM)

Federal Navigation Channel (USACE, 2020)

River Flow Direction

Note:
CPT - cone penetration test
sCPT - seismic cone penetration test
HGL - HydroGeoLogic
in. - inch
max - maximum
MM - Mott MacDonald
RM - River Mile
SIB - Swan Island Basin
USACE - U.S. Army Corps of Engineers

Figure 3-3

Estimated Consolidation Settlement Hypothetical Cap Alternative 2 SIB

Date Prepared: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

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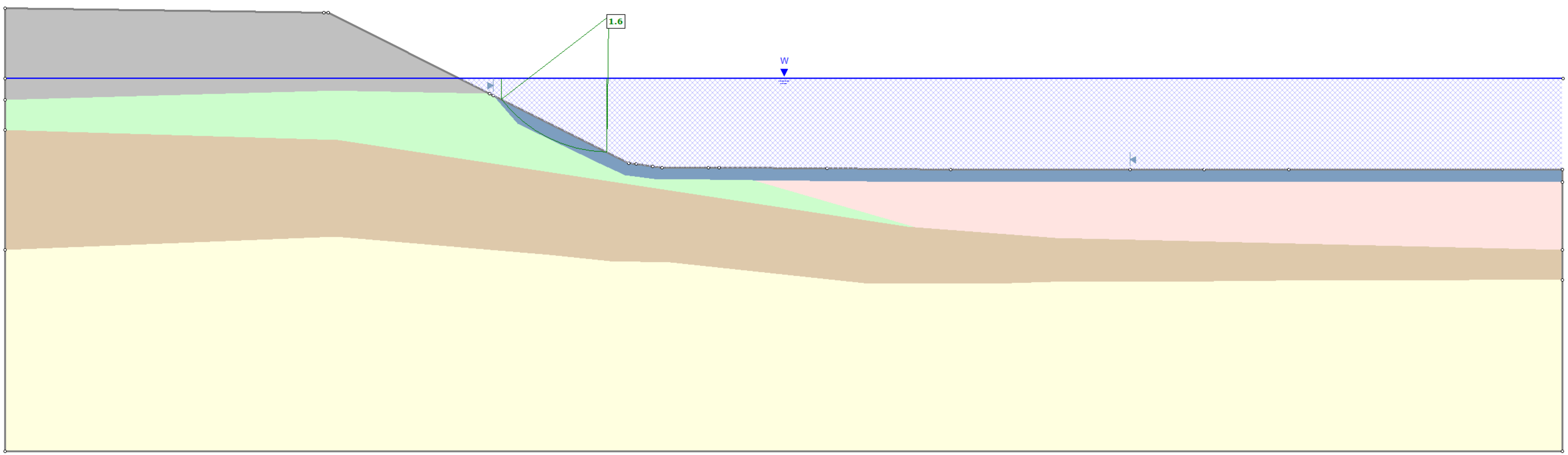
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Fill		135	Mohr-Coulomb	20	36
Basin Fill/Sediment		110	Mohr-Coulomb	20	32
Qa Sand		120	Mohr-Coulomb	20	35
Qf Silt		120	Mohr-Coulomb	20	34
Qf Sand		130	Mohr-Coulomb	20	36
Cap (drained)		115	Mohr-Coulomb	20	30
Cap (residual)		115	Mohr-Coulomb	80	0



Note:
25-degree slope is also referred as 2.2 horizontal distance to 1 vertical distance ratio (2.2H:1V)
BODR = Basis of Design Report
deg = degree
lbs/ft3 = pounds per cubic foot, also referred to as pcf in the BODR
psf = pounds per square foot
Qa = Quaternary alluvium
Qf = Quaternary flood deposits

Figure 3-4

Static Slope Stability Analysis of 4-foot Sand Cap with 25 Degree Slope

Date Prepared: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

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Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
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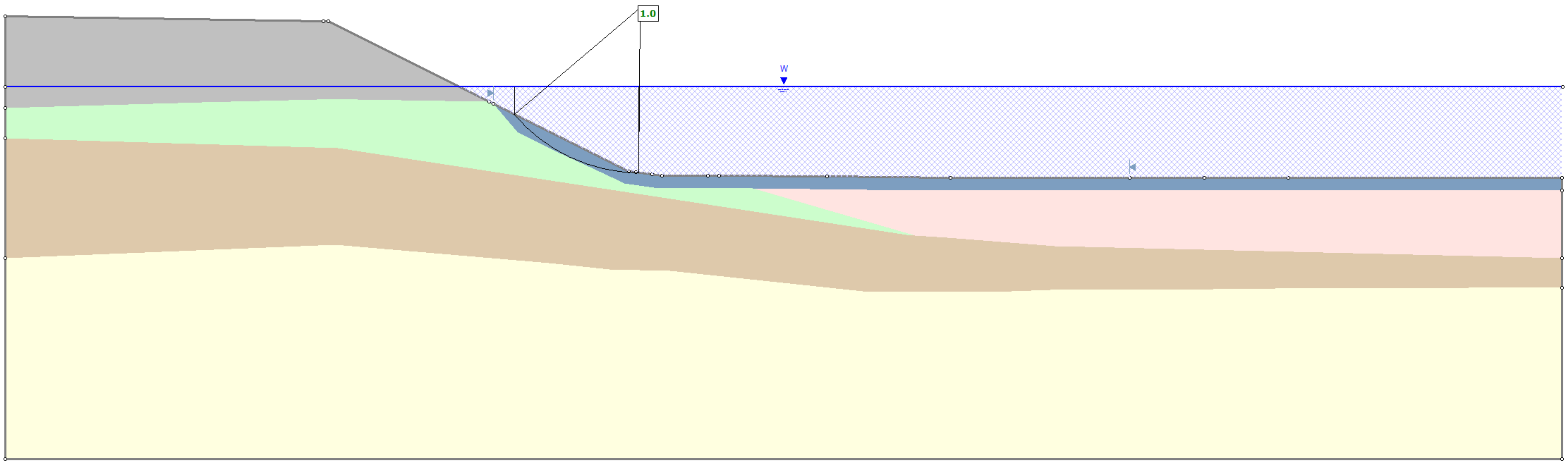
Basin Fill/Sediment		110	Mohr-Coulomb	20	32
Qa Sand		120	Mohr-Coulomb	20	35
Qf Silt		120	Mohr-Coulomb	20	34
Qf Sand		130	Mohr-Coulomb	20	36
Cap (drained)		115	Mohr-Coulomb	20	30
Cap (residual)		115	Mohr-Coulomb	80	0



Note:
25-degree slope is also referred as 2.2 horizontal distance to 1 vertical distance ratio (2.2H:1V)
BODR = Basis of Design Report
deg = degree
lbs/ft3 = pounds per cubic foot, also referred to as pcf in the BODR
psf = pounds per square foot
Qa = Quaternary alluvium
Qf = Quaternary flood deposits

Figure 3-5

Pseudo-Static Slope Stability Analysis of 4-foot Sand Cap with 25 Degree Slope

Date Prepared: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

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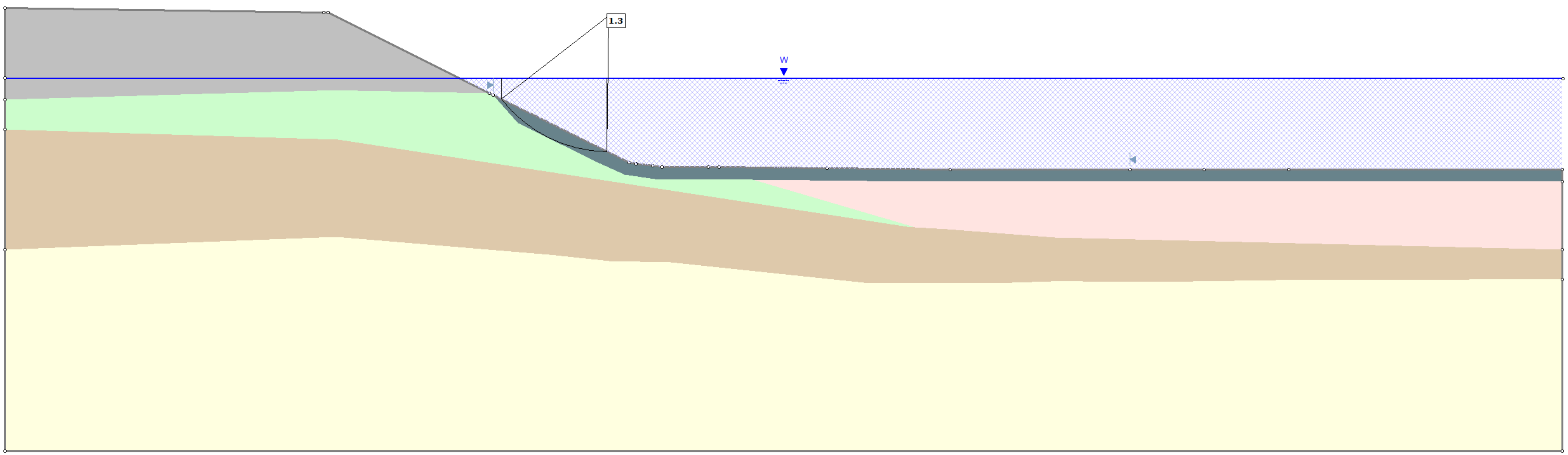
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Fill		135	Mohr-Coulomb	20	36
Basin Fill/Sediment		110	Mohr-Coulomb	20	32
Qa Sand		120	Mohr-Coulomb	20	35
Qf Silt		120	Mohr-Coulomb	20	34
Qf Sand		130	Mohr-Coulomb	20	36
Cap (drained)		115	Mohr-Coulomb	20	30
Cap (residual)		115	Mohr-Coulomb	80	0



Note:
25-degree slope is also referred as 2.2 horizontal distance to 1 vertical distance ratio (2.2H:1V)
BODR = Basis of Design Report
deg = degree
lbs/ft3 = pounds per cubic foot, also referred to as pcf in the BODR
psf = pounds per square foot
Qa = Quaternary alluvium
Qf = Quaternary flood deposits

Figure 3-6

Liquefaction Induced Flow Failure of 4-foot Sand Cap with 25 Degree Slope

Date Prepared: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

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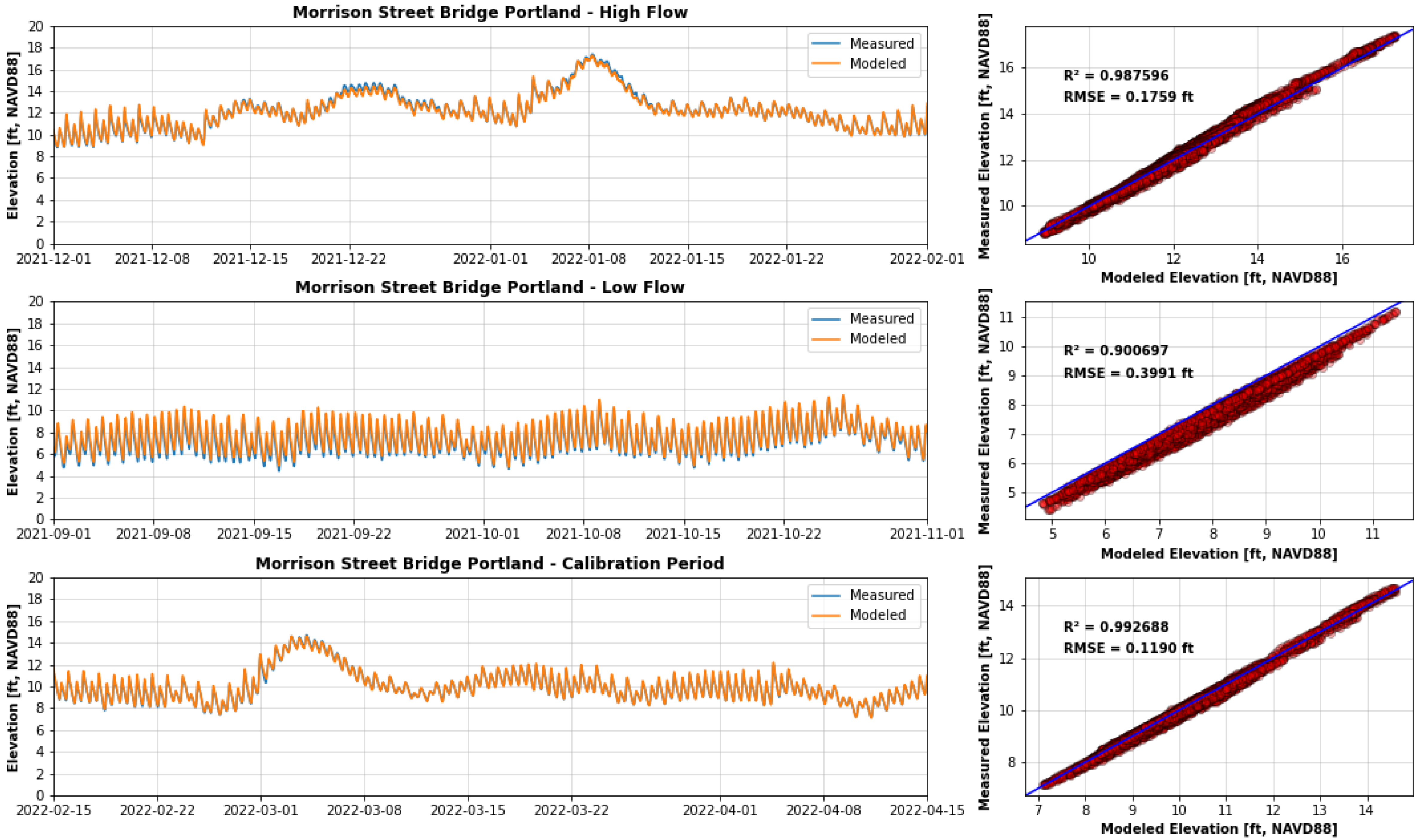

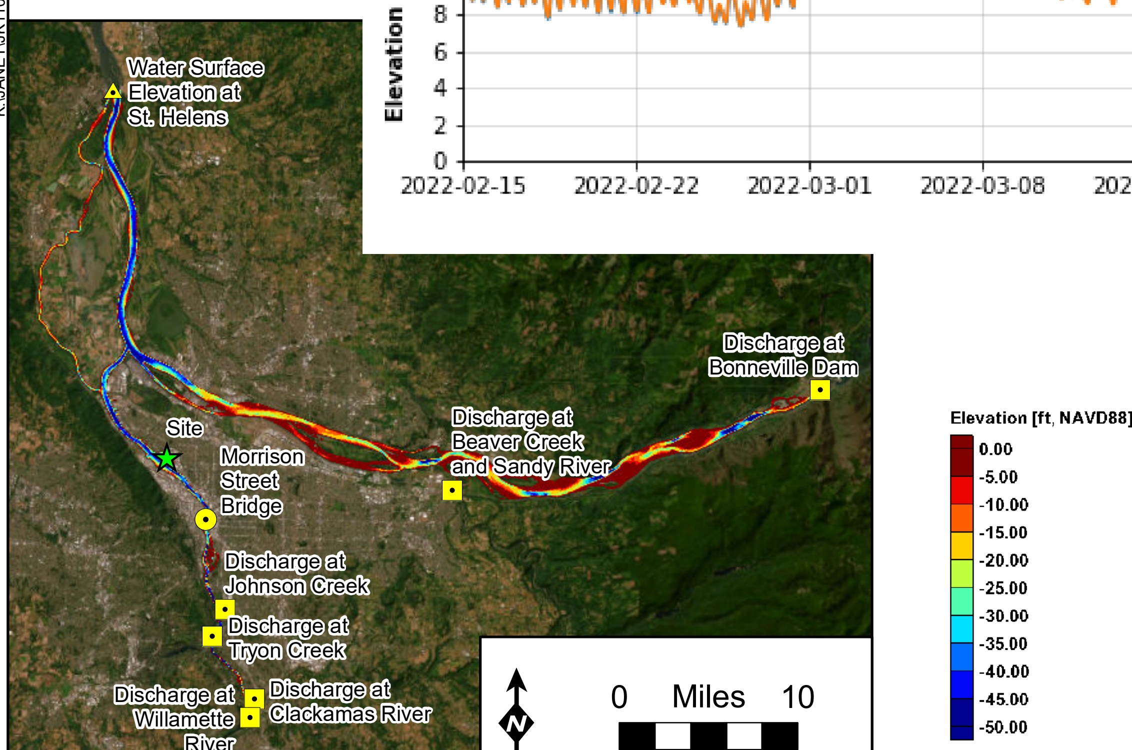

Notes:
ft/s – feet per second
NAVD88 – North American Vertical Datum of 1988
R^2 – coefficient of determination
RMSE – Root Mean Square Error

Figure 3-7

Hydrodynamic Model Validation at Morrison Street

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP HGL MOTT MACDONALD BRIDGEWATER GROUP

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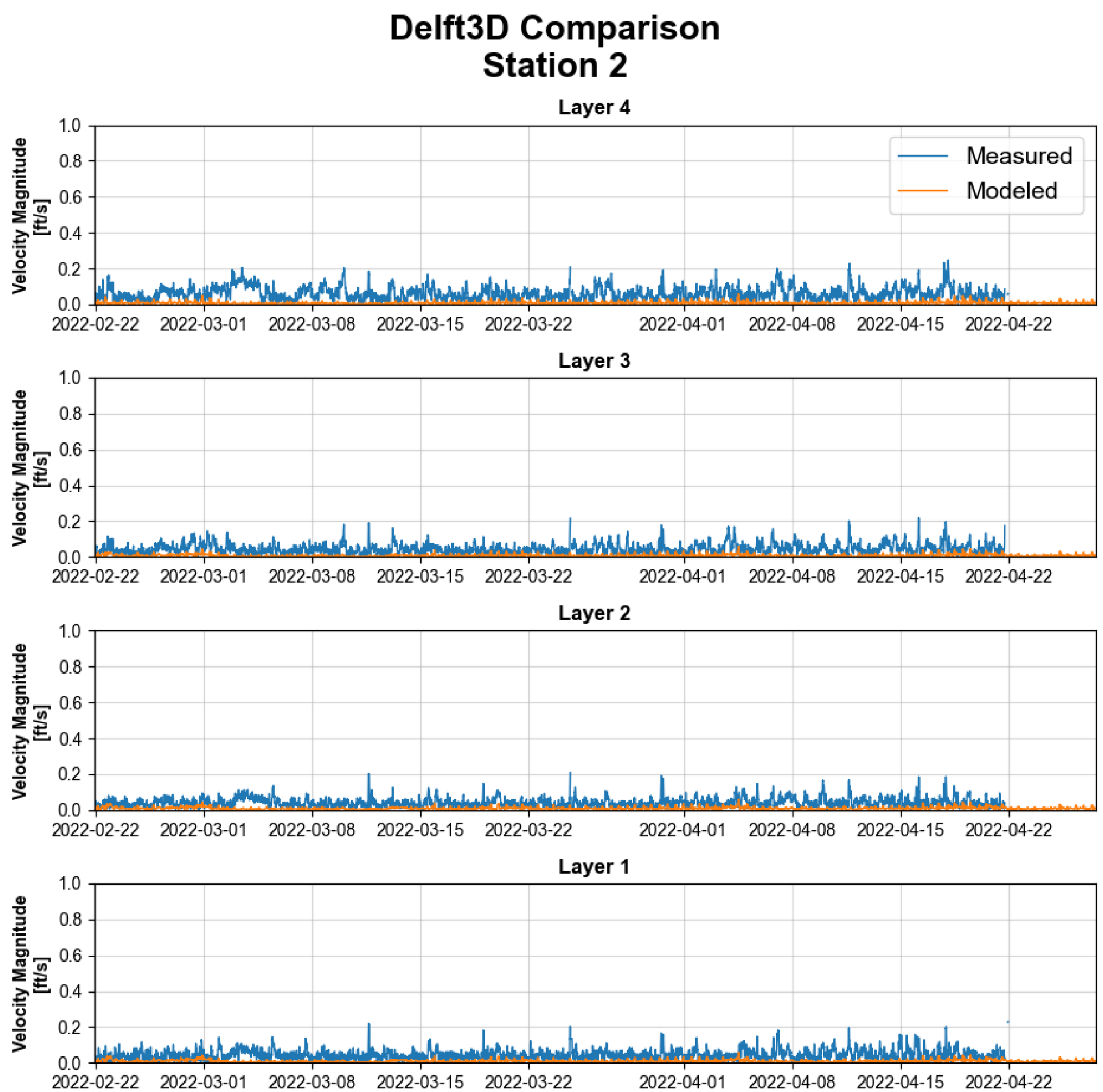

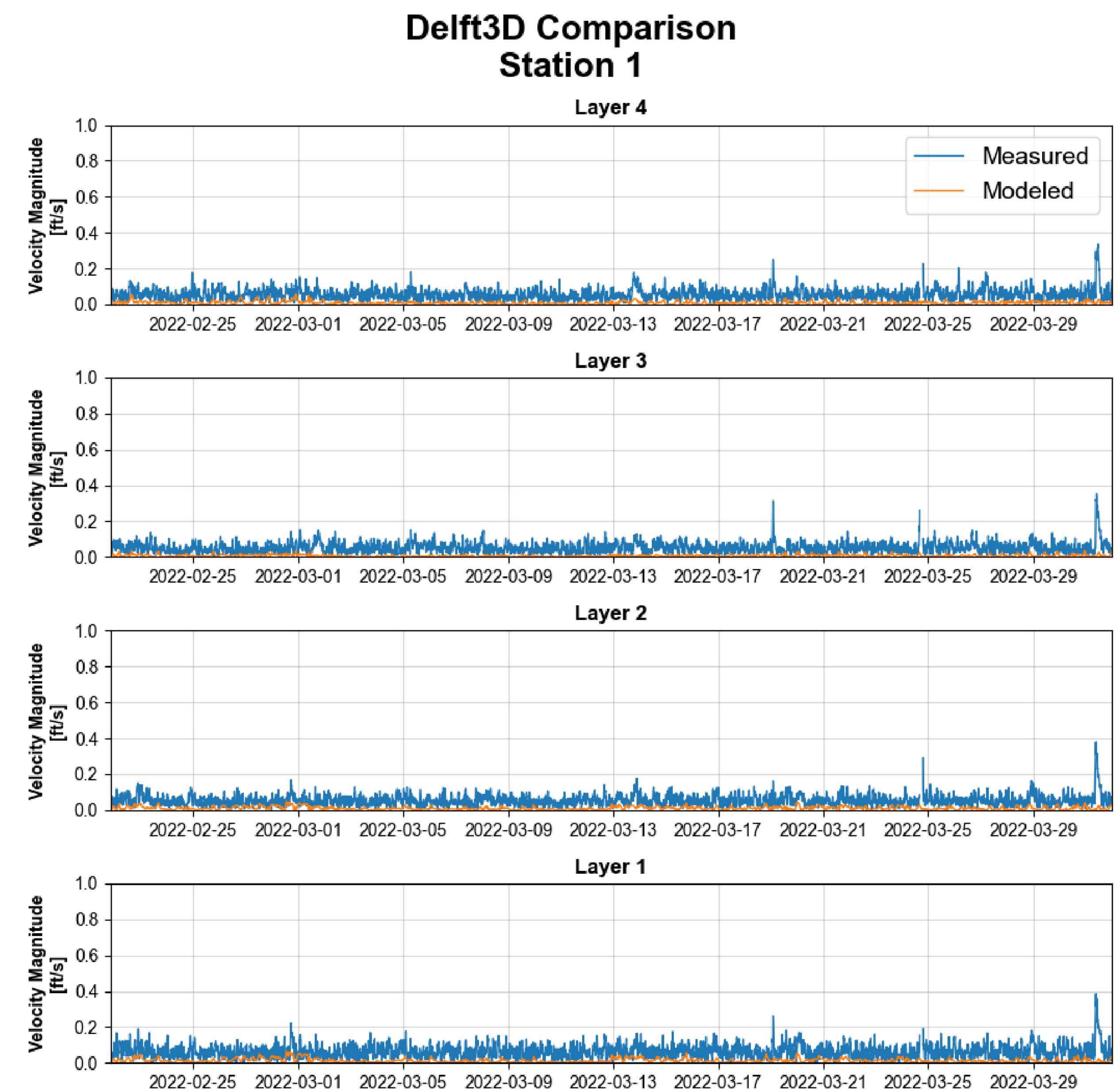

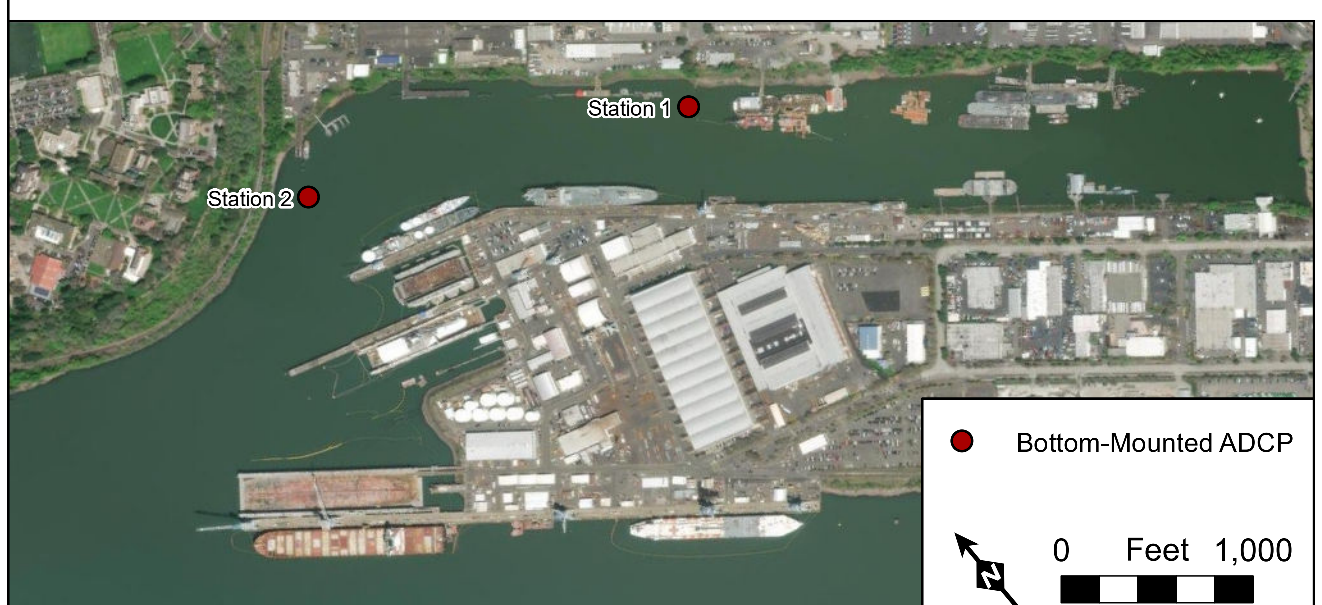

Notes:
ADCP – Acoustic Doppler Current Profiler
ft/s – feet per second

Figure 3-8

Hydrodynamic Model Validation in Swan Island Basin

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

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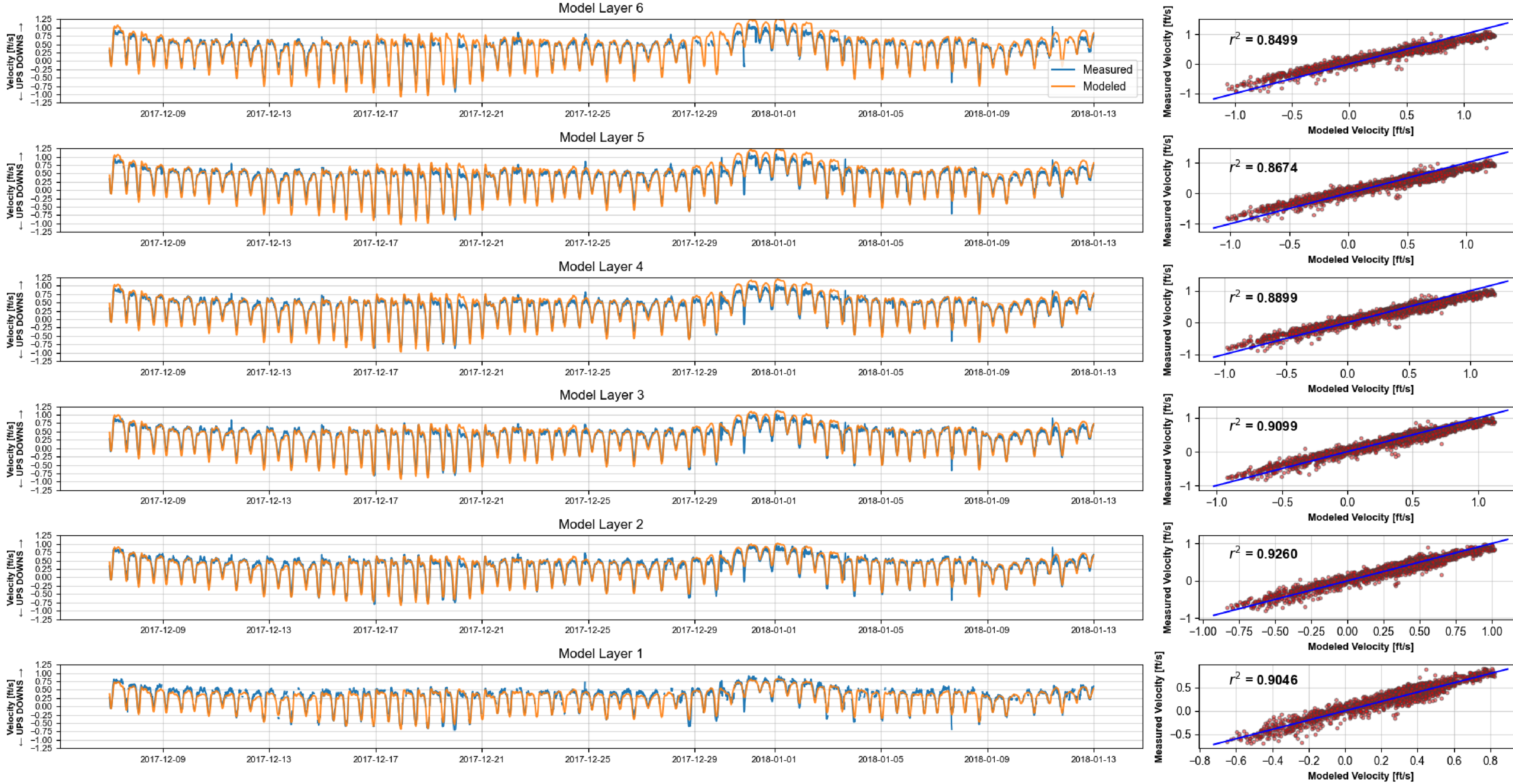

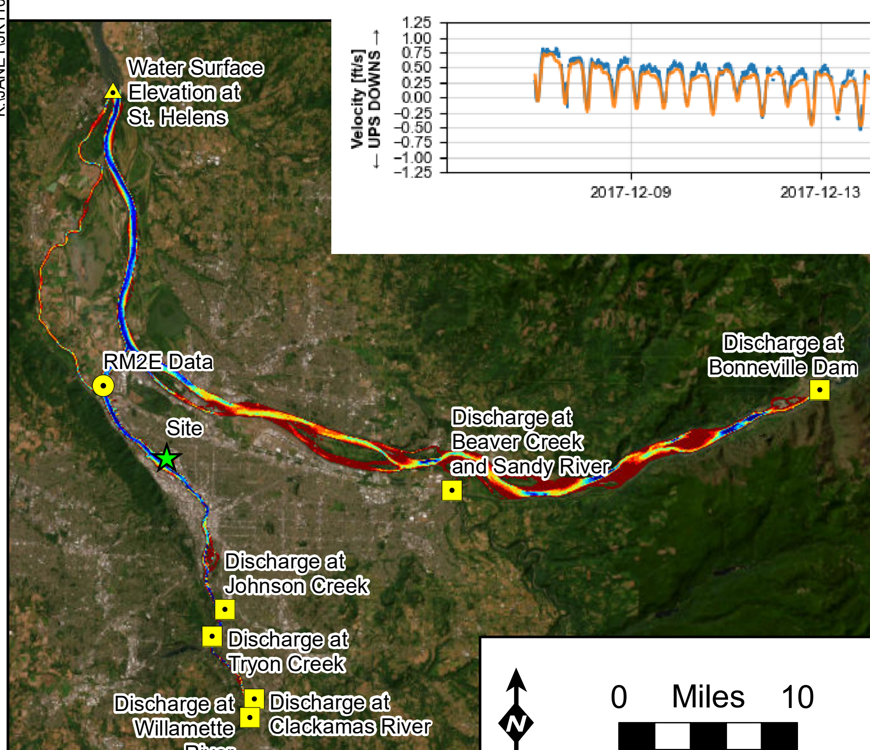

Elevation [ft, NAVD88]
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
-30.00
-35.00
-40.00
-45.00
-50.00

Notes:
ft/s – feet per second
NAVD88 – North American Vertical Datum of 1988
r^2 – coefficient of determination

Figure 3-9

Hydrodynamic Model Validation at River Mile 2 East

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

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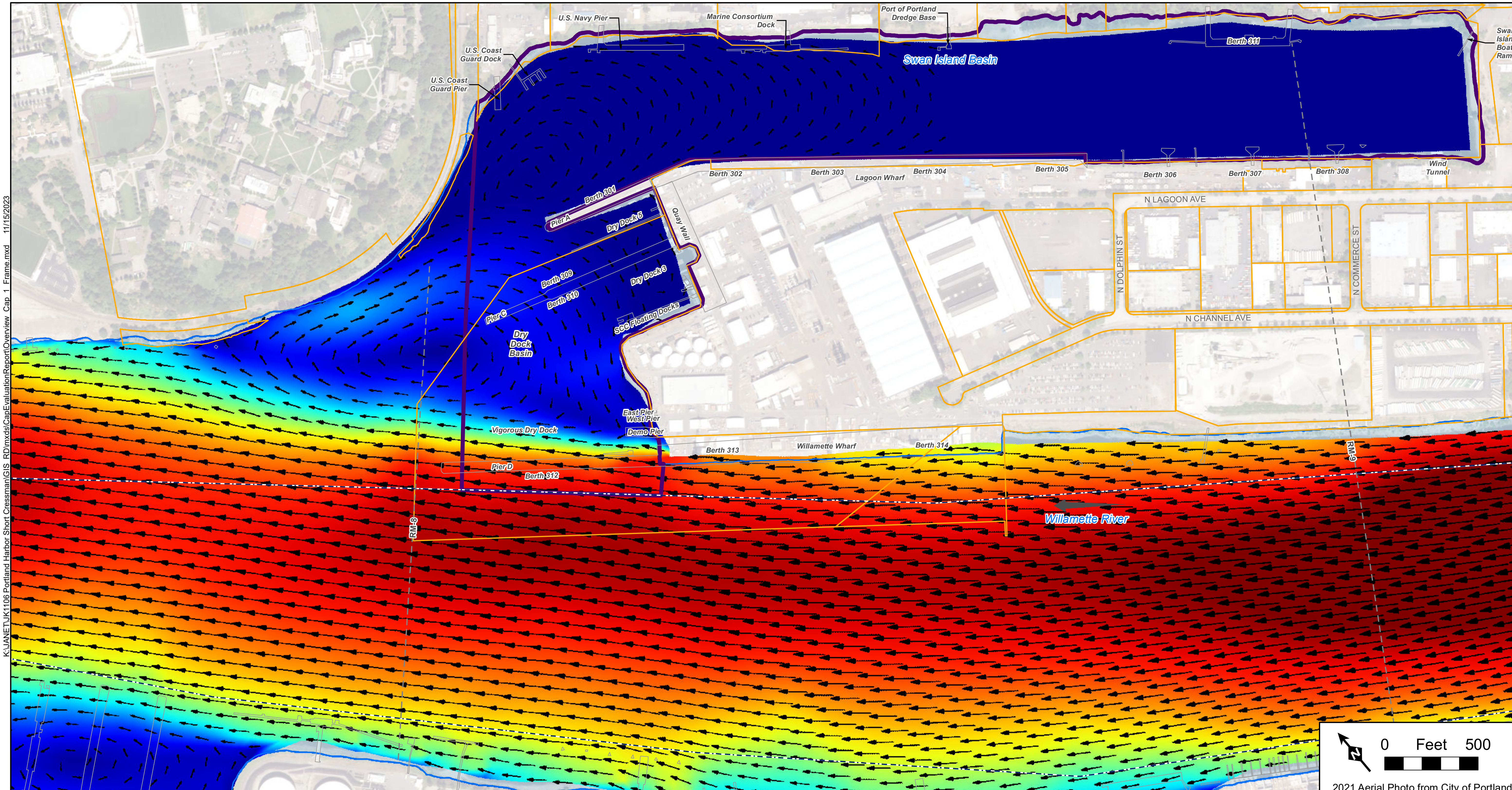

River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

Depth Average Velocity [ft/s]

4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00

Notes:
ft/s – feet per second
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 3-10

100-year Flood Event
Peak Depth-Averaged Velocities

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP

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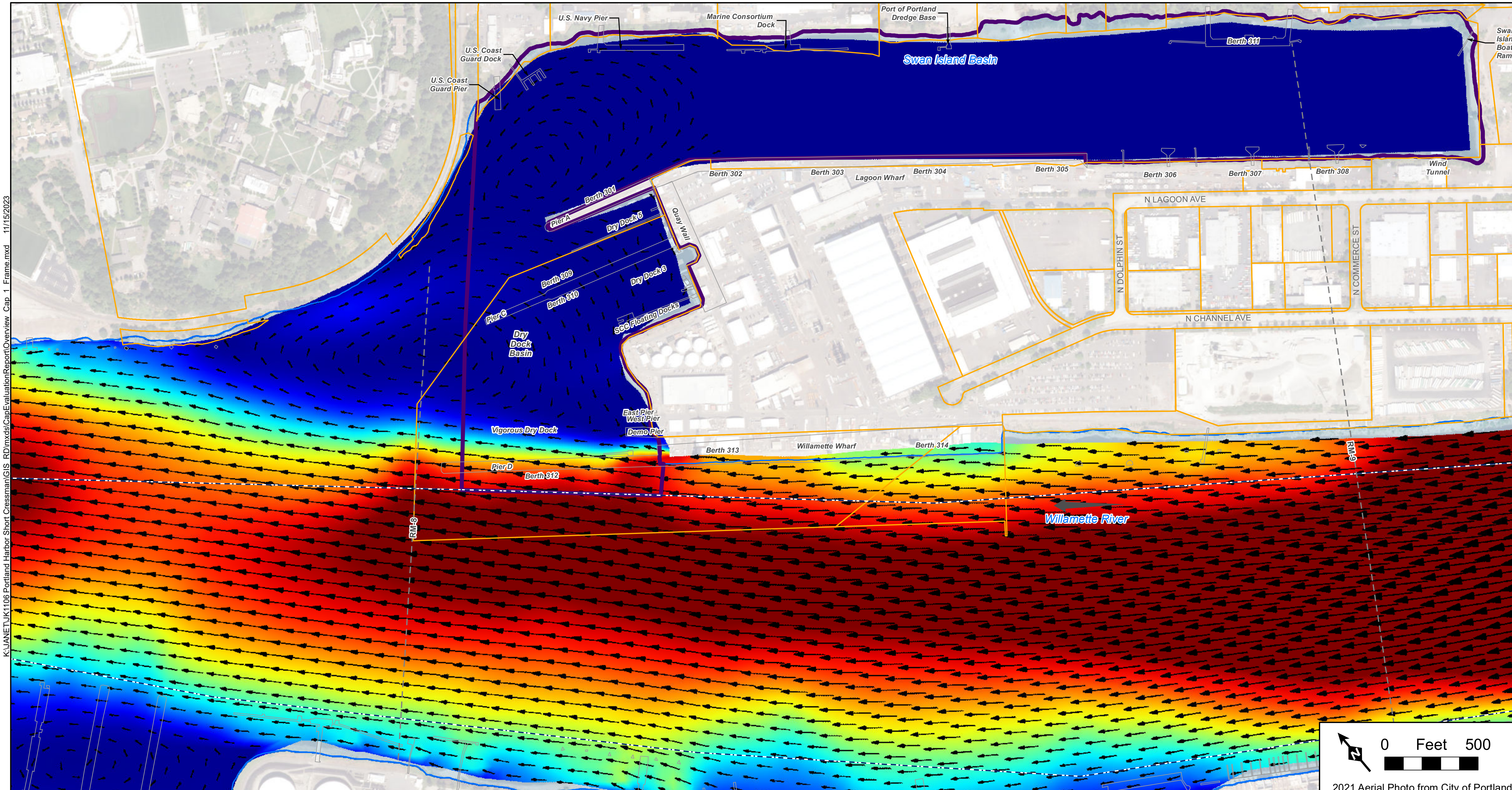

City Stormwater Outfall
River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

Bed Shear Stress [Pa]
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00

Notes:
Pa – Pascals
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 3-11

100-year Flood Event Bed Shear Stresses

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
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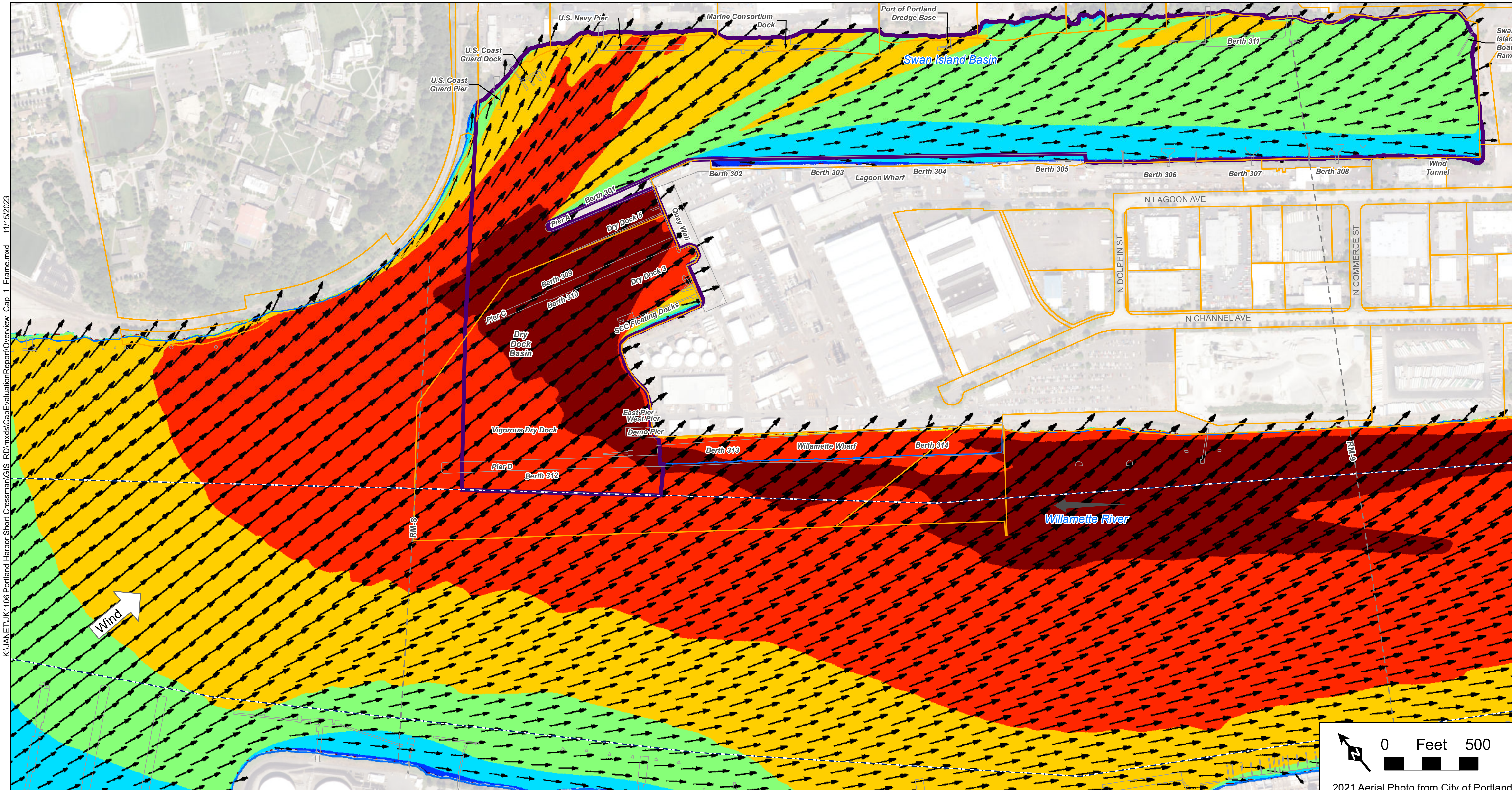

River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

Significant Wave Height [ft]
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00

Notes:
ft – feet
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 3-12

100-year Storm Waves, Example from West

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
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BRIDGEWATER GROUP

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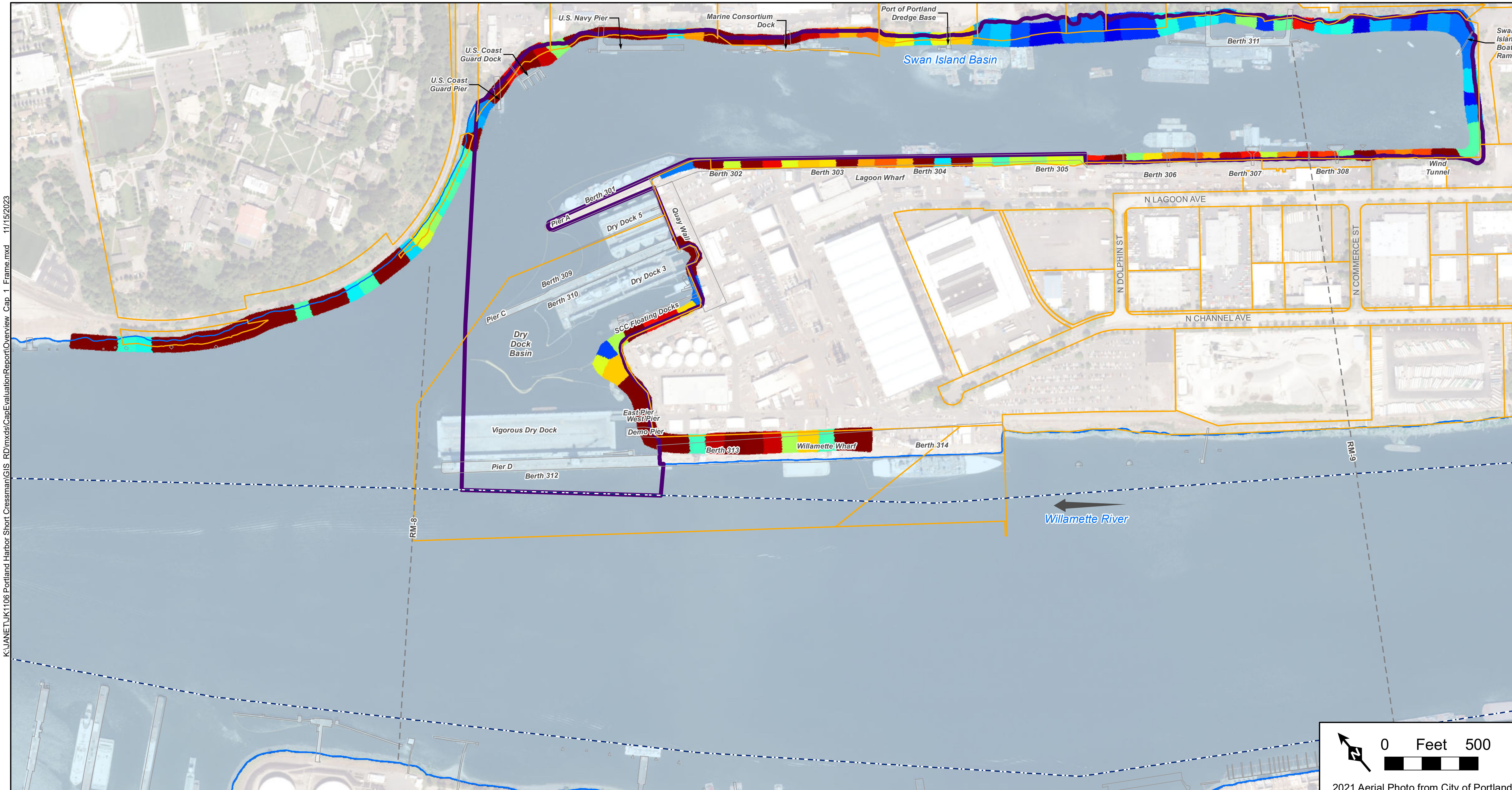

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- - - River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

Bed Shear Stress [Pa]
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00

Notes:
Pa – Pascals
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 3-13

100-year Storm Waves, Peak Bed Shear Stresses

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
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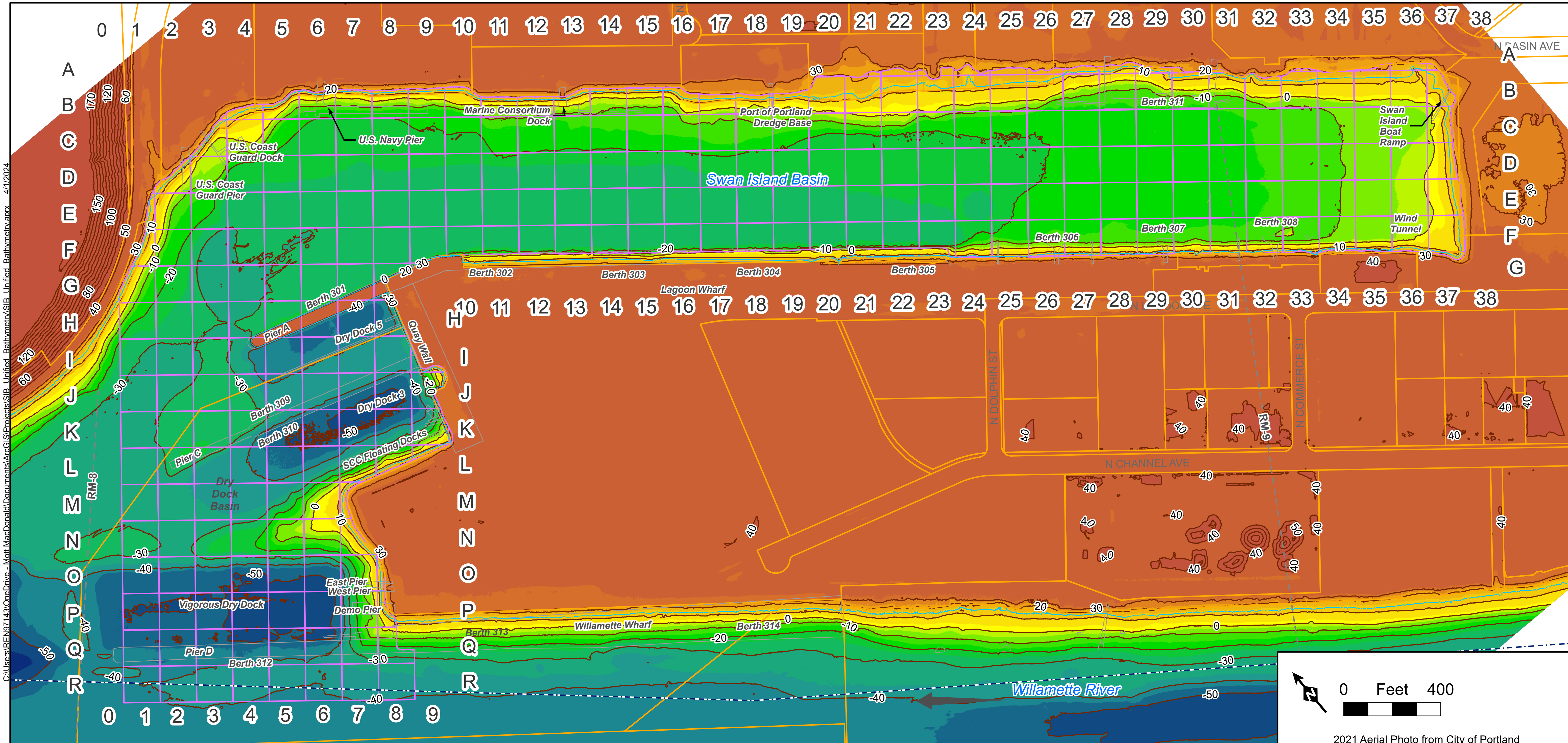

River Mile (RM)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
13-foot NAVD88 Contour
10-ft Elevation Contours (NAVD88)

Unified Elevation Model (Feet, NAVD88)

- -57.4 - -55
- -54.9 - -50
- -49.9 - -45
- -44.9 - -40
- -39.9 - -35
- -34.9 - -30
- -29.9 - -25
- -24.9 - -20
- -19.9 - -15
- -14.9 - -10
- -9.9 - -5
- -4.9 - 0
- 0.1 - 5
- 5.1 - 10
- 10.1 - 15
- 15.1 - 20
- 20.1 - 25
- 25.1 - 30
- 30.1 - 35
- 35.1 - 40
- 40.1 - 180

Notes:
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

Elevation Sources:
David Evans and Associates, 2015
David Evans and Associates, 2018
City of Portland LiDAR, 2019
HydroGeoLogic, 2022

River Flow Direction

Figure 3-14
Unified Elevation Model

Date Prepared: 11/29/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
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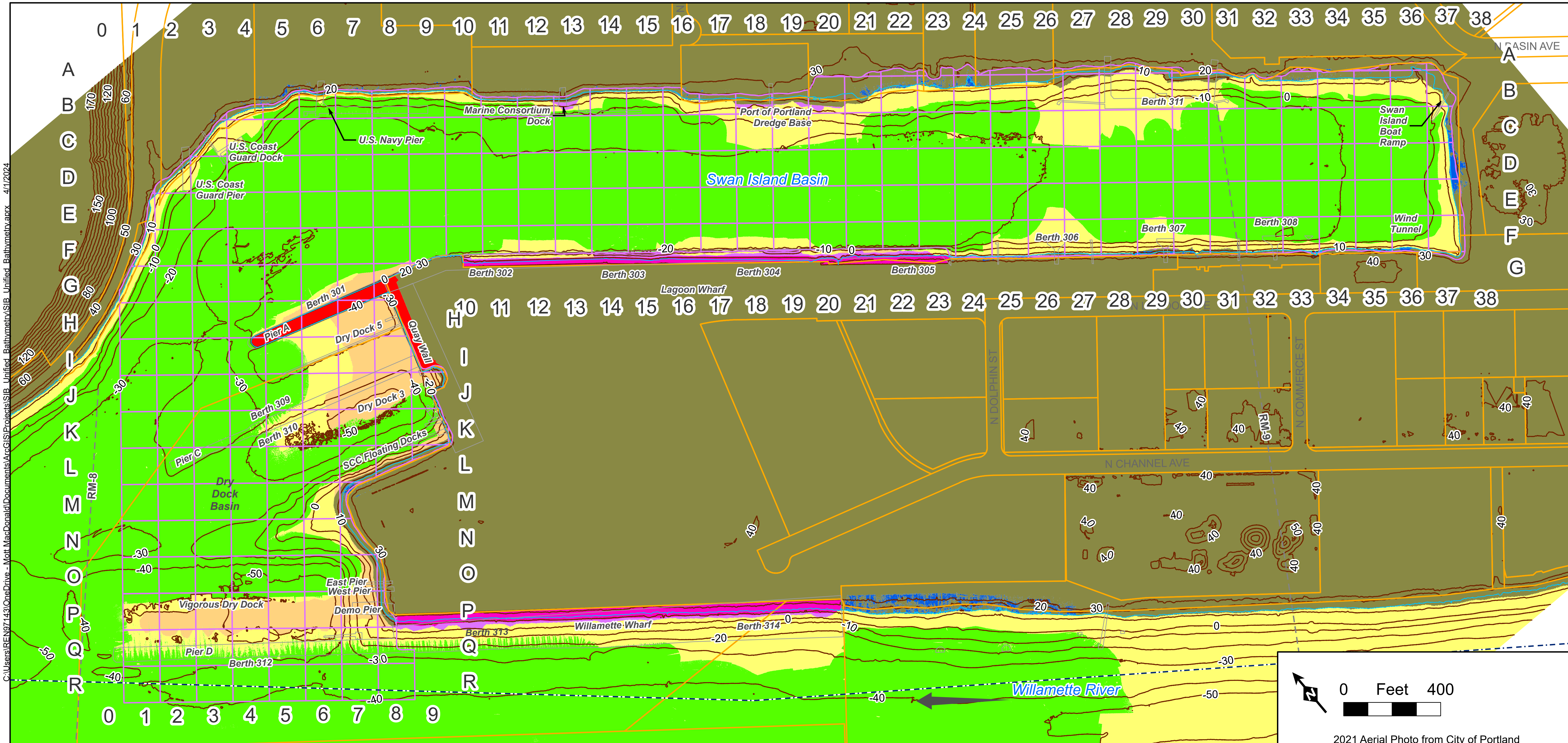

- River Mile (RM)
- Federal Navigation Channel (USACE, 2020)
- Docks and Structures
- Tax Lot Boundary
- 13-foot NAVD88 Contour
- 10-ft Elevation Contours (NAVD88)

Elevation Data Sources

- 2022 HydroGeoLogic - Multibeam Bathymetry
- 2022 eTrac Mobile Terrestrial LiDAR
- Under Warf Interpolation (2022 eTrac Mobile Terrestrial LiDAR)
- 2019 LiDAR - City of Portland
- 2019 LiDAR, First Return Interpolation - City of Portland
- 2018 David Evans & Associates - Multibeam Bathymetry
- 2015 David Evans & Associates - Multibeam Bathymetry
- Interpolation

Notes:
NAVD88 – North American Vertical Datum of 1988
SCC – Shipyard Commerce Center
USACE – U.S. Army Corps of Engineers

Elevation Sources:
David Evans and Associates, 2015
David Evans and Associates, 2018
City of Portland LiDAR, 2019
HydroGeoLogic, 2022

River Flow Direction

Figure 3-15
Data Sources Used in Unified Elevation Model

Prepared on: 4/1/2024
Basis of Design Report
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP

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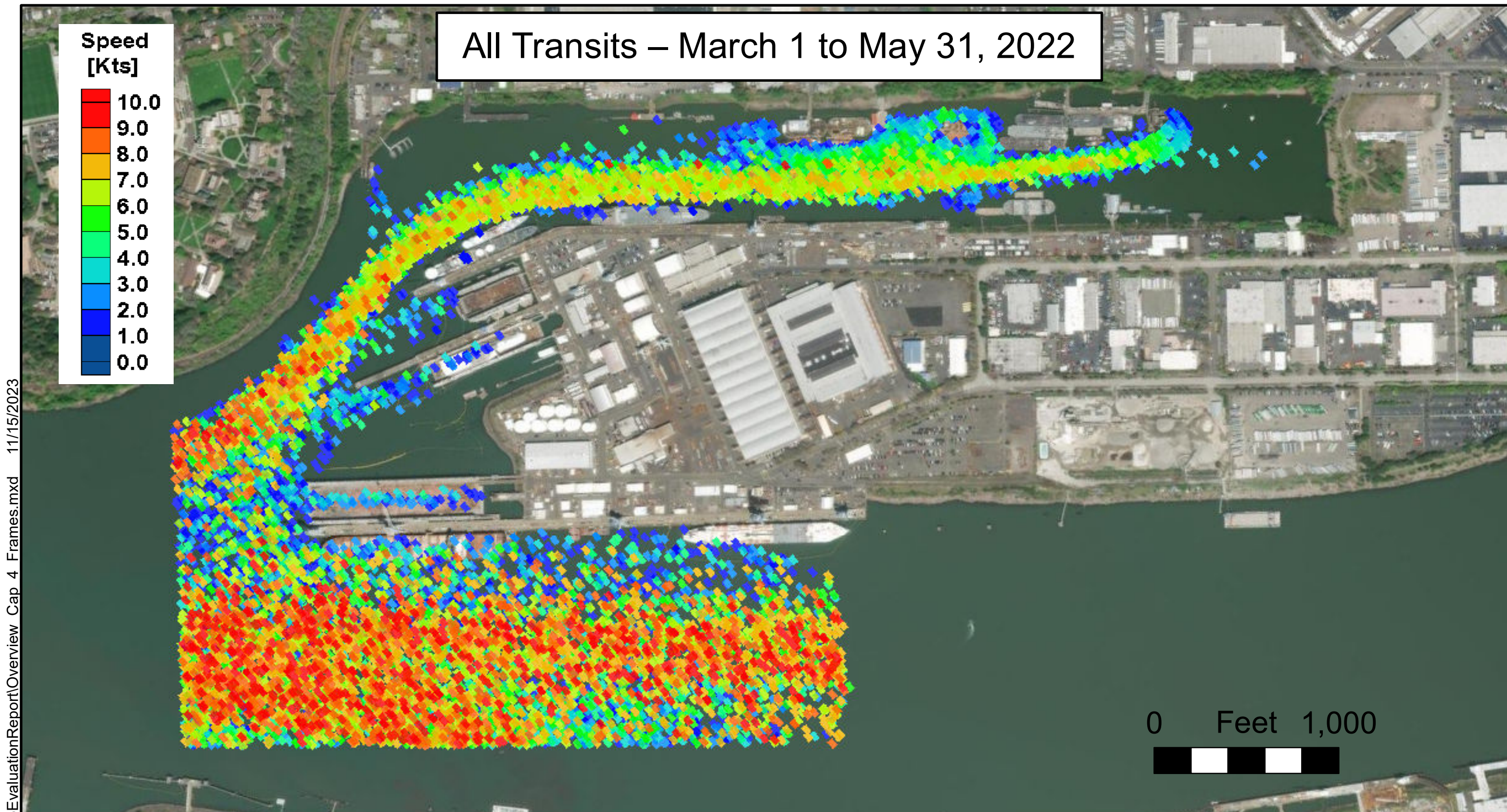

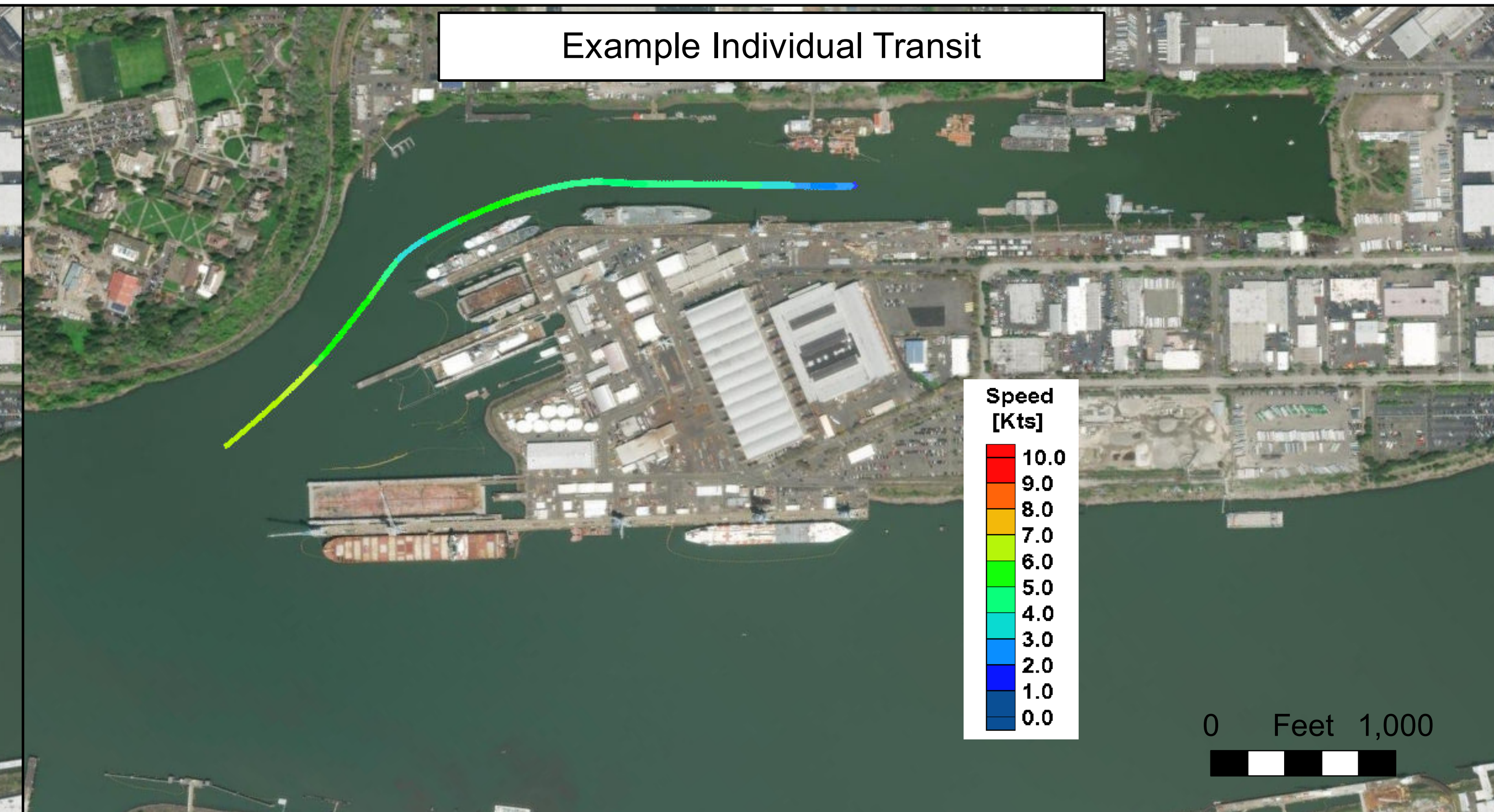

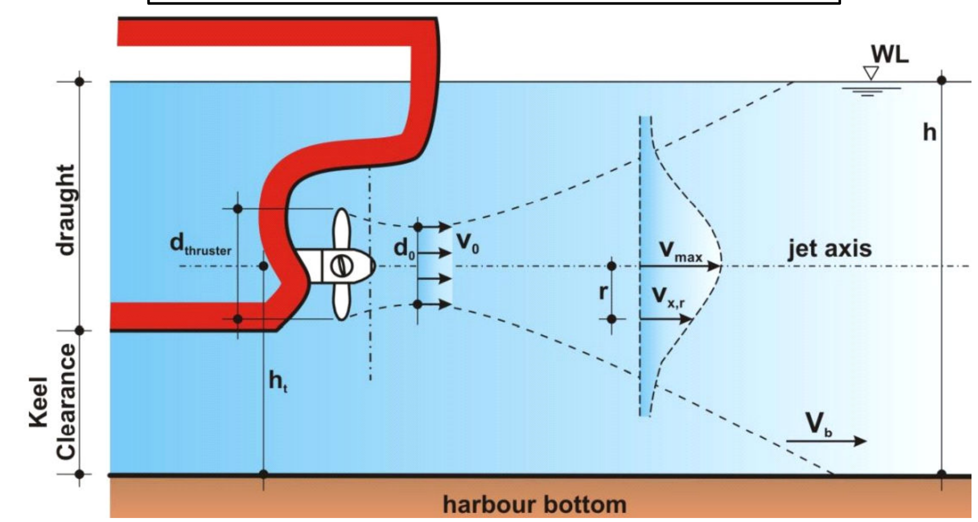

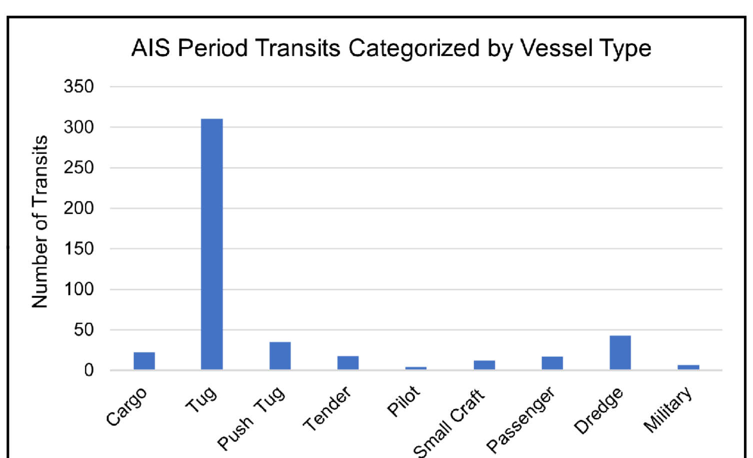

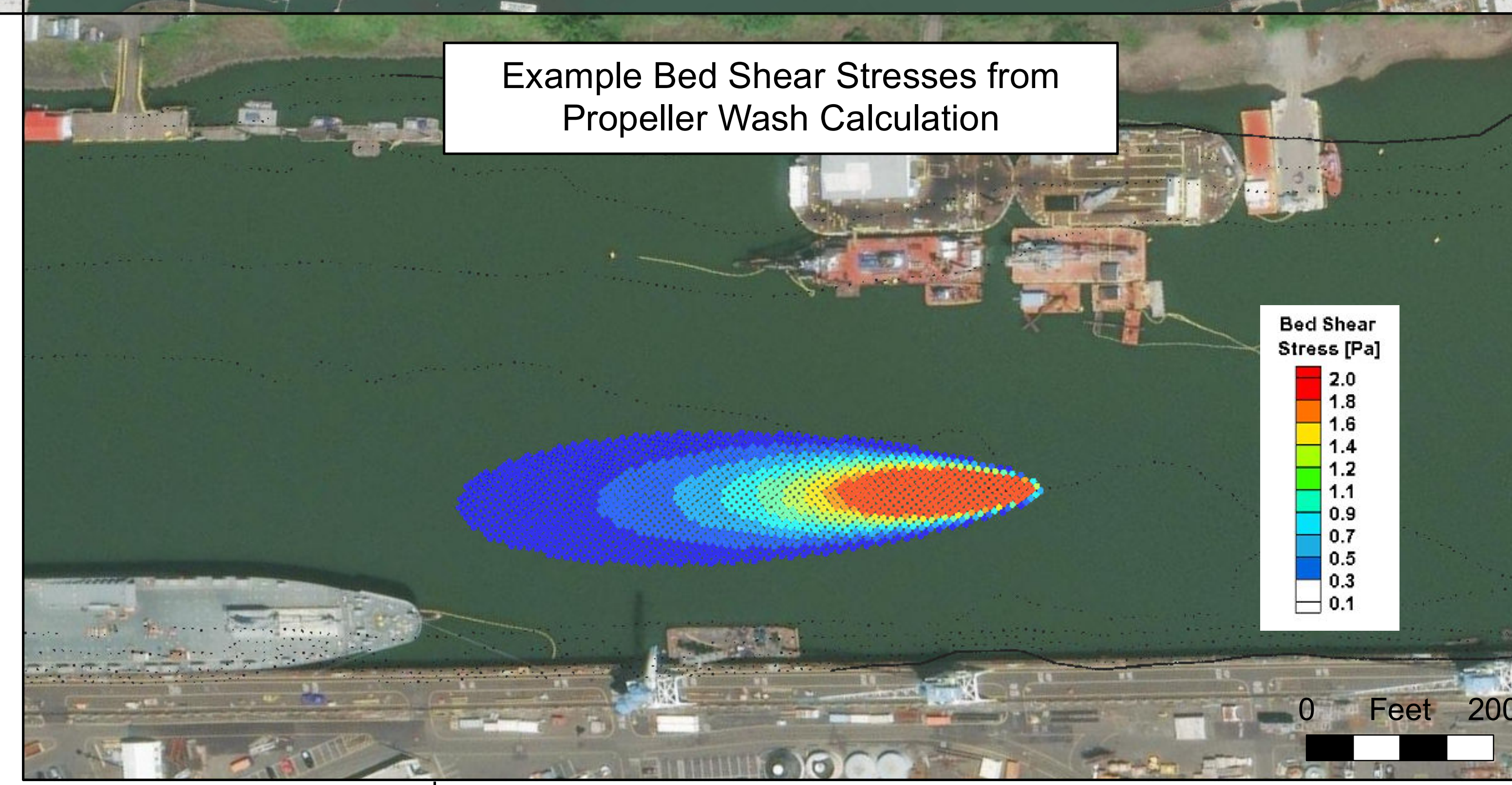

Notes:
d – diameter
kts – knots
Pa – Pascals
USACE – U.S. Army Corps of Engineers
V – velocity
WL – Water Level

Figure 3-16

Observed Vessel Traffic in Swan Island Basin and Example Propeller Wash Calculation

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
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BRIDGEWATER GROUP

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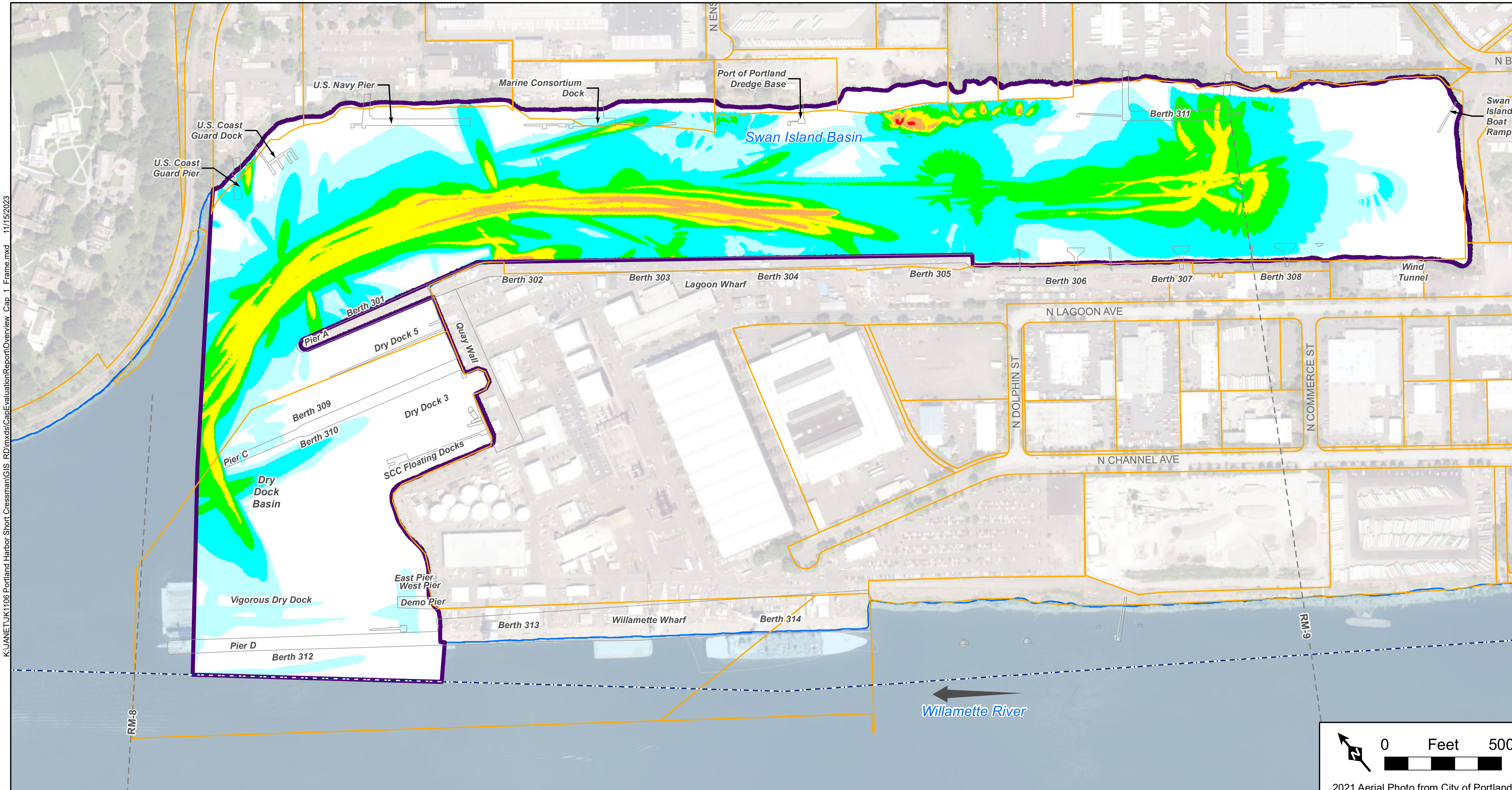

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River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

Bed Shear Stress [Pa]
25.9
12.2
5.7
2.7
1.3
0.47
0.27
0.0

Notes:
Pa – Pascals
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 3-17
Peak Bed Shear Stresses from Propeller Wash

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP HGL MOTT MACDONALD BRIDGEWATER GROUP

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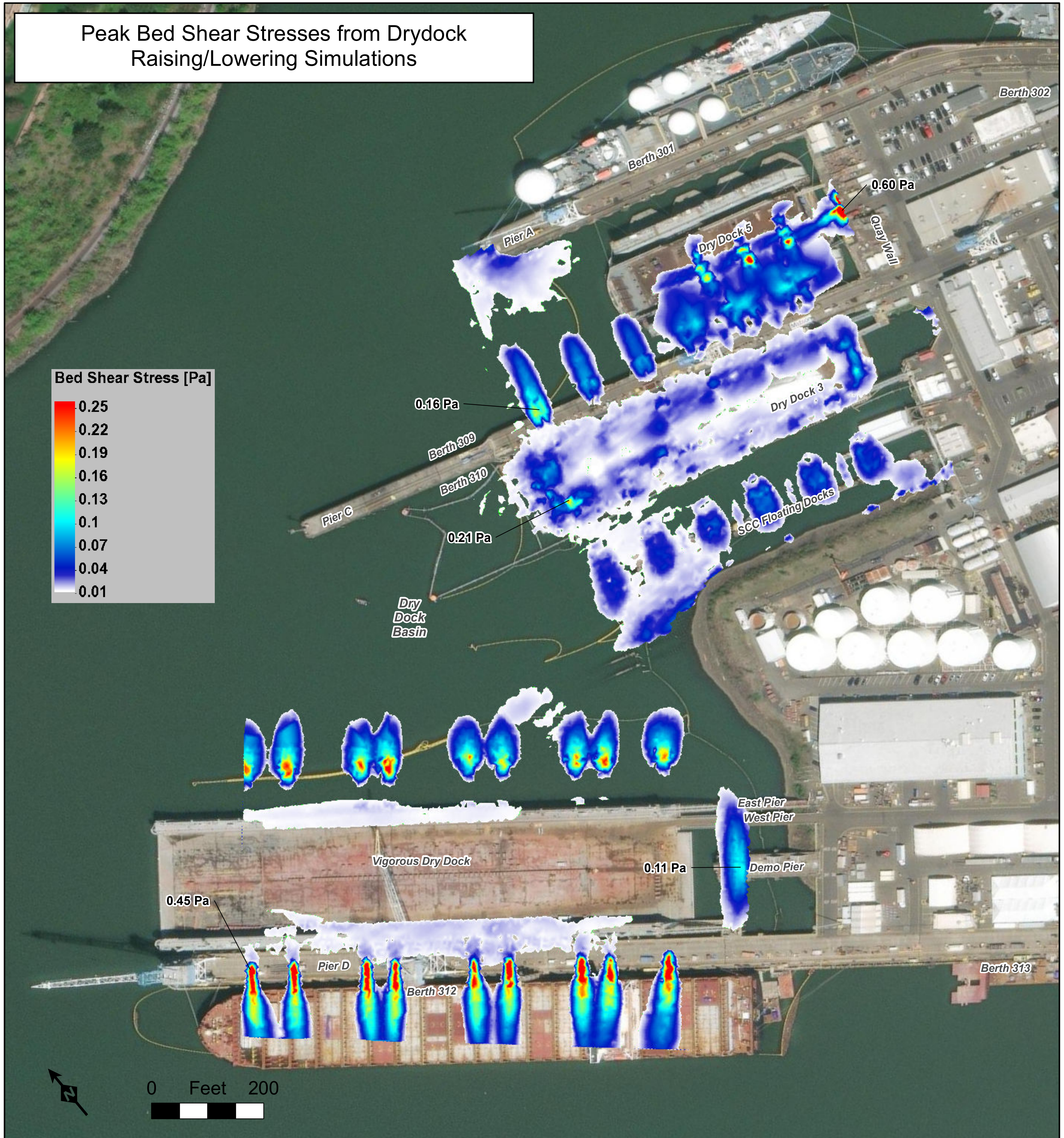
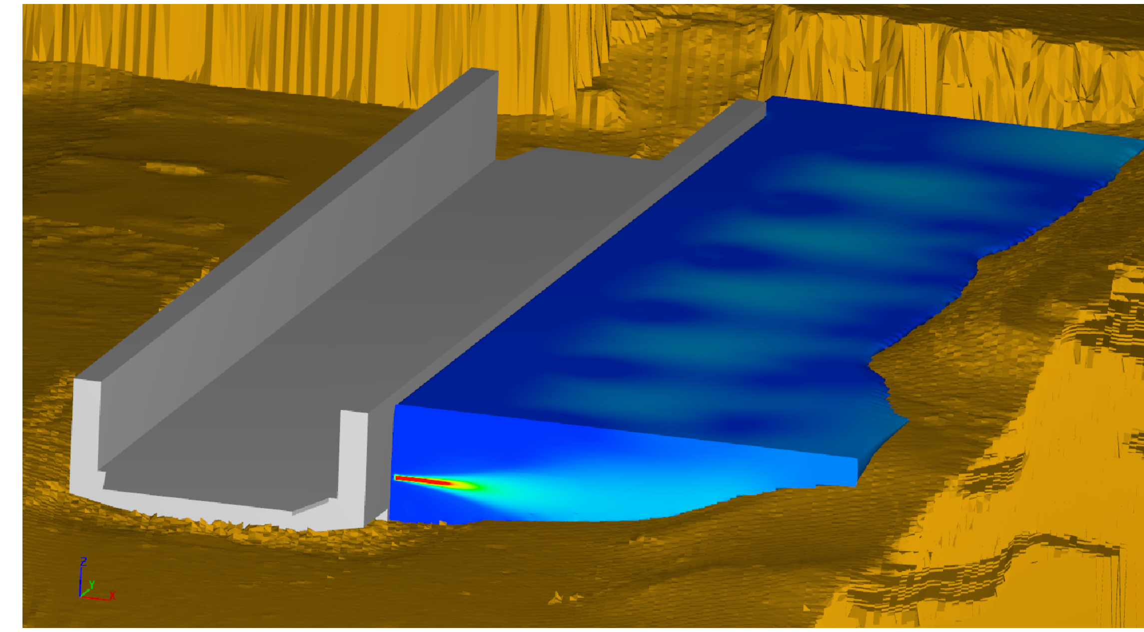
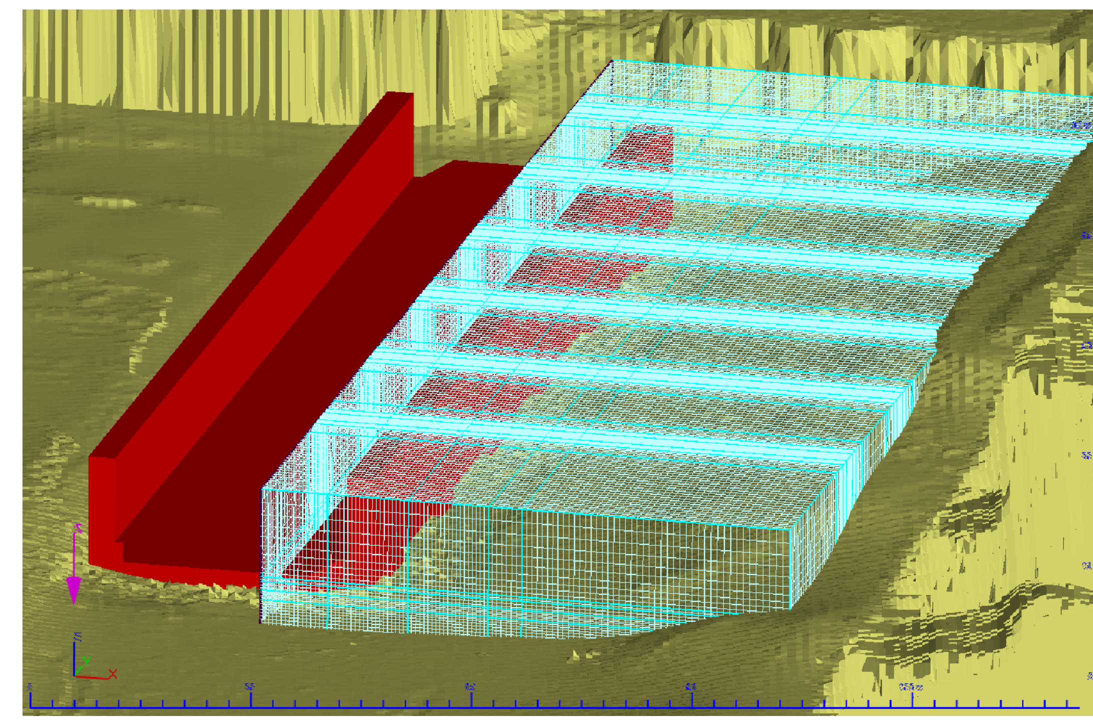




CFD Model Setup for Drydock 3



Notes:
CFD – Computational Fluid Dynamics
Pa – Pascals
SCC – Shipyard Commerce Center

Figure 3-18
Peak Bed Shear Stresses from Drydock Operations

Prepared on: 11/16/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
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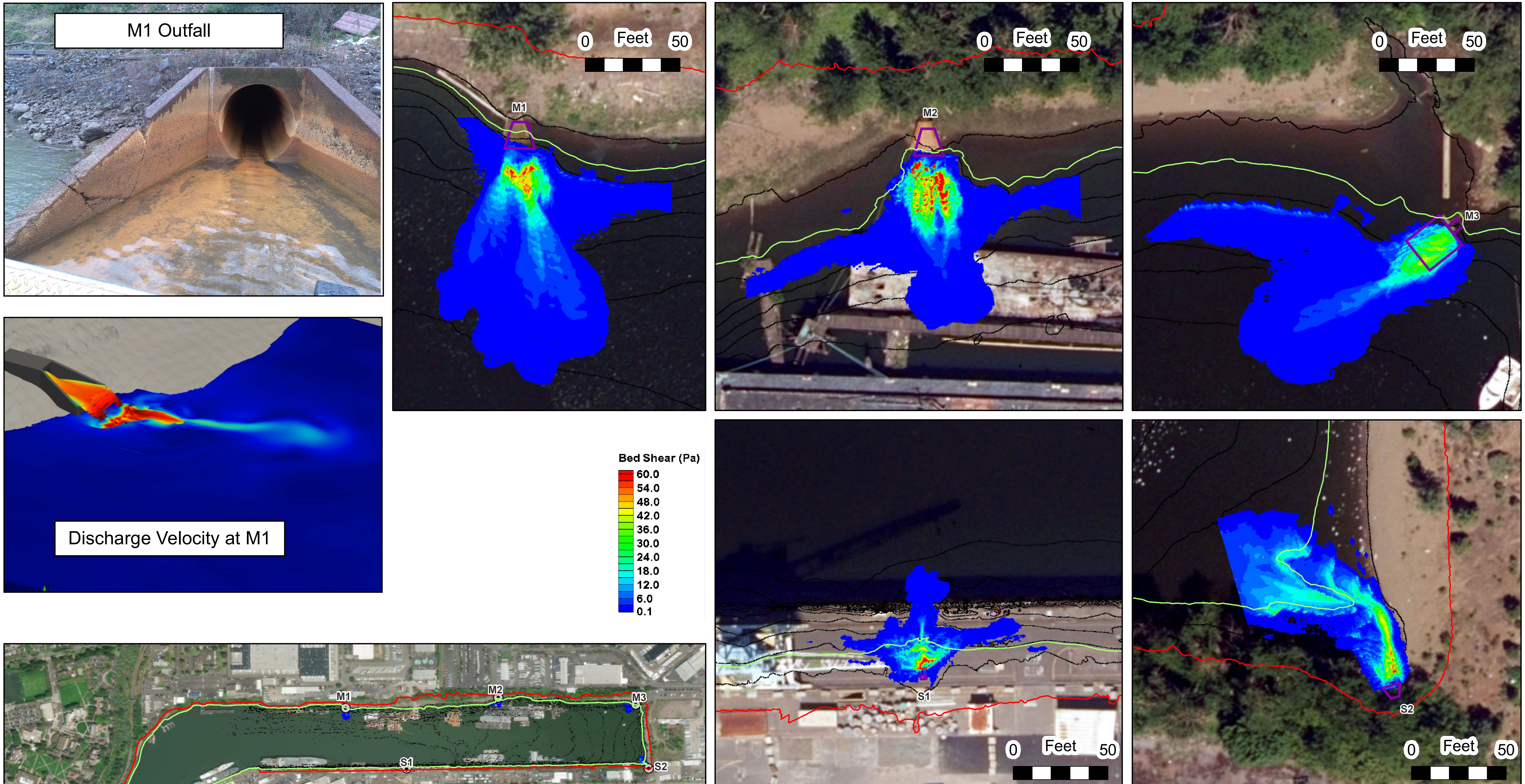

Notes:
Pa - Pascals

City Stormwater Outfall
Mean Low Water (MLW)
Ordinary High Water (OHW)
Existing Outfalls and Armoring

Figure 3-19

Peak Bed Shear Stresses from Outfall Discharges

Prepared on: 1/12/2024
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP

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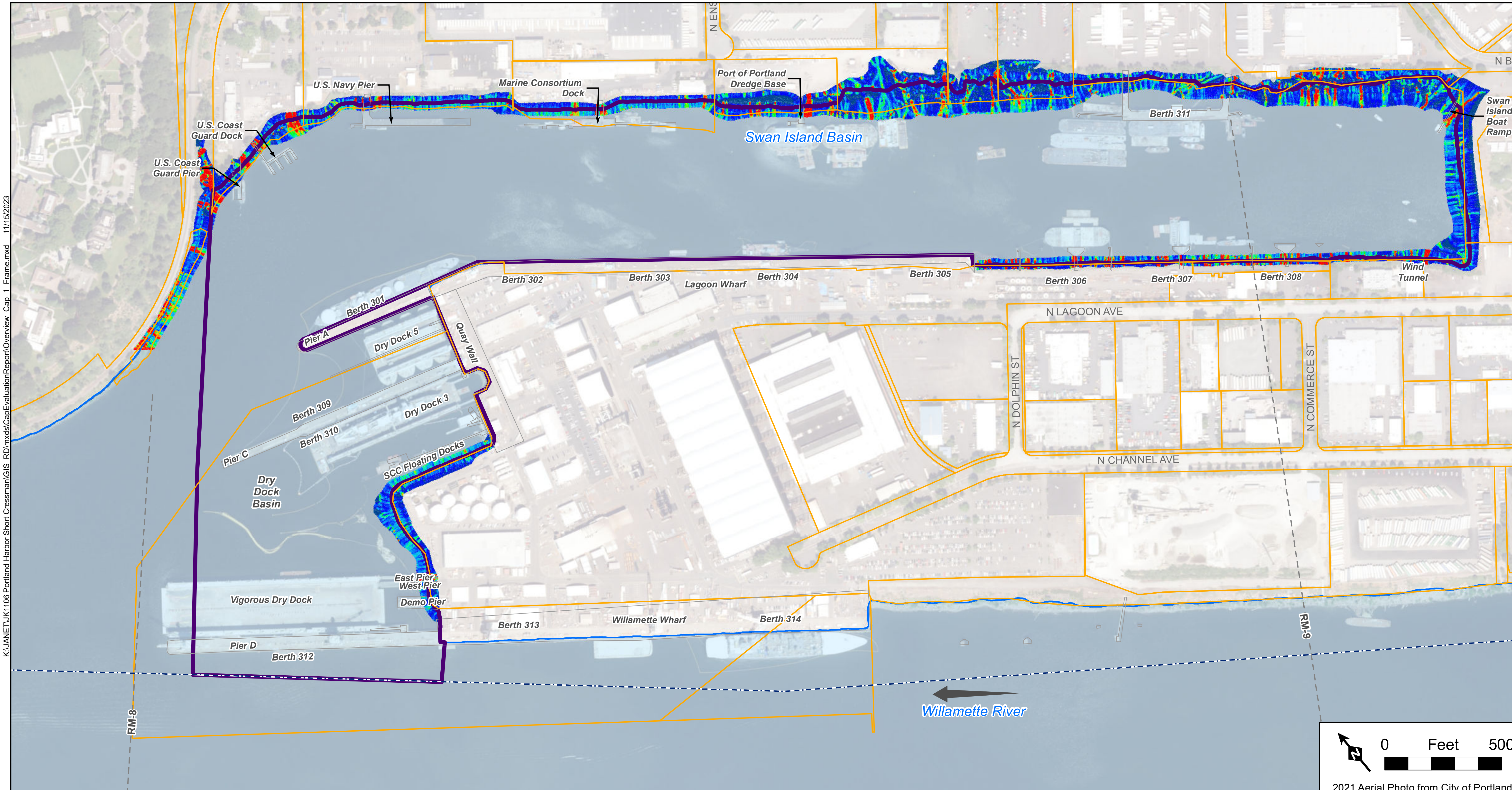

River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

Bed Shear Stress [Pa]
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0

Notes:
Pa – Pascals
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 6-1

Peak Bed Shear Stresses from Rainfall Runoff

Prepared on: 11/18/2023
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
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BRIDGEWATER GROUP

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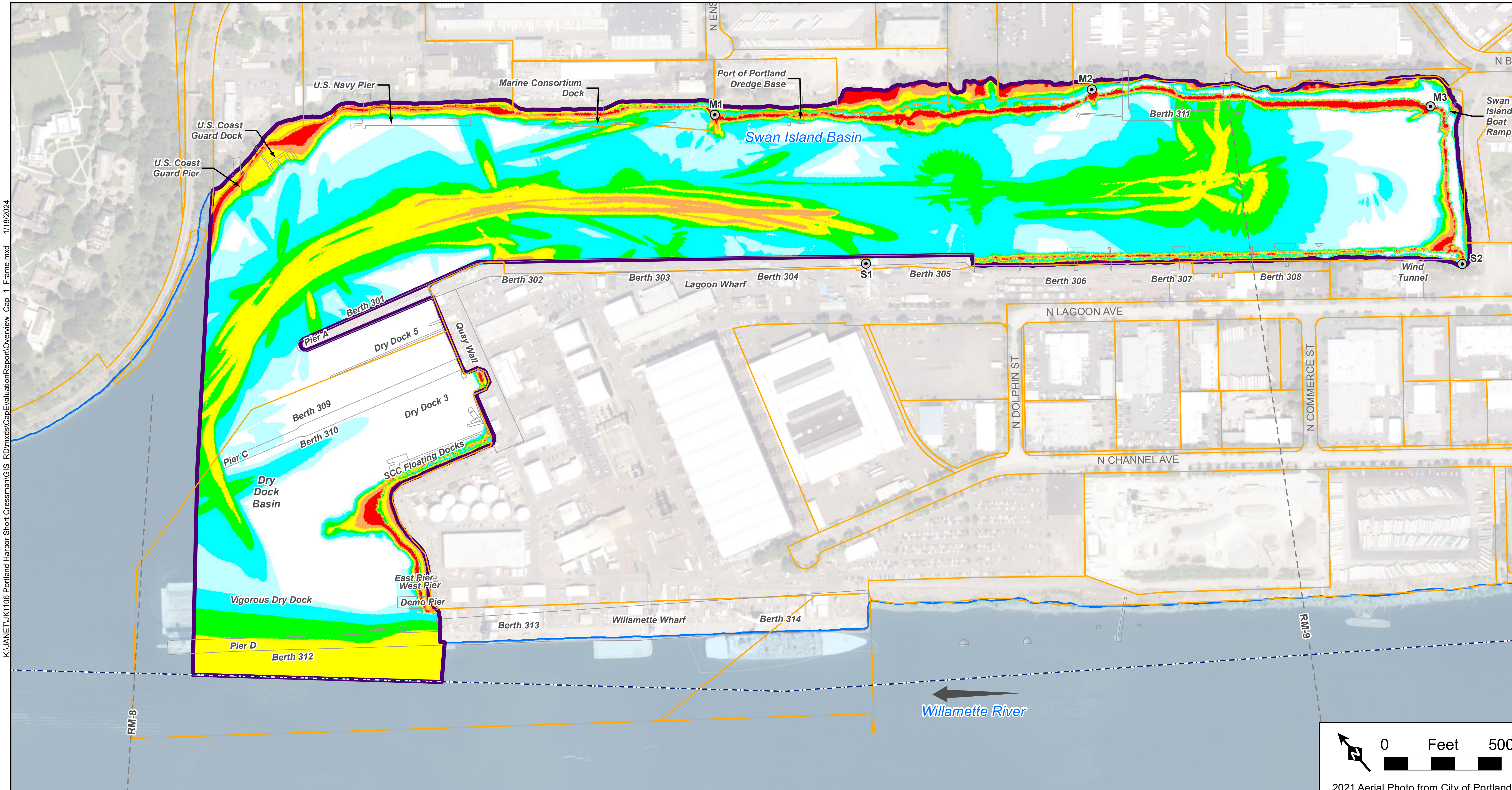

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- City Stormwater Outfall
- River Mile (RM)
- Swan Island Sediment Decision Unit (SDU)
- Federal Navigation Channel (USACE, 2020)
- Docks and Structures
- Tax Lot Boundary
- Ordinary High Water (City of Portland, 2013)
- River Flow Direction

Bed Shear Stress [Pa]

25.9
12.2
5.7
2.7
1.3
0.47
0.27
0.0

Notes:
Pa – Pascals
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Shear stresses exceeding scale limits (25.9 Pa) that are as high as 60 Pa occur in localized areas of SIB embankment slopes due to outfall discharge and wave action and do not show up on this figure.

Figure 6-2

Peak Bed Shear Stresses from All Hydrodynamic Effects

Prepared on: 1/18/2024
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP

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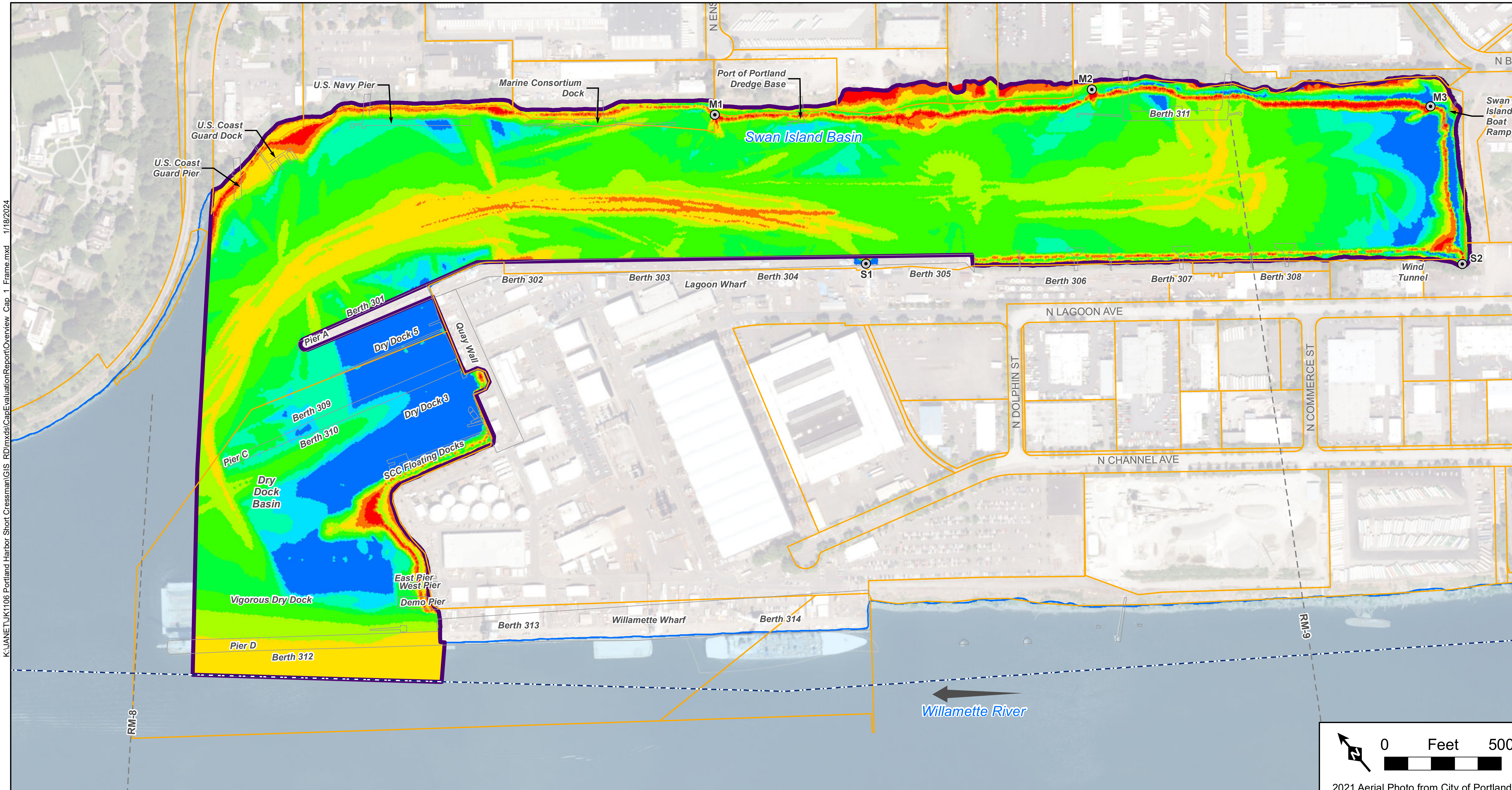

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City Stormwater Outfall
River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

Stable d50[mm]
64.0
32.0
16.0
8.0
4.0
2.0
1.0
0.5
0.25
0.125
0.0

Notes:
d50 – median sediment particle size
mm – millimeter
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Stable grain size d50 exceeding scale limits (64mm) occur in localized areas of SIB embankment slopes due to outfall discharge and wave action.

Figure 6-3

Stable Bed Material Size Based on Peak Bed Shear Stresses

Prepared on: 1/18/2024
Appendix A – Cap Evaluation
Swan Island Basin Remedial Design Group

PACIFIC groundwater GROUP
HGL
MOTT MACDONALD
BRIDGEWATER GROUP

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ATTACHMENT

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ATTACHMENT A

CAPSIM EVALUATION CONCENTRATION PROFILES

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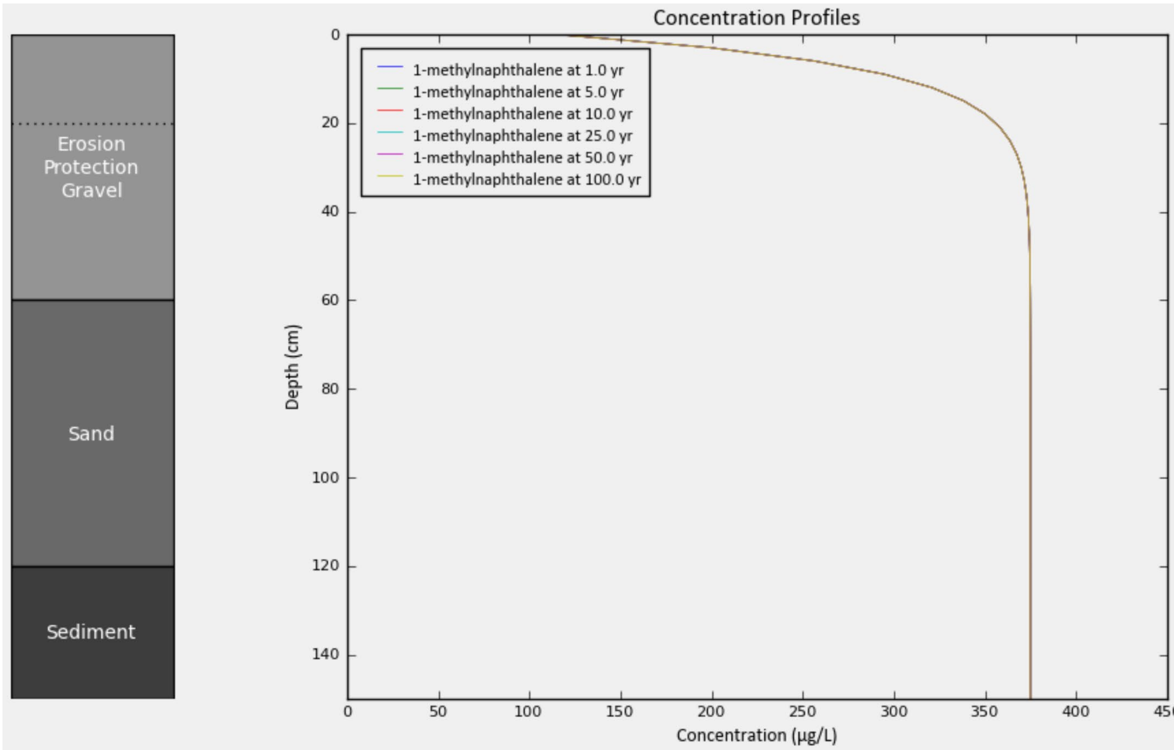
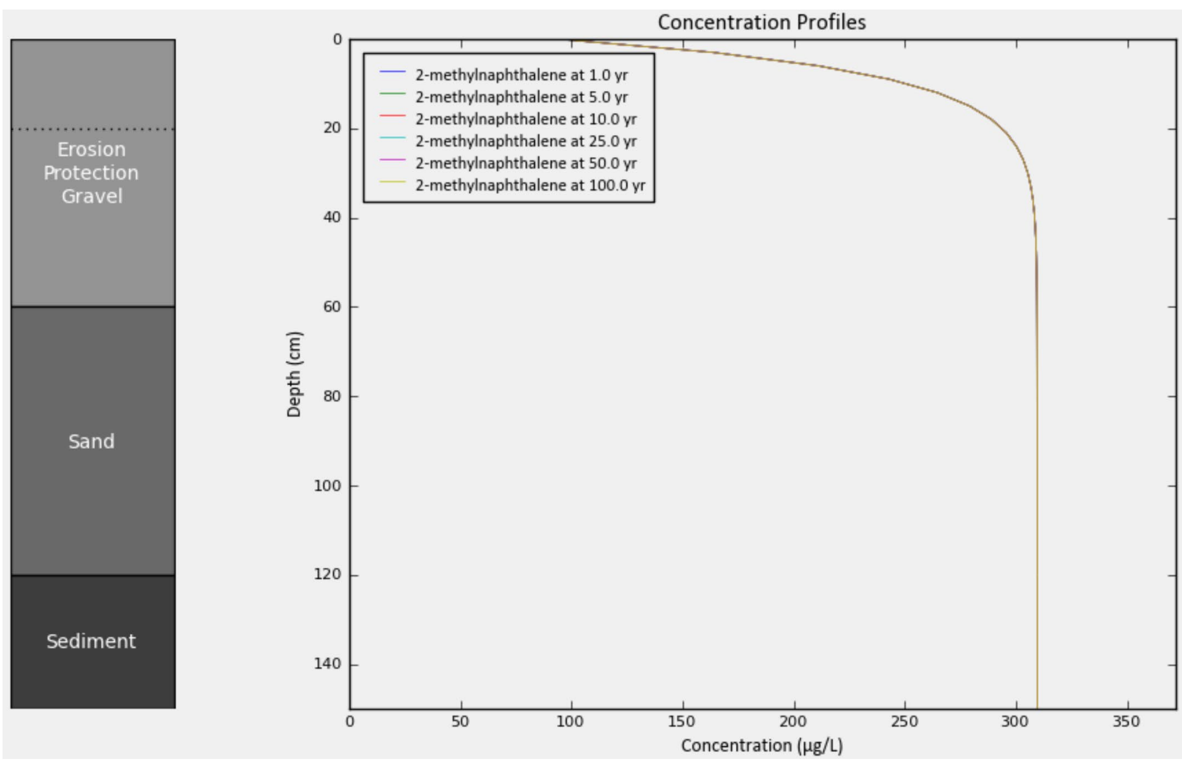
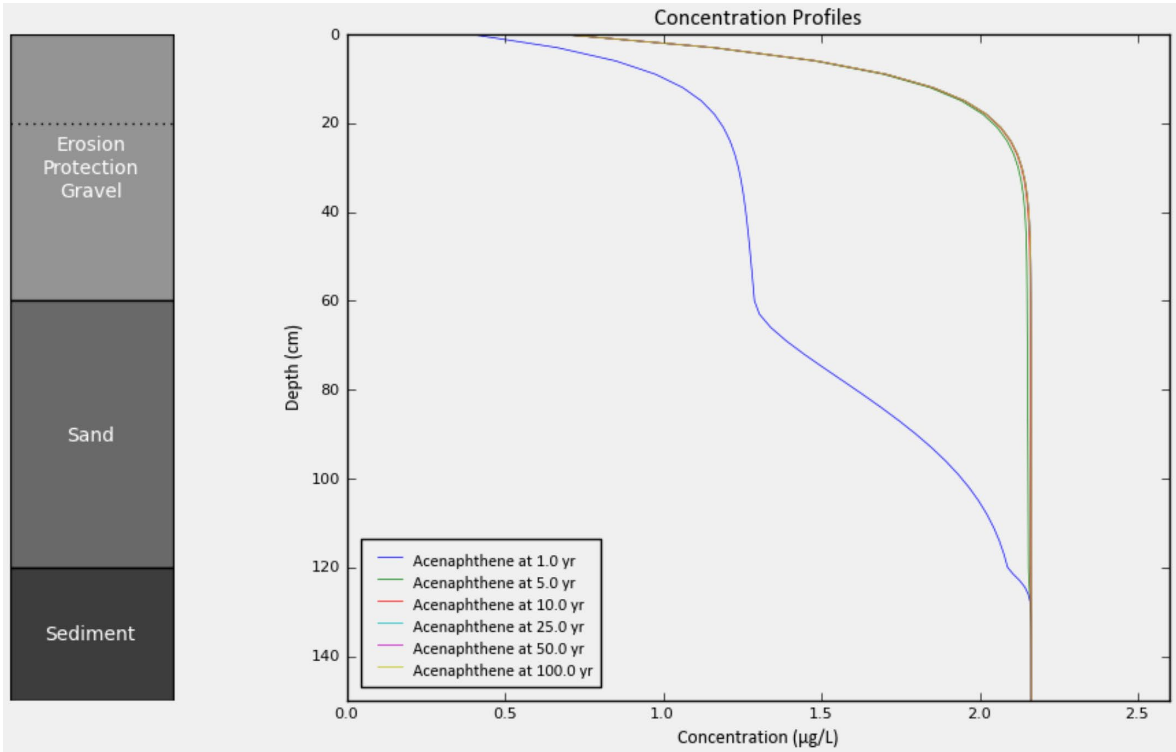
Contents

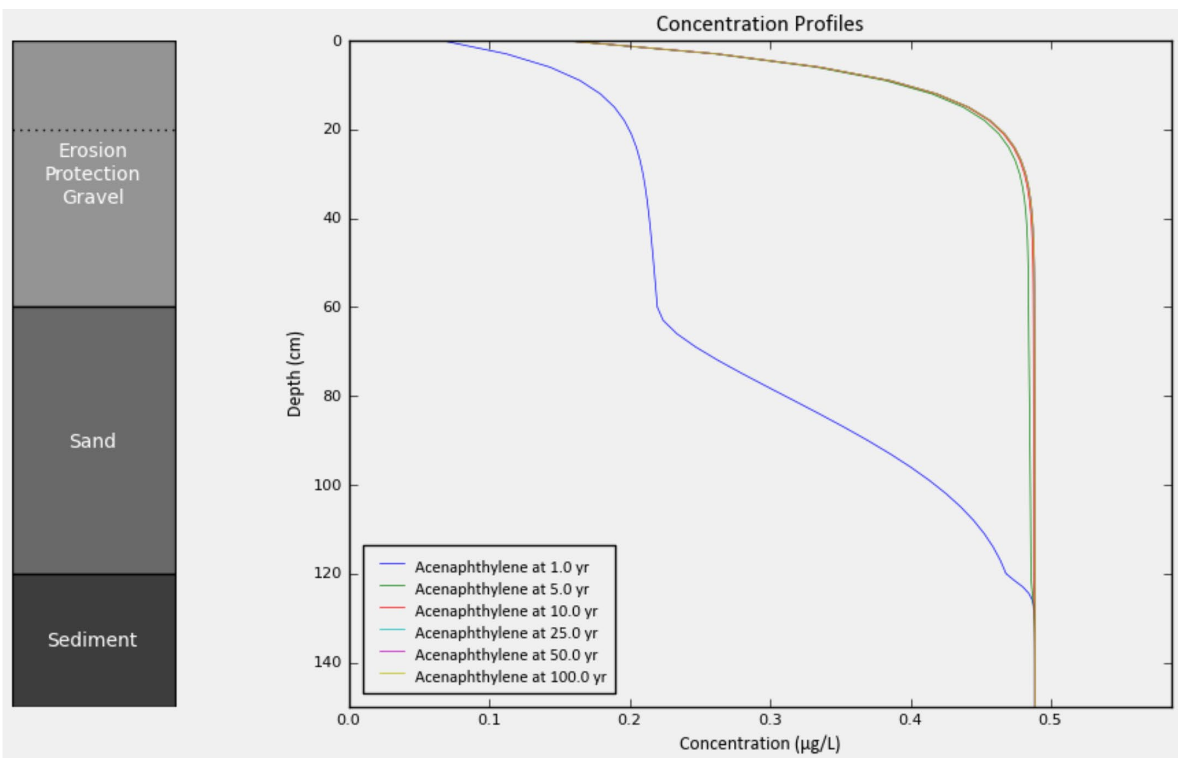
Cap Alternative 1: 60 centimeters [cm] of unamended sand with 60 cm erosion protection layer

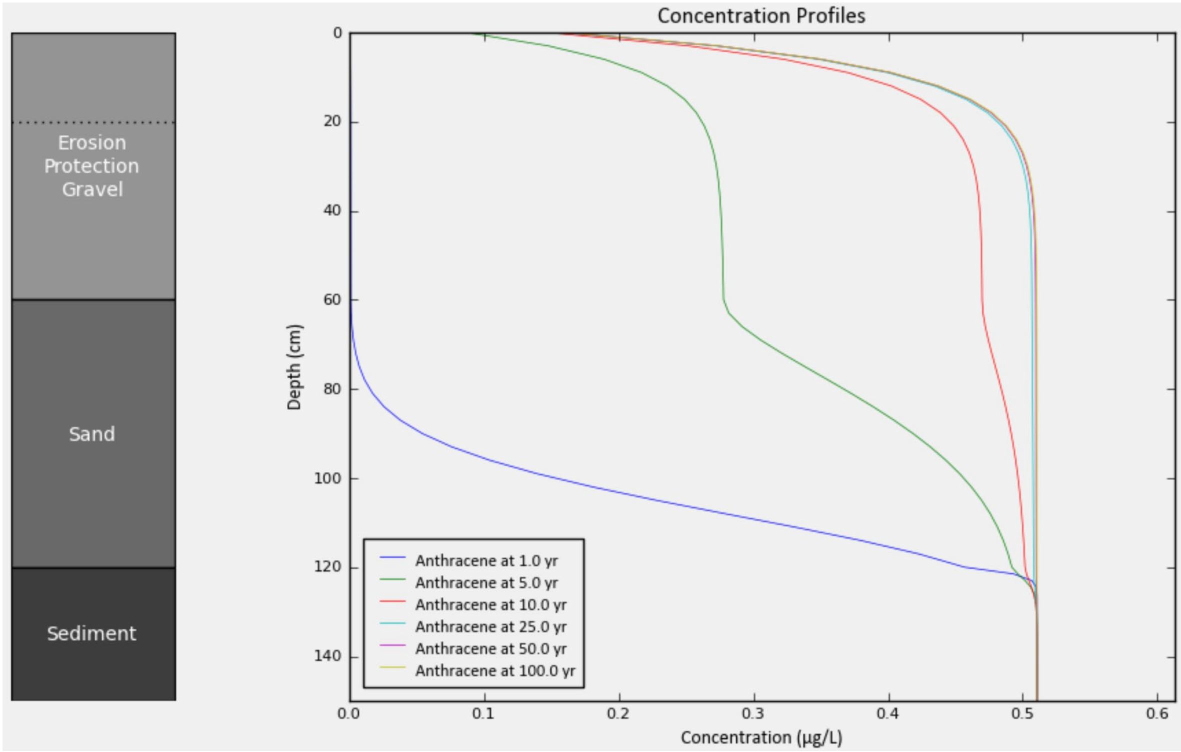
Porewater Concentration – Depth

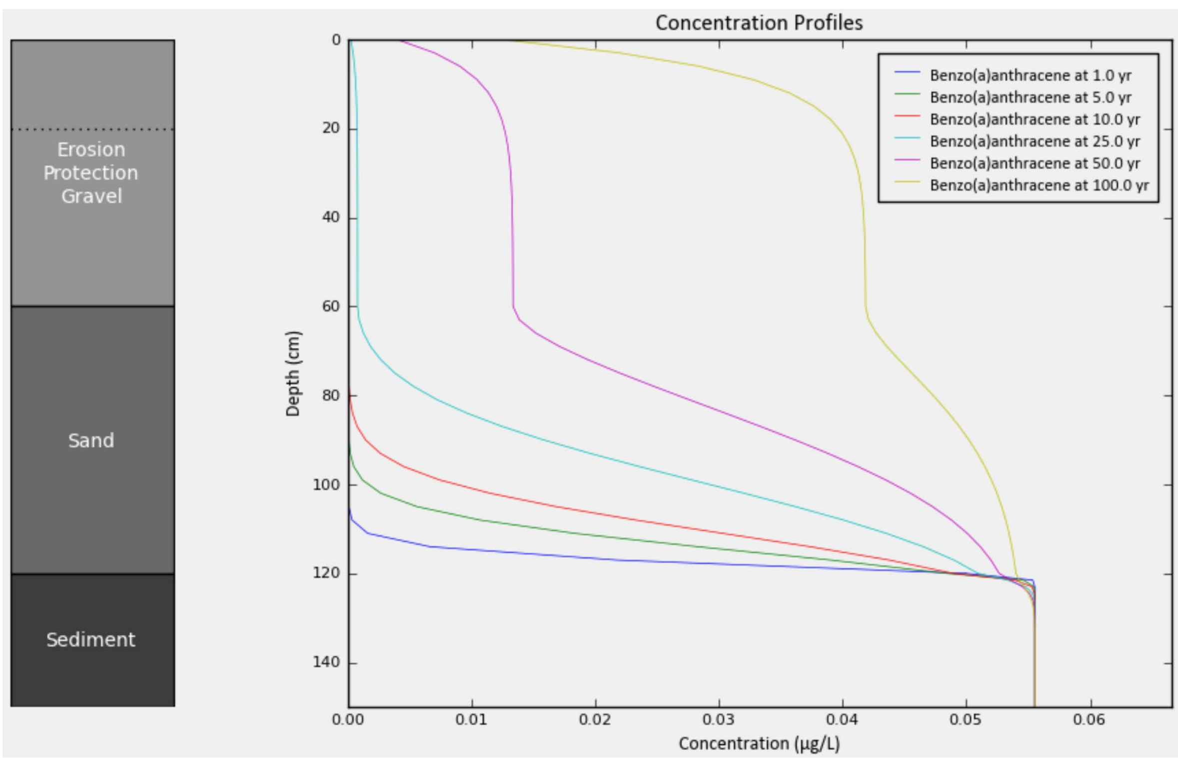


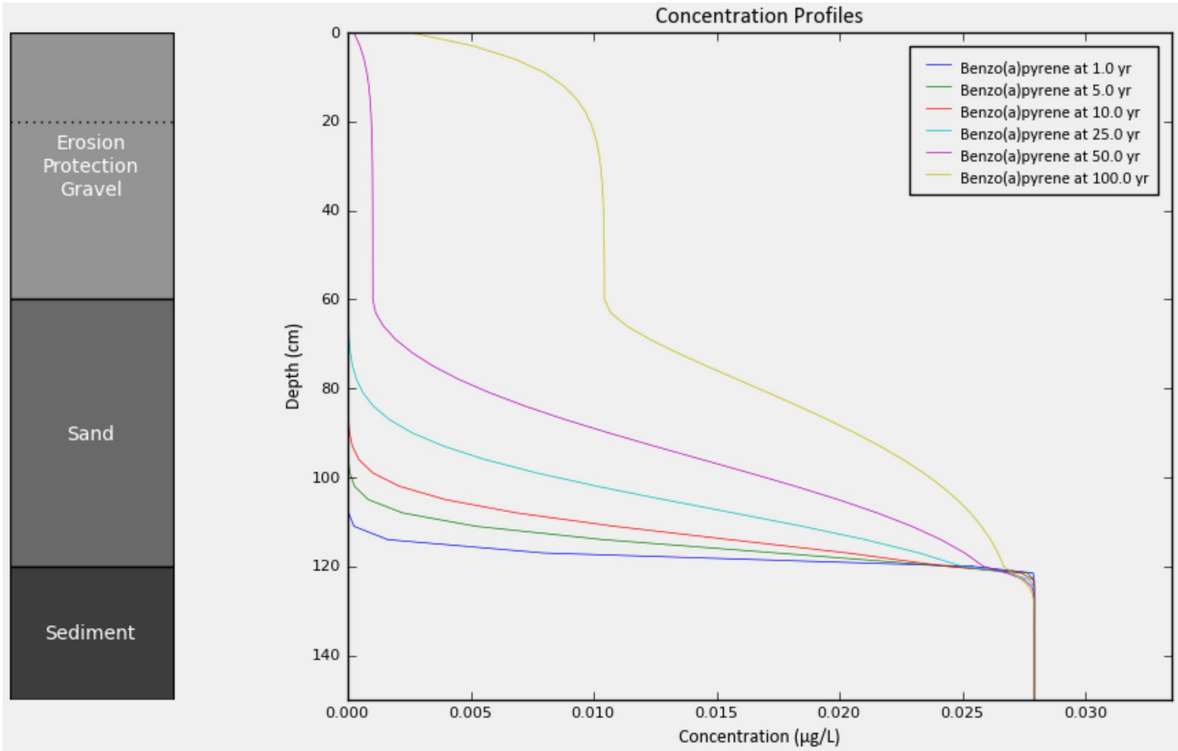


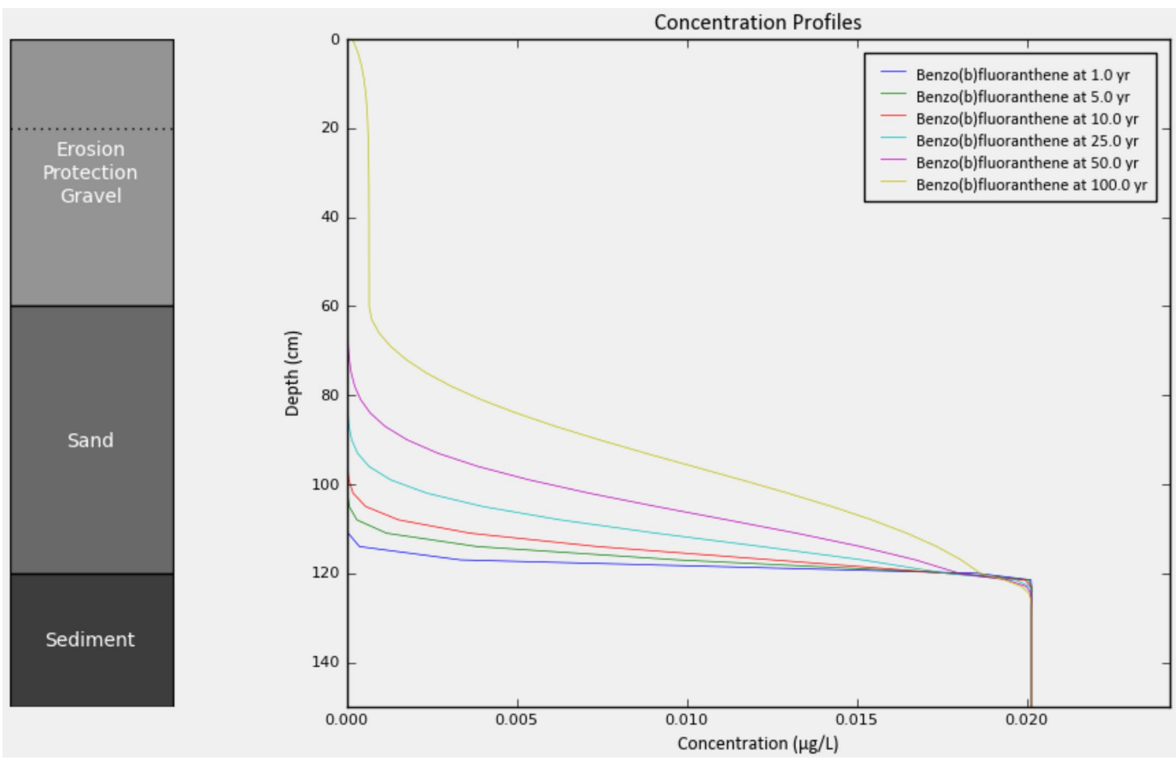

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Acenaphthene at 1.0 yr
Acenaphthene at 5.0 yr
Acenaphthene at 10.0 yr
Acenaphthene at 25.0 yr
Acenaphthene at 50.0 yr
Acenaphthene at 100.0 yr

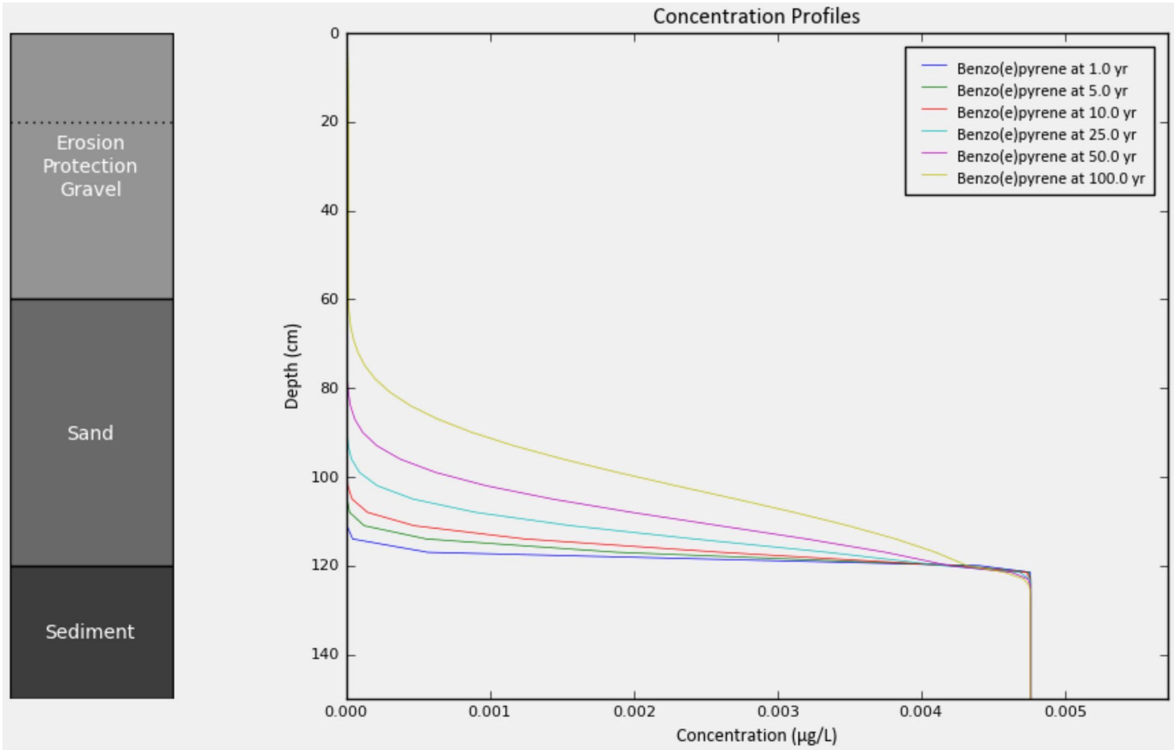

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Acenaphthylene at 1.0 yr
Acenaphthylene at 5.0 yr
Acenaphthylene at 10.0 yr
Acenaphthylene at 25.0 yr
Acenaphthylene at 50.0 yr
Acenaphthylene at 100.0 yr

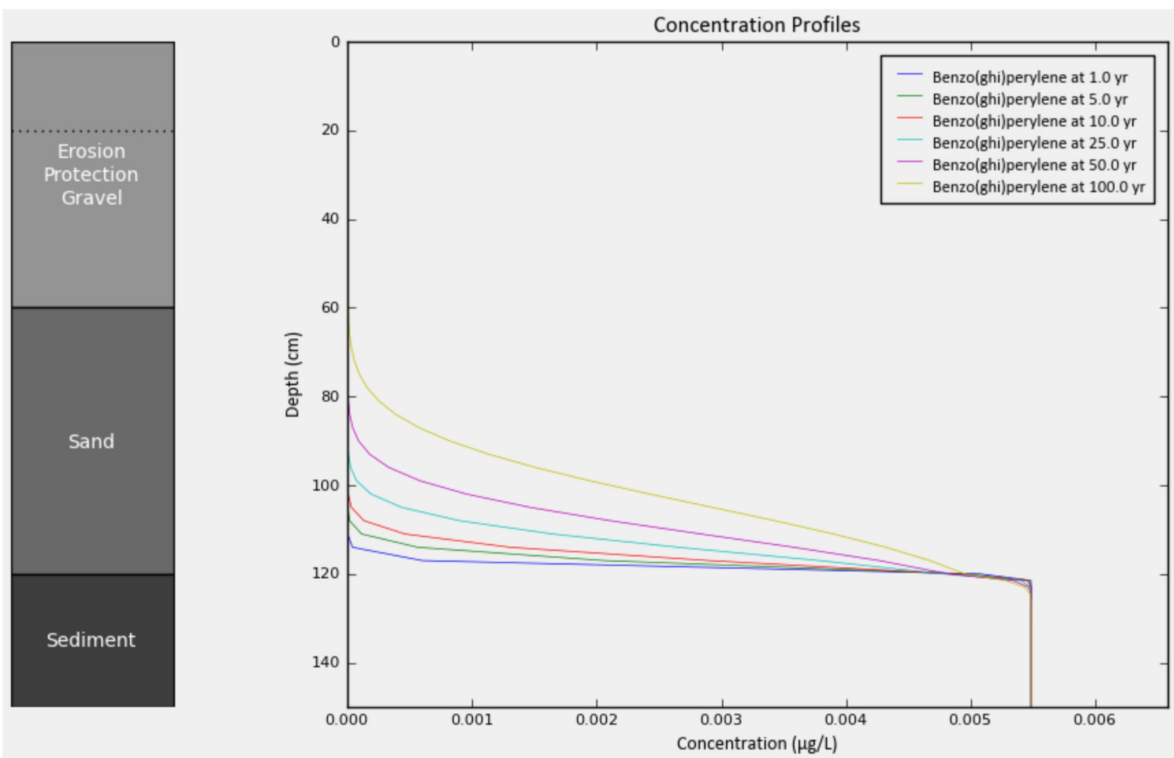

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Anthracene at 1.0 yr
Anthracene at 5.0 yr
Anthracene at 10.0 yr
Anthracene at 25.0 yr
Anthracene at 50.0 yr
Anthracene at 100.0 yr

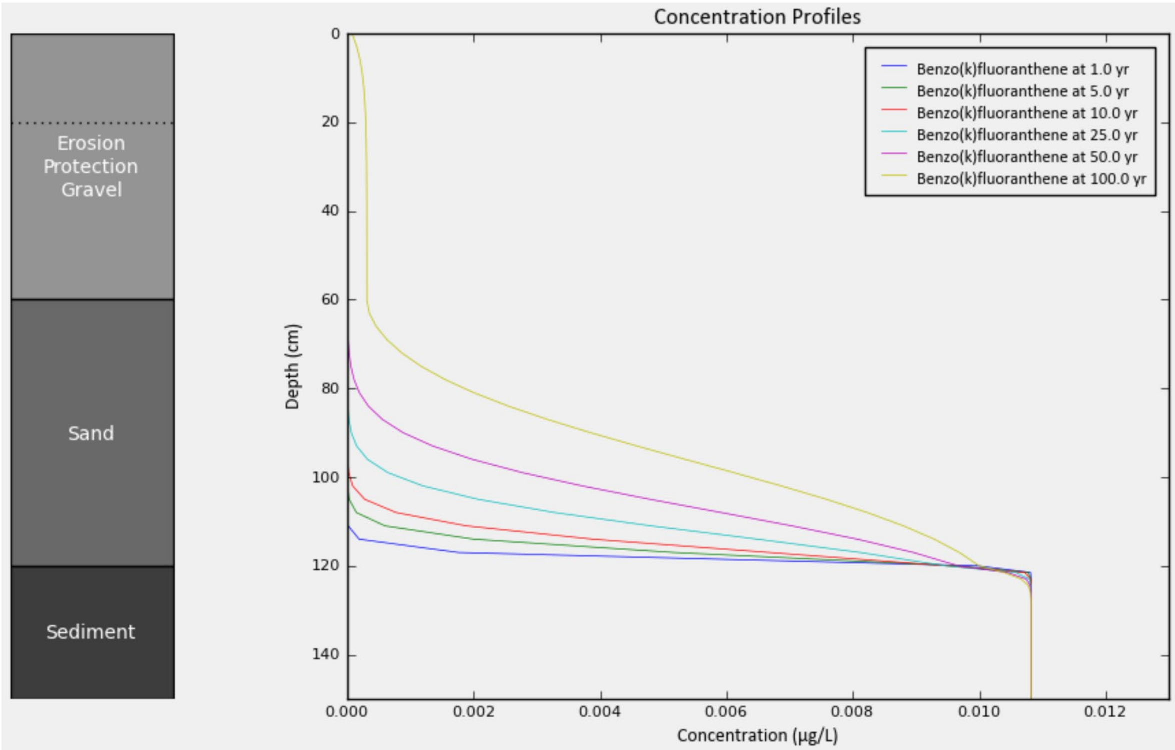

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(a)anthracene at 1.0 yr
Benzo(a)anthracene at 5.0 yr
Benzo(a)anthracene at 10.0 yr
Benzo(a)anthracene at 25.0 yr
Benzo(a)anthracene at 50.0 yr
Benzo(a)anthracene at 100.0 yr

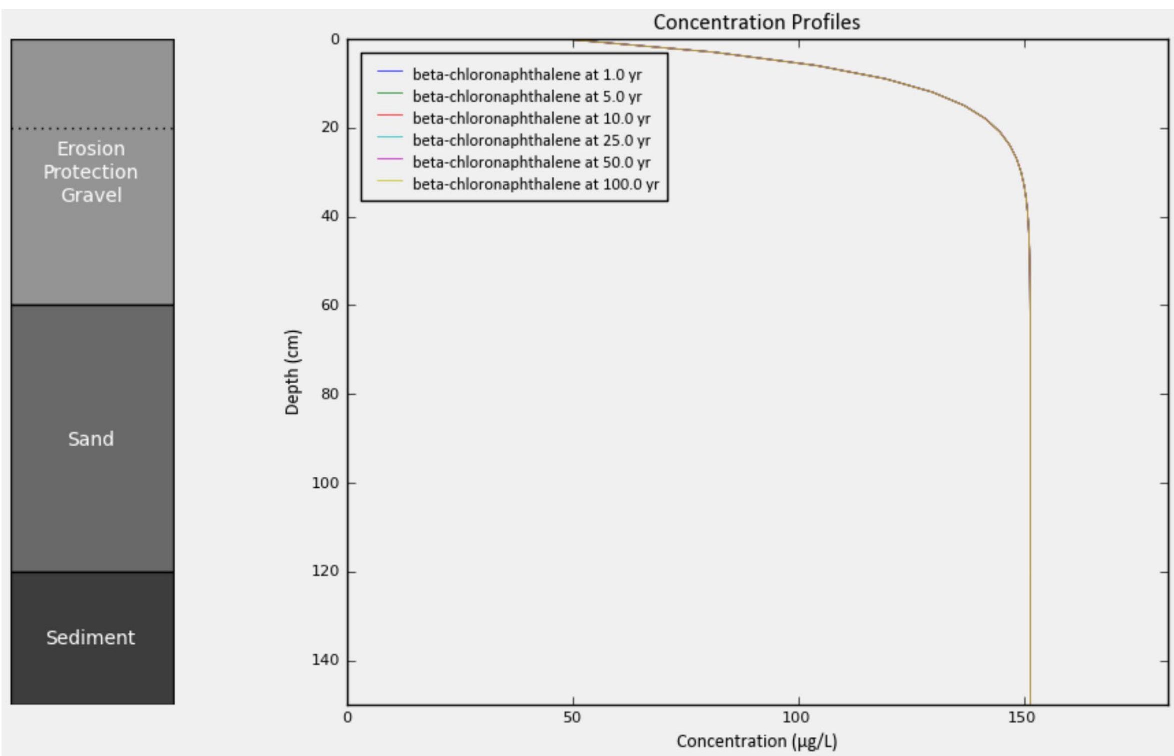

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(a)pyrene at 1.0 yr
Benzo(a)pyrene at 5.0 yr
Benzo(a)pyrene at 10.0 yr
Benzo(a)pyrene at 25.0 yr
Benzo(a)pyrene at 50.0 yr
Benzo(a)pyrene at 100.0 yr

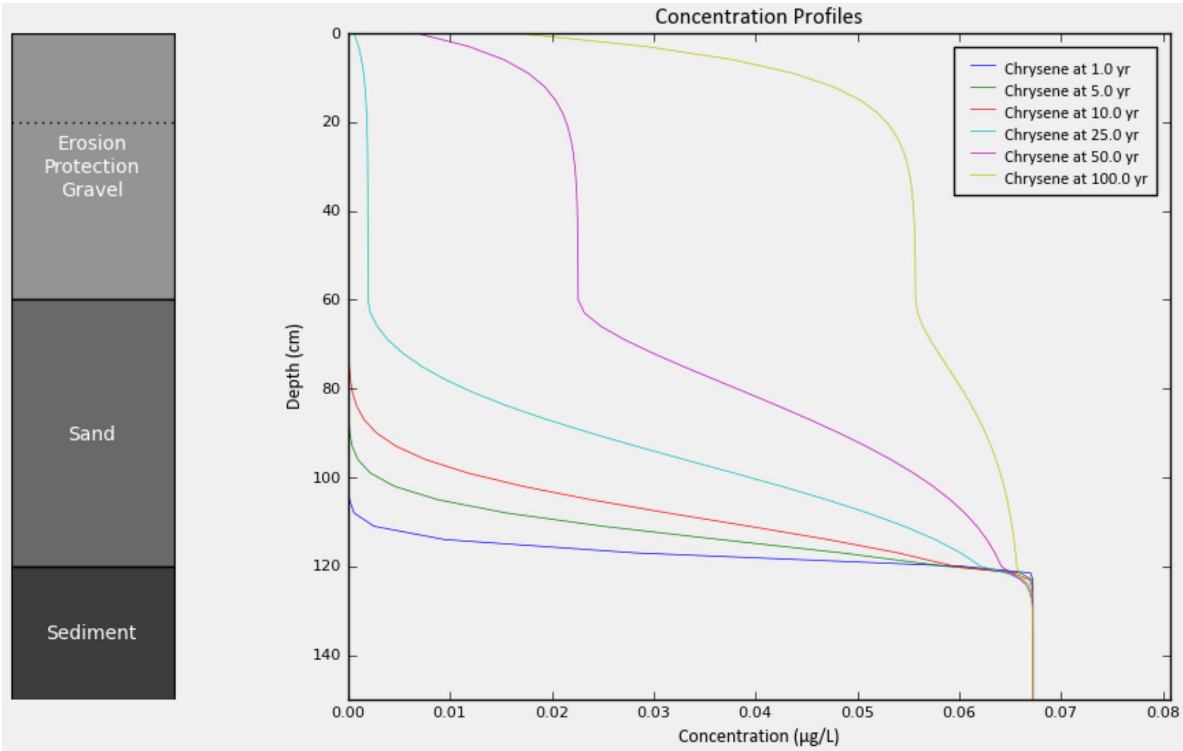

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(b)fluoranthene at 1.0 yr
Benzo(b)fluoranthene at 5.0 yr
Benzo(b)fluoranthene at 10.0 yr
Benzo(b)fluoranthene at 25.0 yr
Benzo(b)fluoranthene at 50.0 yr
Benzo(b)fluoranthene at 100.0 yr

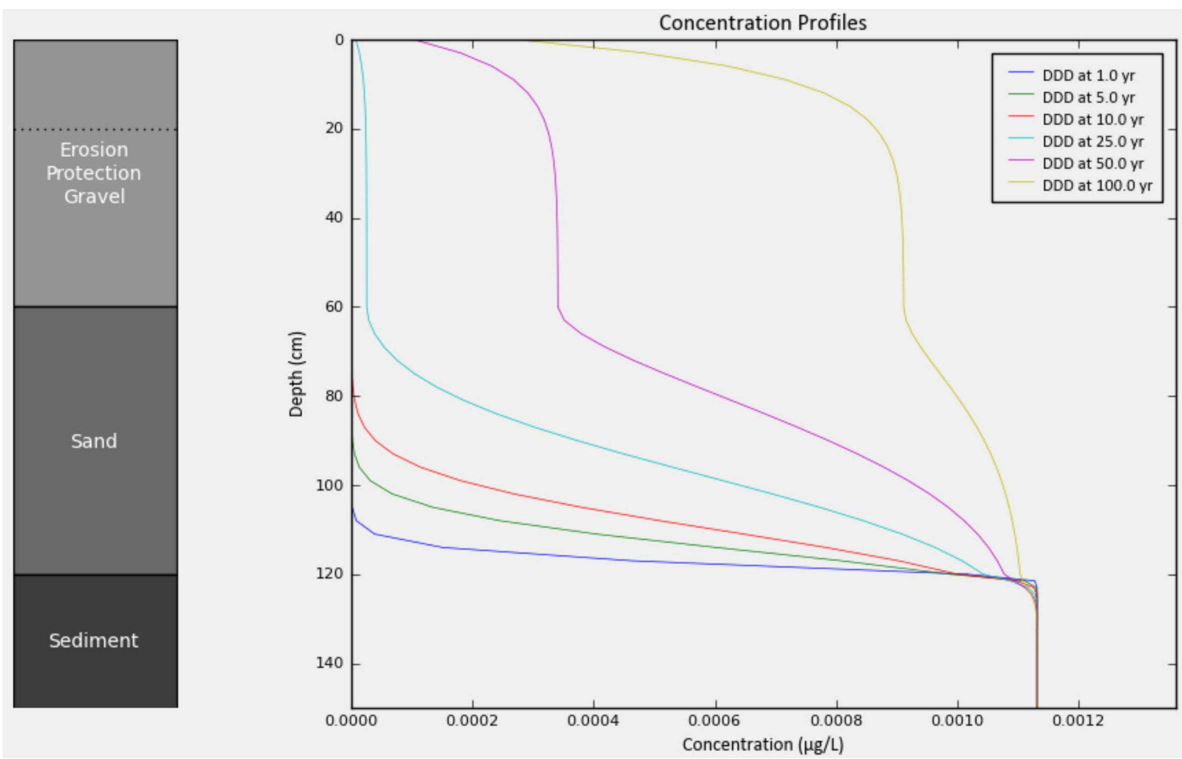

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(e)pyrene at 1.0 yr
Benzo(e)pyrene at 5.0 yr
Benzo(e)pyrene at 10.0 yr
Benzo(e)pyrene at 25.0 yr
Benzo(e)pyrene at 50.0 yr
Benzo(e)pyrene at 100.0 yr

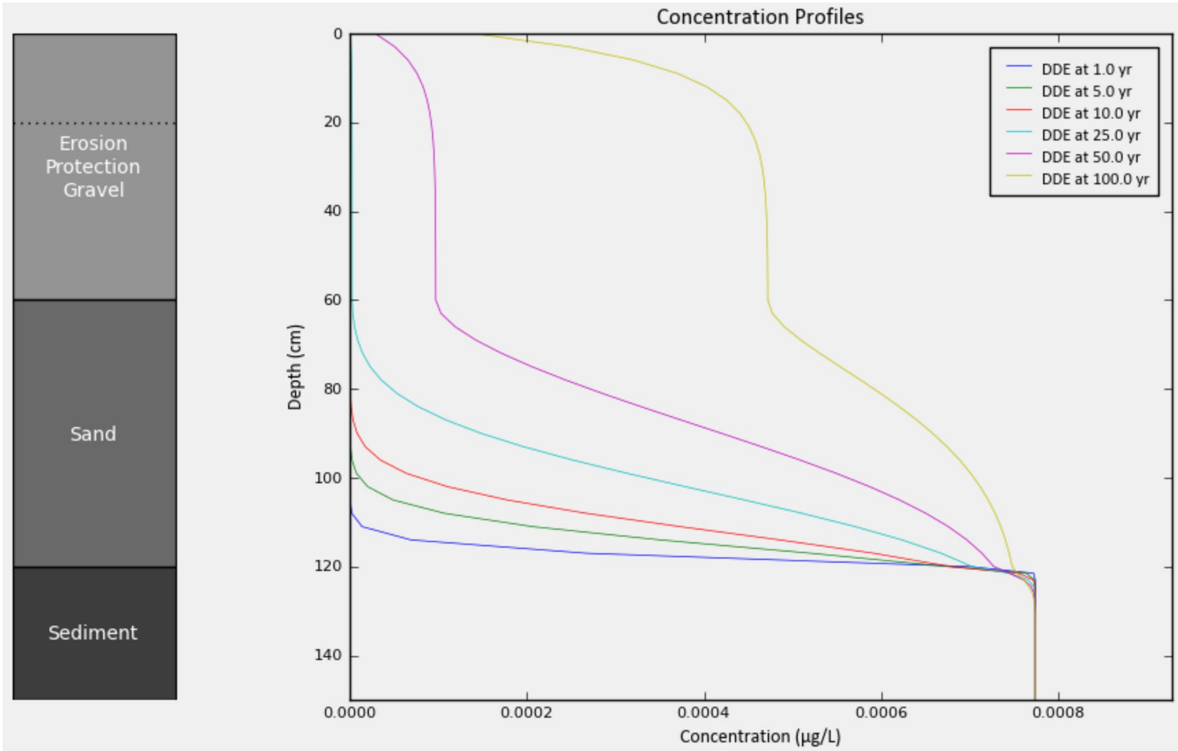

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(ghi)perylene at 1.0 yr
Benzo(ghi)perylene at 5.0 yr
Benzo(ghi)perylene at 10.0 yr
Benzo(ghi)perylene at 25.0 yr
Benzo(ghi)perylene at 50.0 yr
Benzo(ghi)perylene at 100.0 yr

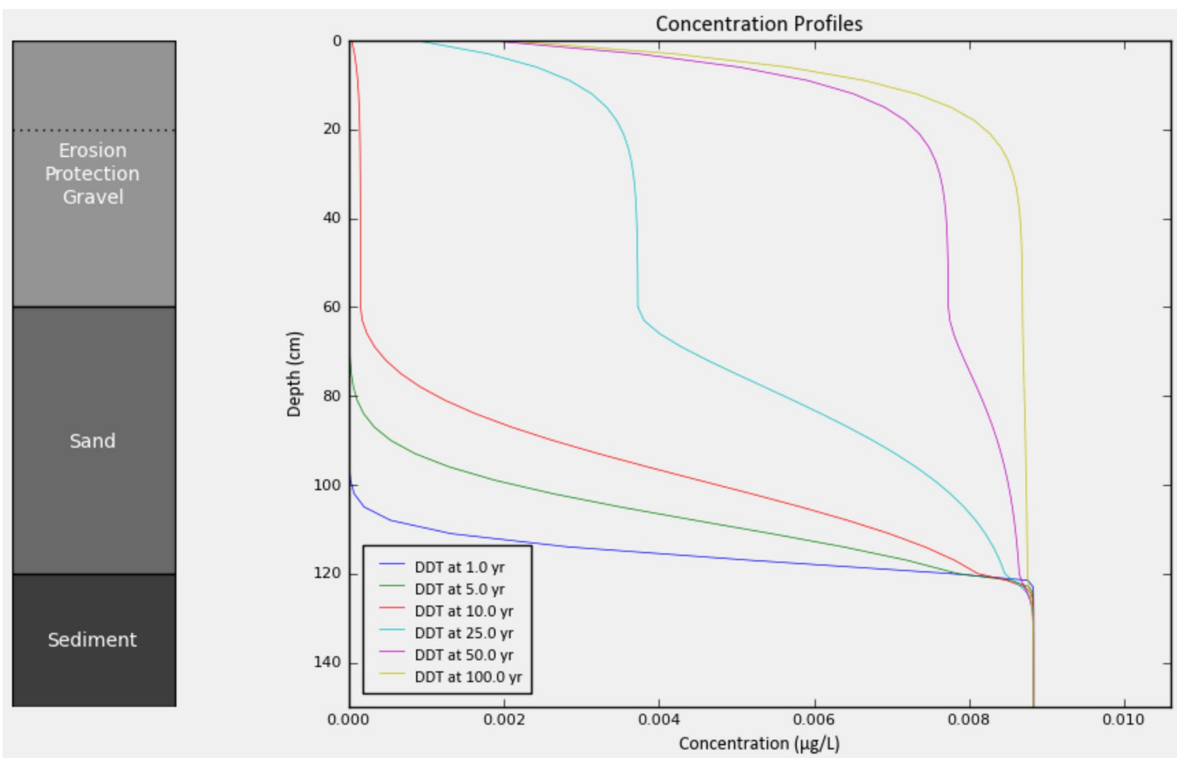

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Benzo(k)fluoranthene at 1.0 yr
Benzo(k)fluoranthene at 5.0 yr
Benzo(k)fluoranthene at 10.0 yr
Benzo(k)fluoranthene at 25.0 yr
Benzo(k)fluoranthene at 50.0 yr
Benzo(k)fluoranthene at 100.0 yr
Depth (cm)
Concentration (µg/L)

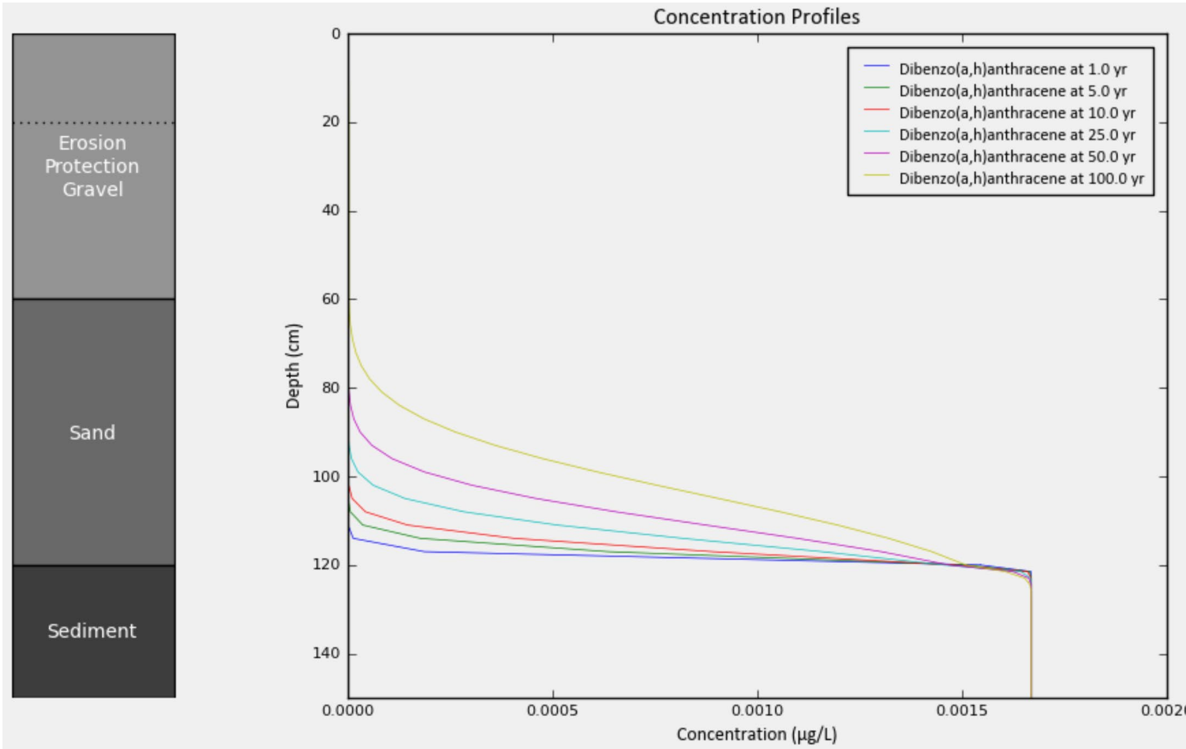

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
beta-chloronaphthalene at 1.0 yr
beta-chloronaphthalene at 5.0 yr
beta-chloronaphthalene at 10.0 yr
beta-chloronaphthalene at 25.0 yr
beta-chloronaphthalene at 50.0 yr
beta-chloronaphthalene at 100.0 yr
Depth (cm)
Concentration (µg/L)

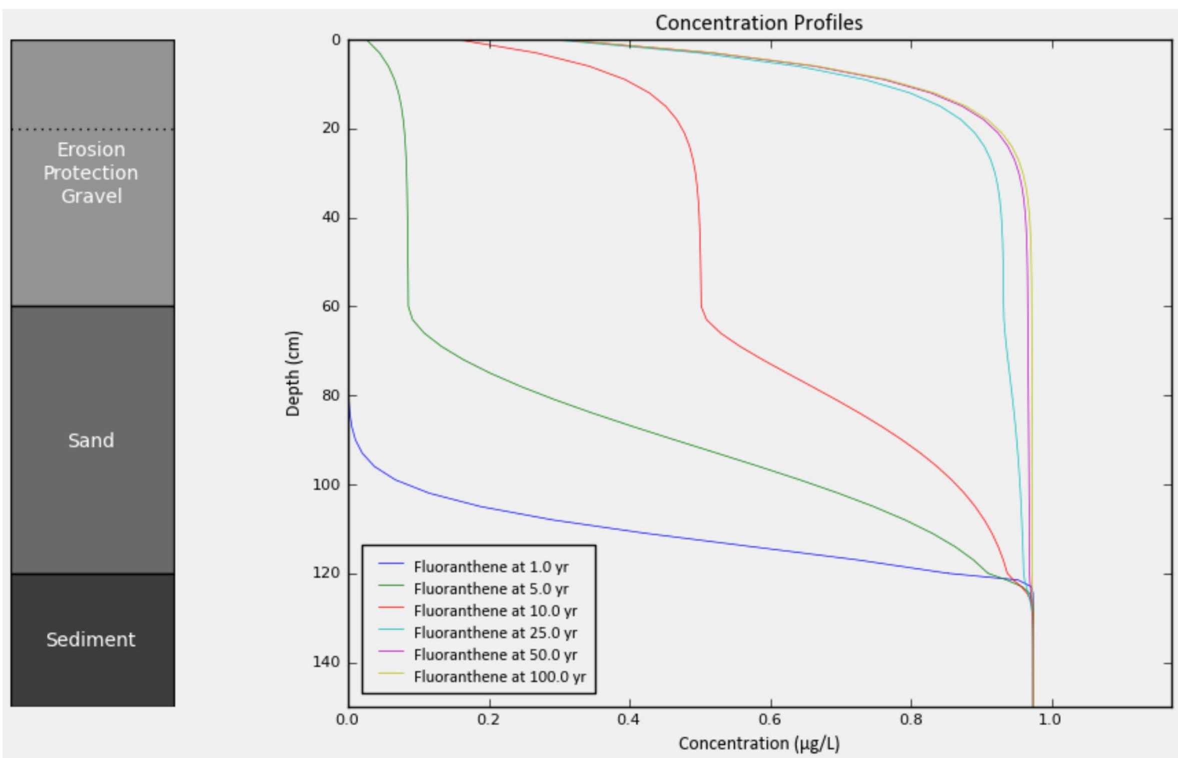

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Chrysene at 1.0 yr
Chrysene at 5.0 yr
Chrysene at 10.0 yr
Chrysene at 25.0 yr
Chrysene at 50.0 yr
Chrysene at 100.0 yr
Depth (cm)
Concentration (μg/L)

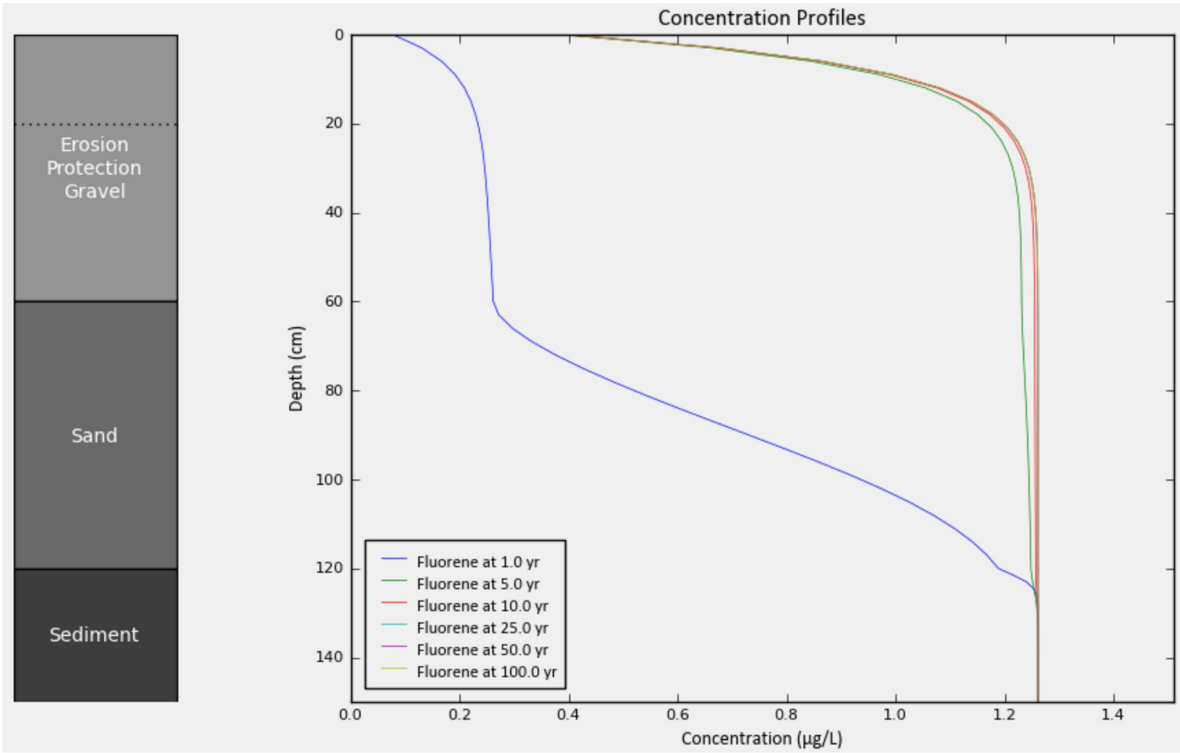

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
DDD at 1.0 yr
DDD at 5.0 yr
DDD at 10.0 yr
DDD at 25.0 yr
DDD at 50.0 yr
DDD at 100.0 yr
Depth (cm)
Concentration (μg/L)

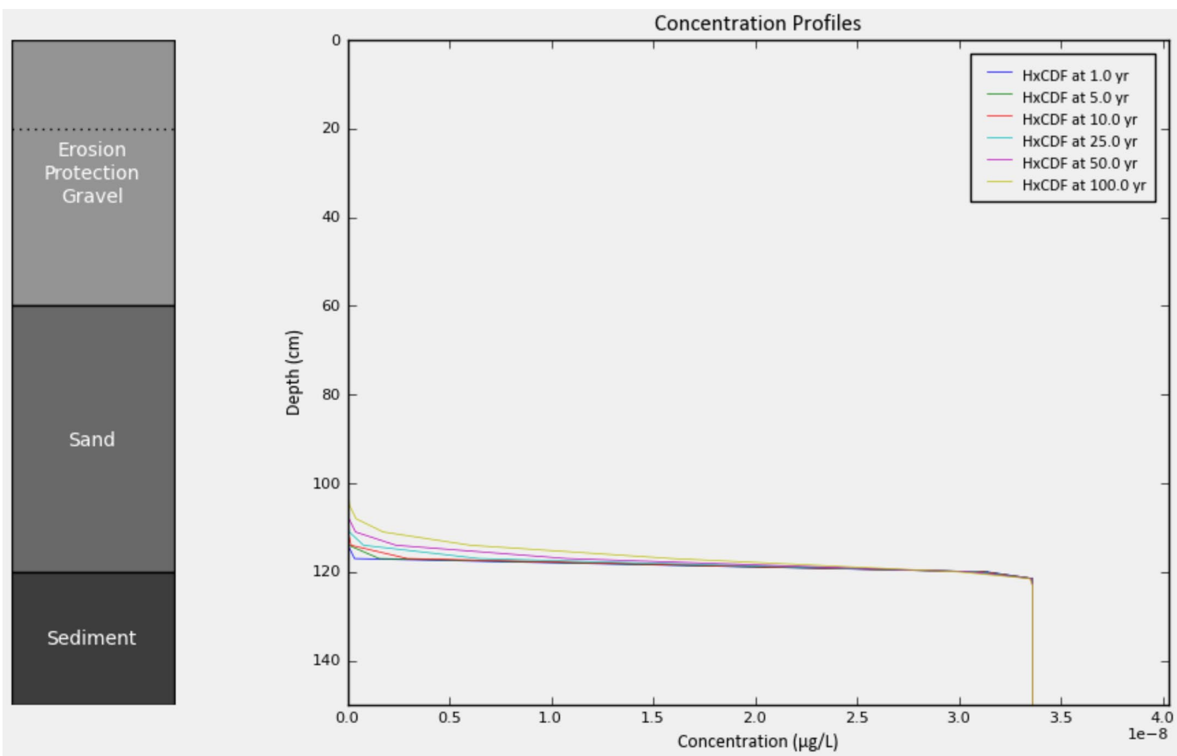

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
DDE at 1.0 yr
DDE at 5.0 yr
DDE at 10.0 yr
DDE at 25.0 yr
DDE at 50.0 yr
DDE at 100.0 yr

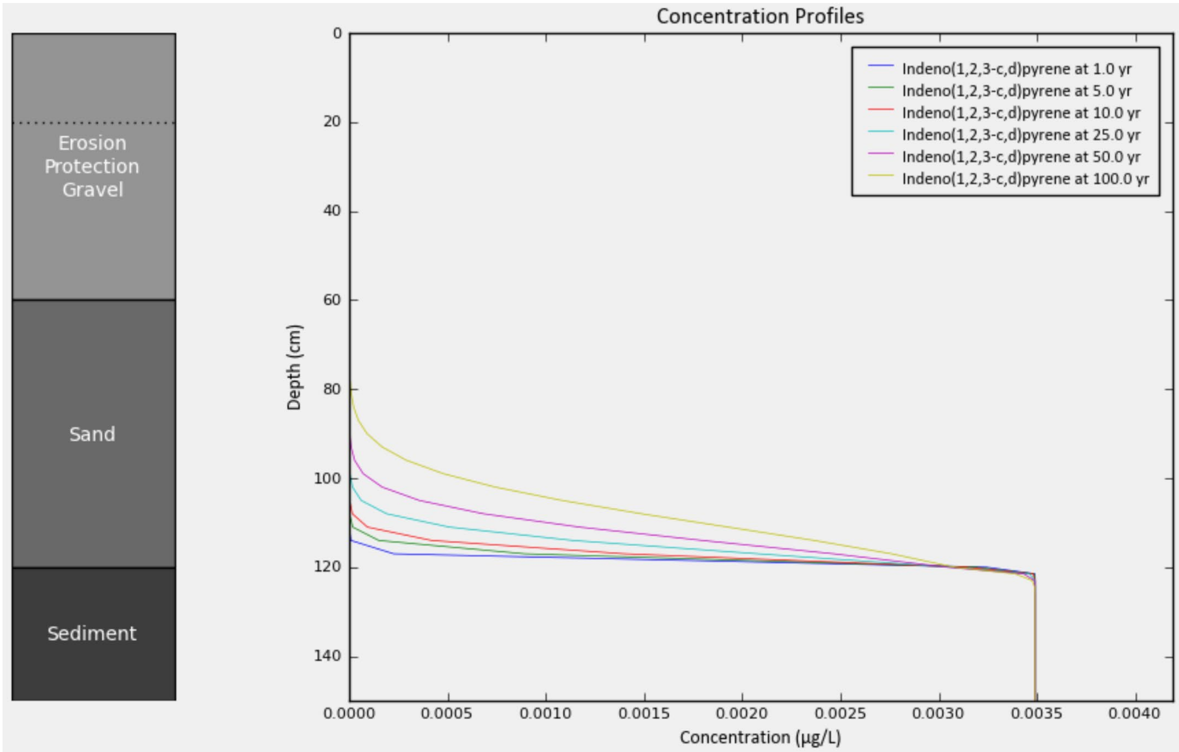

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
DDT at 1.0 yr
DDT at 5.0 yr
DDT at 10.0 yr
DDT at 25.0 yr
DDT at 50.0 yr
DDT at 100.0 yr

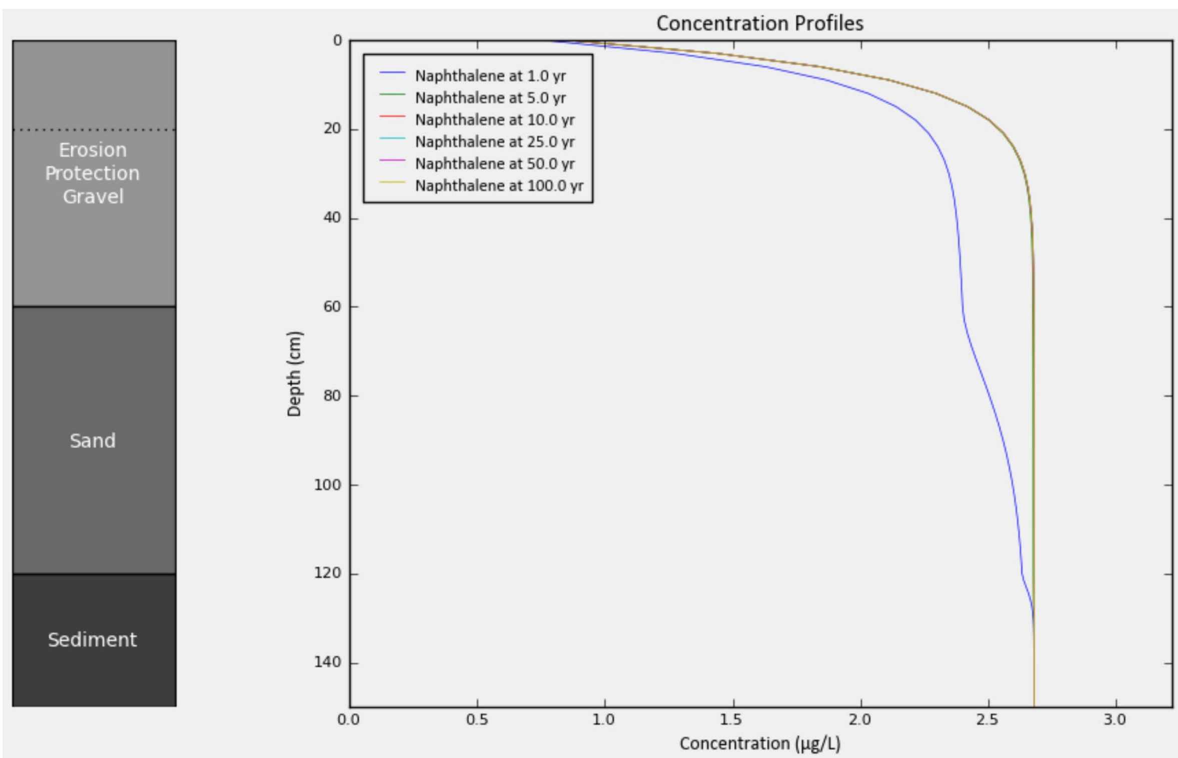

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (μg/L)
Dibenzo(a,h)anthracene at 1.0 yr
Dibenzo(a,h)anthracene at 5.0 yr
Dibenzo(a,h)anthracene at 10.0 yr
Dibenzo(a,h)anthracene at 25.0 yr
Dibenzo(a,h)anthracene at 50.0 yr
Dibenzo(a,h)anthracene at 100.0 yr
0
20
40
60
80
100
120
140
0.0000
0.0005
0.0010
0.0015
0.0020

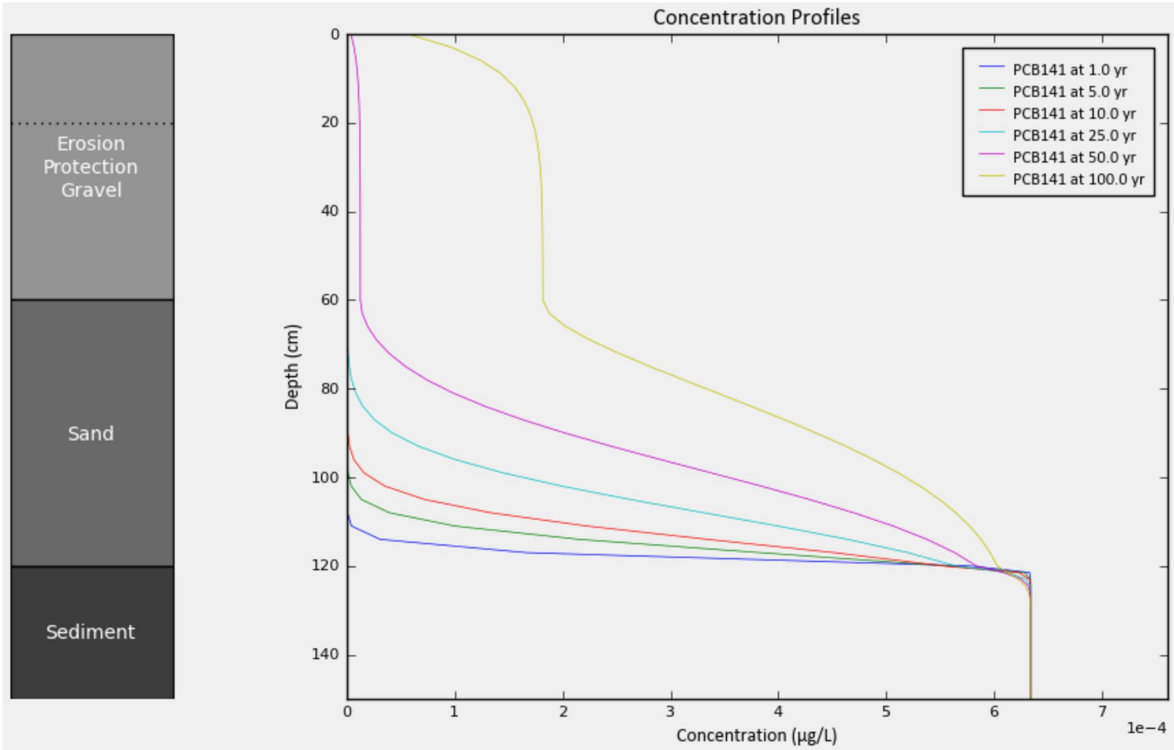

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (μg/L)
Fluoranthene at 1.0 yr
Fluoranthene at 5.0 yr
Fluoranthene at 10.0 yr
Fluoranthene at 25.0 yr
Fluoranthene at 50.0 yr
Fluoranthene at 100.0 yr
0
20
40
60
80
100
120
140
0.0
0.2
0.4
0.6
0.8
1.0

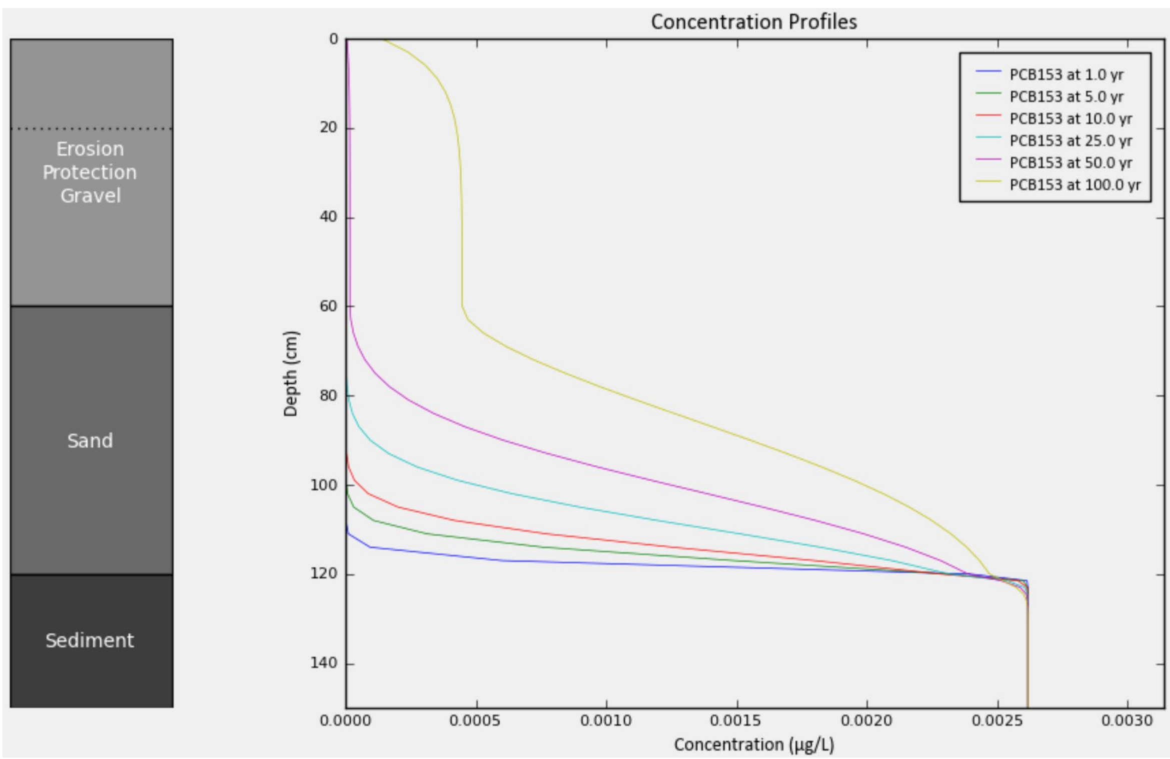

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Fluorene at 1.0 yr
Fluorene at 5.0 yr
Fluorene at 10.0 yr
Fluorene at 25.0 yr
Fluorene at 50.0 yr
Fluorene at 100.0 yr

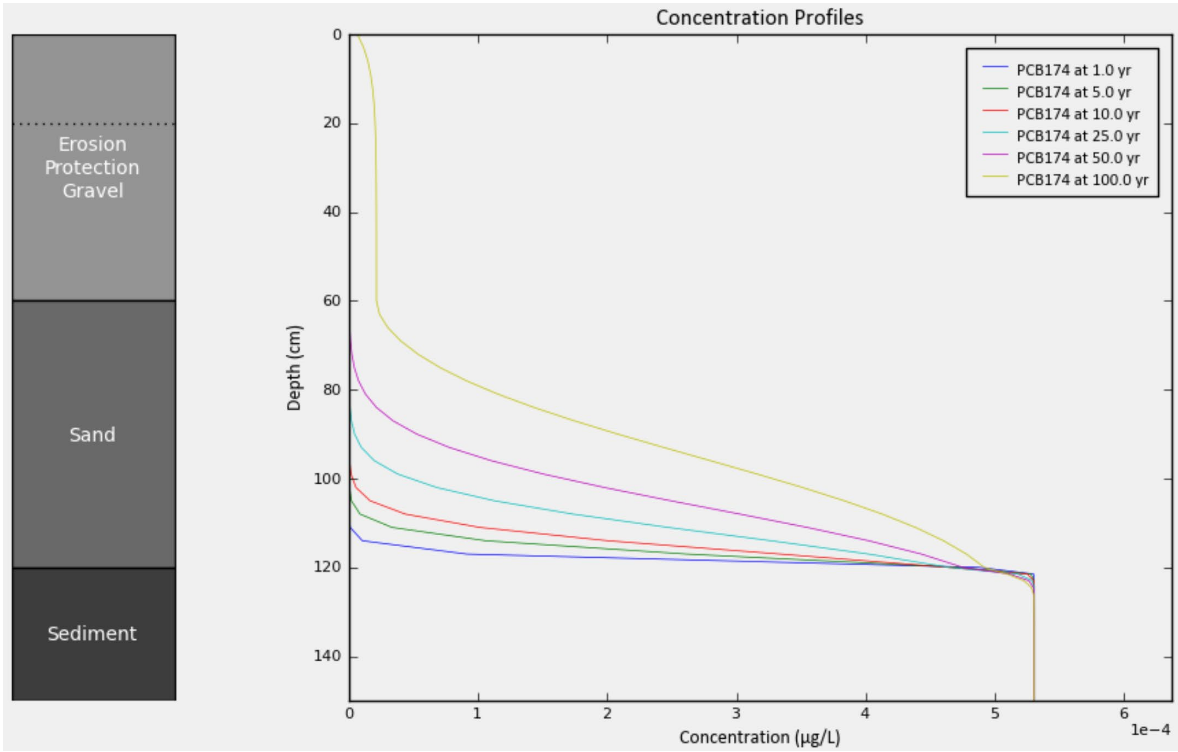

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−8
HxCDF at 1.0 yr
HxCDF at 5.0 yr
HxCDF at 10.0 yr
HxCDF at 25.0 yr
HxCDF at 50.0 yr
HxCDF at 100.0 yr

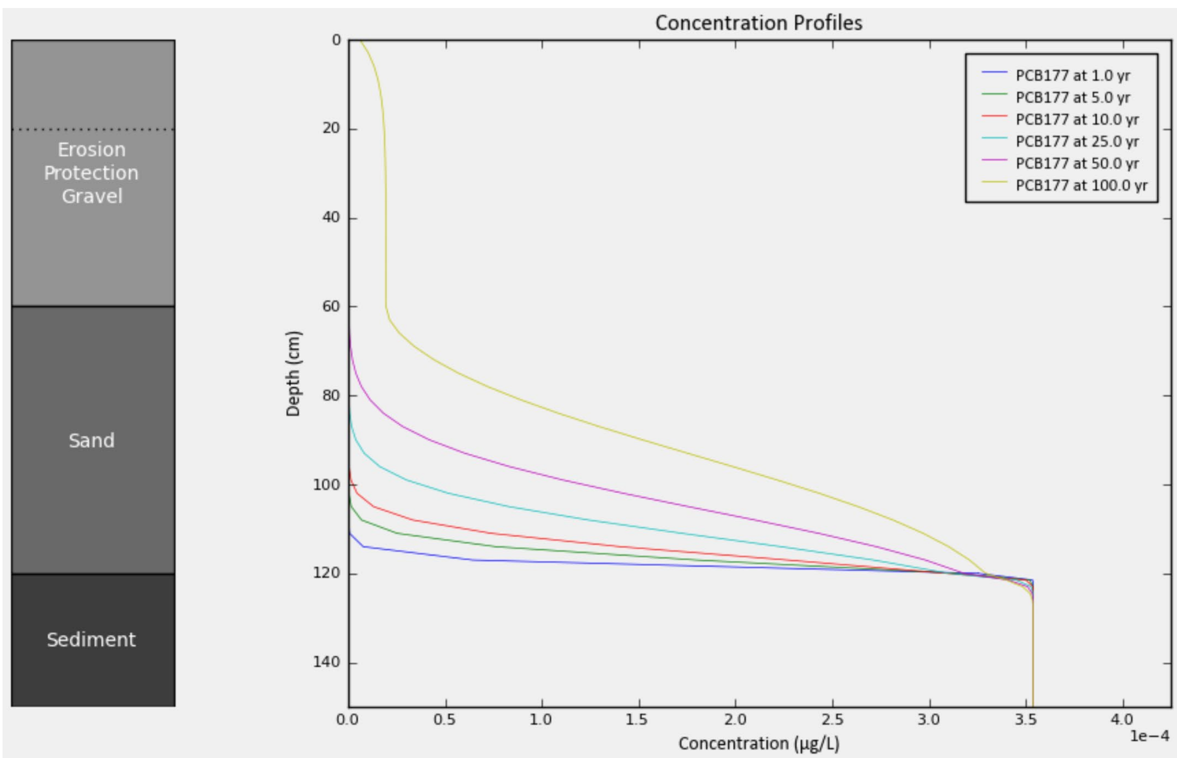

Erosion
Protection
Gravel
Sand
Sediment
Concentration Profiles
Indeno(1,2,3-c,d)pyrene at 1.0 yr
Indeno(1,2,3-c,d)pyrene at 5.0 yr
Indeno(1,2,3-c,d)pyrene at 10.0 yr
Indeno(1,2,3-c,d)pyrene at 25.0 yr
Indeno(1,2,3-c,d)pyrene at 50.0 yr
Indeno(1,2,3-c,d)pyrene at 100.0 yr
Depth (cm)
Concentration (µg/L)

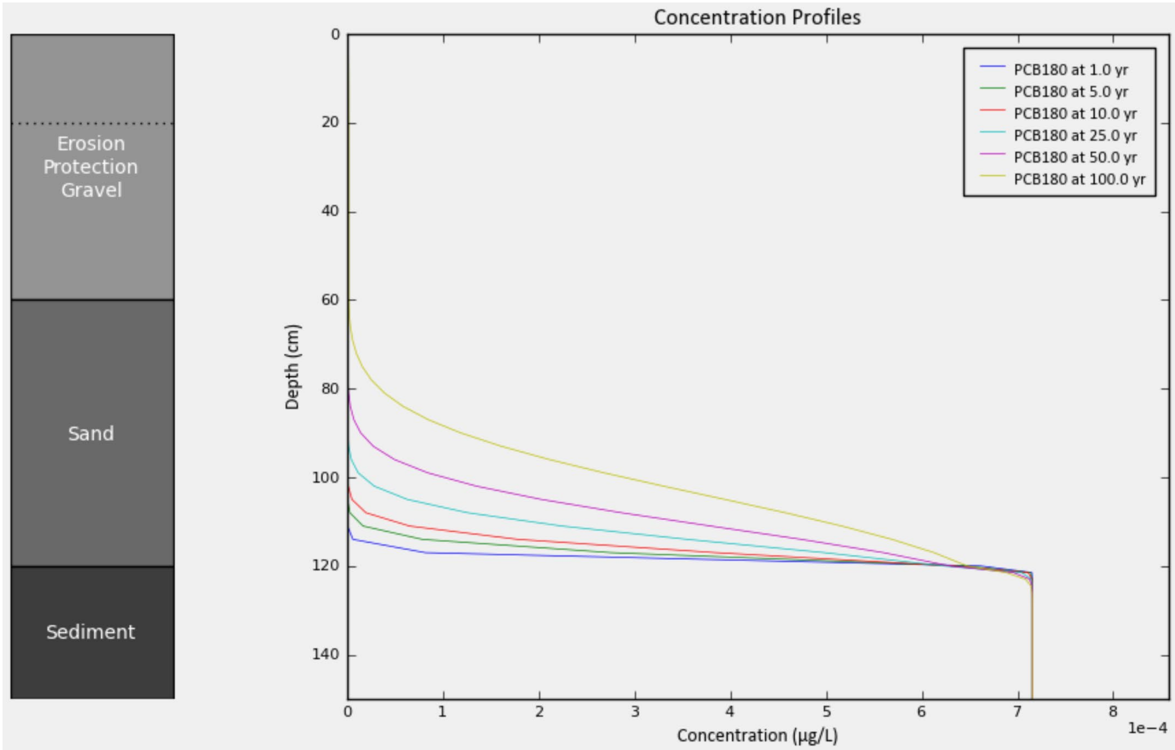

Erosion
Protection
Gravel
Sand
Sediment
Concentration Profiles
Naphthalene at 1.0 yr
Naphthalene at 5.0 yr
Naphthalene at 10.0 yr
Naphthalene at 25.0 yr
Naphthalene at 50.0 yr
Naphthalene at 100.0 yr
Depth (cm)
Concentration (µg/L)

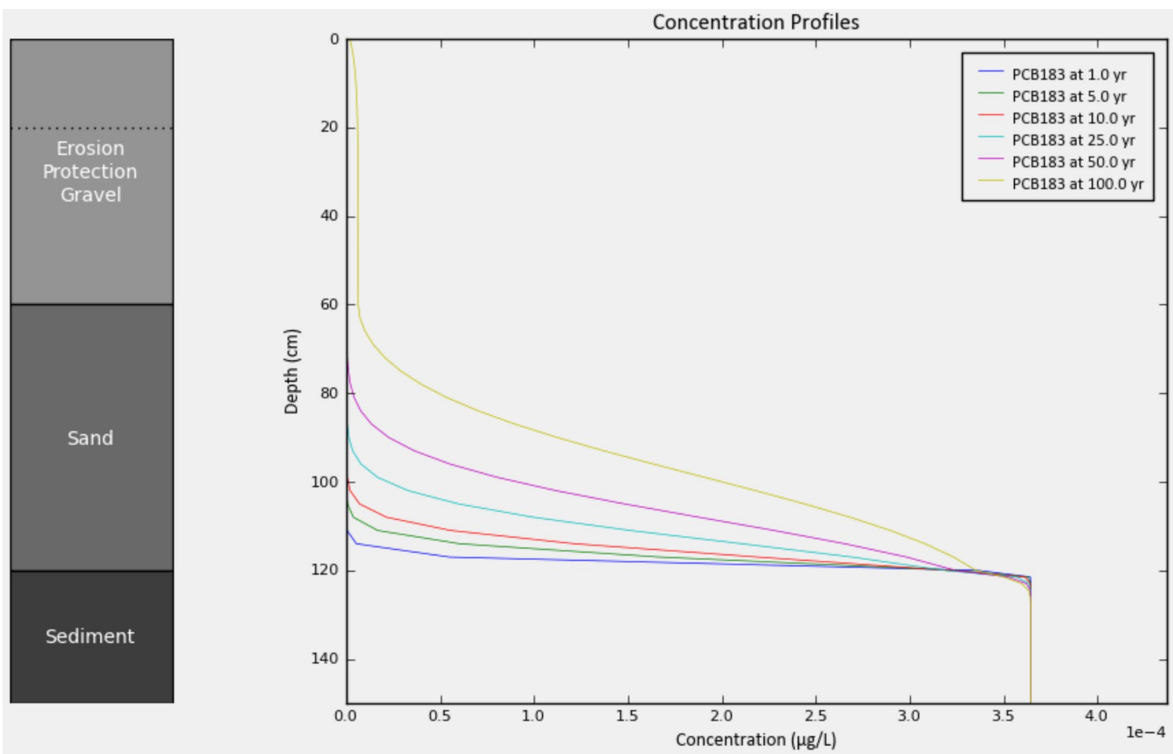

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−4
PCB141 at 1.0 yr
PCB141 at 5.0 yr
PCB141 at 10.0 yr
PCB141 at 25.0 yr
PCB141 at 50.0 yr
PCB141 at 100.0 yr

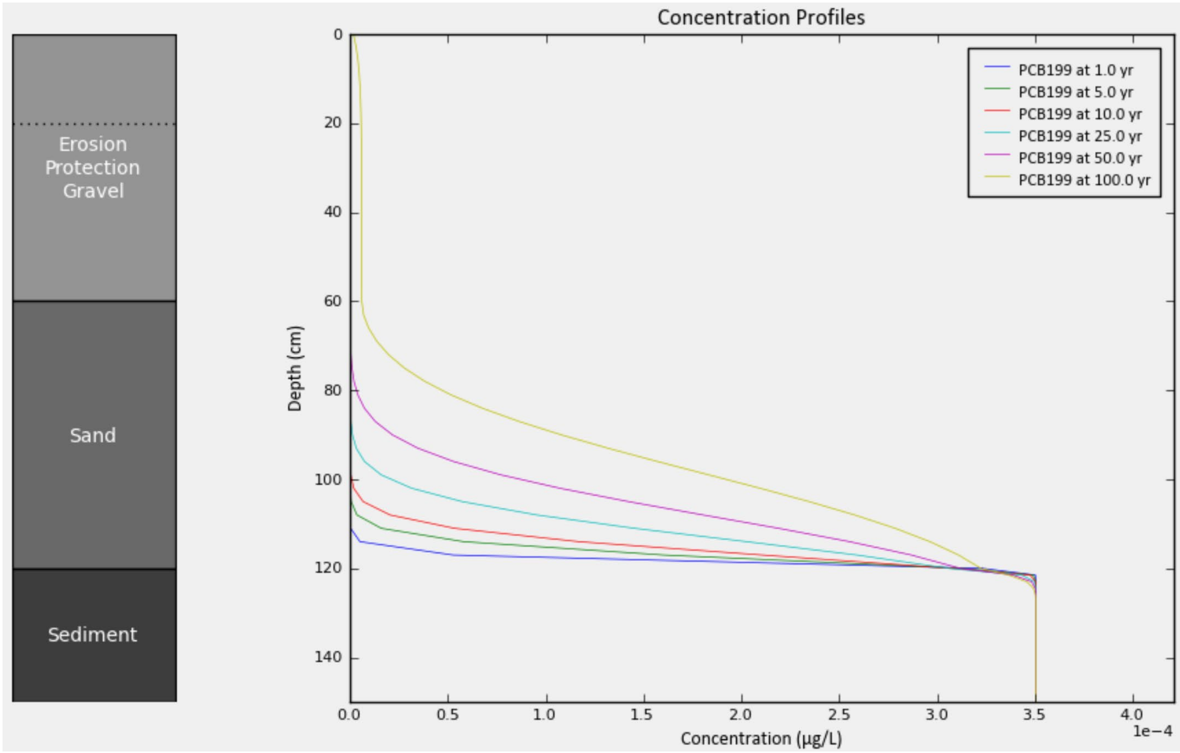

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
PCB153 at 1.0 yr
PCB153 at 5.0 yr
PCB153 at 10.0 yr
PCB153 at 25.0 yr
PCB153 at 50.0 yr
PCB153 at 100.0 yr

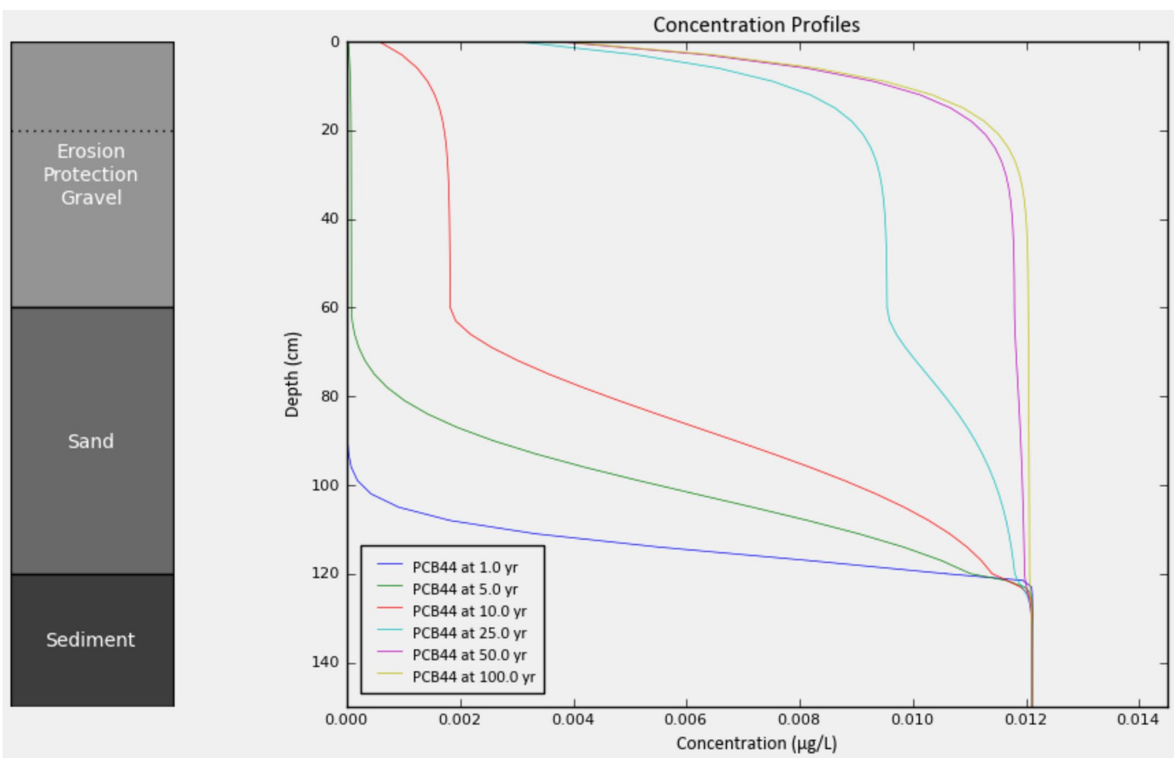

Erosion
Protection
Gravel
Sand
Sediment
Concentration Profiles
PCB174 at 1.0 yr
PCB174 at 5.0 yr
PCB174 at 10.0 yr
PCB174 at 25.0 yr
PCB174 at 50.0 yr
PCB174 at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−4

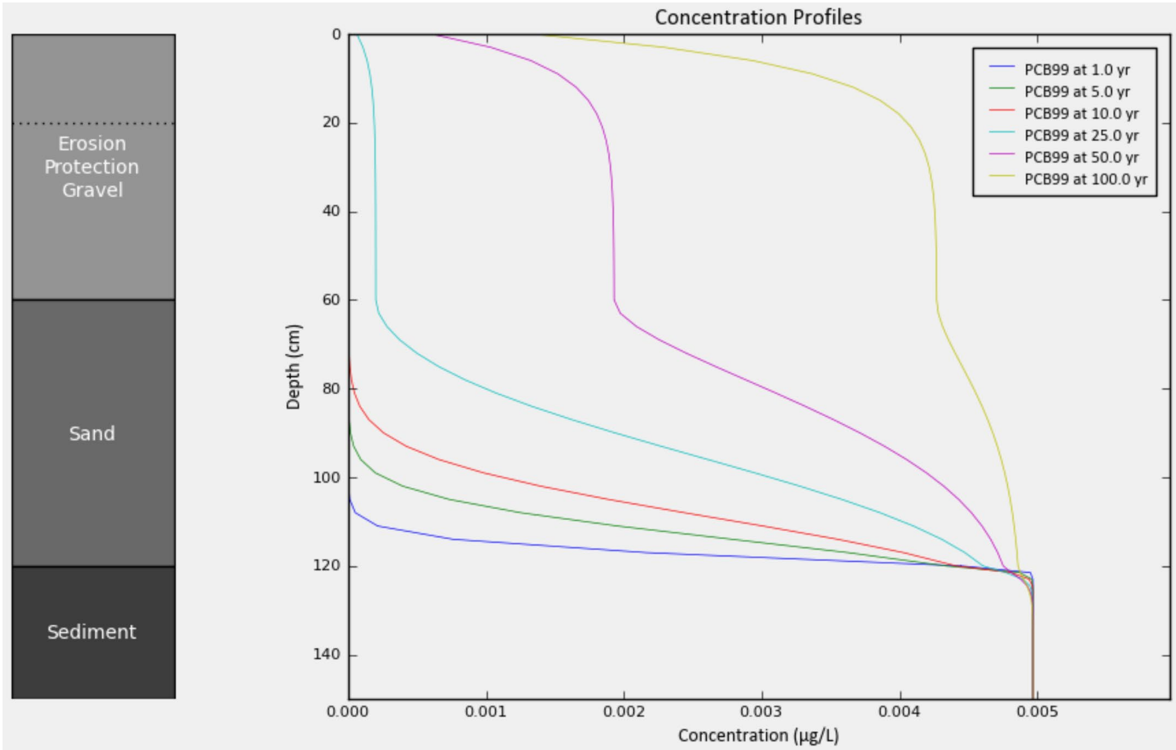

Erosion
Protection
Gravel
Sand
Sediment
Concentration Profiles
PCB177 at 1.0 yr
PCB177 at 5.0 yr
PCB177 at 10.0 yr
PCB177 at 25.0 yr
PCB177 at 50.0 yr
PCB177 at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−4

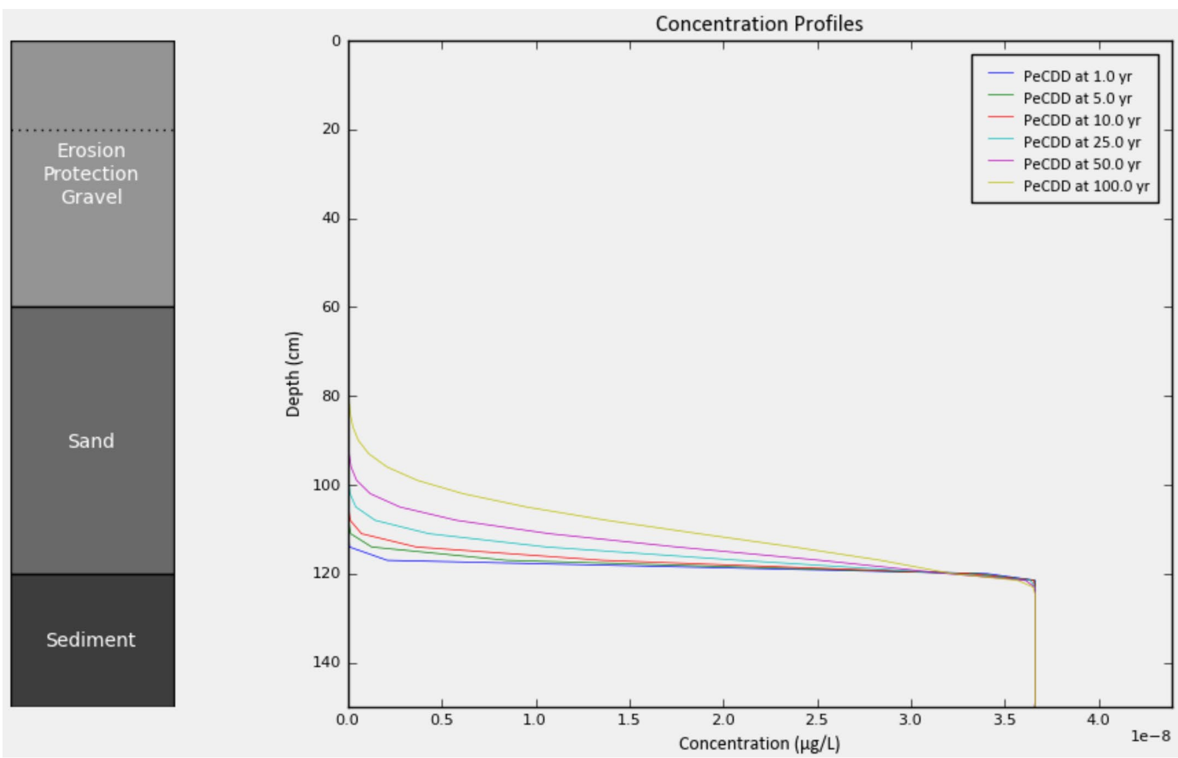

Erosion
Protection
Gravel
Sand
Sediment
Concentration Profiles
PCB180 at 1.0 yr
PCB180 at 5.0 yr
PCB180 at 10.0 yr
PCB180 at 25.0 yr
PCB180 at 50.0 yr
PCB180 at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−4

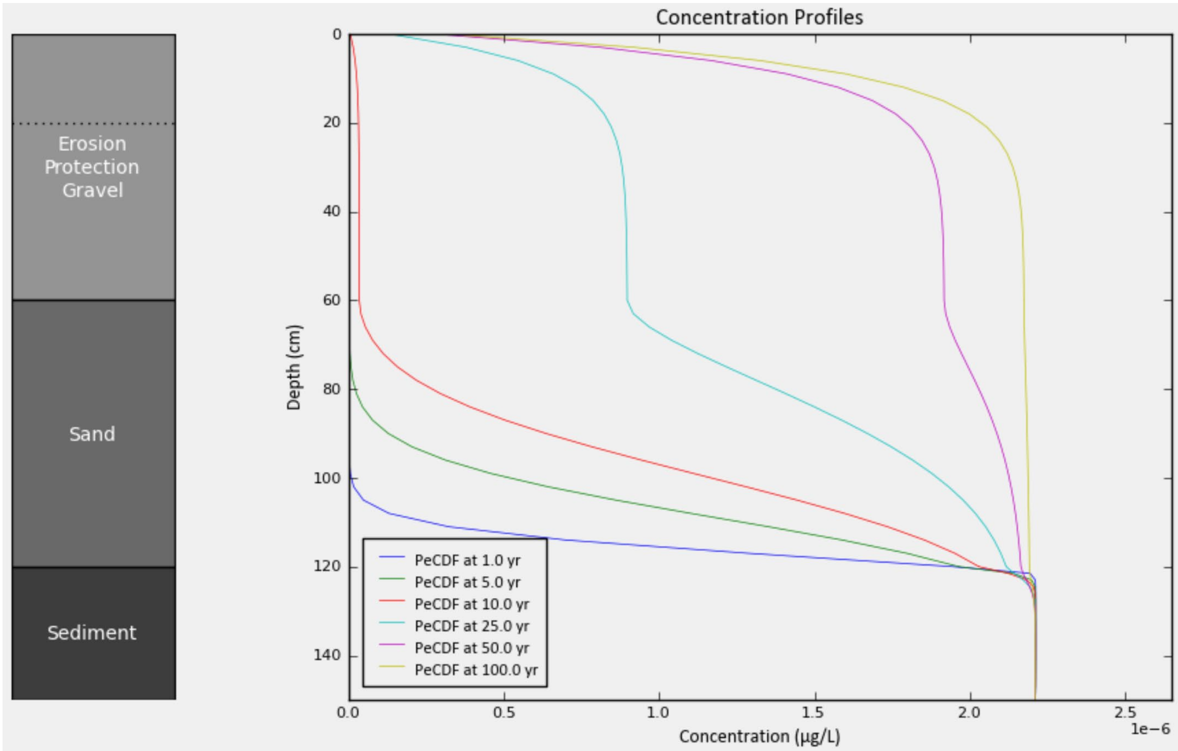

Erosion
Protection
Gravel
Sand
Sediment
Concentration Profiles
PCB183 at 1.0 yr
PCB183 at 5.0 yr
PCB183 at 10.0 yr
PCB183 at 25.0 yr
PCB183 at 50.0 yr
PCB183 at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−4

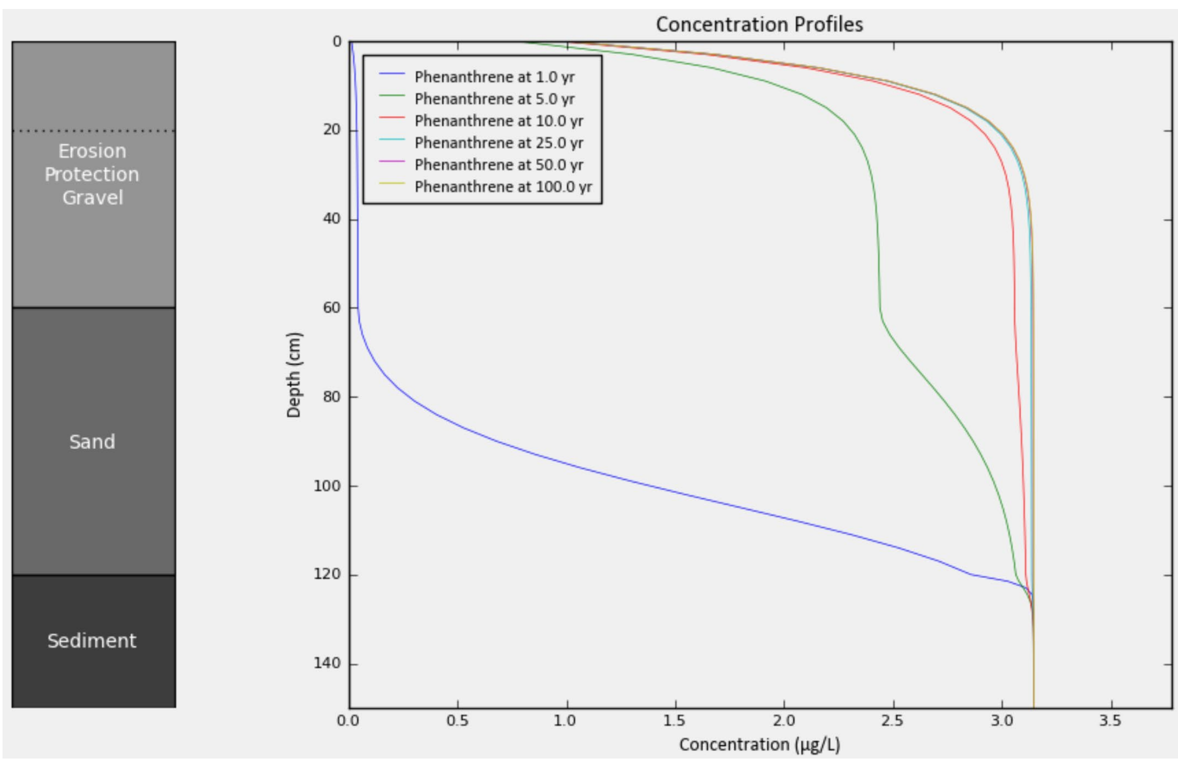

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
PCB199 at 1.0 yr
PCB199 at 5.0 yr
PCB199 at 10.0 yr
PCB199 at 25.0 yr
PCB199 at 50.0 yr
PCB199 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

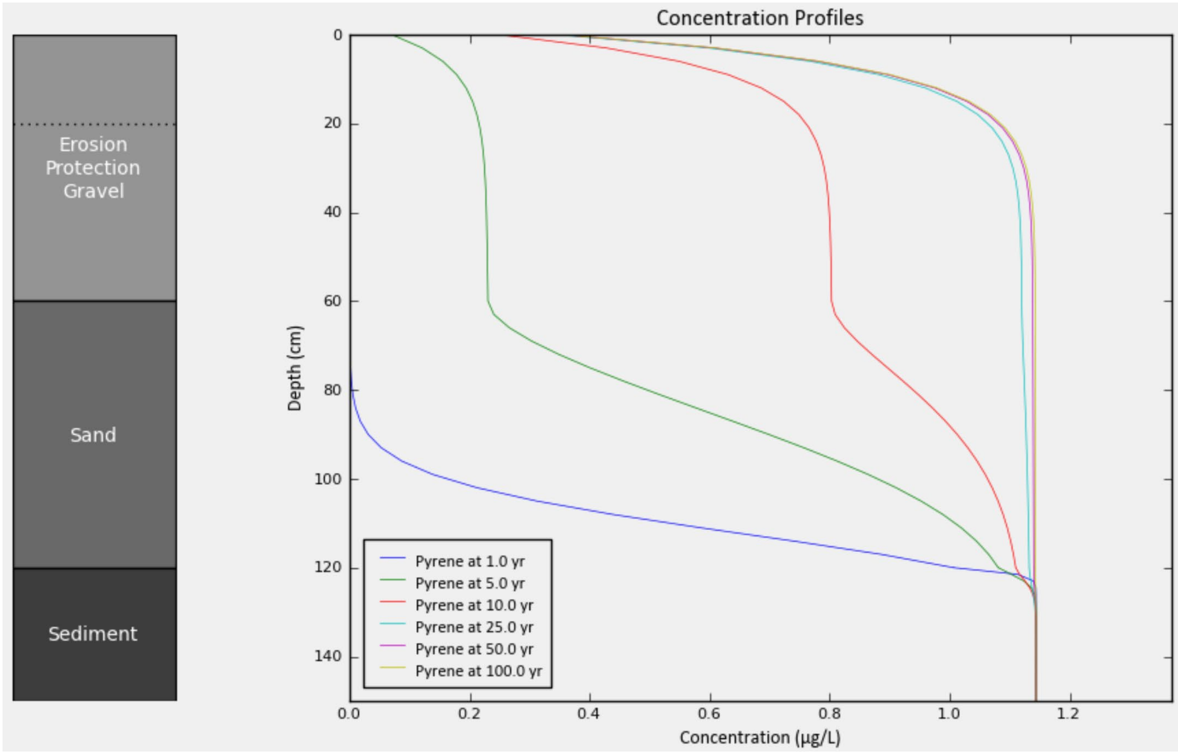

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
PCB44 at 1.0 yr
PCB44 at 5.0 yr
PCB44 at 10.0 yr
PCB44 at 25.0 yr
PCB44 at 50.0 yr
PCB44 at 100.0 yr
Depth (cm)
Concentration (µg/L)

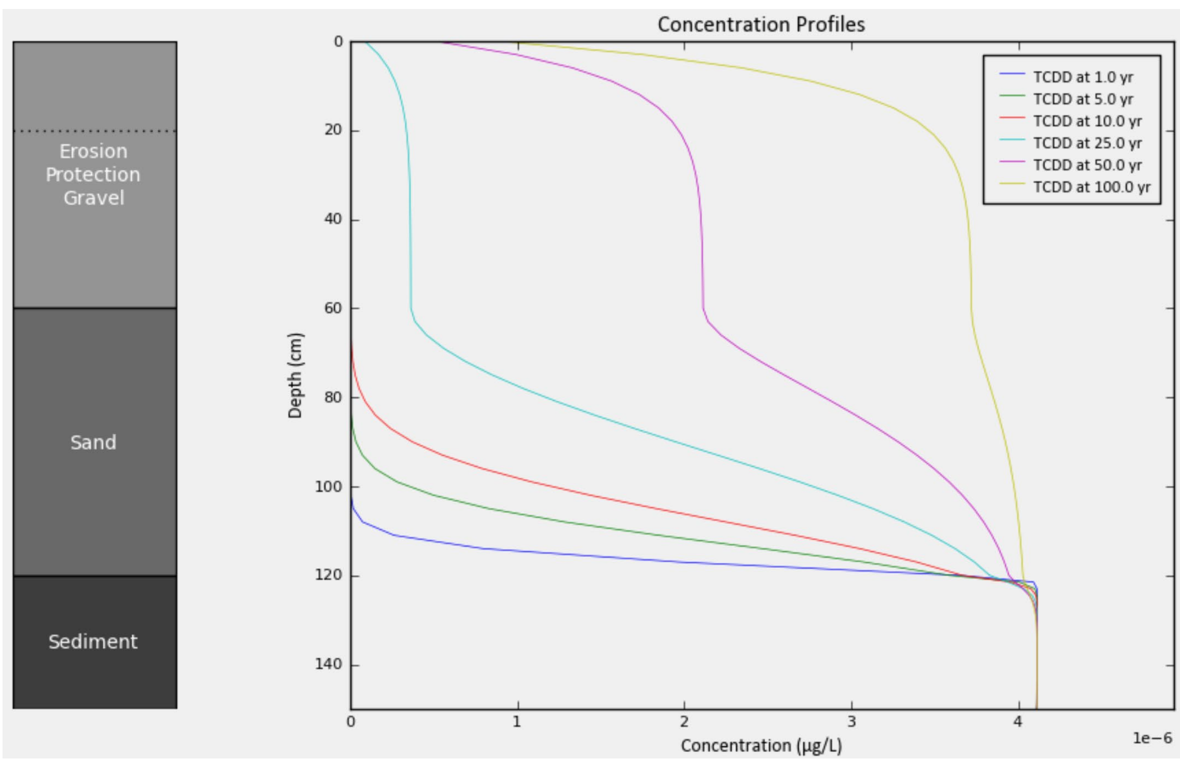

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (μg/L)
PCB99 at 1.0 yr
PCB99 at 5.0 yr
PCB99 at 10.0 yr
PCB99 at 25.0 yr
PCB99 at 50.0 yr
PCB99 at 100.0 yr

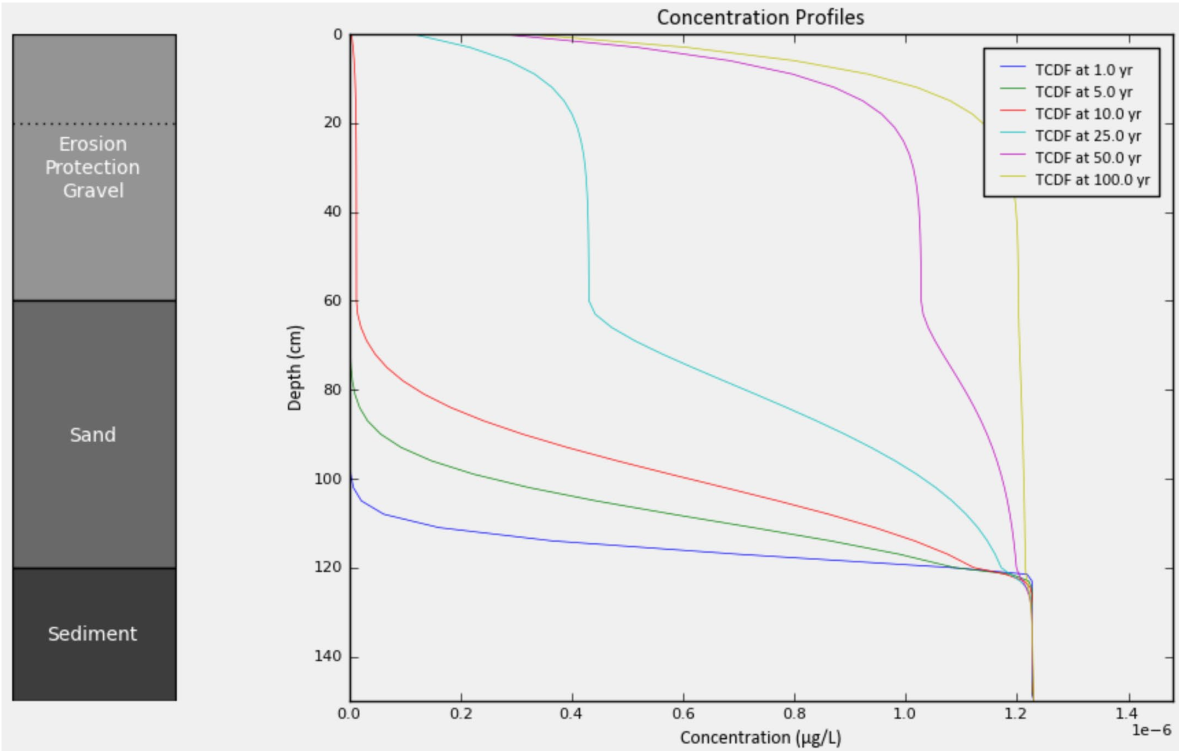

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (μg/L)
1e−8
PeCDD at 1.0 yr
PeCDD at 5.0 yr
PeCDD at 10.0 yr
PeCDD at 25.0 yr
PeCDD at 50.0 yr
PeCDD at 100.0 yr

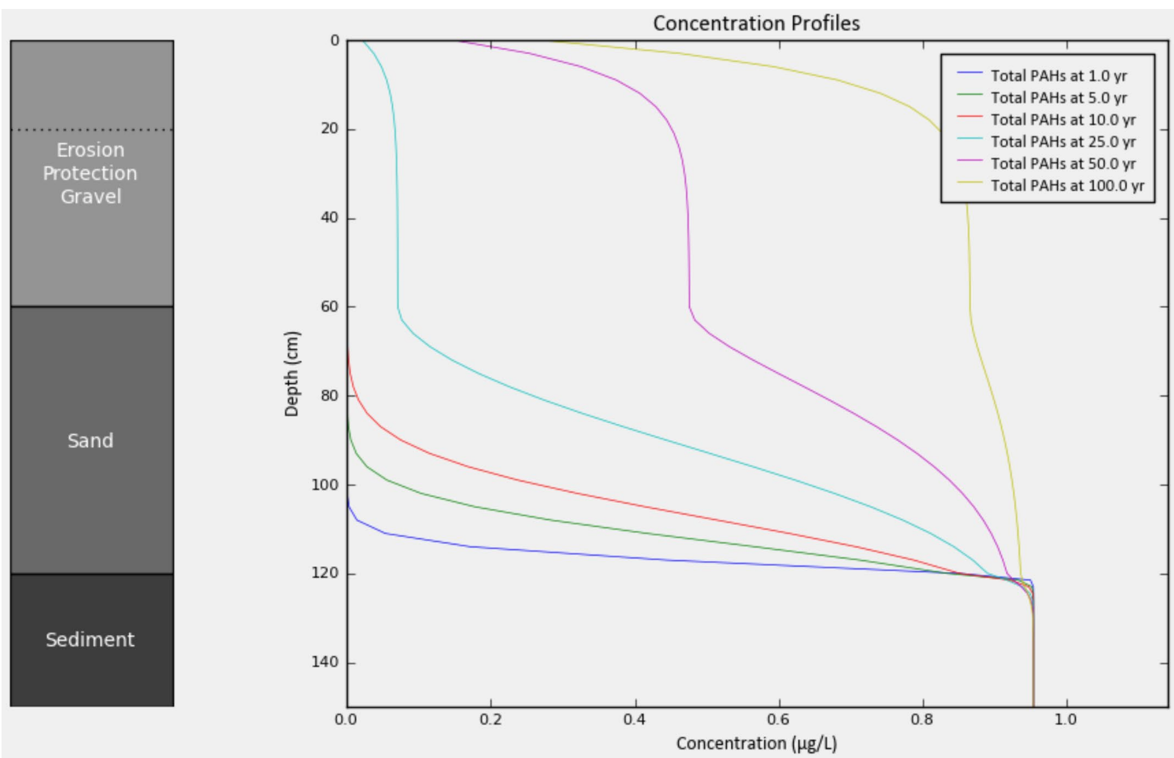

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−6
PeCDF at 1.0 yr
PeCDF at 5.0 yr
PeCDF at 10.0 yr
PeCDF at 25.0 yr
PeCDF at 50.0 yr
PeCDF at 100.0 yr

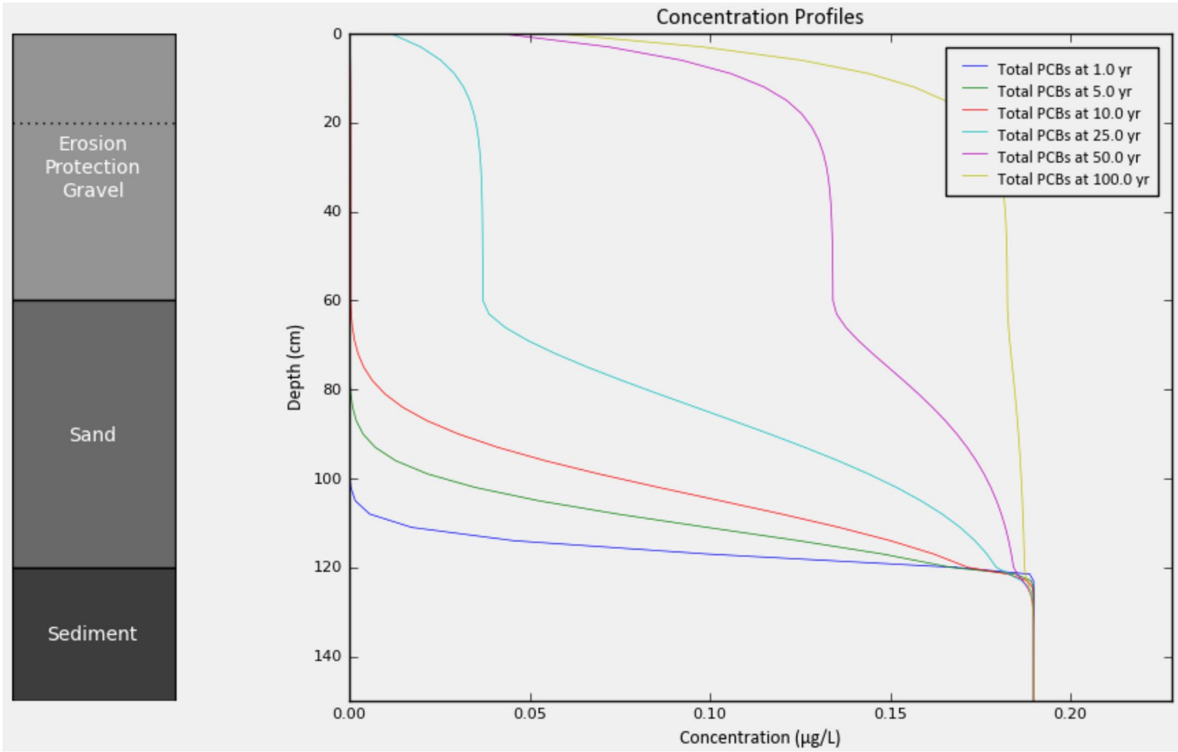

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Phenanthrene at 1.0 yr
Phenanthrene at 5.0 yr
Phenanthrene at 10.0 yr
Phenanthrene at 25.0 yr
Phenanthrene at 50.0 yr
Phenanthrene at 100.0 yr

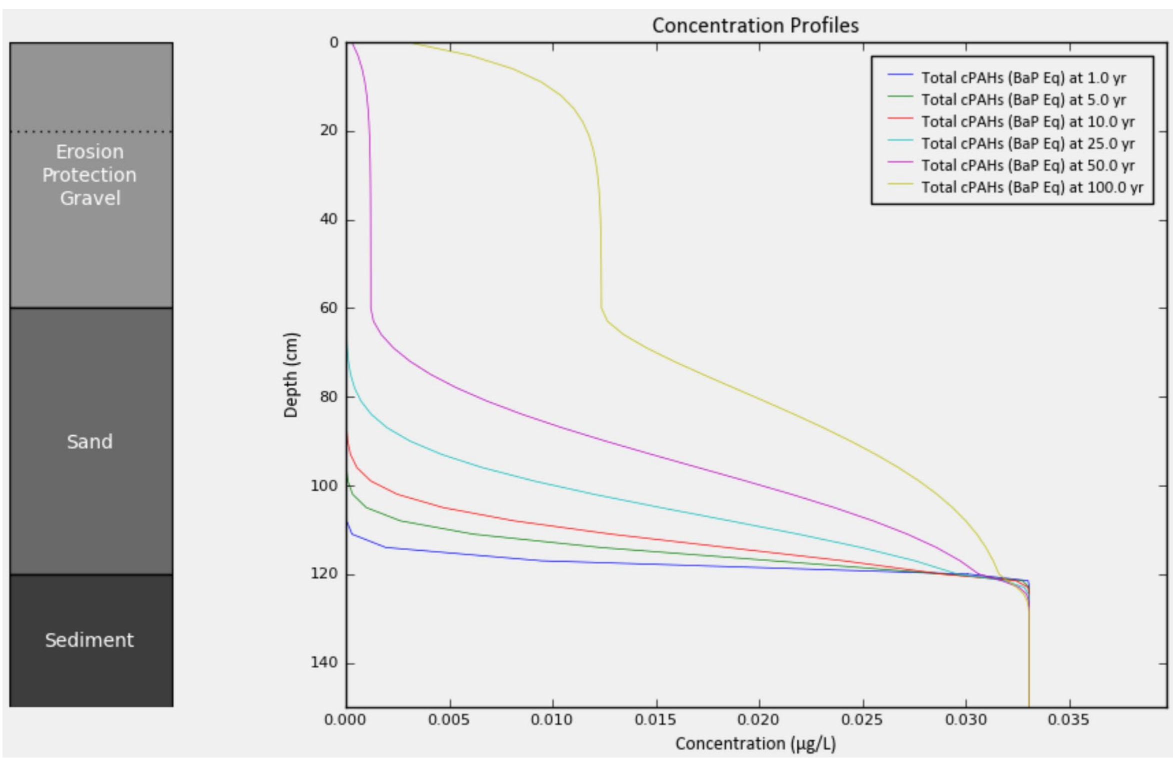

Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Pyrene at 1.0 yr
Pyrene at 5.0 yr
Pyrene at 10.0 yr
Pyrene at 25.0 yr
Pyrene at 50.0 yr
Pyrene at 100.0 yr


Concentration Profiles
Erosion Protection Gravel
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−6
TCDD at 1.0 yr
TCDD at 5.0 yr
TCDD at 10.0 yr
TCDD at 25.0 yr
TCDD at 50.0 yr
TCDD at 100.0 yr

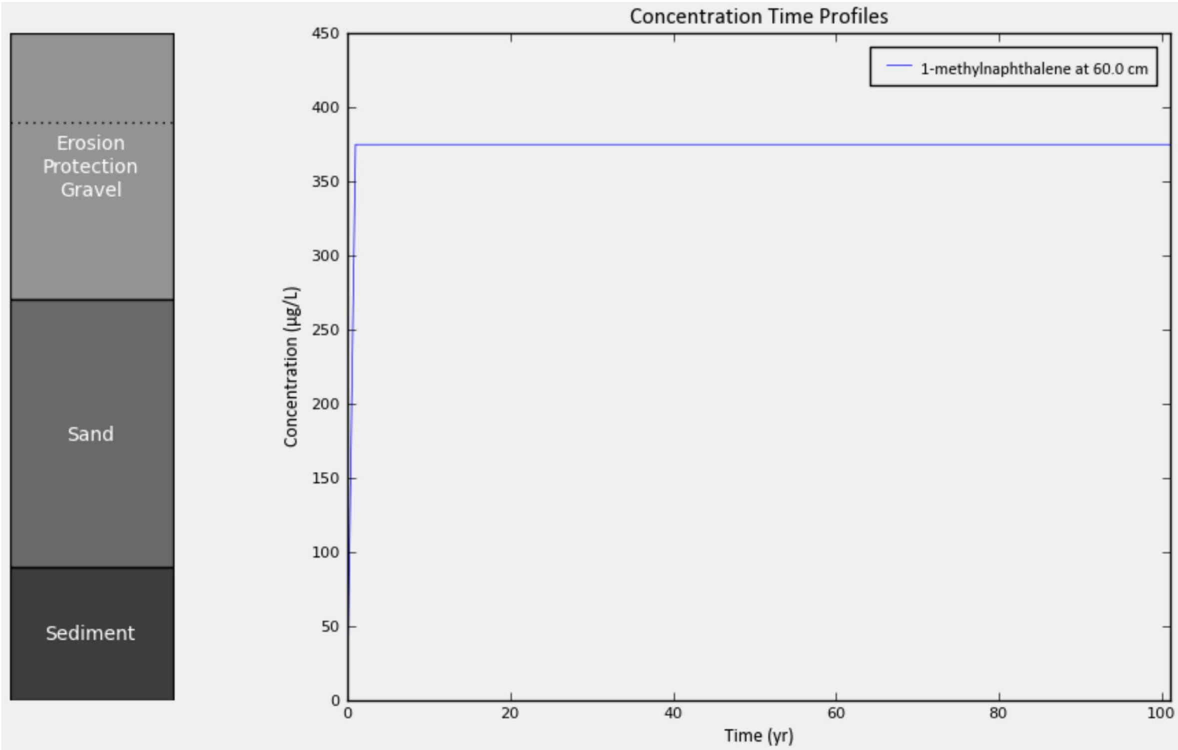

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
1e−6
TCDF at 1.0 yr
TCDF at 5.0 yr
TCDF at 10.0 yr
TCDF at 25.0 yr
TCDF at 50.0 yr
TCDF at 100.0 yr

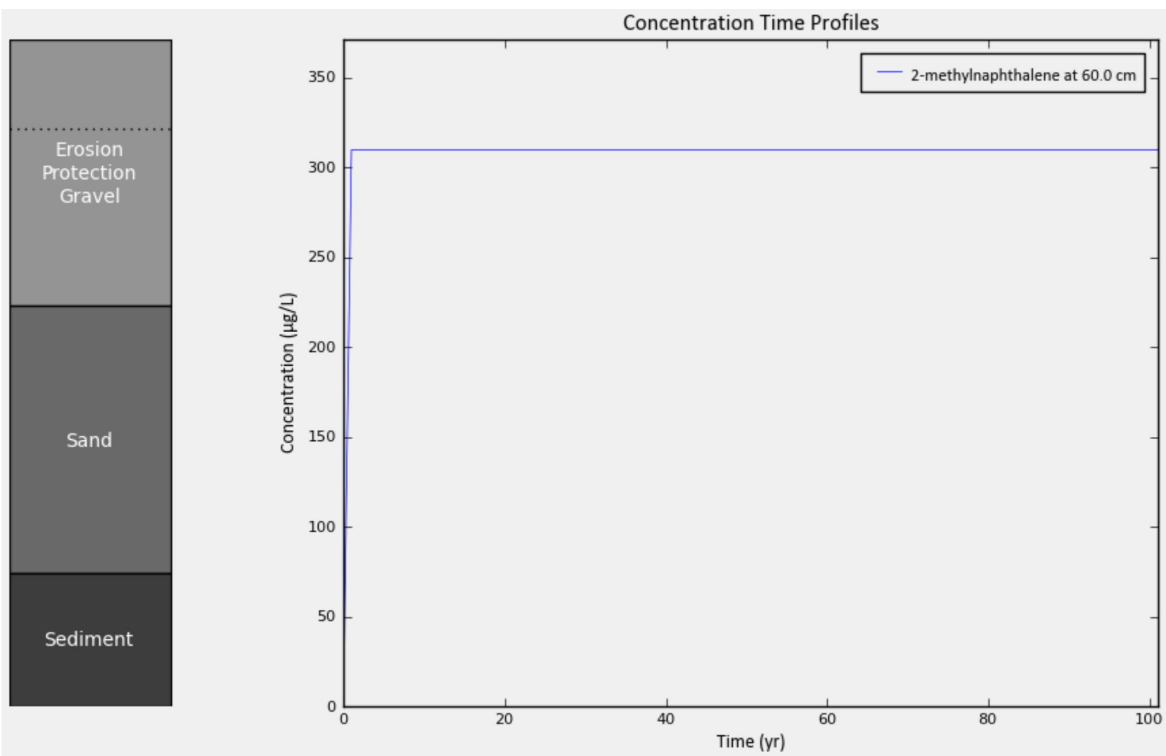

Erosion Protection Gravel
Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Total PAHs at 1.0 yr
Total PAHs at 5.0 yr
Total PAHs at 10.0 yr
Total PAHs at 25.0 yr
Total PAHs at 50.0 yr
Total PAHs at 100.0 yr

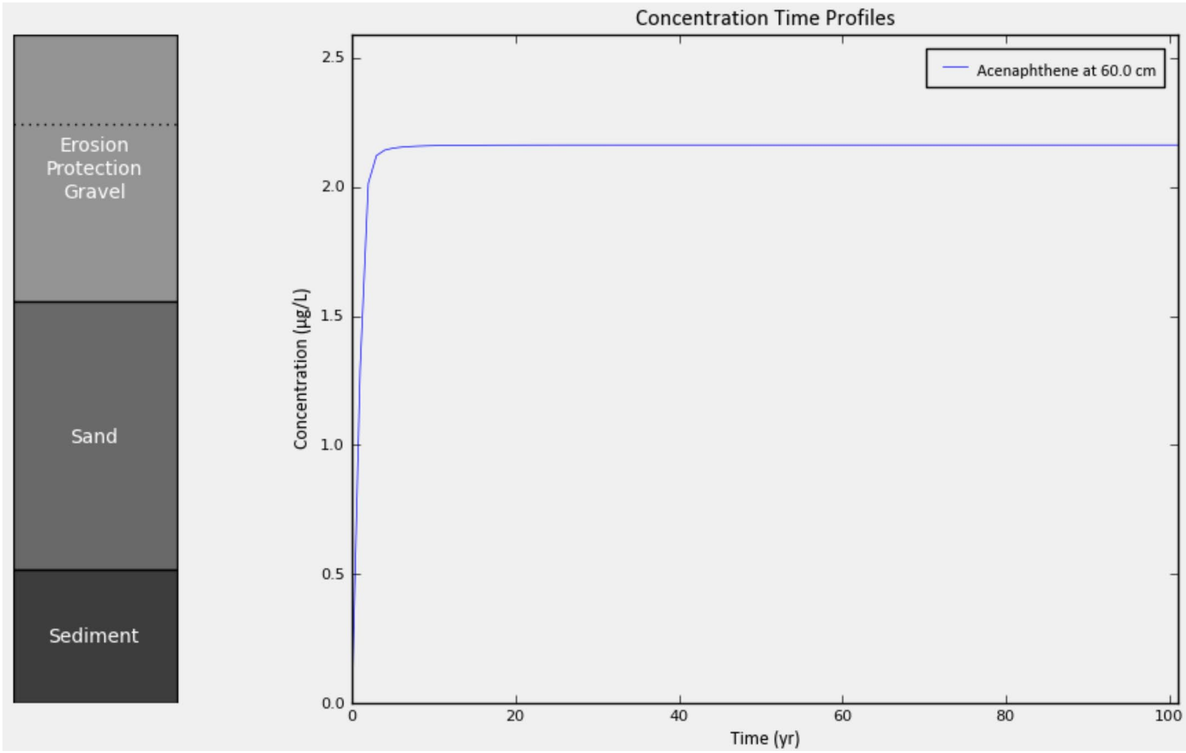

Erosion
Protection
Gravel
Sand
Sediment
Concentration Profiles
Total PCBs at 1.0 yr
Total PCBs at 5.0 yr
Total PCBs at 10.0 yr
Total PCBs at 25.0 yr
Total PCBs at 50.0 yr
Total PCBs at 100.0 yr
Depth (cm)
Concentration (μg/L)


Erosion
Protection
Gravel
Sand
Sediment
Concentration Profiles
Total cPAHs (BaP Eq) at 1.0 yr
Total cPAHs (BaP Eq) at 5.0 yr
Total cPAHs (BaP Eq) at 10.0 yr
Total cPAHs (BaP Eq) at 25.0 yr
Total cPAHs (BaP Eq) at 50.0 yr
Total cPAHs (BaP Eq) at 100.0 yr
Depth (cm)
Concentration (μg/L)

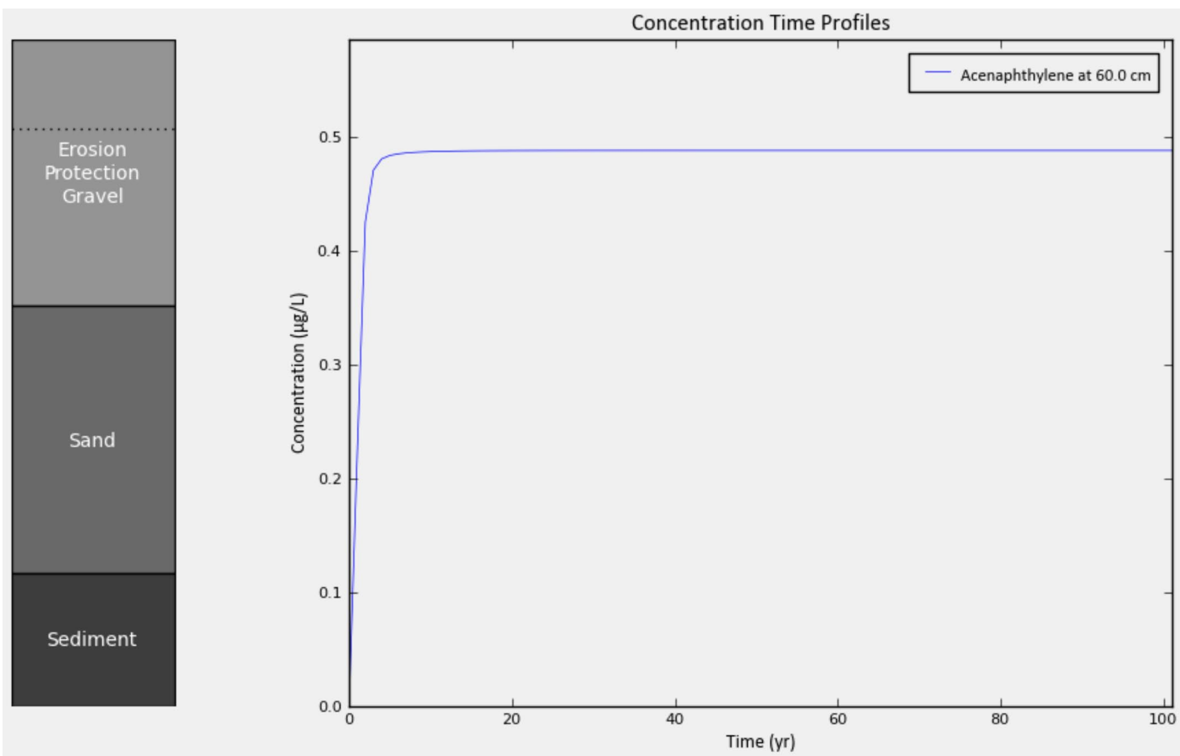
Porewater Concentration – Time



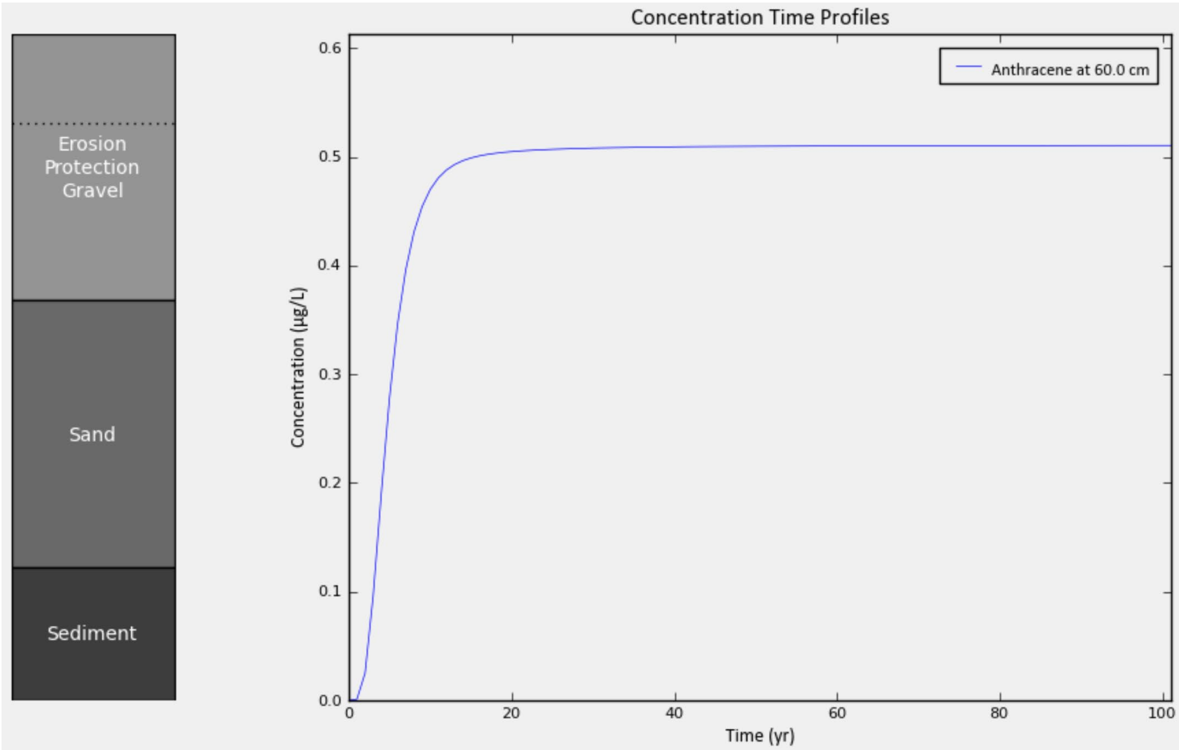


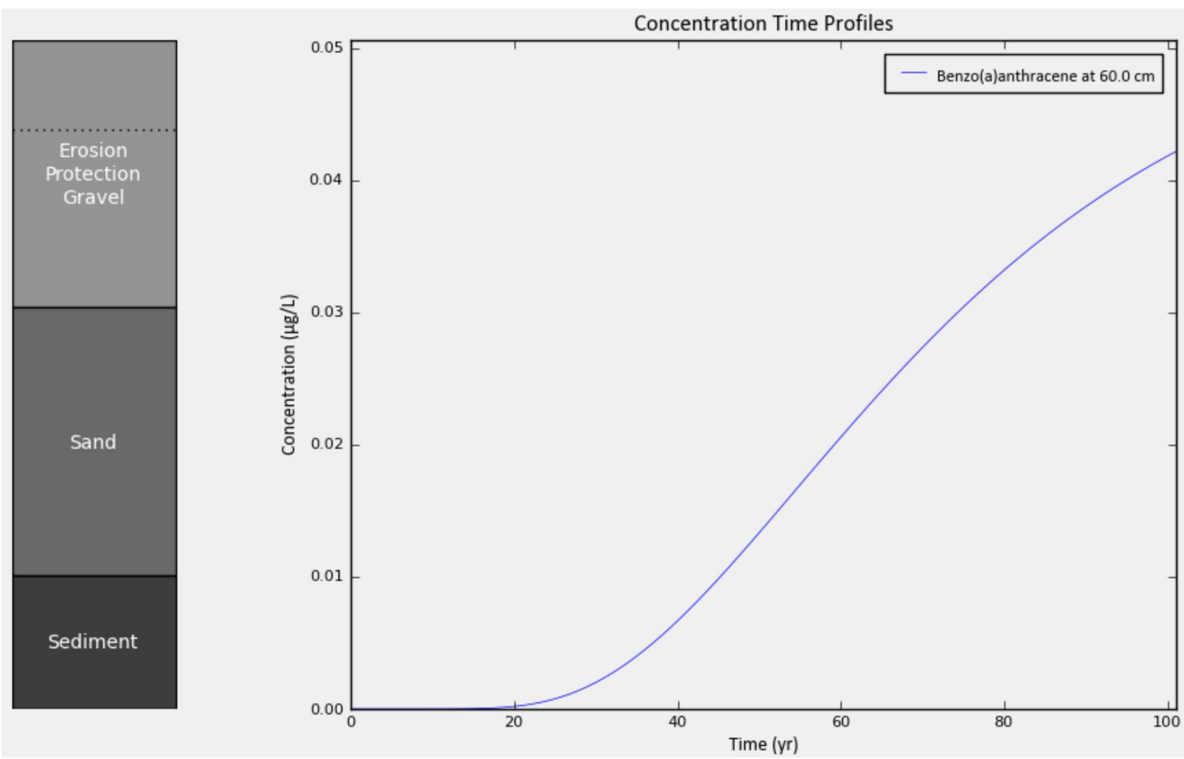


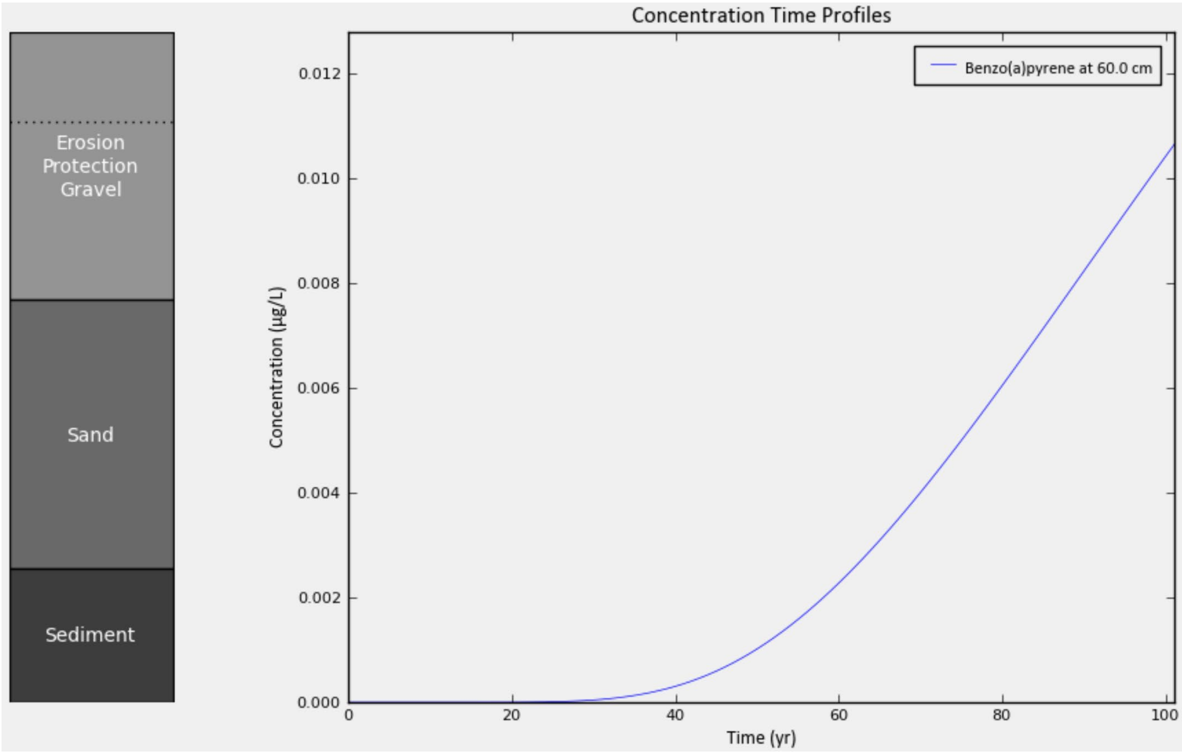
Erosion Protection Gravel
Sand
Sediment
Concentration Time Profiles
Acenaphthene at 60.0 cm
Concentration (µg/L)
Time (yr)
0.0
0.5
1.0
1.5
2.0
2.5
0
20
40
60
80
100

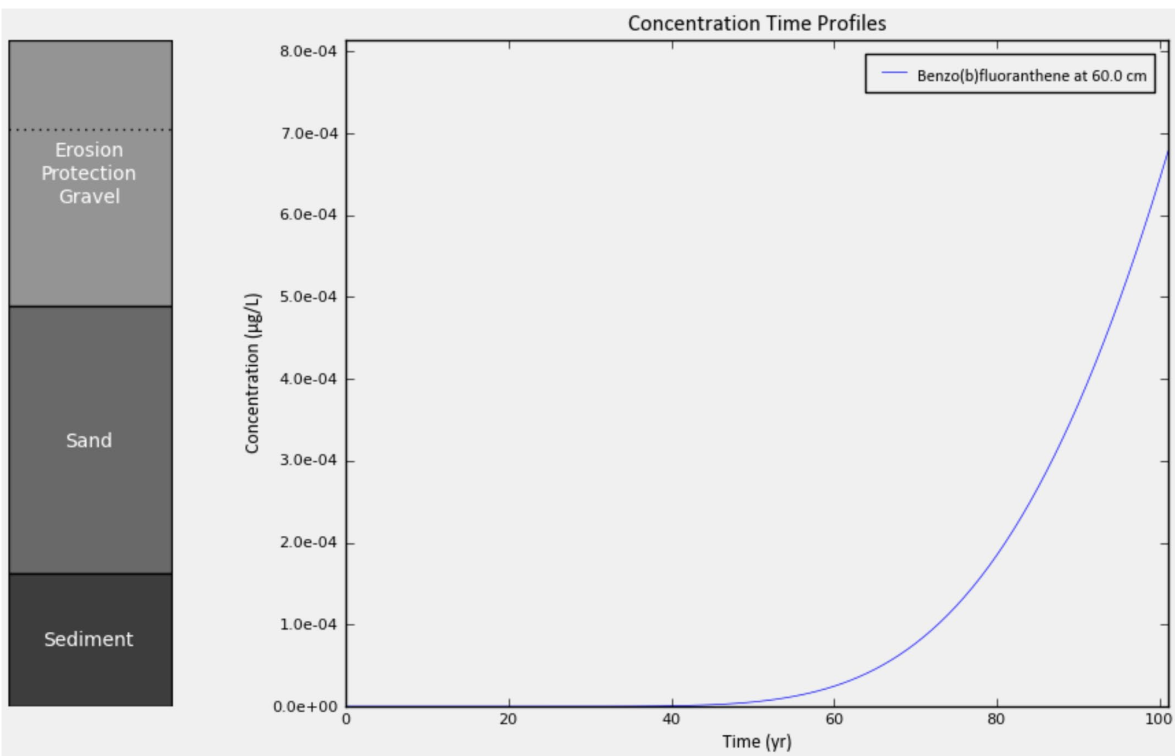


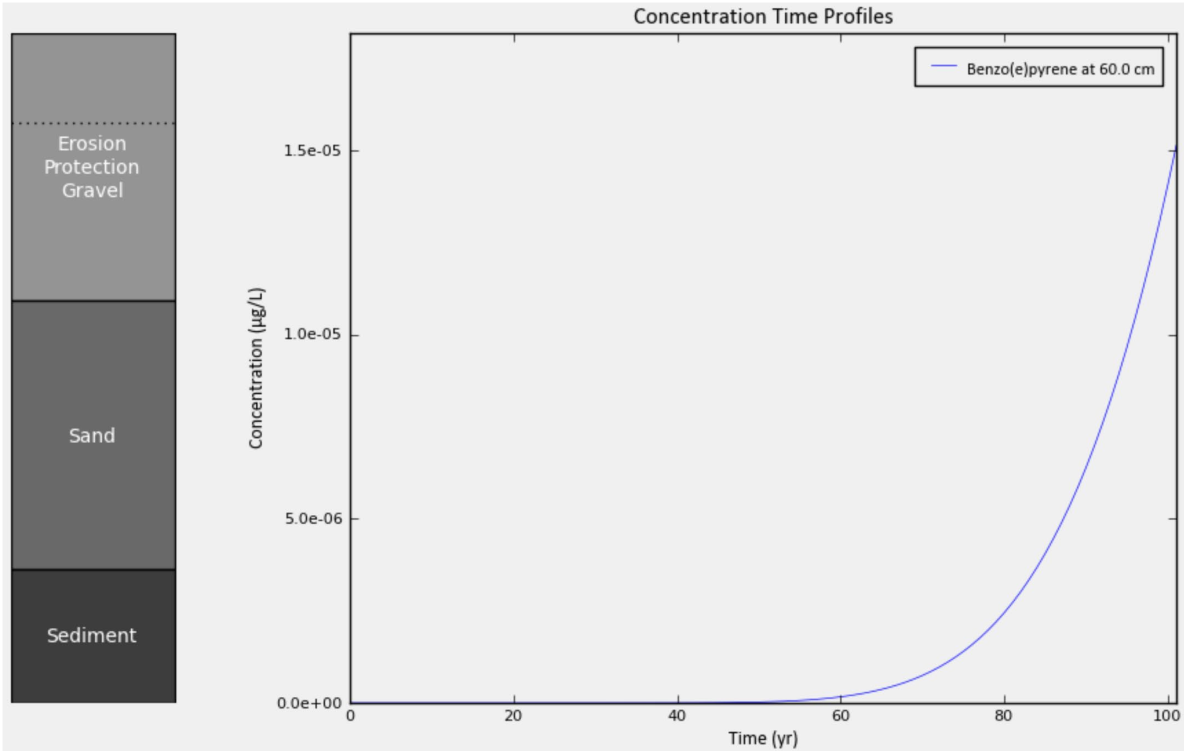
Erosion Protection Gravel
Sand
Sediment
Concentration Time Profiles
Acenaphthylene at 60.0 cm
Concentration (µg/L)
Time (yr)
0.0
0.1
0.2
0.3
0.4
0.5
0
20
40
60
80
100

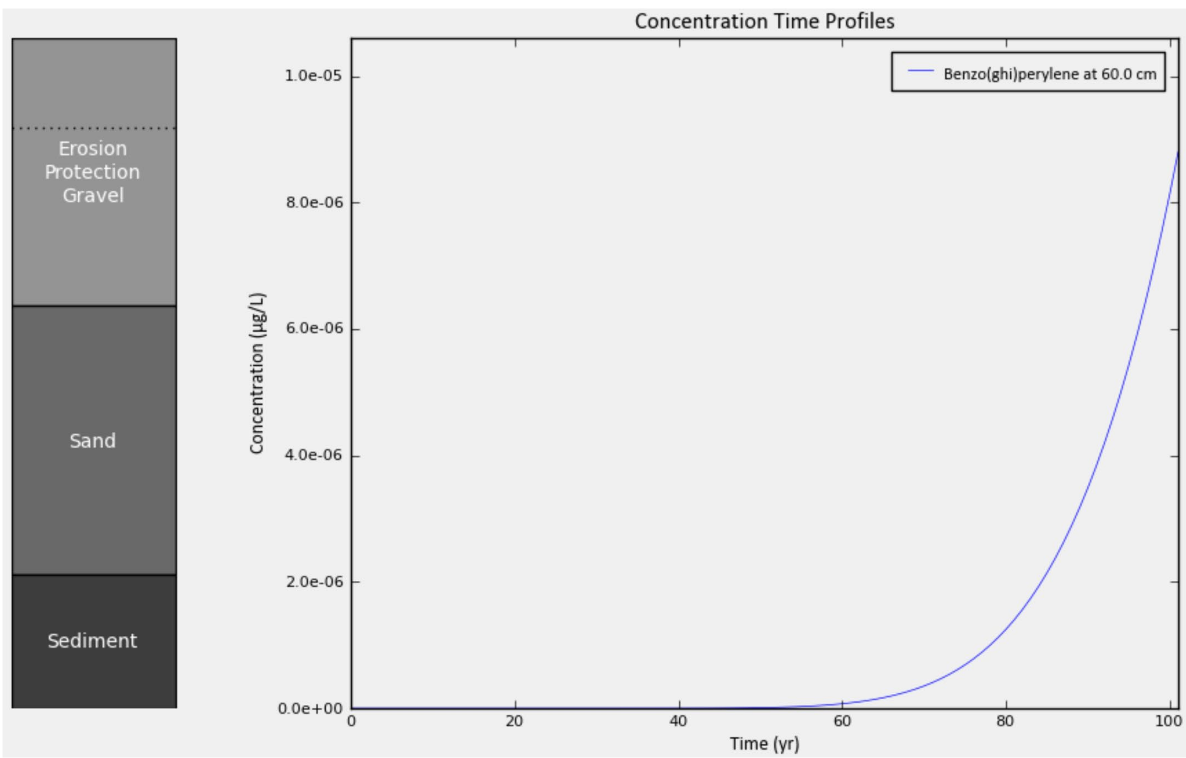

Erosion Protection Gravel
Sand
Sediment
Concentration Time Profiles
Anthracene at 60.0 cm
Concentration (µg/L)
Time (yr)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
20
40
60
80
100

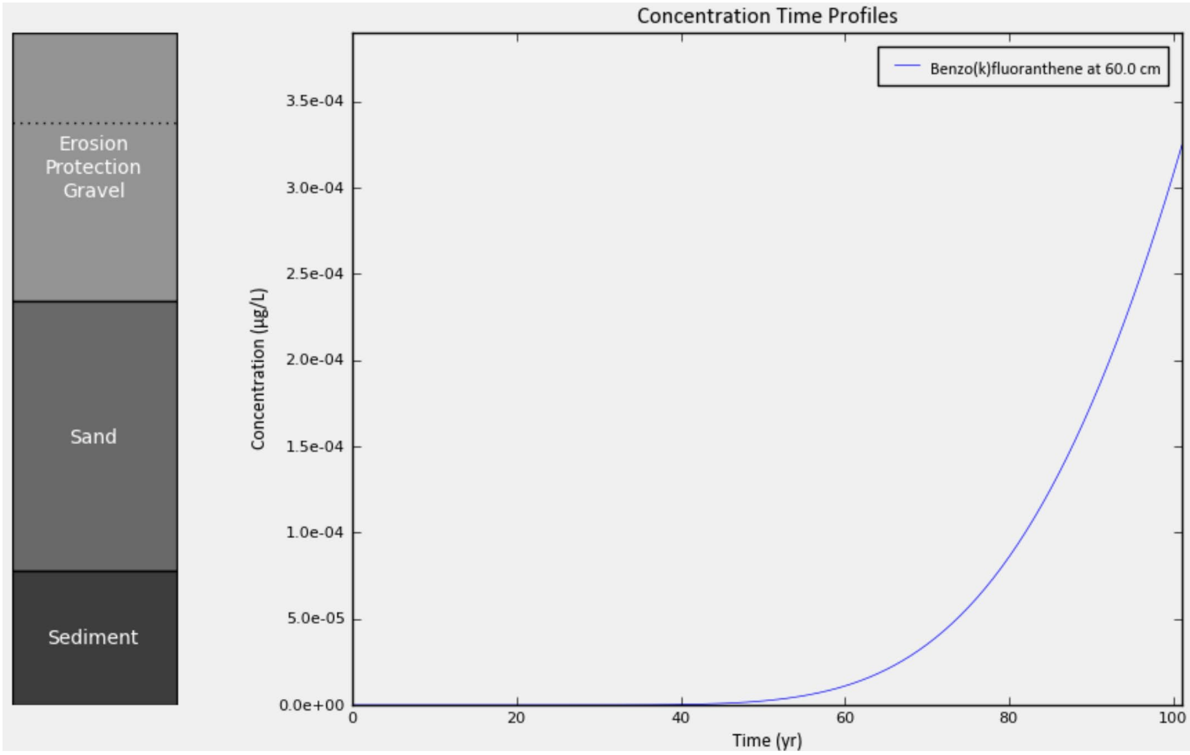

Erosion Protection Gravel
Sand
Sediment
Concentration Time Profiles
Benzo(a)anthracene at 60.0 cm
Concentration (µg/L)
Time (yr)
0.00
0.01
0.02
0.03
0.04
0.05
0
20
40
60
80
100

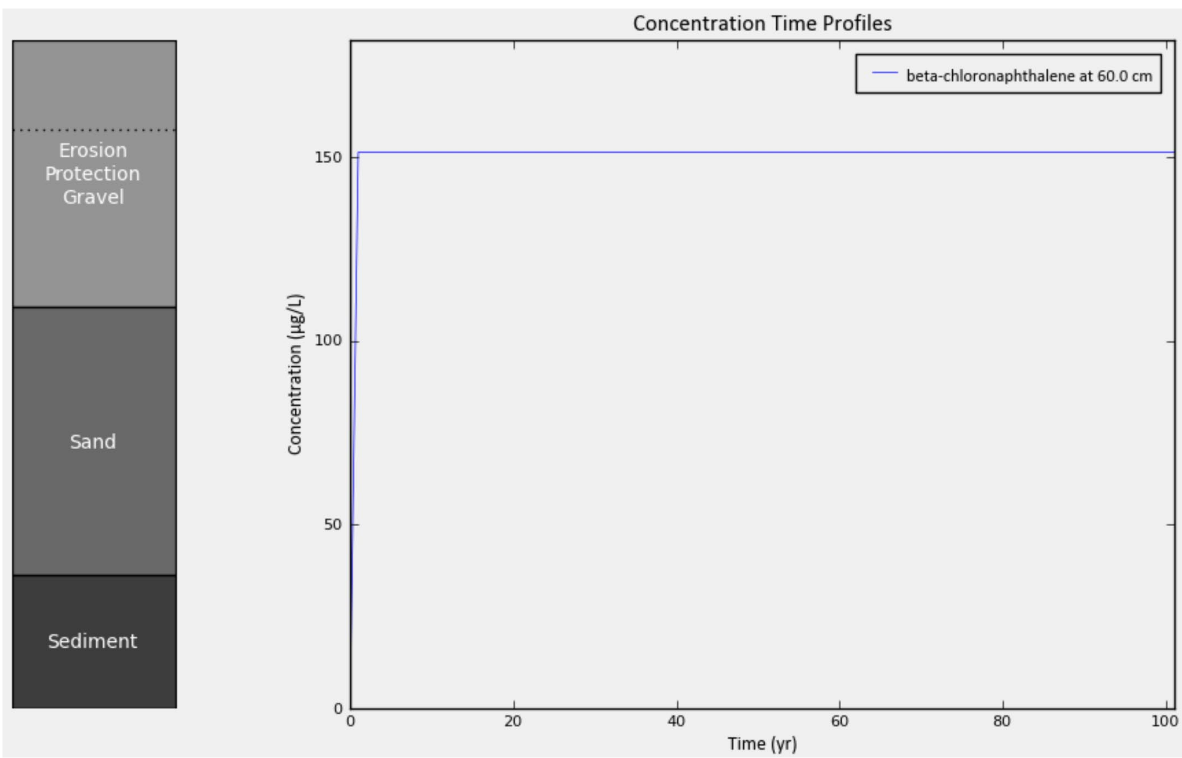

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Benzo(a)pyrene at 60.0 cm
Concentration (µg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0
20
40
60
80
100
Time (yr)

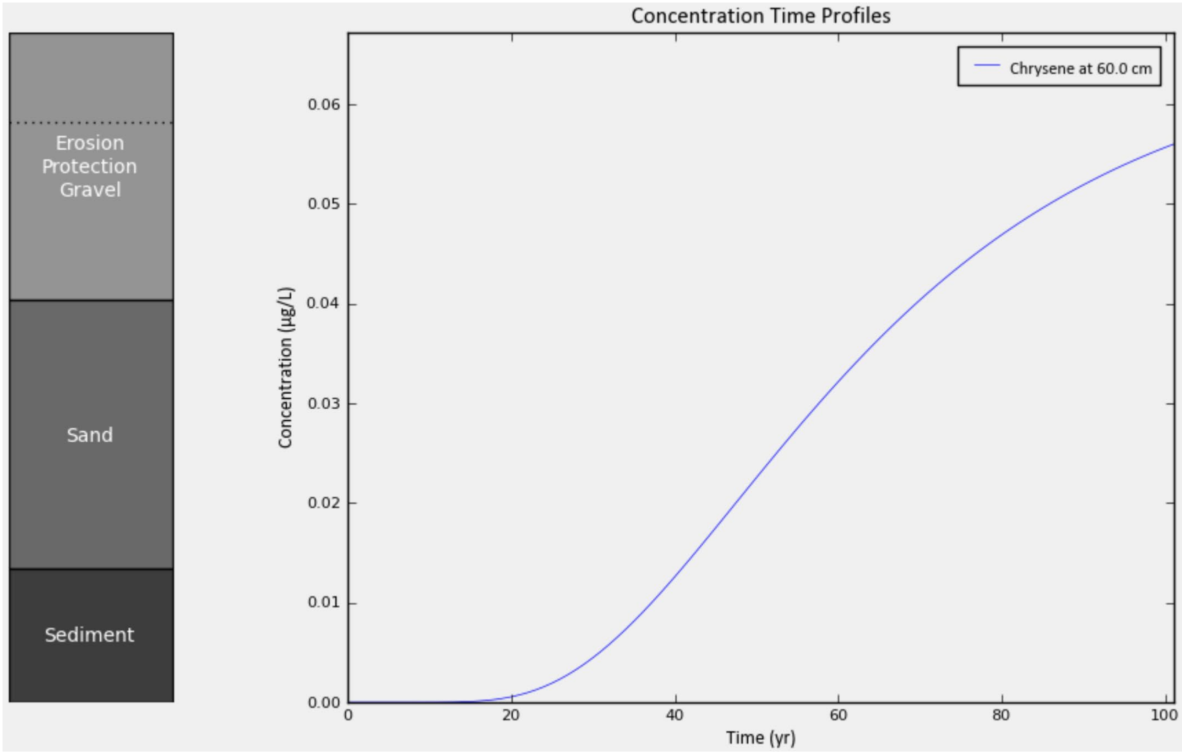

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Benzo(b)fluoranthene at 60.0 cm
Concentration (µg/L)
8.0e-04
7.0e-04
6.0e-04
5.0e-04
4.0e-04
3.0e-04
2.0e-04
1.0e-04
0.0e+00
0
20
40
60
80
100
Time (yr)

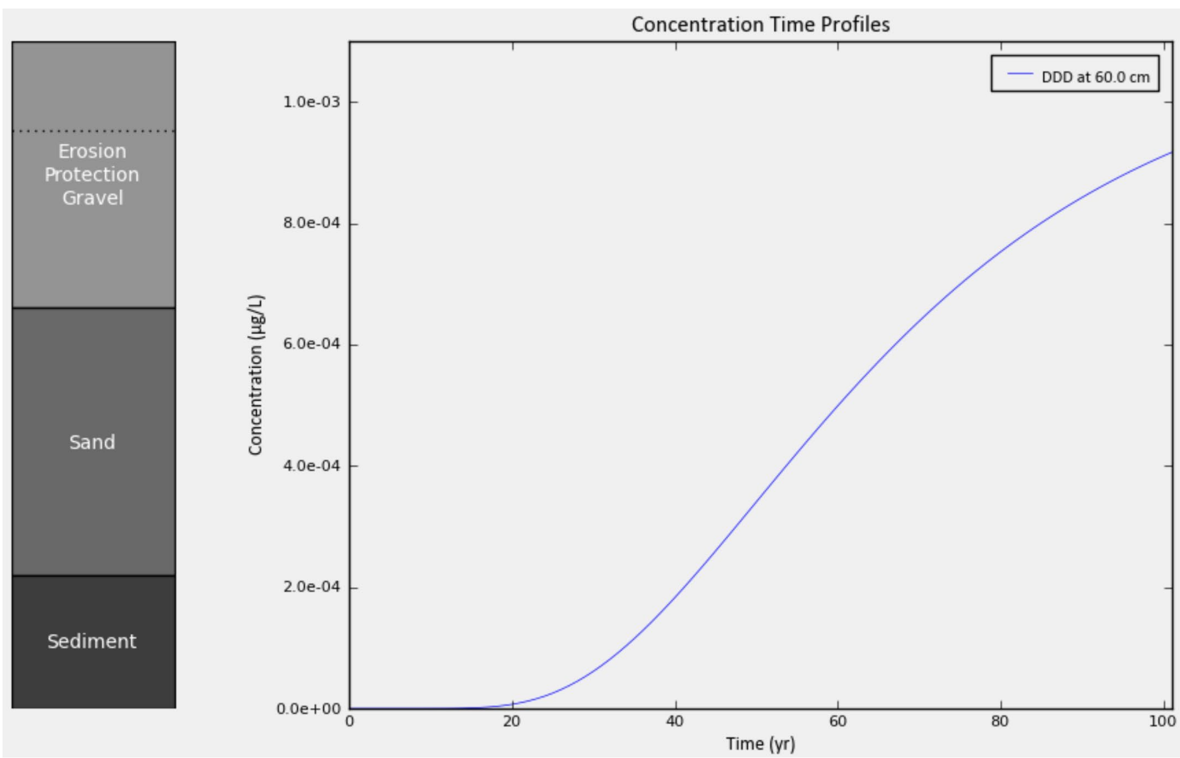

Concentration Time Profiles
Benzo(e)pyrene at 60.0 cm
Erosion Protection Gravel
Sand
Sediment
Concentration (µg/L)
1.5e-05
1.0e-05
5.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

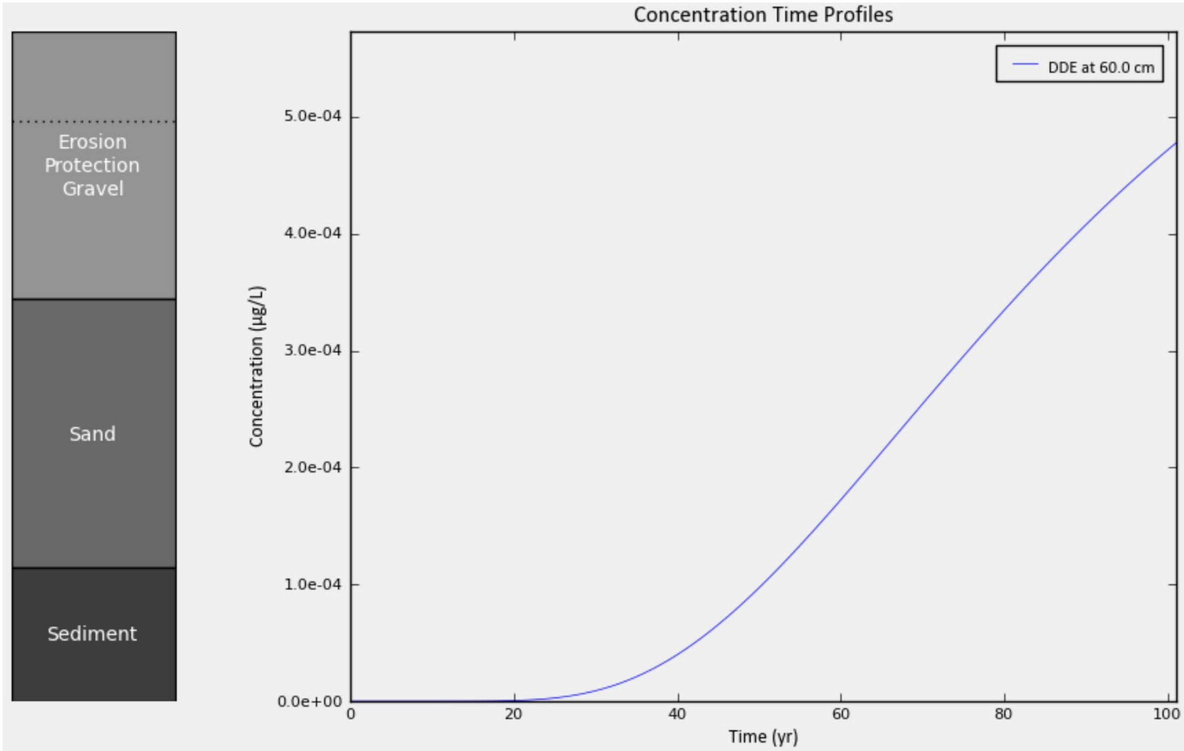

Concentration Time Profiles
Benzo(ghi)perylene at 60.0 cm
Erosion Protection Gravel
Sand
Sediment
Concentration (µg/L)
1.0e-05
8.0e-06
6.0e-06
4.0e-06
2.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

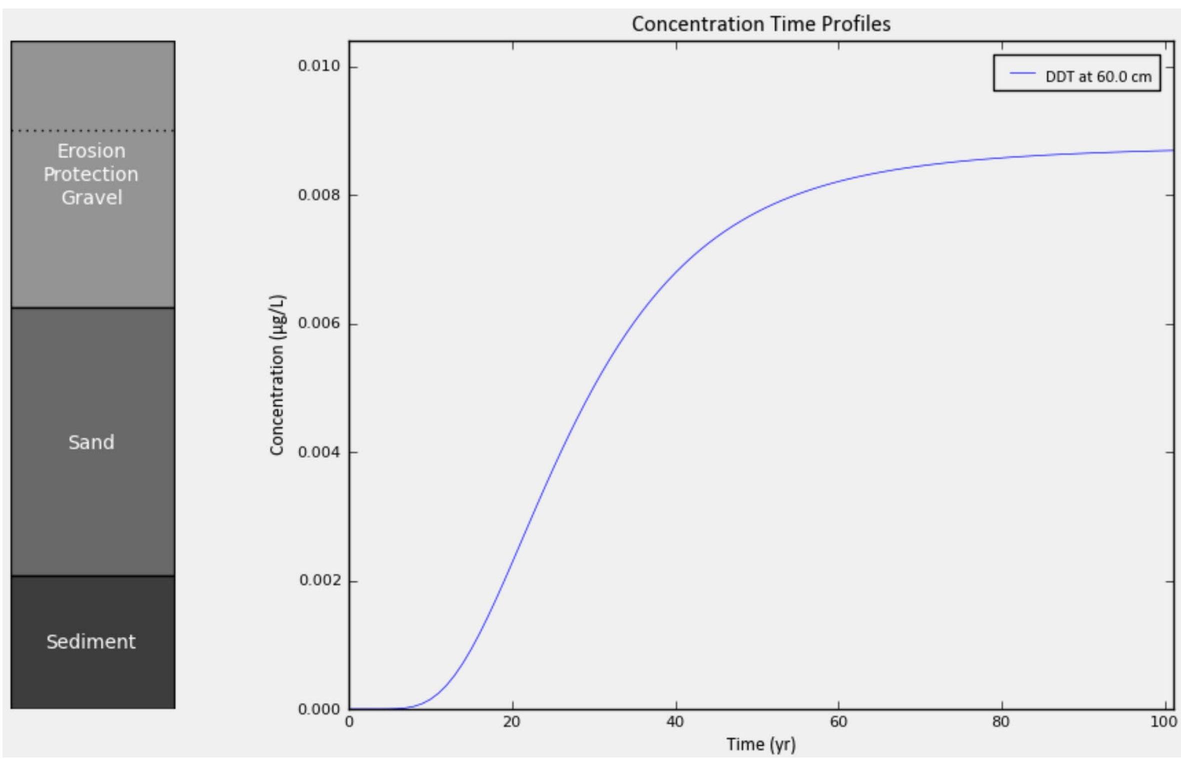

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Benzo(k)fluoranthene at 60.0 cm
Concentration (µg/L)
3.5e-04
3.0e-04
2.5e-04
2.0e-04
1.5e-04
1.0e-04
5.0e-05
0.0e+00
0
20
40
60
80
100
Time (yr)

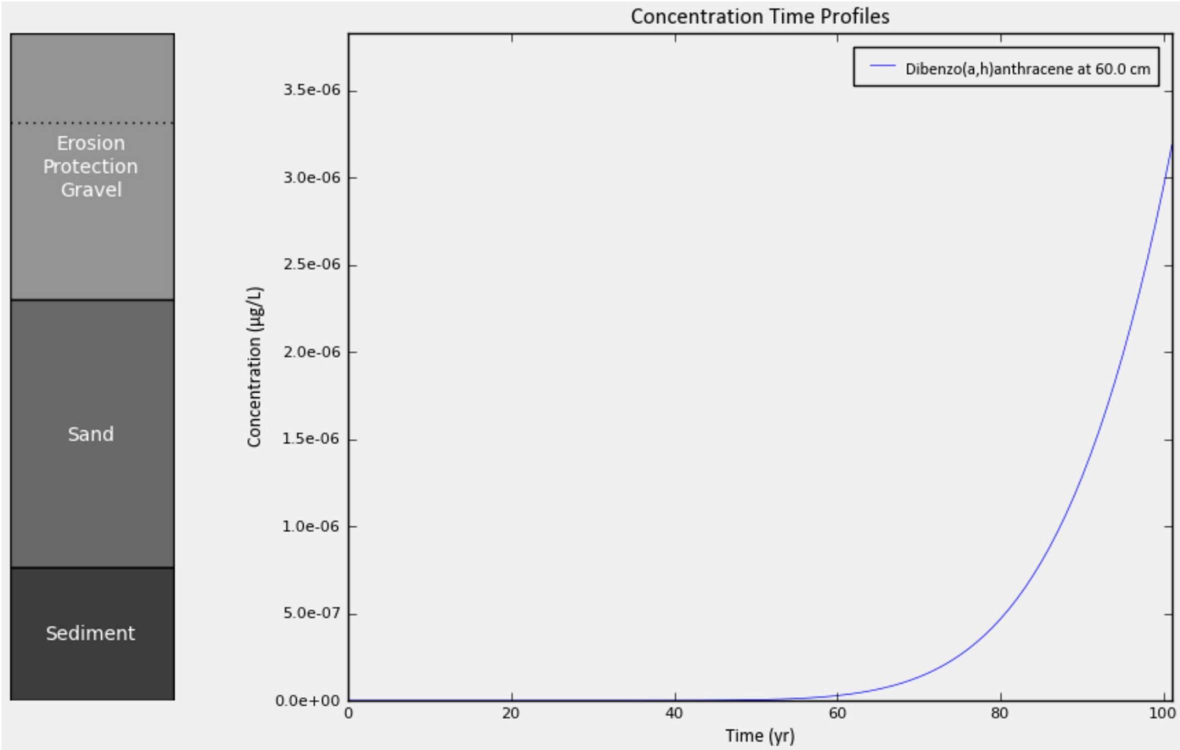

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
beta-chloronaphthalene at 60.0 cm
Concentration (µg/L)
150
100
50
0
0
20
40
60
80
100
Time (yr)

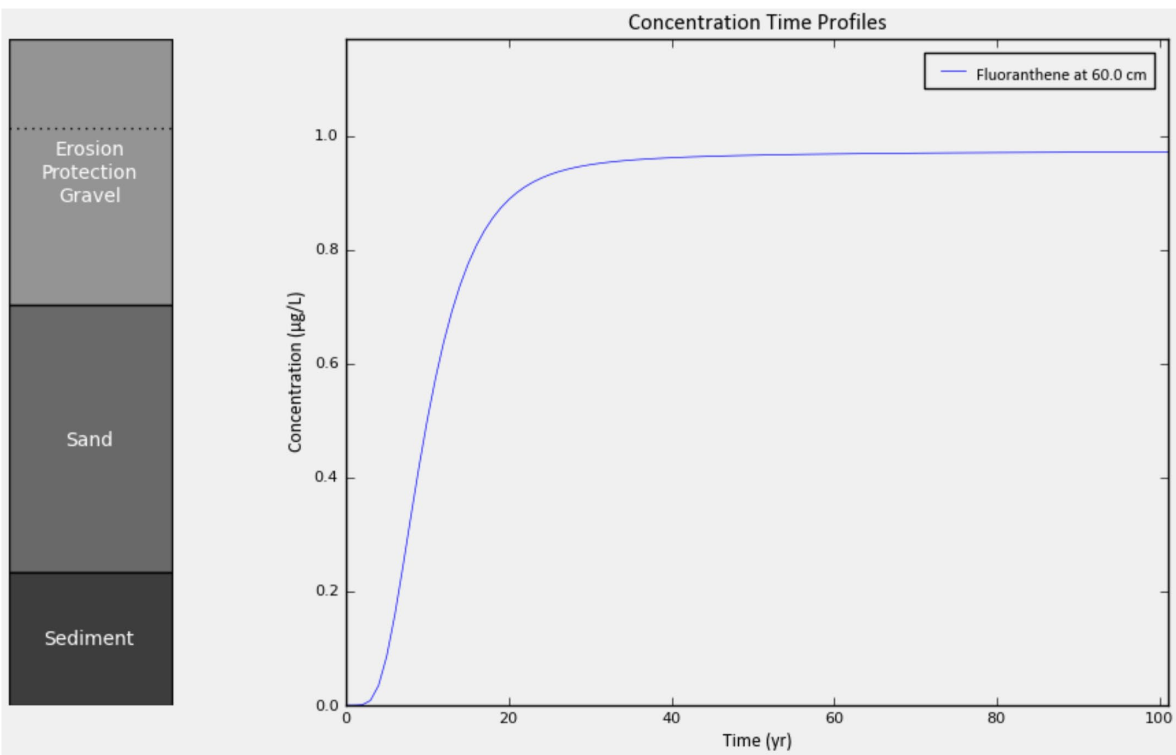

Erosion Protection Gravel
Sand
Sediment
Concentration Time Profiles
Chrysene at 60.0 cm
Concentration (µg/L)
0.00
0.01
0.02
0.03
0.04
0.05
0.06
Time (yr)
0
20
40
60
80
100

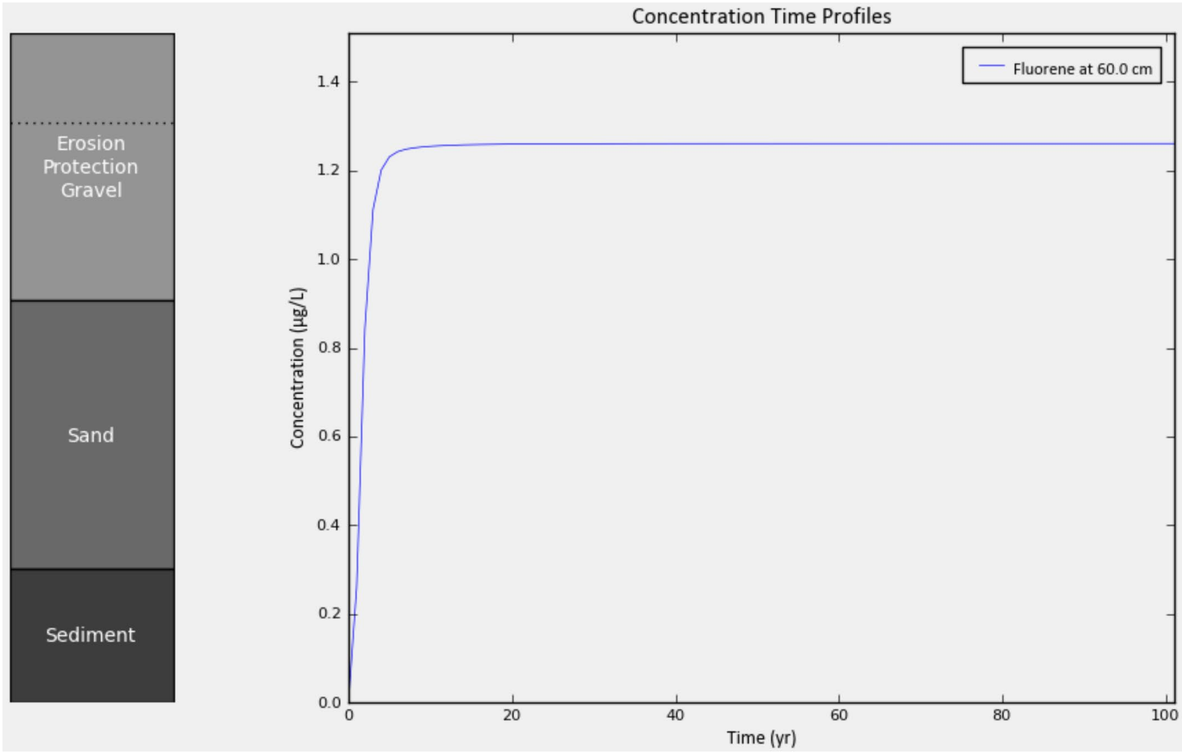

Erosion Protection Gravel
Sand
Sediment
Concentration Time Profiles
DDD at 60.0 cm
Concentration (µg/L)
0.0e+00
2.0e-04
4.0e-04
6.0e-04
8.0e-04
1.0e-03
Time (yr)
0
20
40
60
80
100

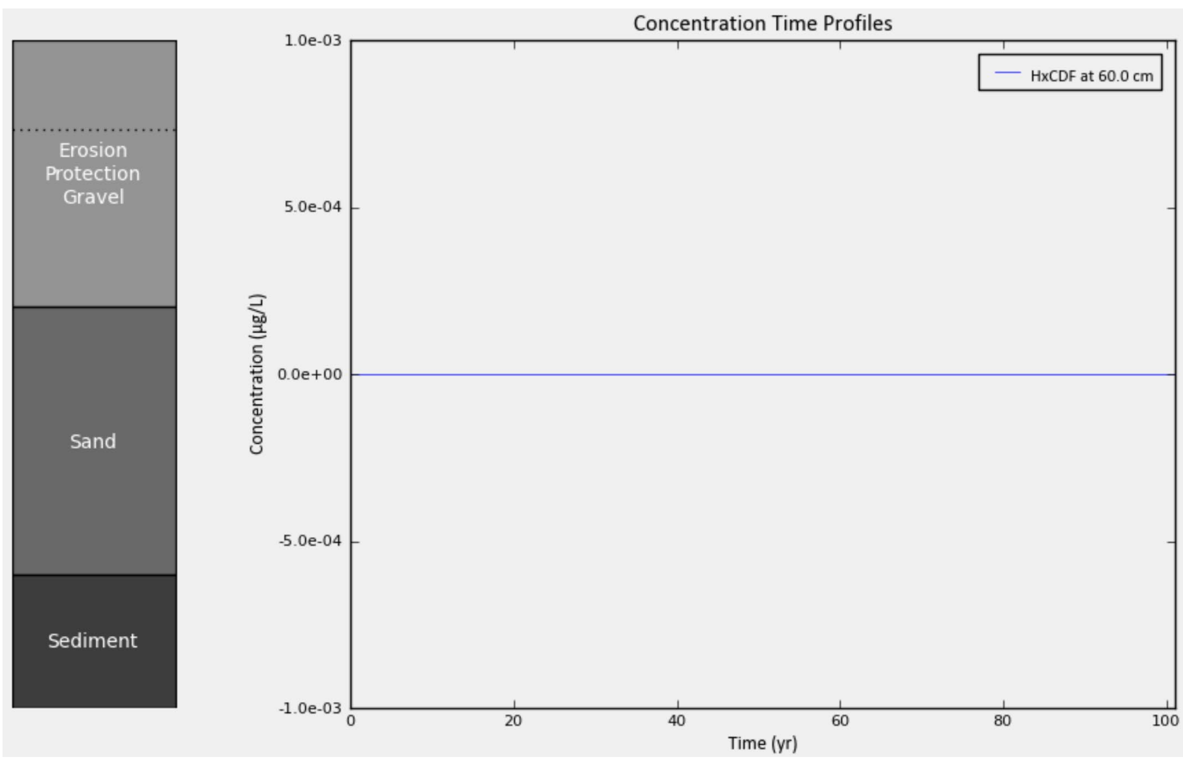

Concentration Time Profiles
DDE at 60.0 cm
Erosion Protection Gravel
Sand
Sediment
Concentration (µg/L)
5.0e-04
4.0e-04
3.0e-04
2.0e-04
1.0e-04
0.0e+00
0
20
40
60
80
100
Time (yr)

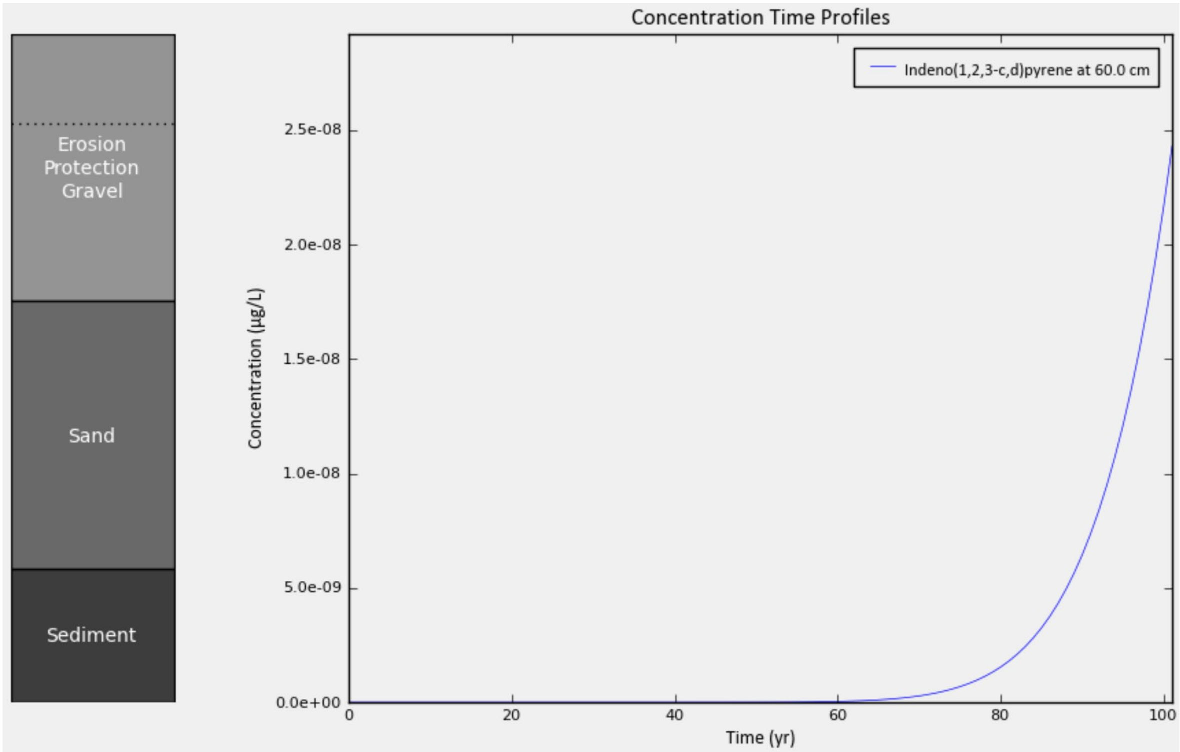

Concentration Time Profiles
DDT at 60.0 cm
Erosion Protection Gravel
Sand
Sediment
Concentration (µg/L)
0.010
0.008
0.006
0.004
0.002
0.000
0
20
40
60
80
100
Time (yr)

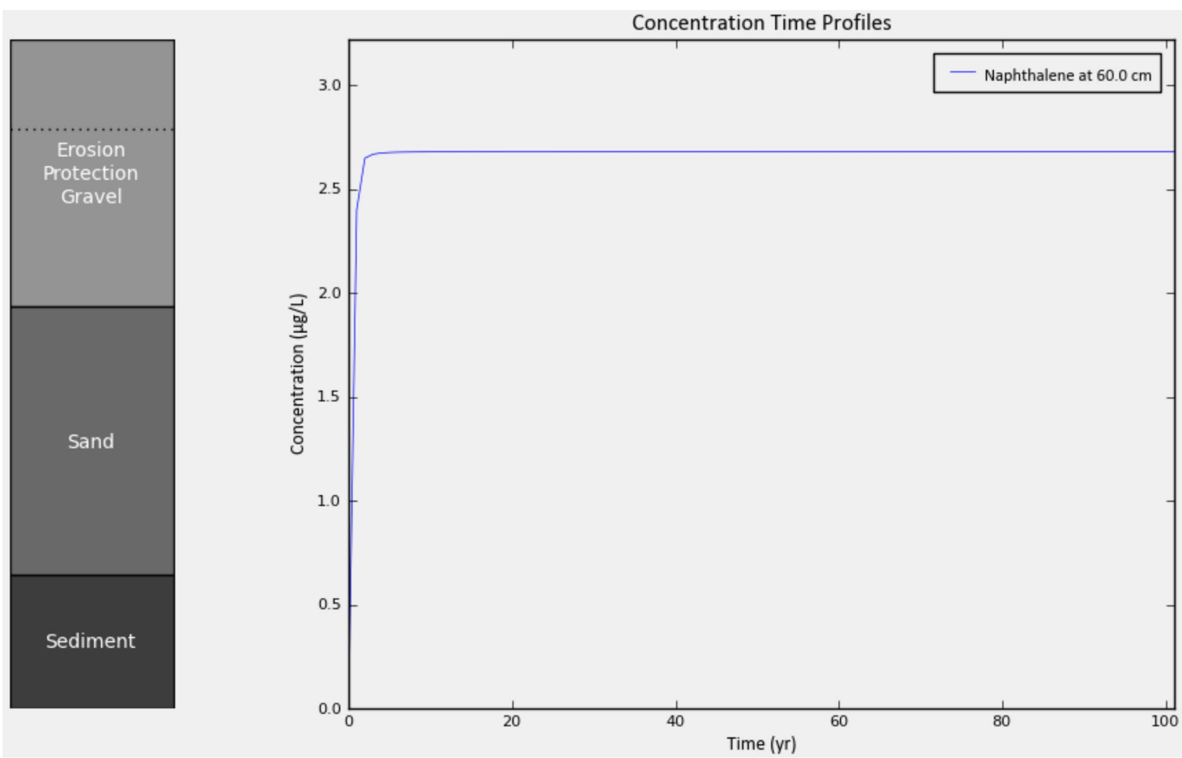

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Dibenzo(a,h)anthracene at 60.0 cm
Concentration (µg/L)
Time (yr)
0.0e+00
5.0e-07
1.0e-06
1.5e-06
2.0e-06
2.5e-06
3.0e-06
3.5e-06
0
20
40
60
80
100

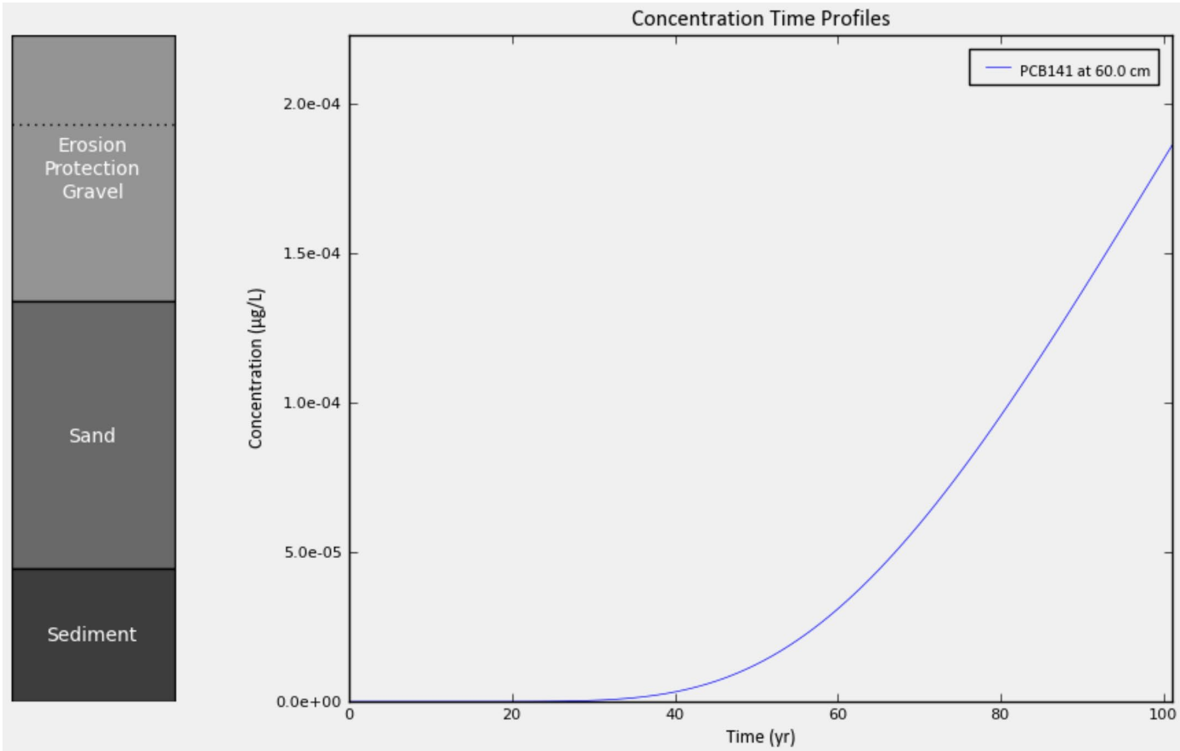

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Fluoranthene at 60.0 cm
Concentration (µg/L)
Time (yr)
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100

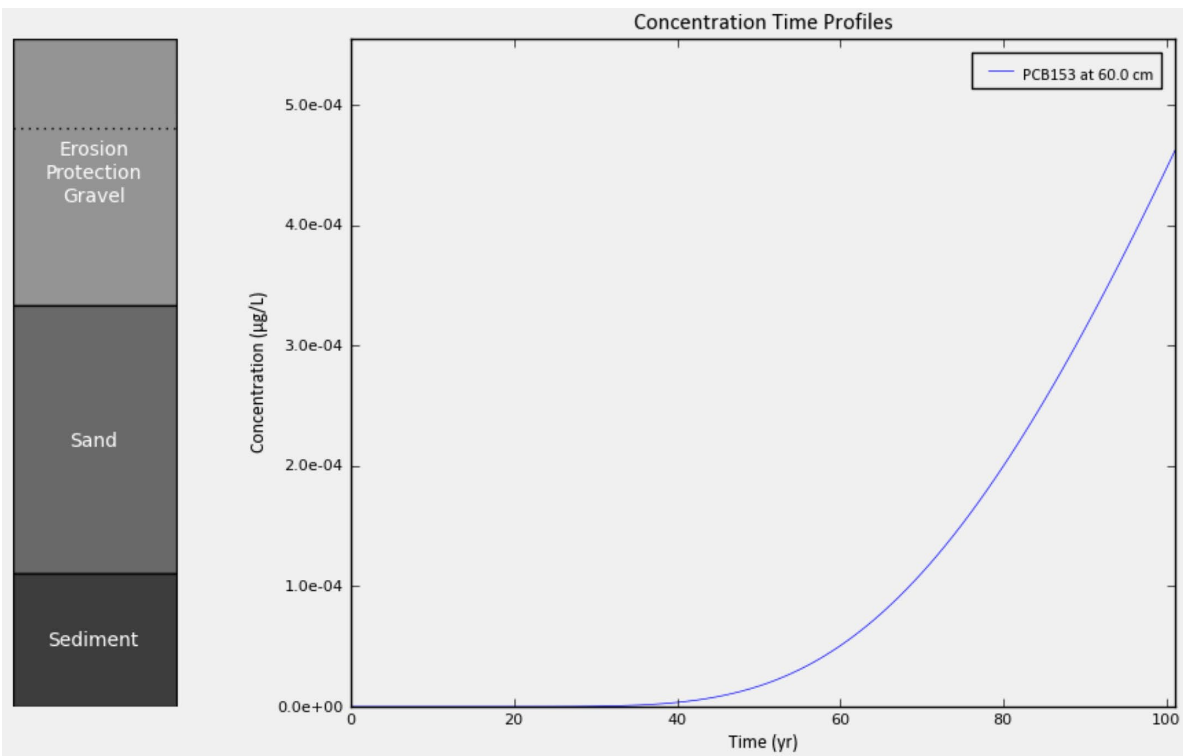

Concentration Time Profiles
Erosion Protection Gravel
Sand
Sediment
Fluorene at 60.0 cm
Concentration (µg/L)
Time (yr)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100

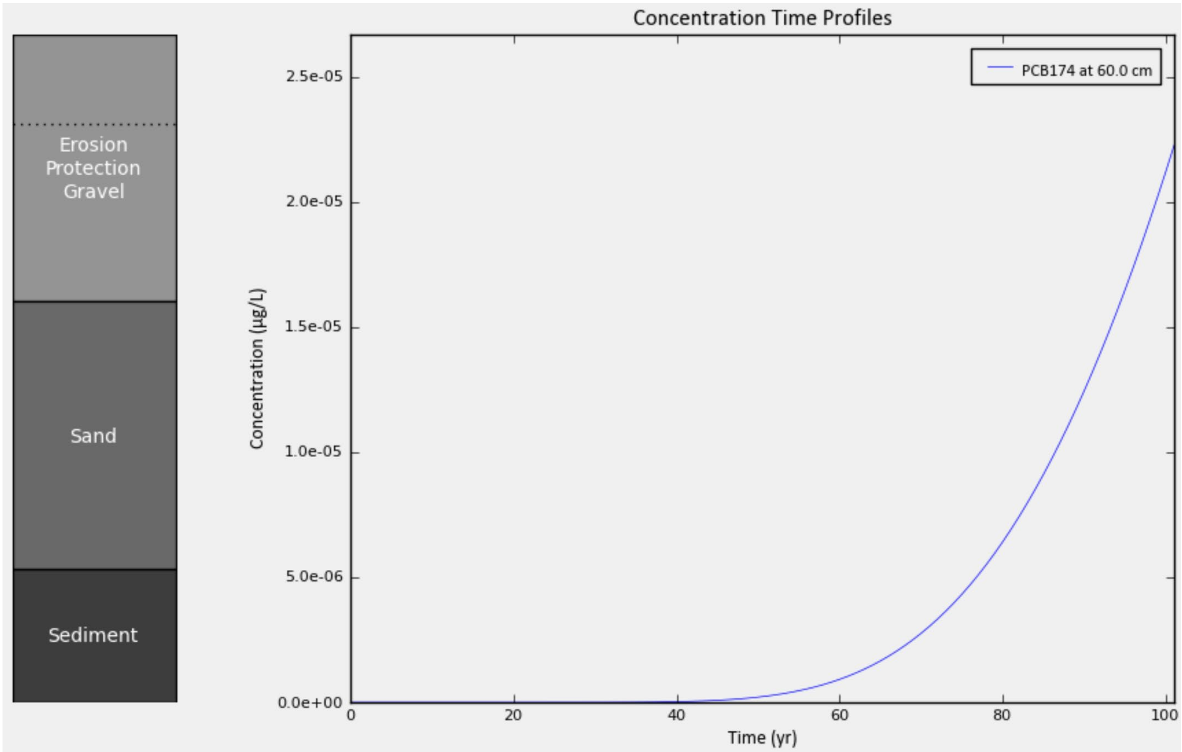

Concentration Time Profiles
Erosion Protection Gravel
Sand
Sediment
HxCDF at 60.0 cm
Concentration (µg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100

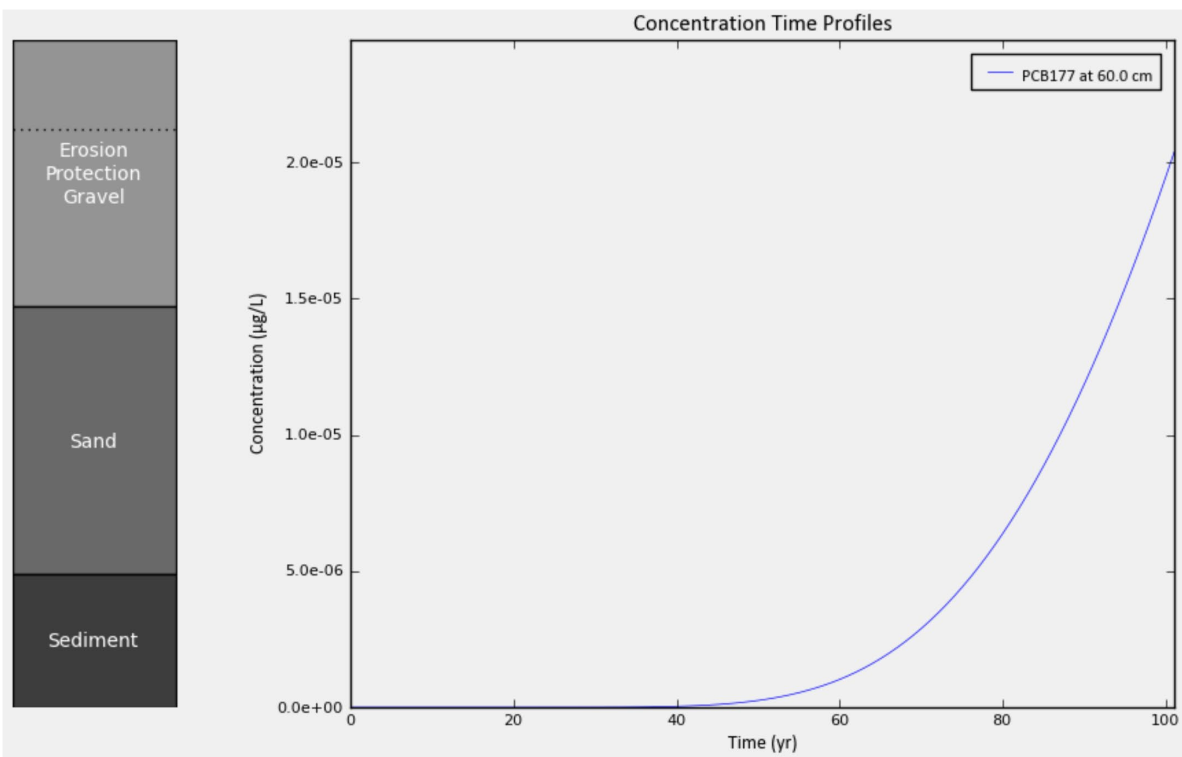

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Indeno(1,2,3-c,d)pyrene at 60.0 cm
Concentration (µg/L)
Time (yr)
0.0e+00
5.0e-09
1.0e-08
1.5e-08
2.0e-08
2.5e-08
0
20
40
60
80
100

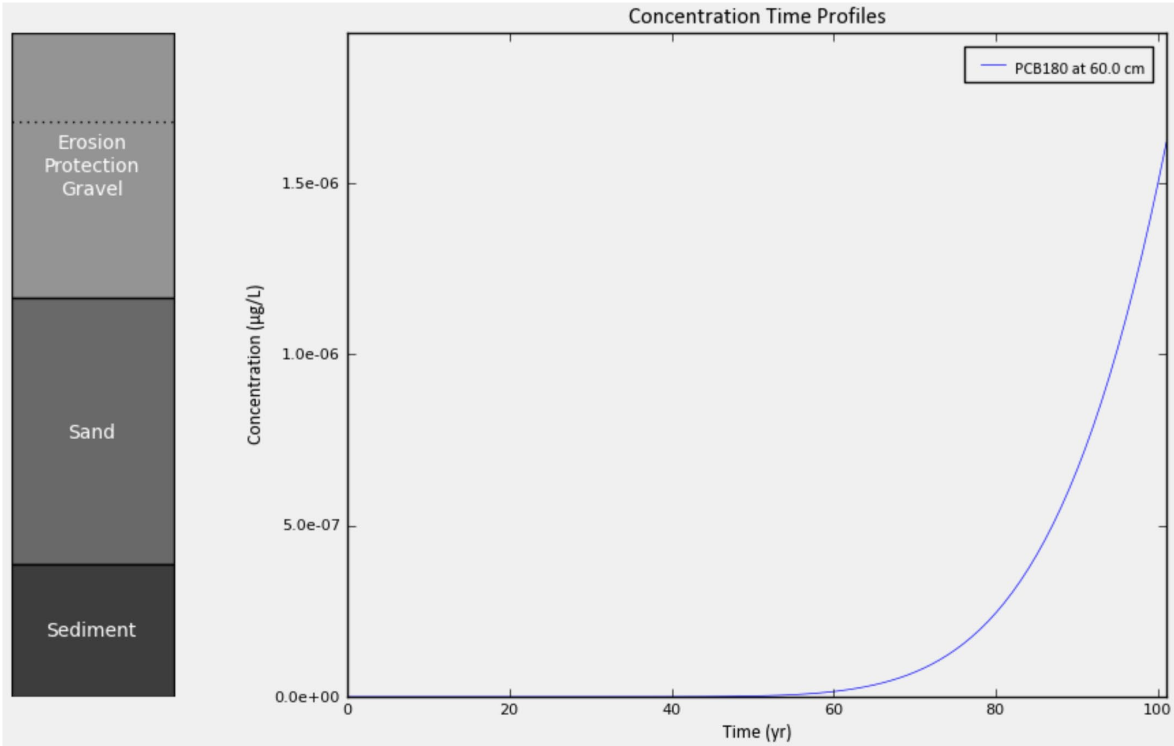

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Naphthalene at 60.0 cm
Concentration (µg/L)
Time (yr)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
20
40
60
80
100

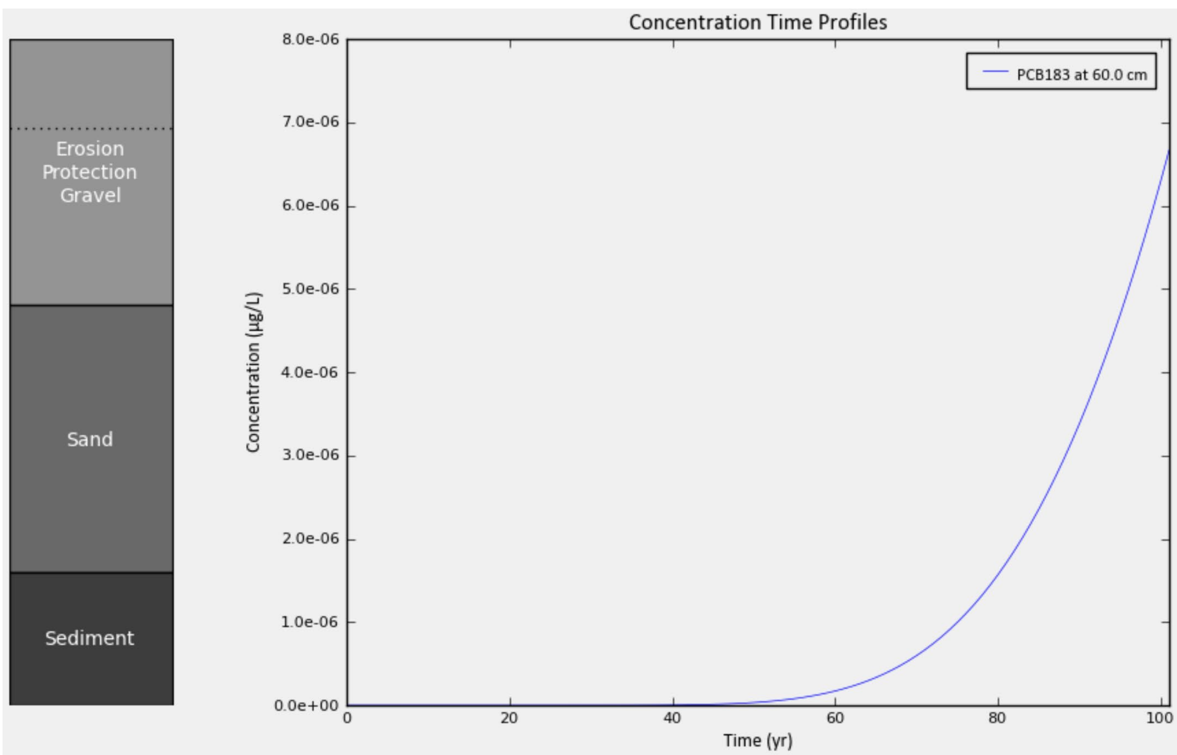

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PCB141 at 60.0 cm
Concentration (µg/L)
2.0e-04
1.5e-04
1.0e-04
5.0e-05
0.0e+00
0
20
40
60
80
100
Time (yr)

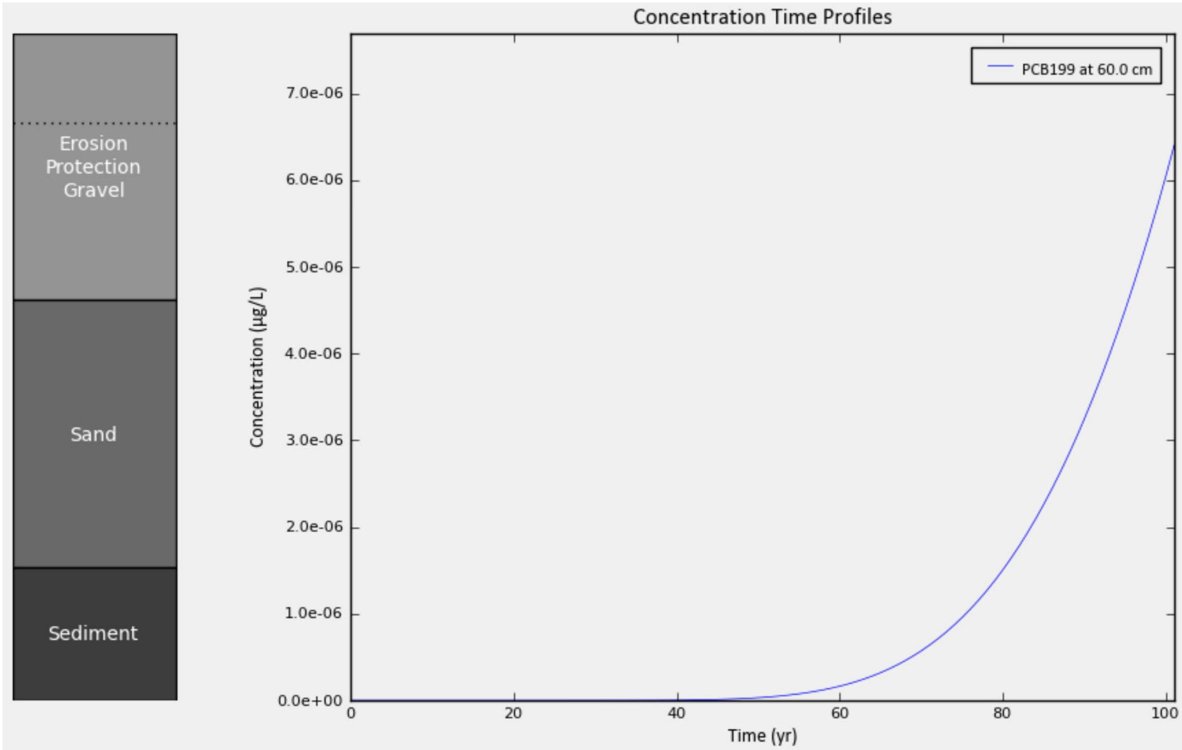

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PCB153 at 60.0 cm
Concentration (µg/L)
5.0e-04
4.0e-04
3.0e-04
2.0e-04
1.0e-04
0.0e+00
0
20
40
60
80
100
Time (yr)

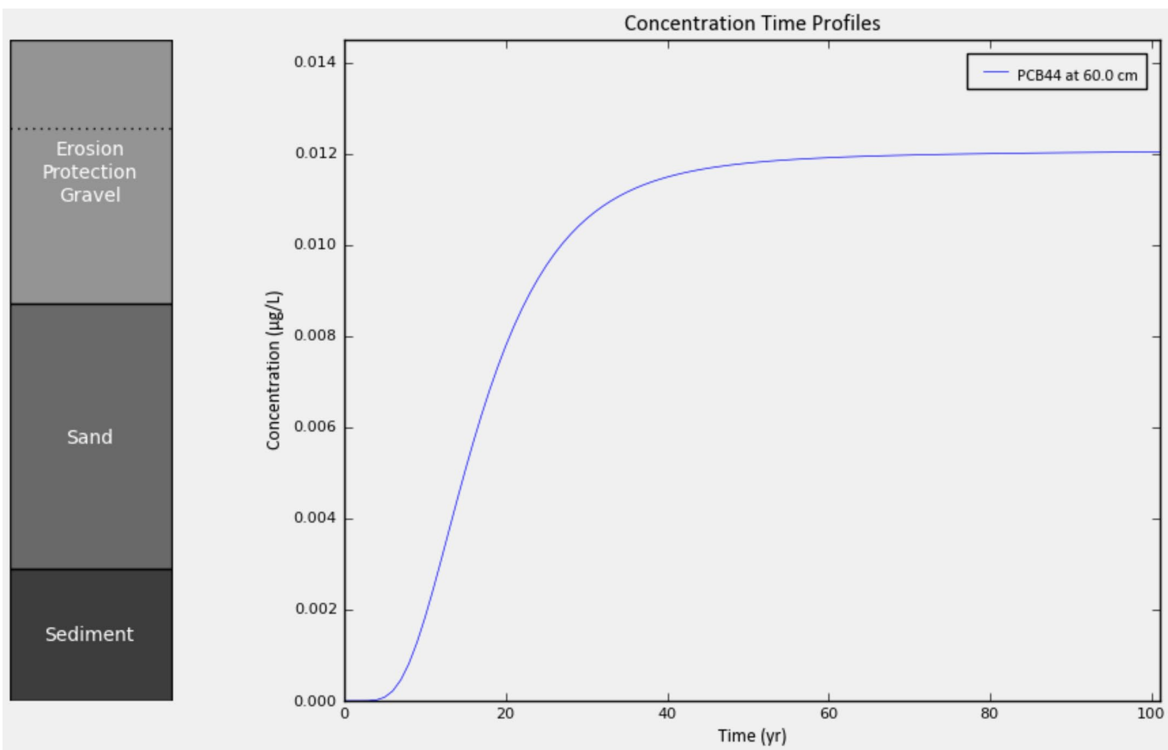

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PCB174 at 60.0 cm
Concentration (µg/L)
2.5e-05
2.0e-05
1.5e-05
1.0e-05
5.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

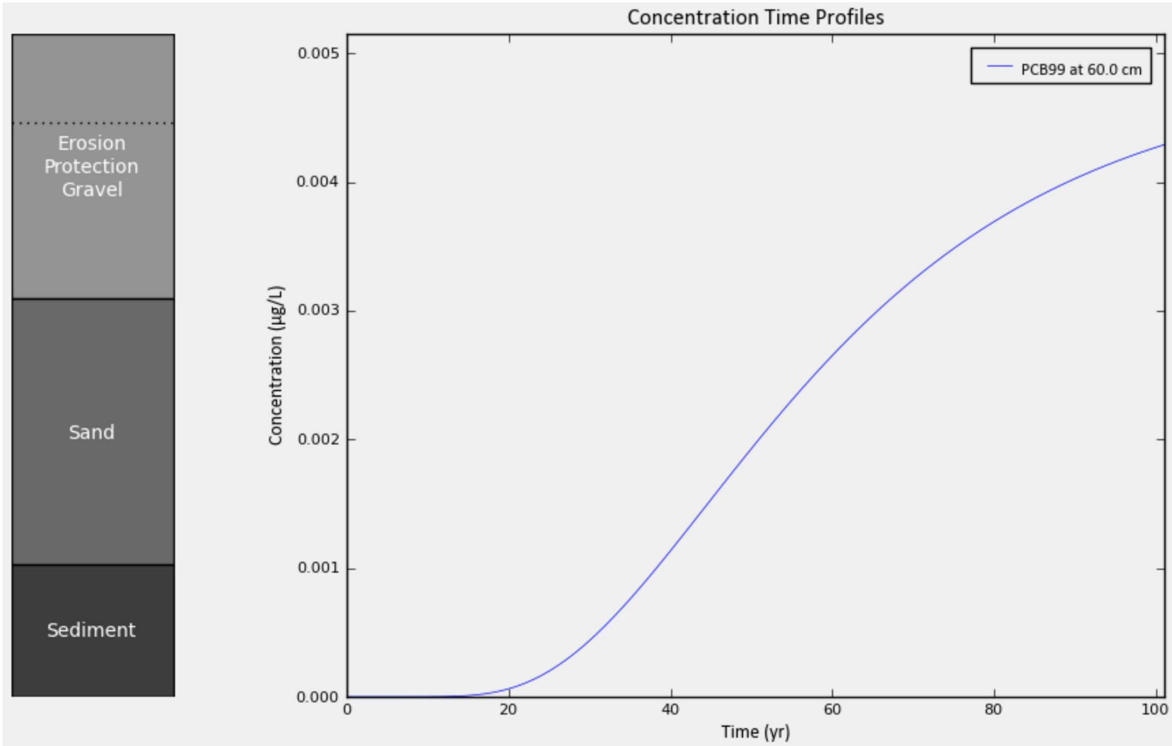

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PCB177 at 60.0 cm
Concentration (µg/L)
2.0e-05
1.5e-05
1.0e-05
5.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

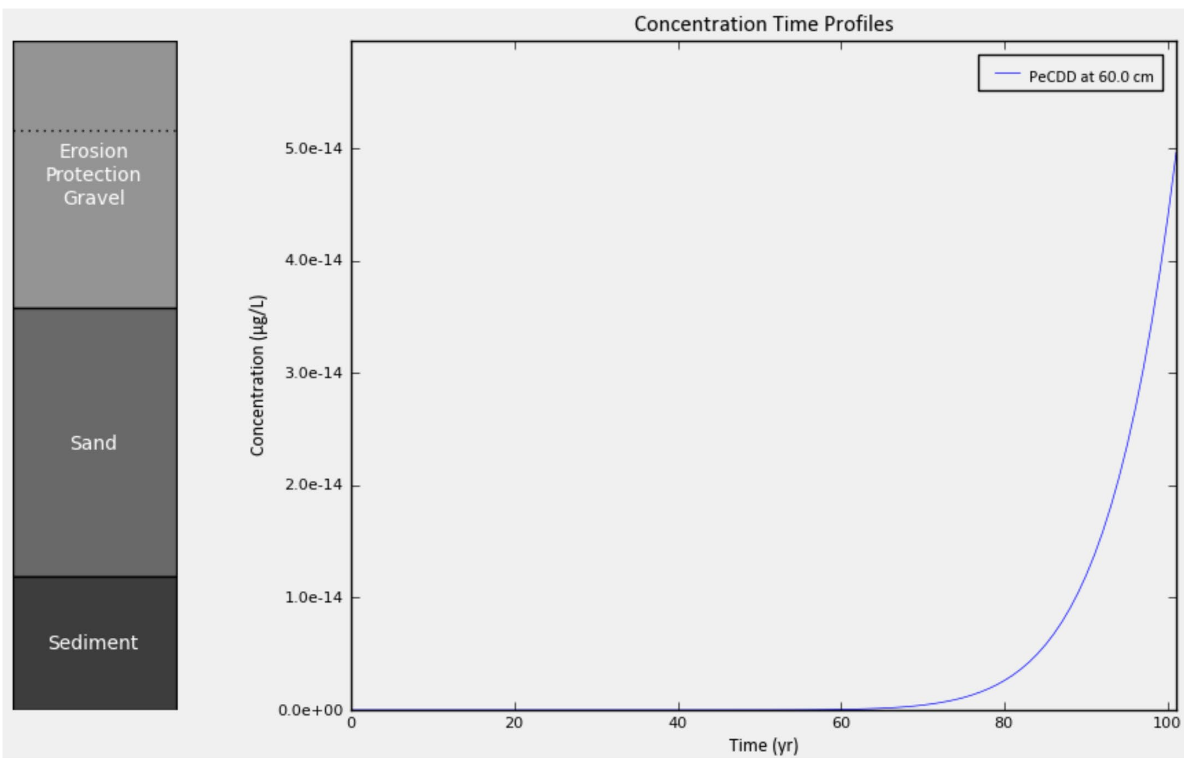

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PCB180 at 60.0 cm
Concentration (µg/L)
1.5e-06
1.0e-06
5.0e-07
0.0e+00
0
20
40
60
80
100
Time (yr)

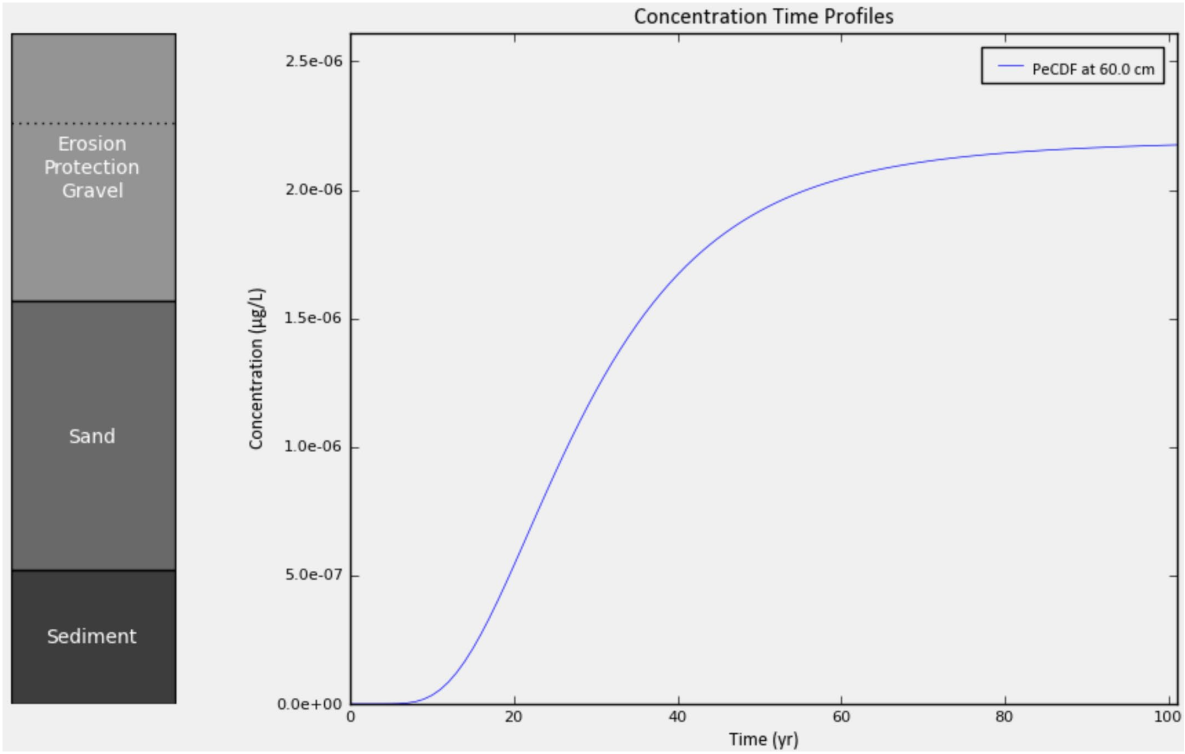

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PCB183 at 60.0 cm
Concentration (µg/L)
8.0e-06
7.0e-06
6.0e-06
5.0e-06
4.0e-06
3.0e-06
2.0e-06
1.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

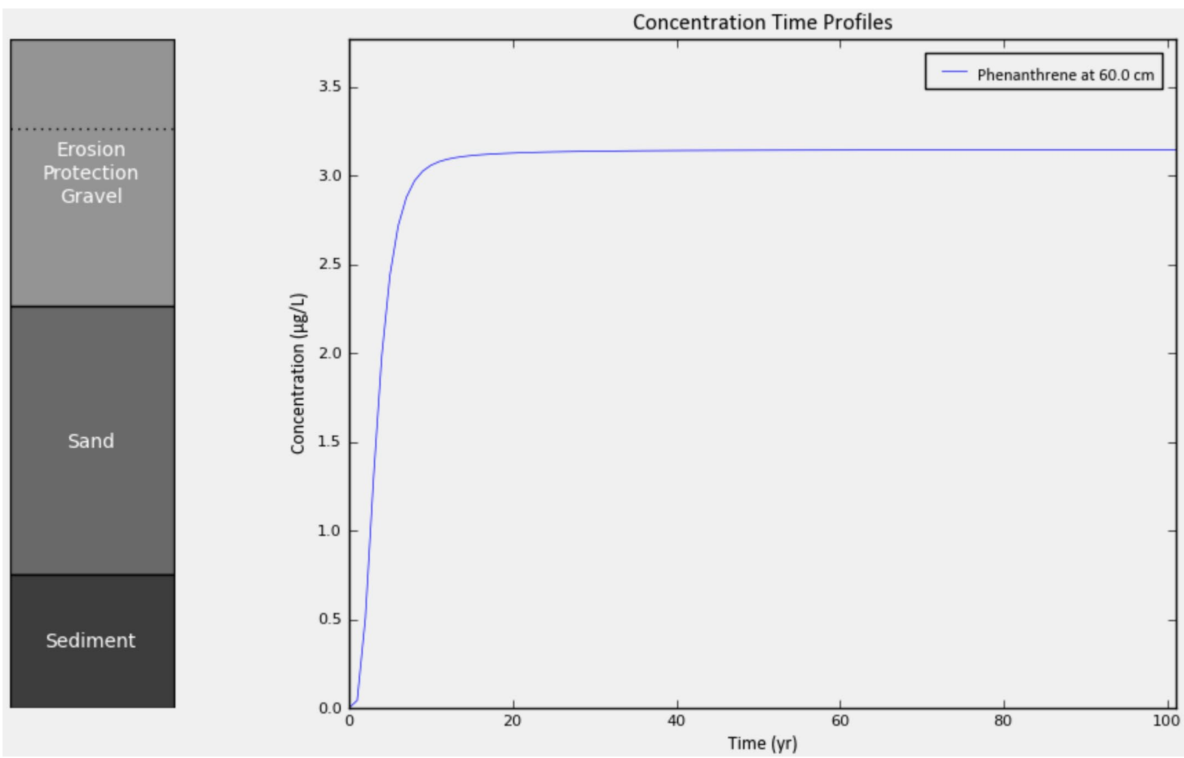

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PCB199 at 60.0 cm
Concentration (µg/L)
7.0e-06
6.0e-06
5.0e-06
4.0e-06
3.0e-06
2.0e-06
1.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

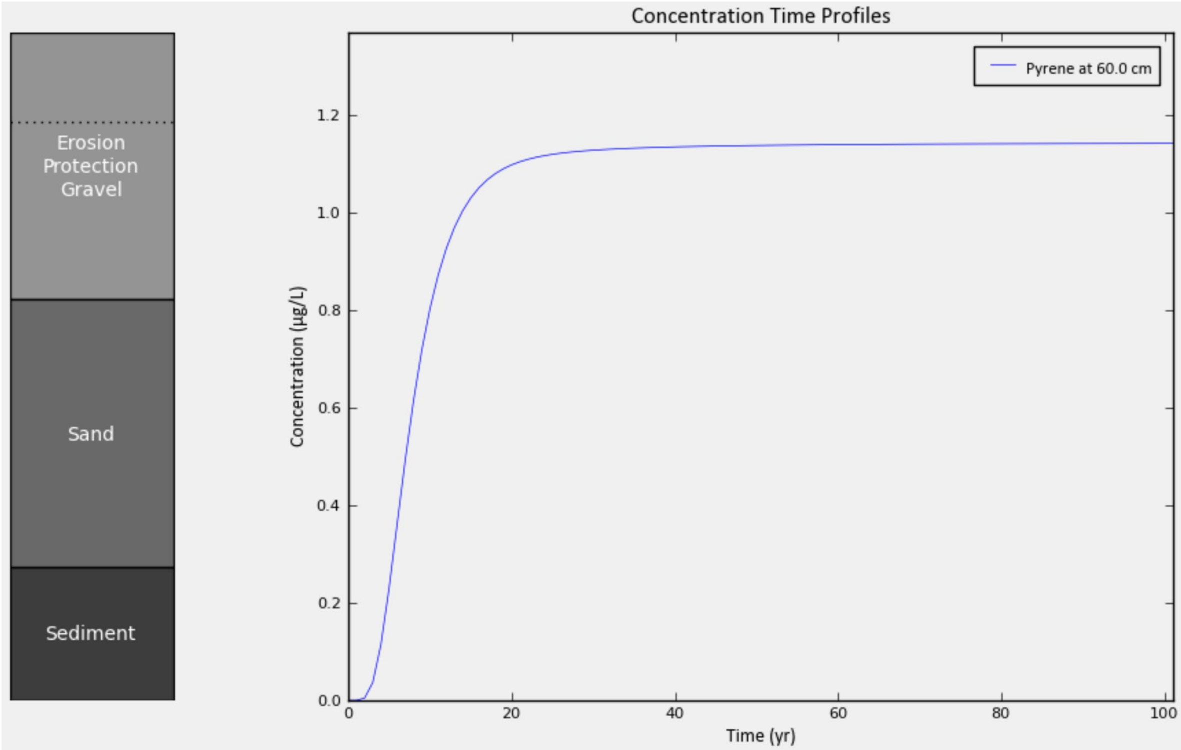

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PCB44 at 60.0 cm
Concentration (µg/L)
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0
20
40
60
80
100
Time (yr)

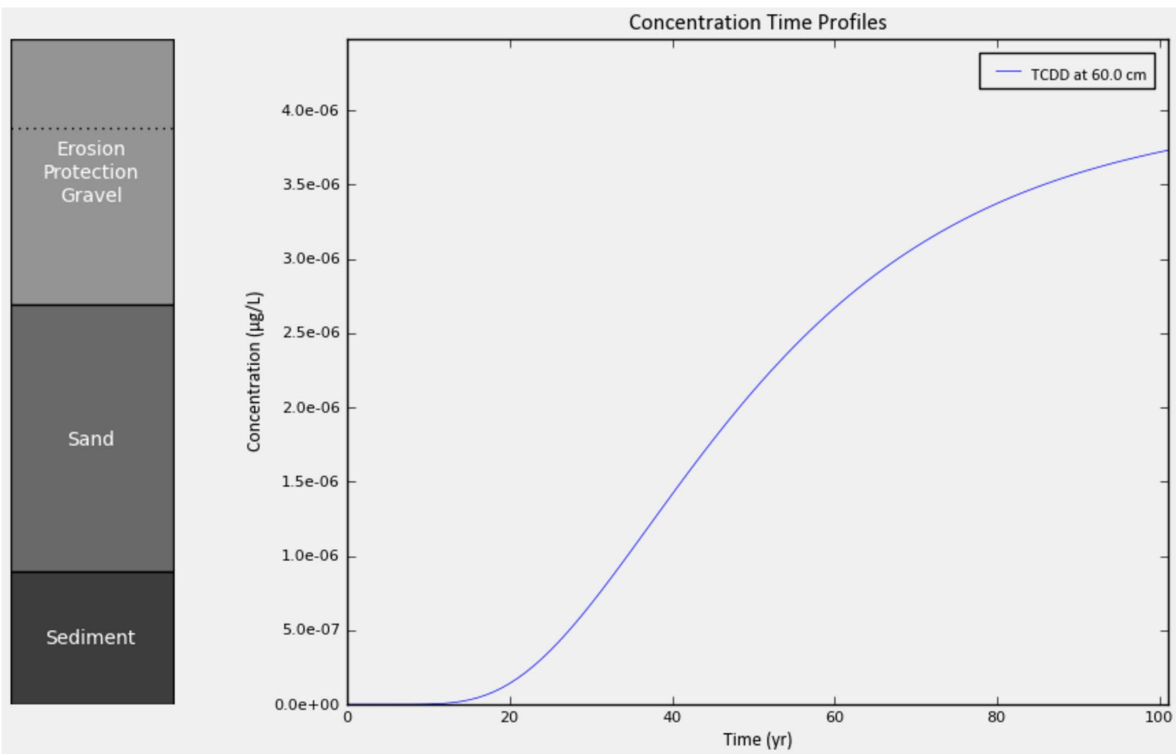

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PCB99 at 60.0 cm
Concentration (µg/L)
0.005
0.004
0.003
0.002
0.001
0.000
0
20
40
60
80
100
Time (yr)

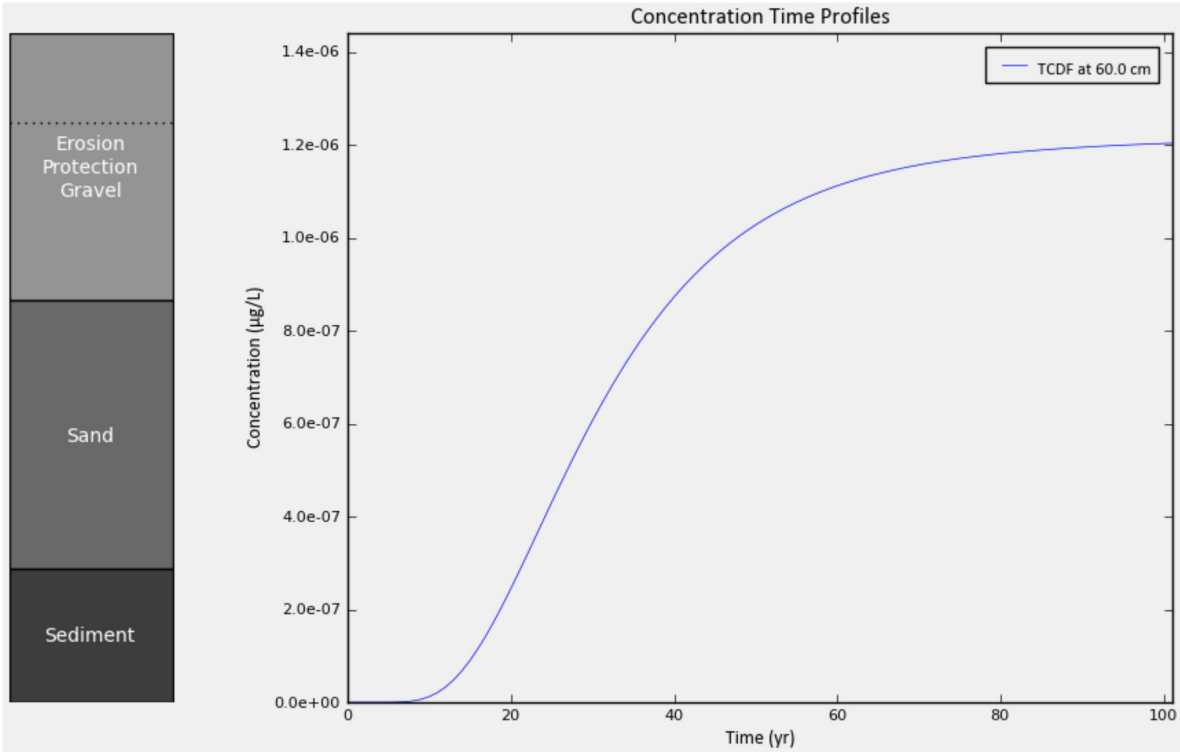

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PeCDD at 60.0 cm
Concentration (µg/L)
5.0e-14
4.0e-14
3.0e-14
2.0e-14
1.0e-14
0.0e+00
0
20
40
60
80
100
Time (yr)

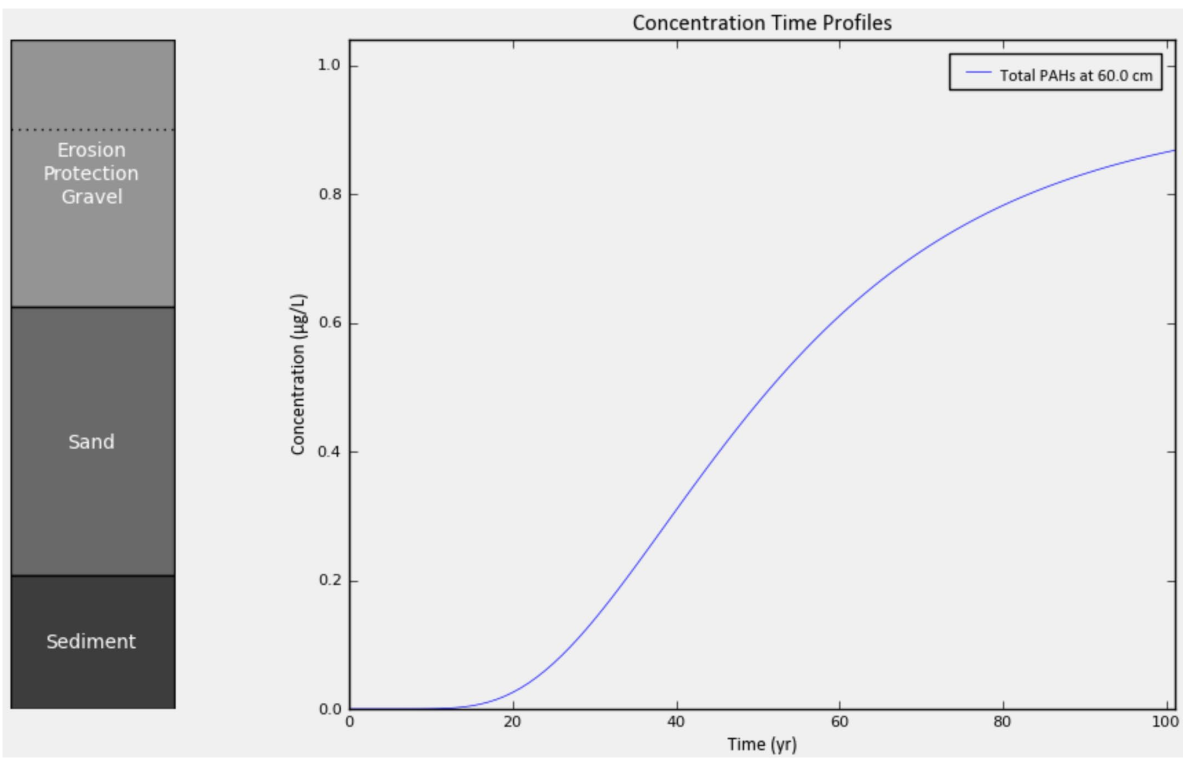

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
PeCDF at 60.0 cm
Concentration (µg/L)
Time (yr)
2.5e-06
2.0e-06
1.5e-06
1.0e-06
5.0e-07
0.0e+00
0
20
40
60
80
100

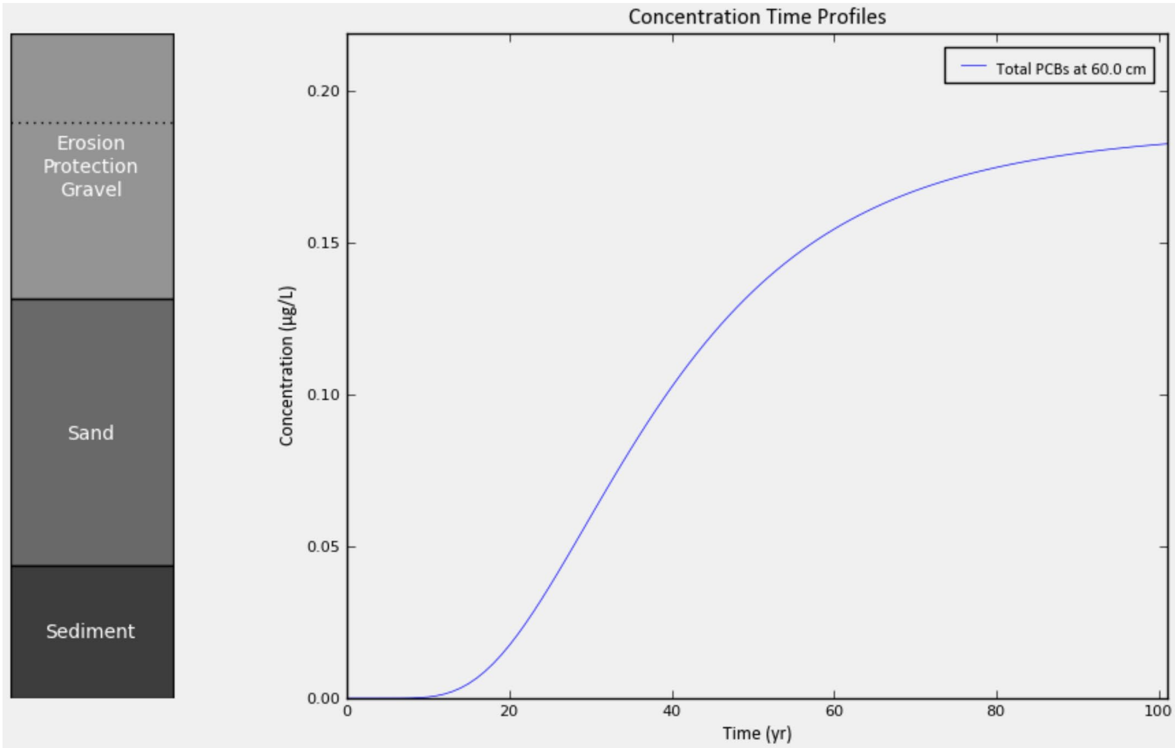

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Phenanthrene at 60.0 cm
Concentration (µg/L)
Time (yr)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100

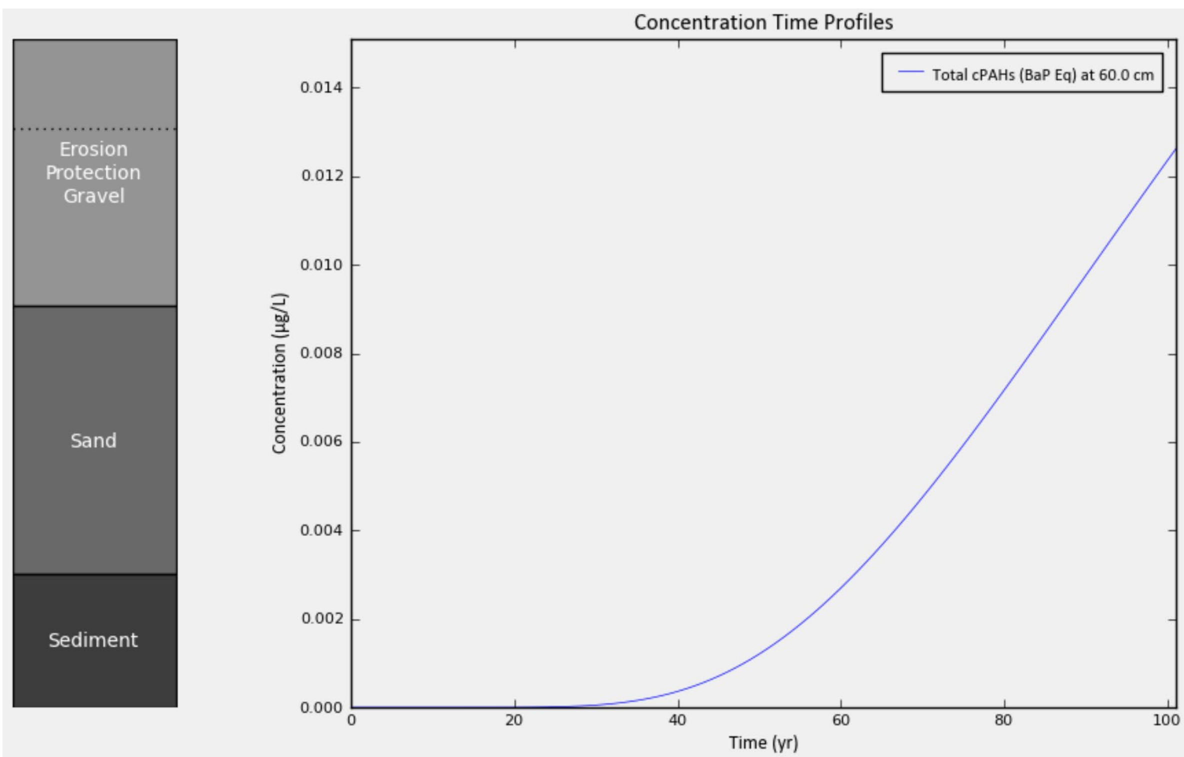

Concentration Time Profiles
Pyrene at 60.0 cm
Erosion
Protection
Gravel
Sand
Sediment
Concentration (µg/L)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0
20
40
60
80
100
Time (yr)


Concentration Time Profiles
TCDD at 60.0 cm
Erosion
Protection
Gravel
Sand
Sediment
Concentration (µg/L)
0.0e+00
5.0e-07
1.0e-06
1.5e-06
2.0e-06
2.5e-06
3.0e-06
3.5e-06
4.0e-06
0
20
40
60
80
100
Time (yr)


Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
TCDF at 60.0 cm
Concentration (µg/L)
1.4e-06
1.2e-06
1.0e-06
8.0e-07
6.0e-07
4.0e-07
2.0e-07
0.0e+00
0
20
40
60
80
100
Time (yr)

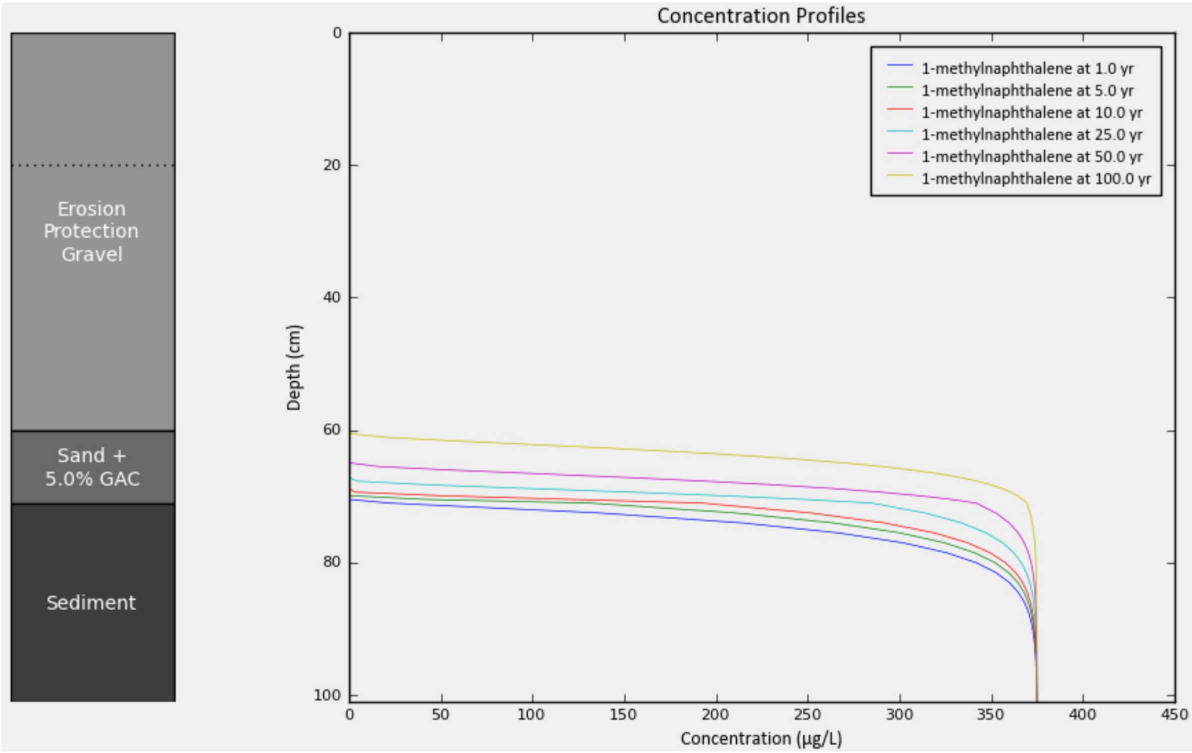

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Total PAHs at 60.0 cm
Concentration (µg/L)
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Time (yr)

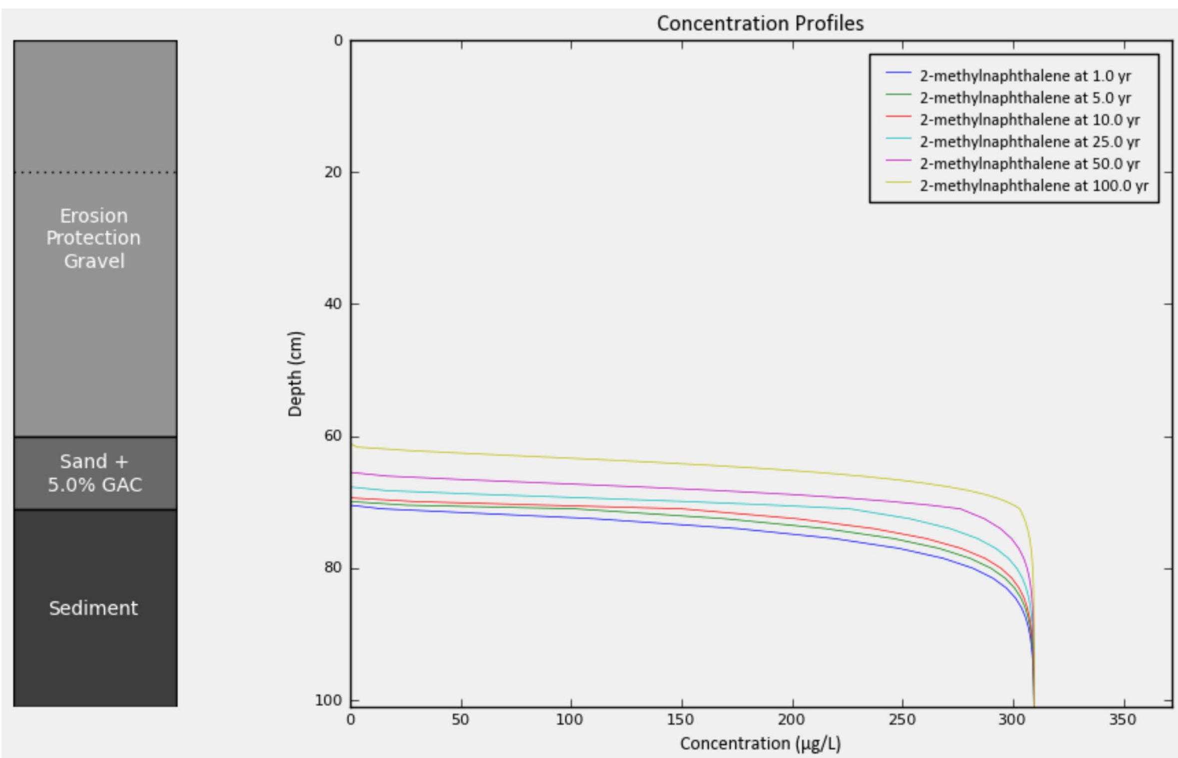

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Total PCBs at 60.0 cm
Concentration (µg/L)
0.00
0.05
0.10
0.15
0.20
0
20
40
60
80
100
Time (yr)

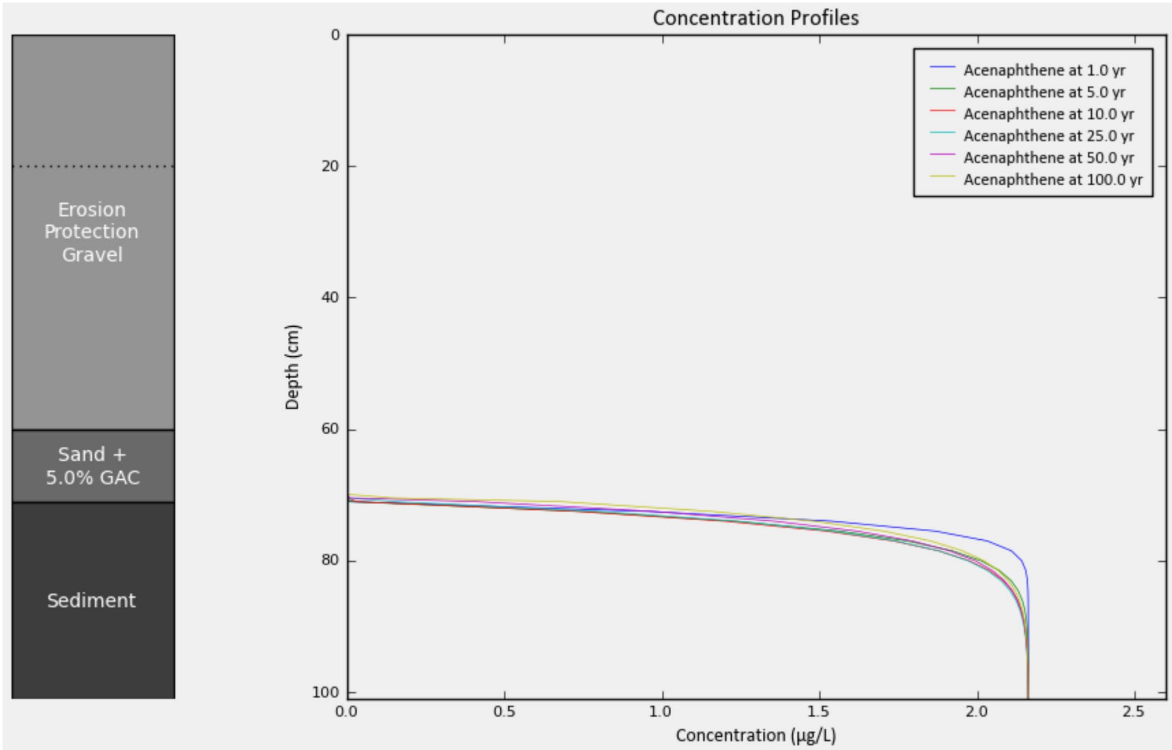

Erosion
Protection
Gravel
Sand
Sediment
Concentration Time Profiles
Total cPAHs (BaP Eq) at 60.0 cm
Concentration (µg/L)
0.000
0.002
0.004
0.006
0.008
0.010
0.012
0.014
0
20
40
60
80
100
Time (yr)

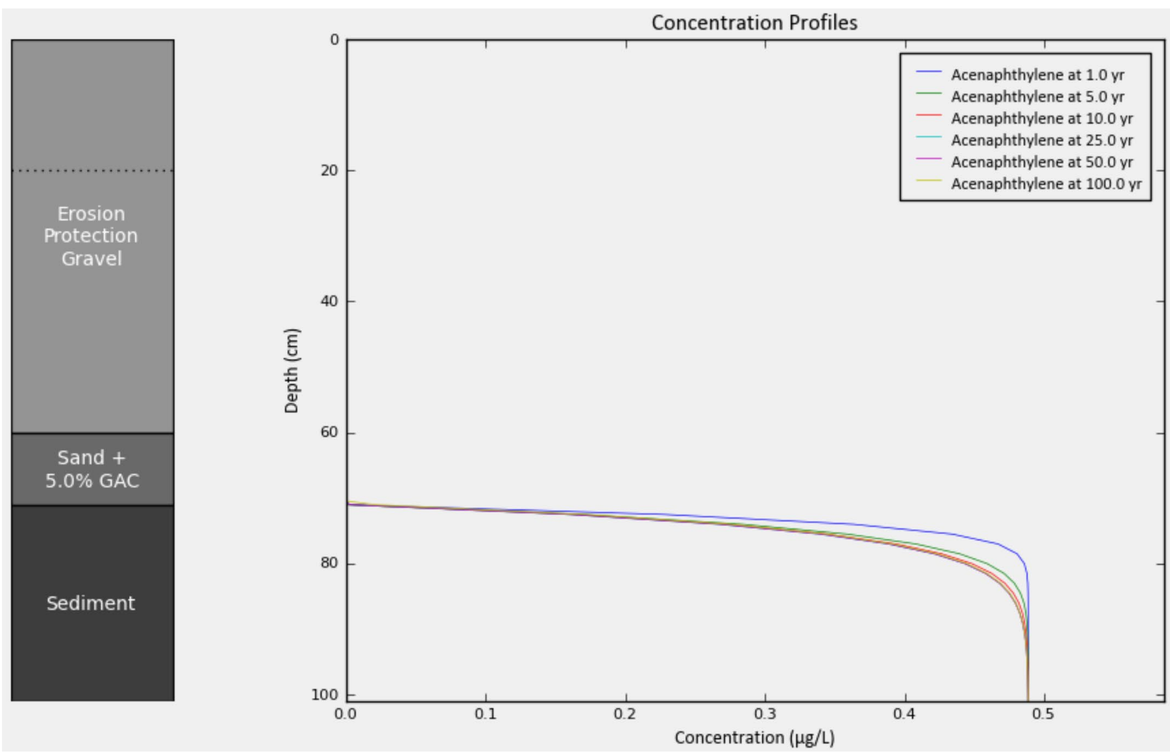
Cap Alternative 2: 11 cm of 5.0% GAC amended sand with 60 cm erosion protection layer

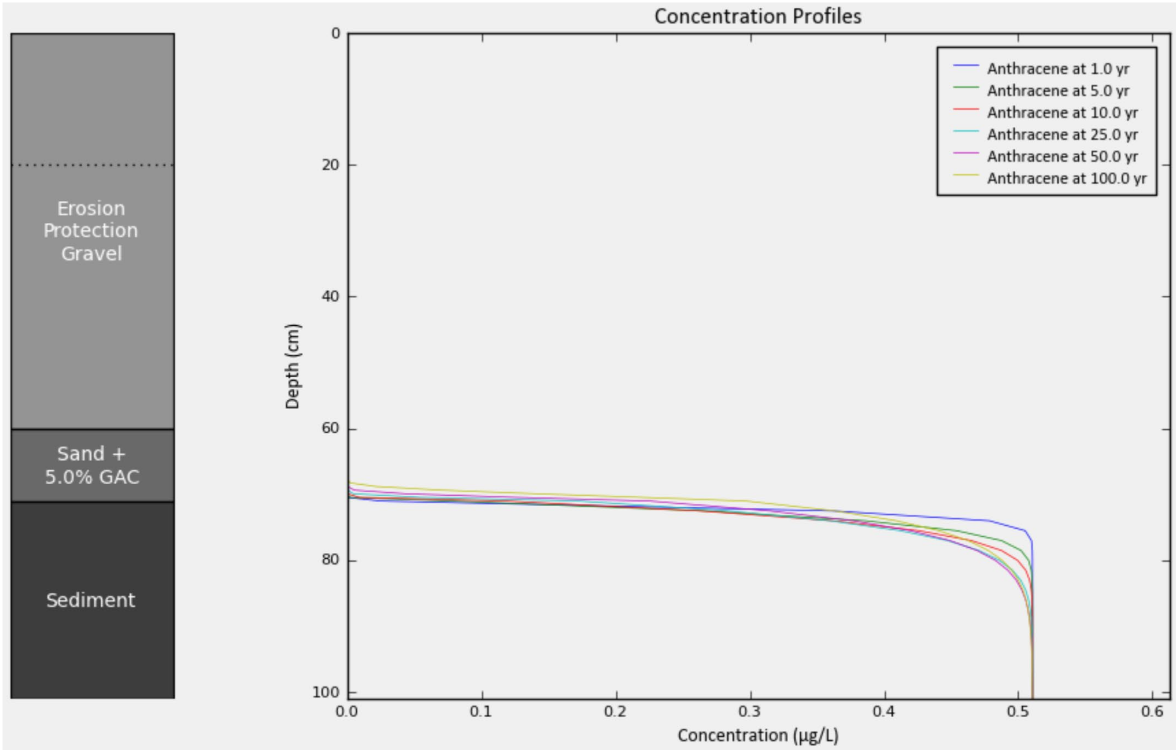
Porewater Concentration – Depth

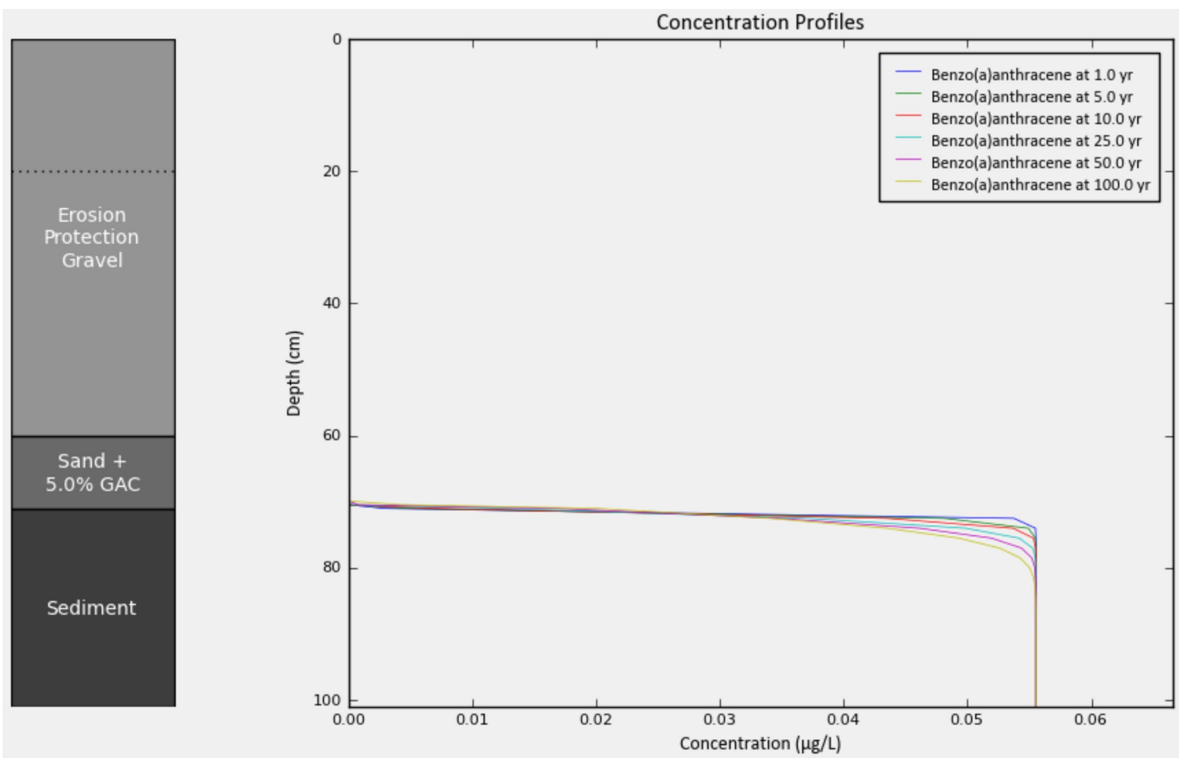


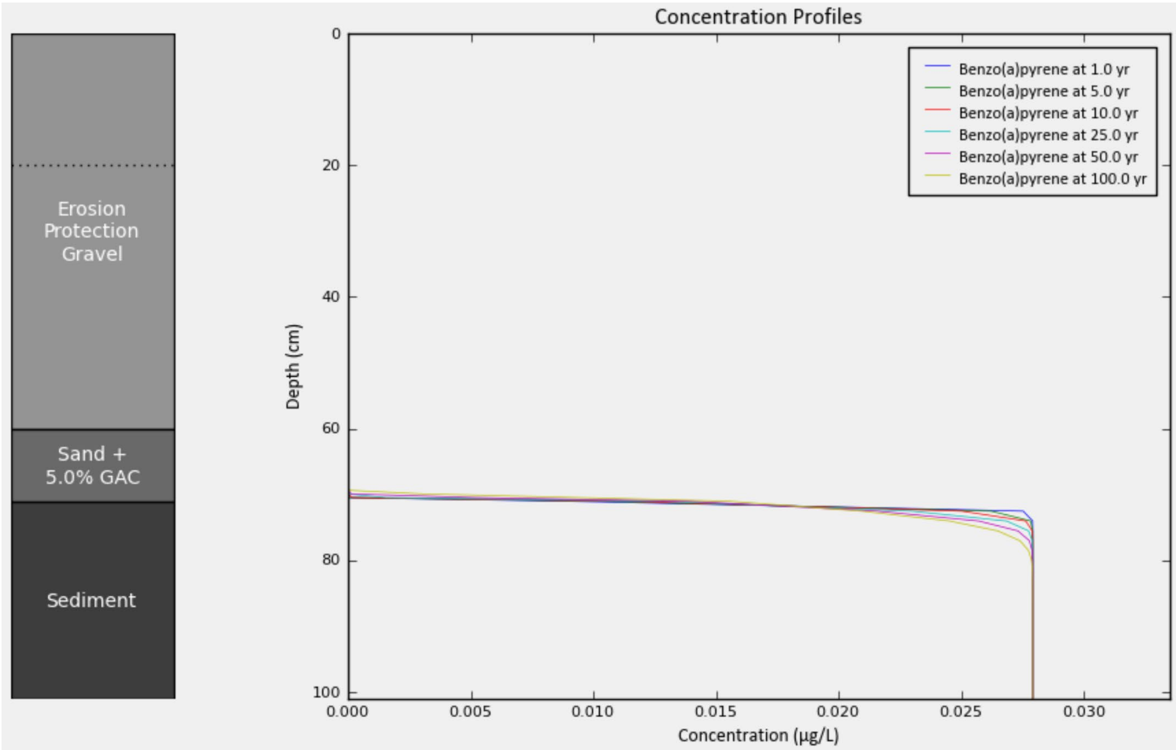


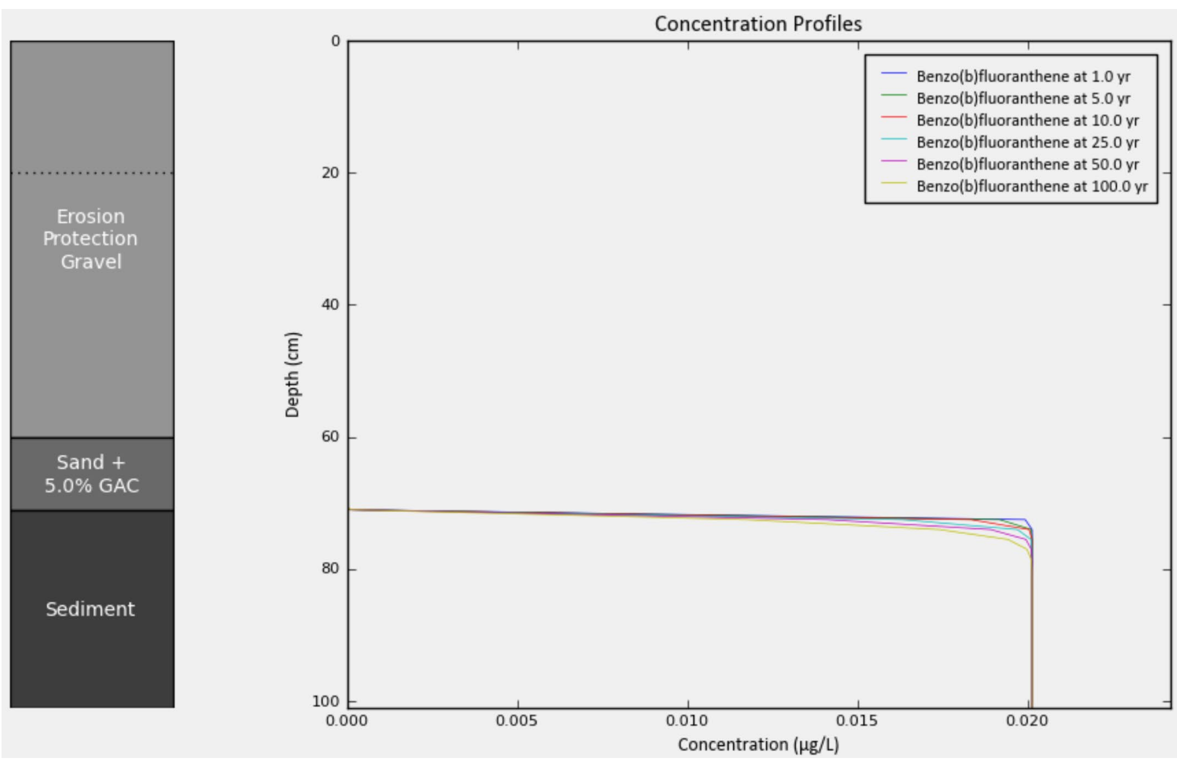

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Acenaphthene at 1.0 yr
Acenaphthene at 5.0 yr
Acenaphthene at 10.0 yr
Acenaphthene at 25.0 yr
Acenaphthene at 50.0 yr
Acenaphthene at 100.0 yr

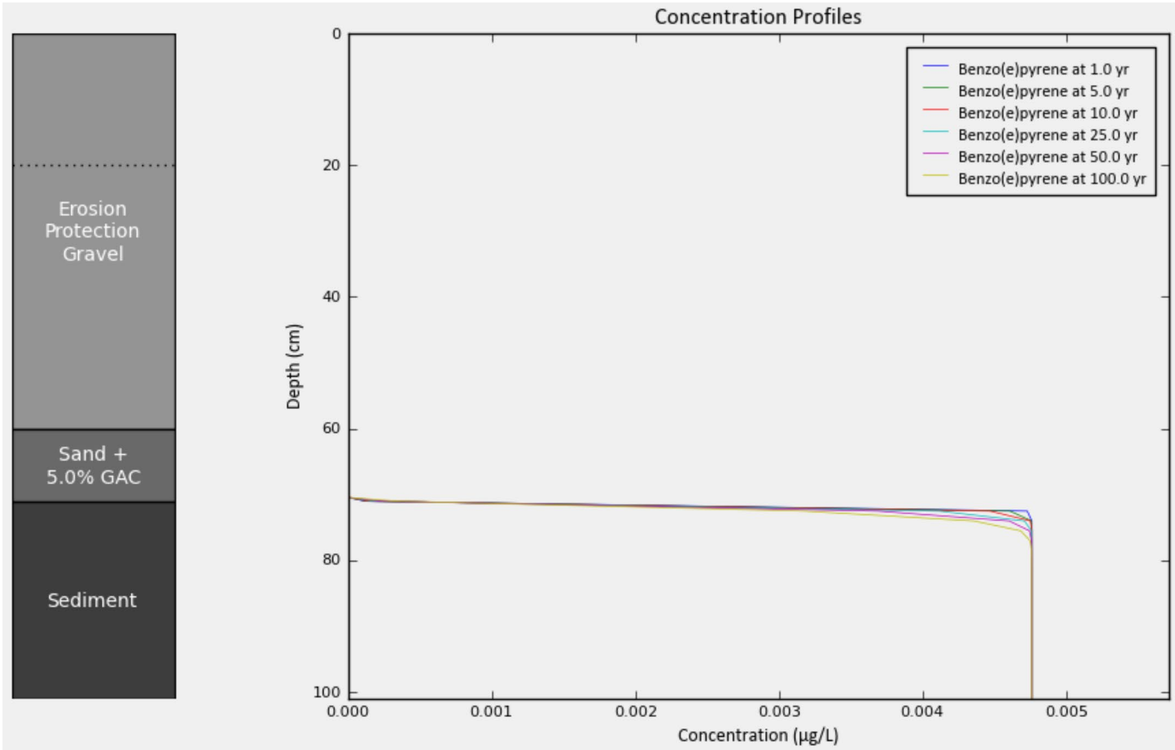

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Acenaphthylene at 1.0 yr
Acenaphthylene at 5.0 yr
Acenaphthylene at 10.0 yr
Acenaphthylene at 25.0 yr
Acenaphthylene at 50.0 yr
Acenaphthylene at 100.0 yr

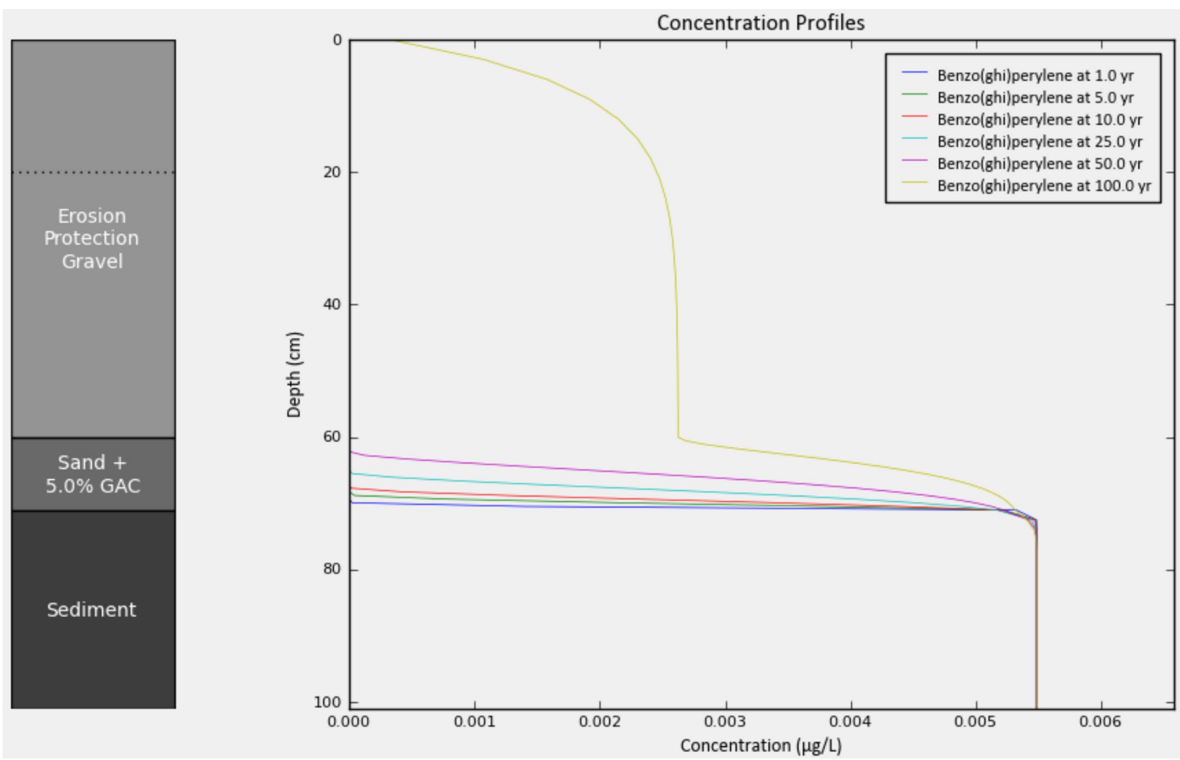

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Anthracene at 1.0 yr
Anthracene at 5.0 yr
Anthracene at 10.0 yr
Anthracene at 25.0 yr
Anthracene at 50.0 yr
Anthracene at 100.0 yr

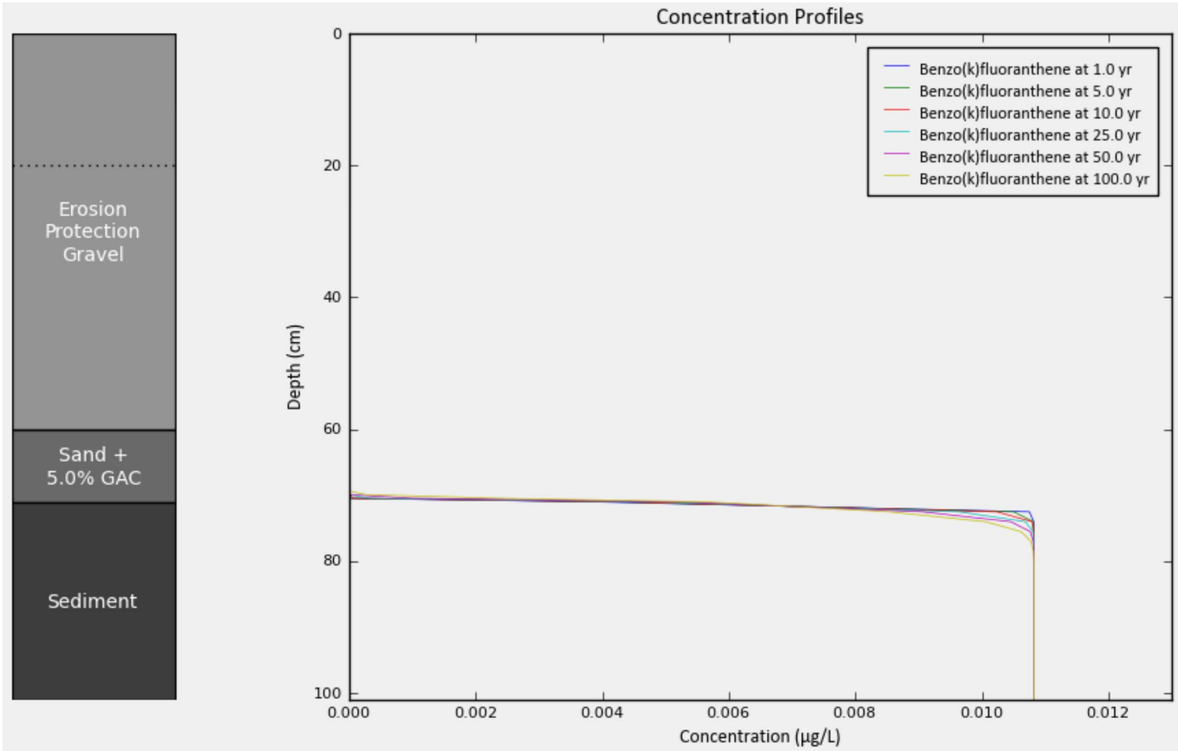

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(a)anthracene at 1.0 yr
Benzo(a)anthracene at 5.0 yr
Benzo(a)anthracene at 10.0 yr
Benzo(a)anthracene at 25.0 yr
Benzo(a)anthracene at 50.0 yr
Benzo(a)anthracene at 100.0 yr

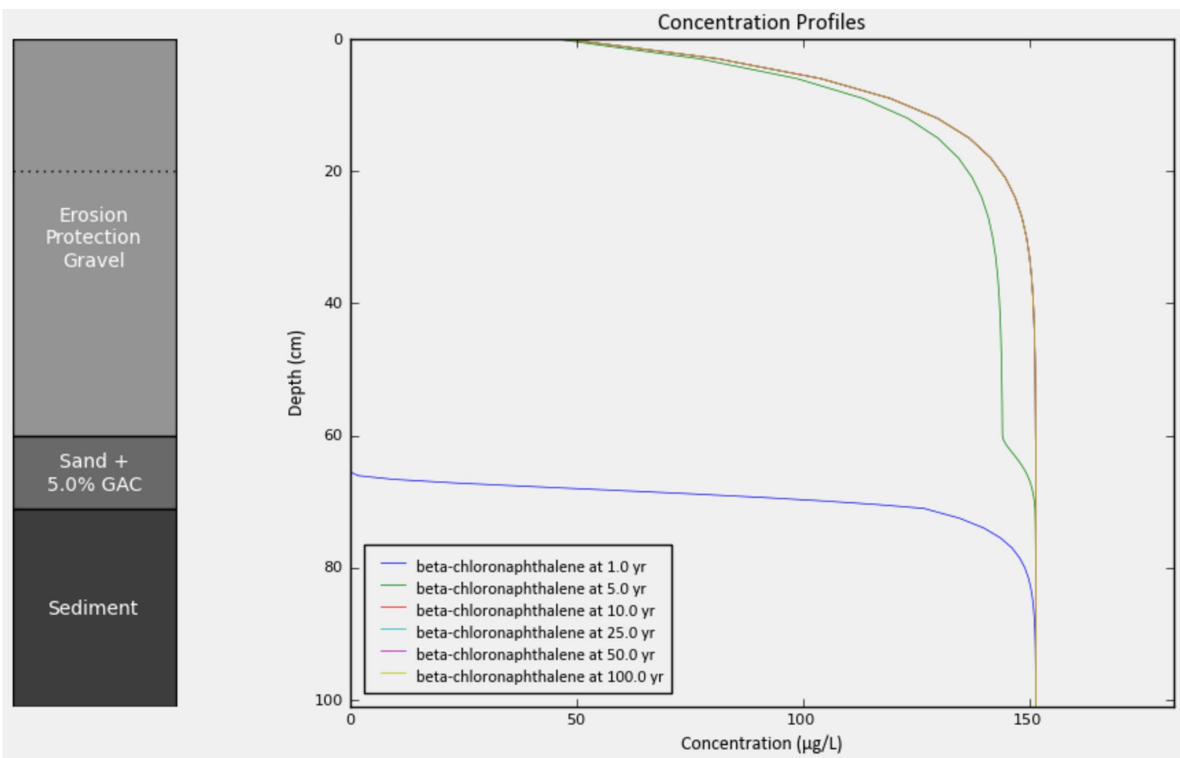

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(a)pyrene at 1.0 yr
Benzo(a)pyrene at 5.0 yr
Benzo(a)pyrene at 10.0 yr
Benzo(a)pyrene at 25.0 yr
Benzo(a)pyrene at 50.0 yr
Benzo(a)pyrene at 100.0 yr

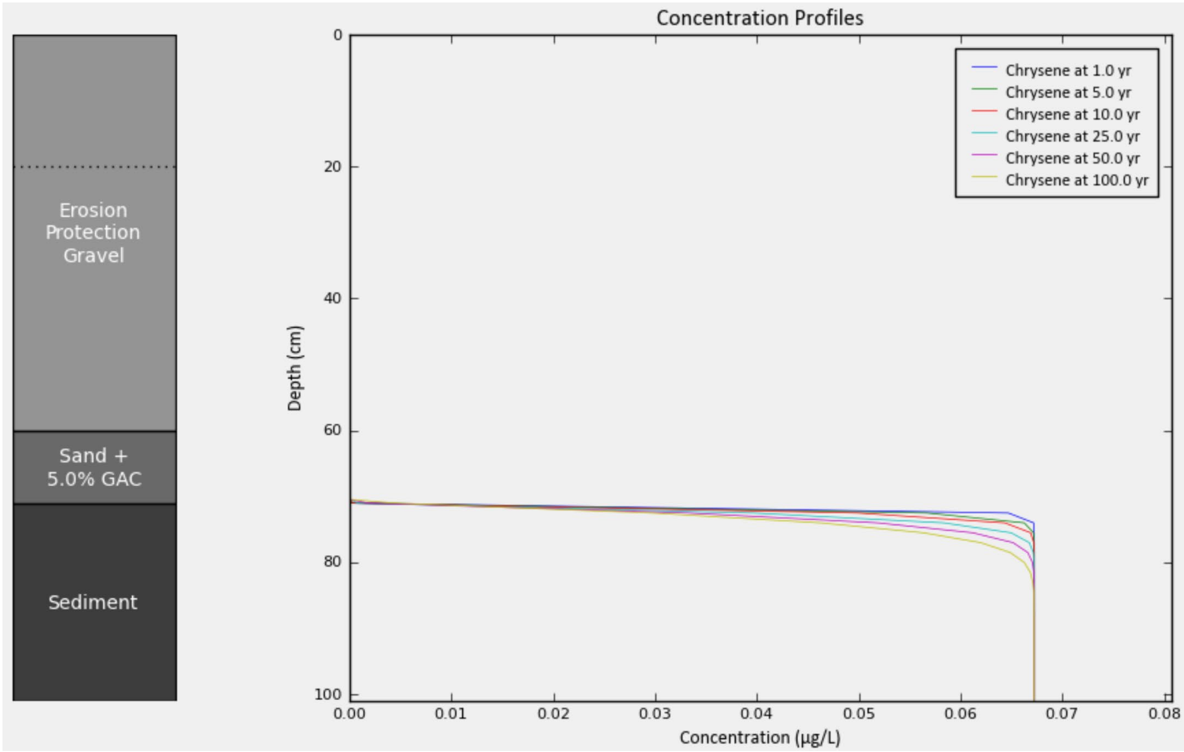

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(b)fluoranthene at 1.0 yr
Benzo(b)fluoranthene at 5.0 yr
Benzo(b)fluoranthene at 10.0 yr
Benzo(b)fluoranthene at 25.0 yr
Benzo(b)fluoranthene at 50.0 yr
Benzo(b)fluoranthene at 100.0 yr

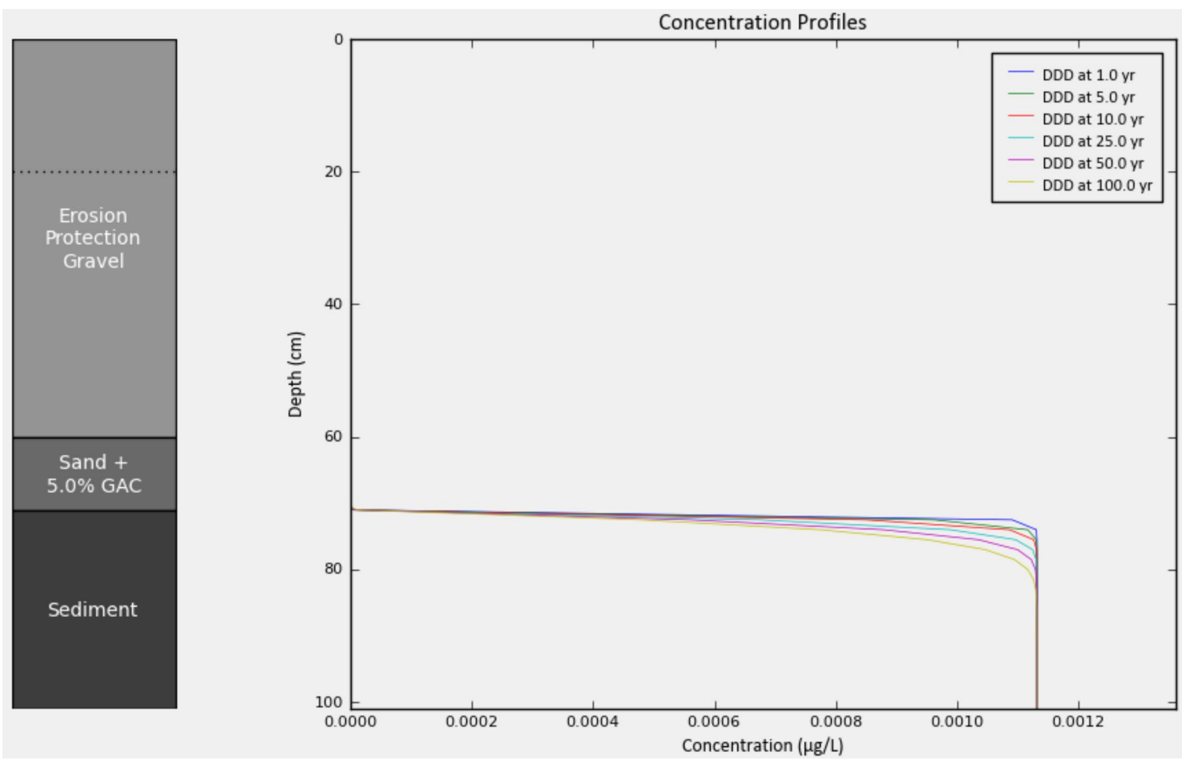

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(e)pyrene at 1.0 yr
Benzo(e)pyrene at 5.0 yr
Benzo(e)pyrene at 10.0 yr
Benzo(e)pyrene at 25.0 yr
Benzo(e)pyrene at 50.0 yr
Benzo(e)pyrene at 100.0 yr

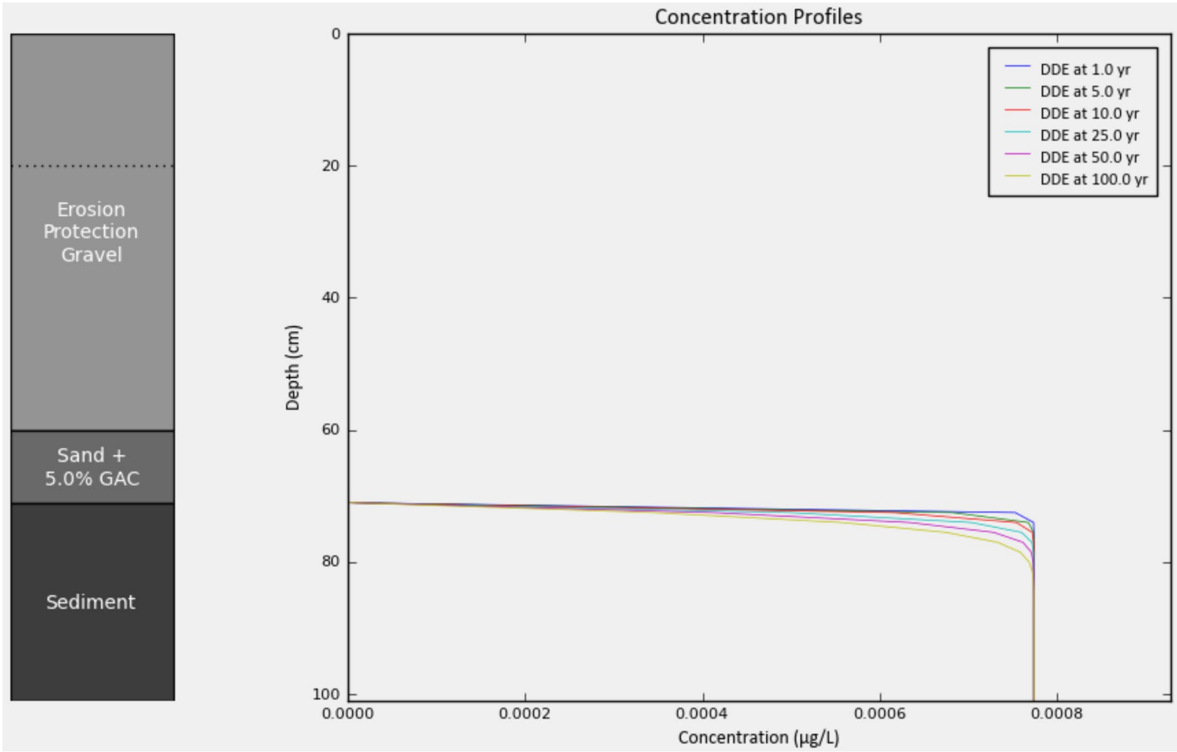

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(ghi)perylene at 1.0 yr
Benzo(ghi)perylene at 5.0 yr
Benzo(ghi)perylene at 10.0 yr
Benzo(ghi)perylene at 25.0 yr
Benzo(ghi)perylene at 50.0 yr
Benzo(ghi)perylene at 100.0 yr

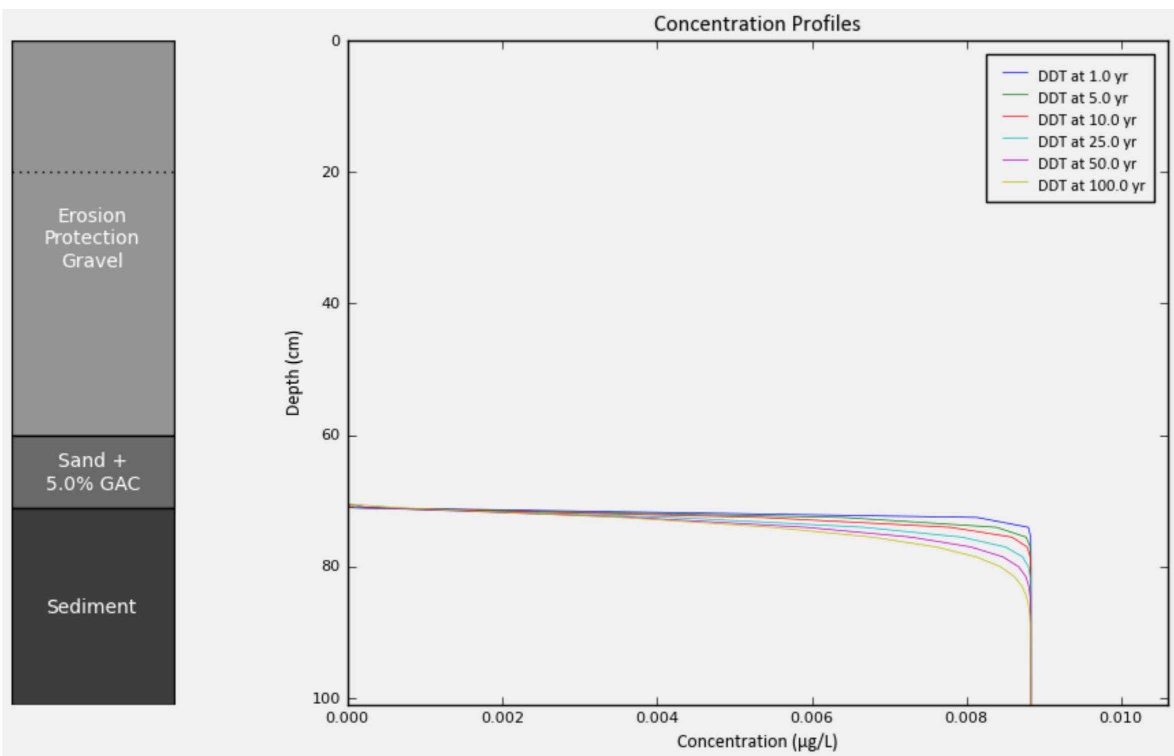

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(k)fluoranthene at 1.0 yr
Benzo(k)fluoranthene at 5.0 yr
Benzo(k)fluoranthene at 10.0 yr
Benzo(k)fluoranthene at 25.0 yr
Benzo(k)fluoranthene at 50.0 yr
Benzo(k)fluoranthene at 100.0 yr

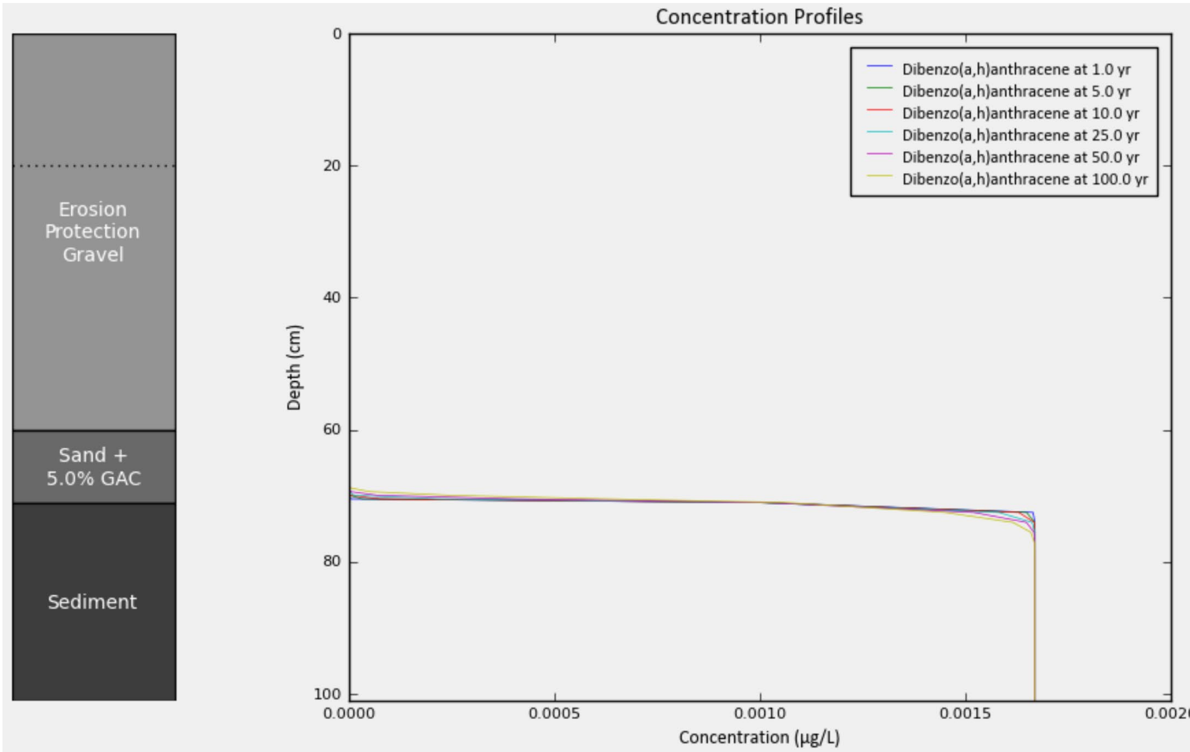

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
beta-chloronaphthalene at 1.0 yr
beta-chloronaphthalene at 5.0 yr
beta-chloronaphthalene at 10.0 yr
beta-chloronaphthalene at 25.0 yr
beta-chloronaphthalene at 50.0 yr
beta-chloronaphthalene at 100.0 yr

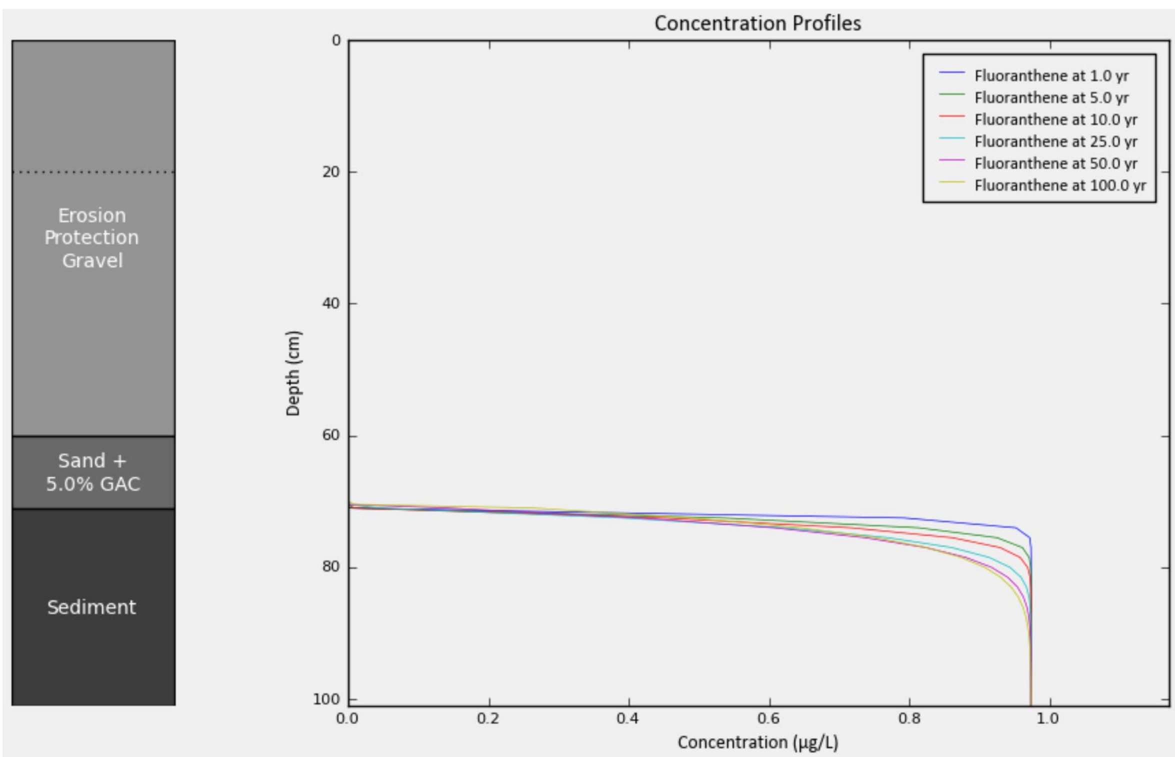

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
Chrysene at 1.0 yr
Chrysene at 5.0 yr
Chrysene at 10.0 yr
Chrysene at 25.0 yr
Chrysene at 50.0 yr
Chrysene at 100.0 yr

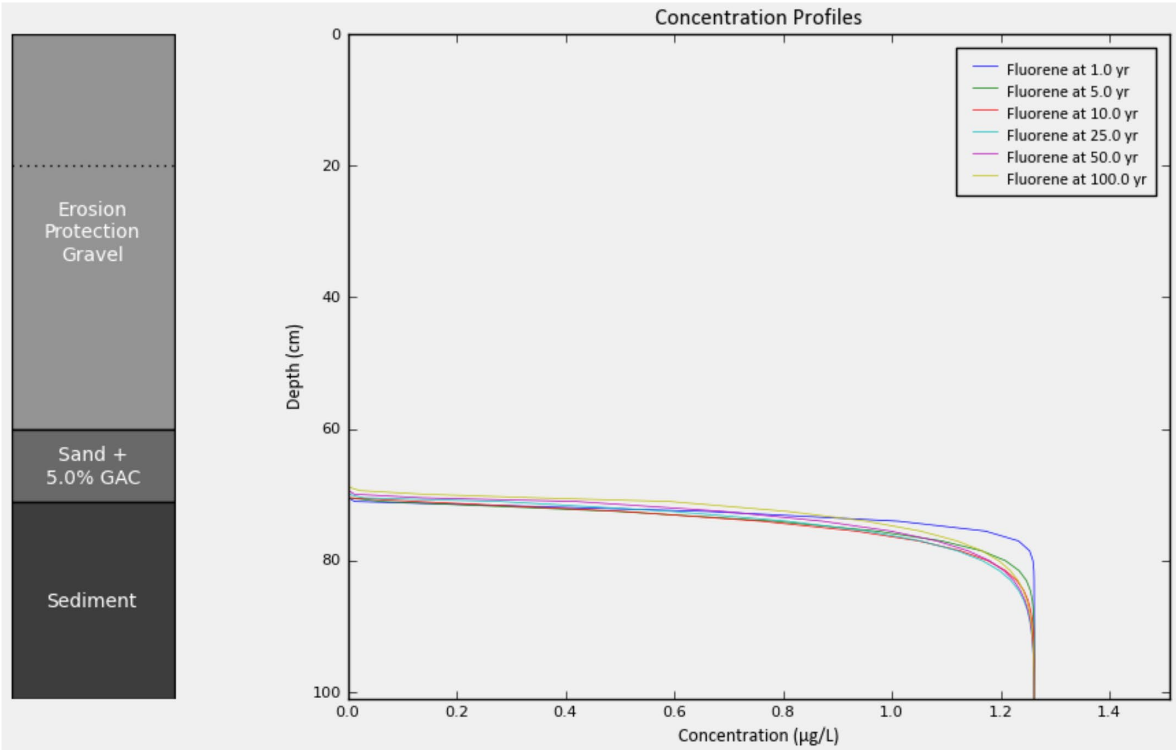

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
DDD at 1.0 yr
DDD at 5.0 yr
DDD at 10.0 yr
DDD at 25.0 yr
DDD at 50.0 yr
DDD at 100.0 yr

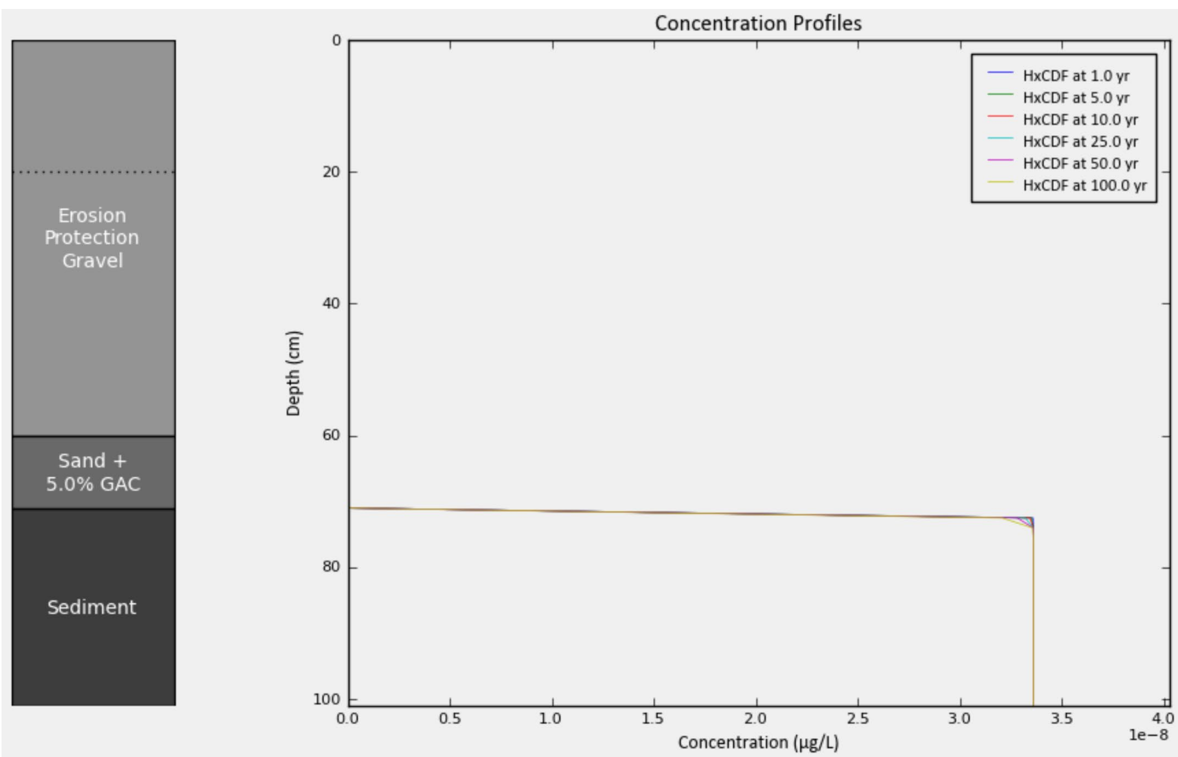

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (μg/L)
DDE at 1.0 yr
DDE at 5.0 yr
DDE at 10.0 yr
DDE at 25.0 yr
DDE at 50.0 yr
DDE at 100.0 yr
0
20
40
60
80
100
0.0000
0.0002
0.0004
0.0006
0.0008

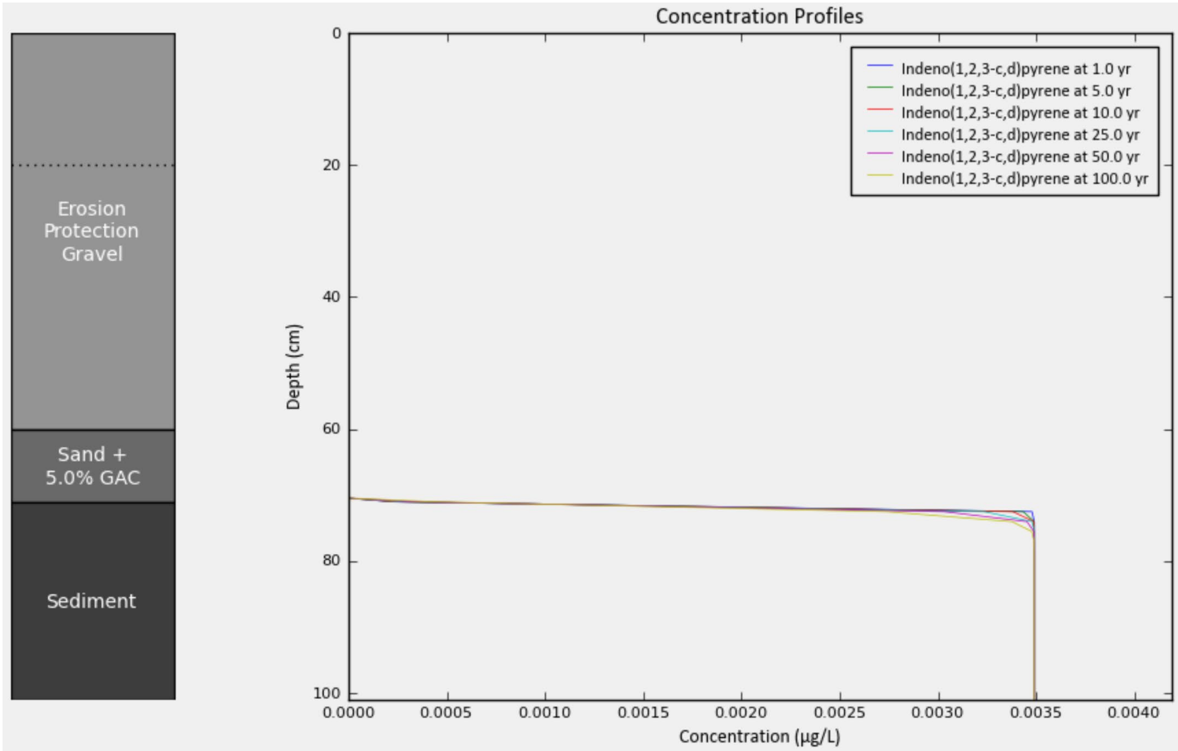

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (μg/L)
DDT at 1.0 yr
DDT at 5.0 yr
DDT at 10.0 yr
DDT at 25.0 yr
DDT at 50.0 yr
DDT at 100.0 yr
0
20
40
60
80
100
0.000
0.002
0.004
0.006
0.008
0.010

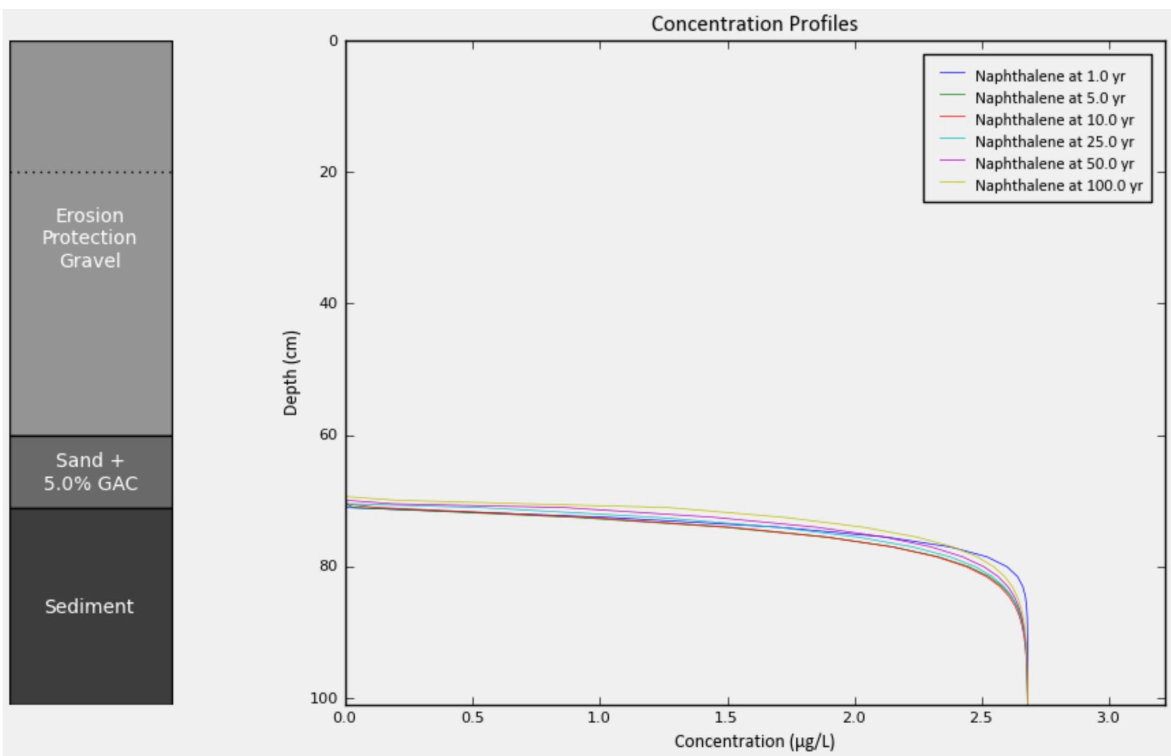

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Dibenzo(a,h)anthracene at 1.0 yr
Dibenzo(a,h)anthracene at 5.0 yr
Dibenzo(a,h)anthracene at 10.0 yr
Dibenzo(a,h)anthracene at 25.0 yr
Dibenzo(a,h)anthracene at 50.0 yr
Dibenzo(a,h)anthracene at 100.0 yr
Depth (cm)
0
20
40
60
80
100
0.0000
0.0005
0.0010
0.0015
0.0020
Concentration (μg/L)

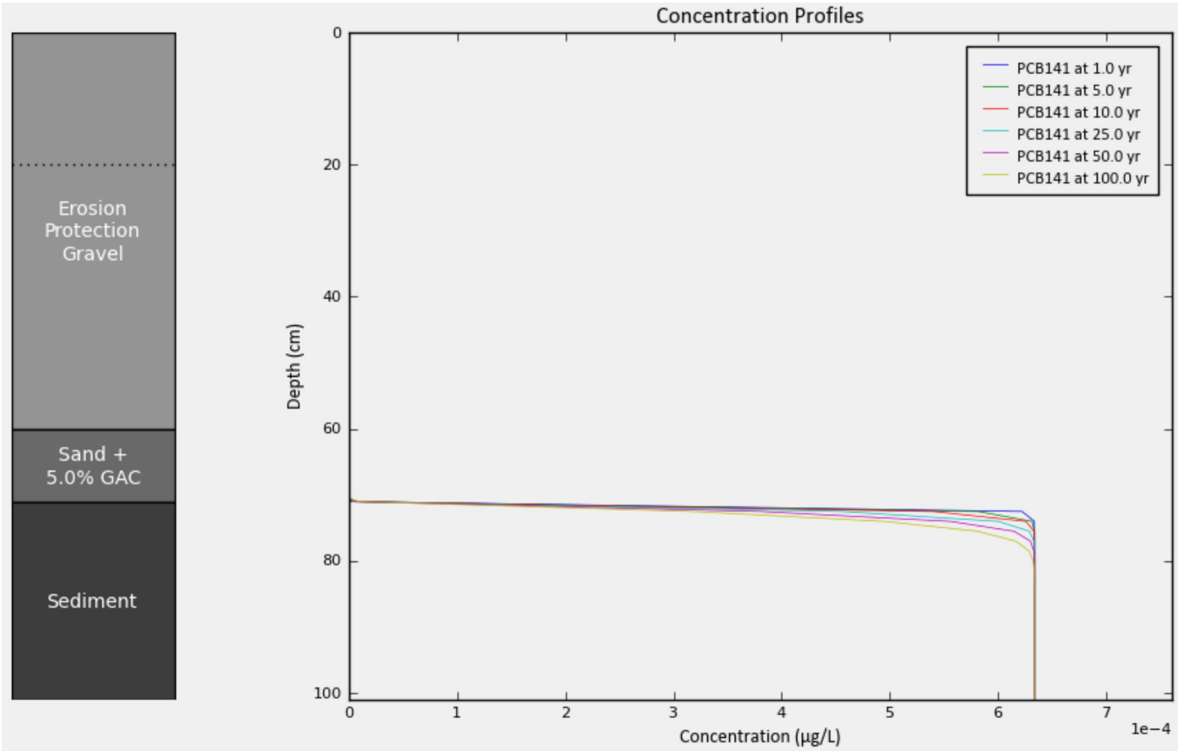

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Fluoranthene at 1.0 yr
Fluoranthene at 5.0 yr
Fluoranthene at 10.0 yr
Fluoranthene at 25.0 yr
Fluoranthene at 50.0 yr
Fluoranthene at 100.0 yr
Depth (cm)
0
20
40
60
80
100
0.0
0.2
0.4
0.6
0.8
1.0
Concentration (μg/L)

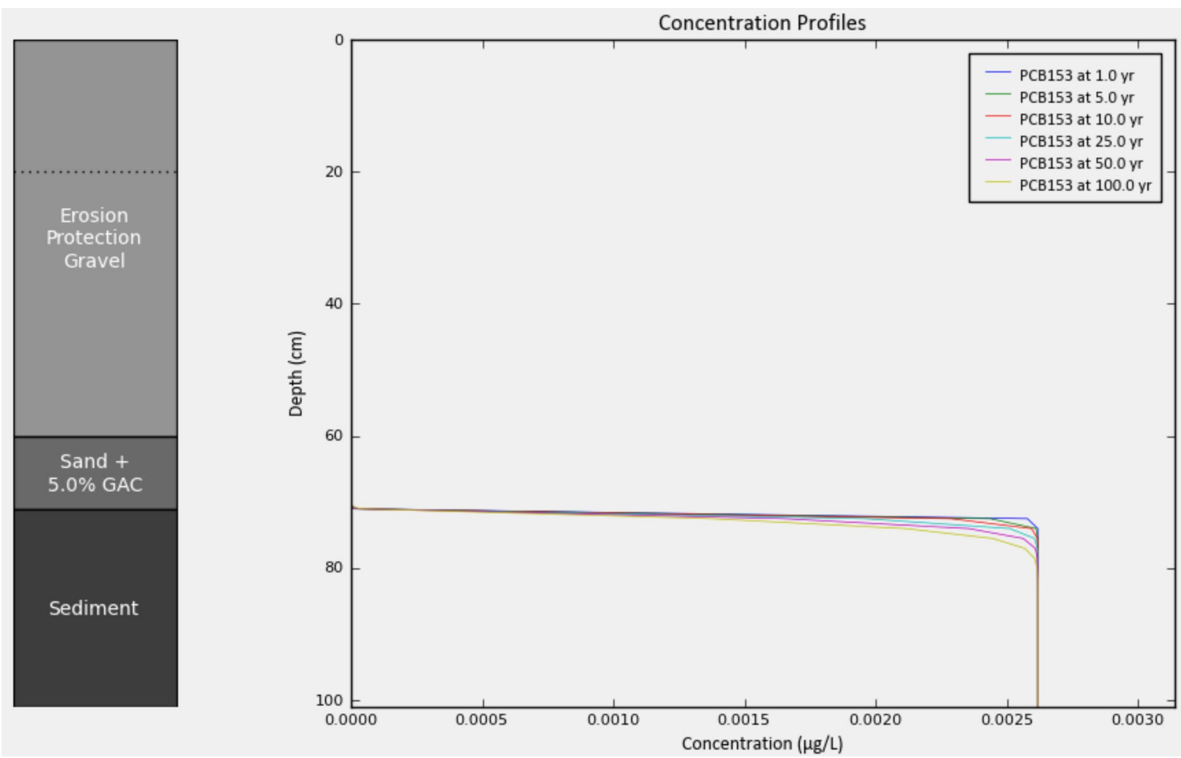

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
Fluorene at 1.0 yr
Fluorene at 5.0 yr
Fluorene at 10.0 yr
Fluorene at 25.0 yr
Fluorene at 50.0 yr
Fluorene at 100.0 yr

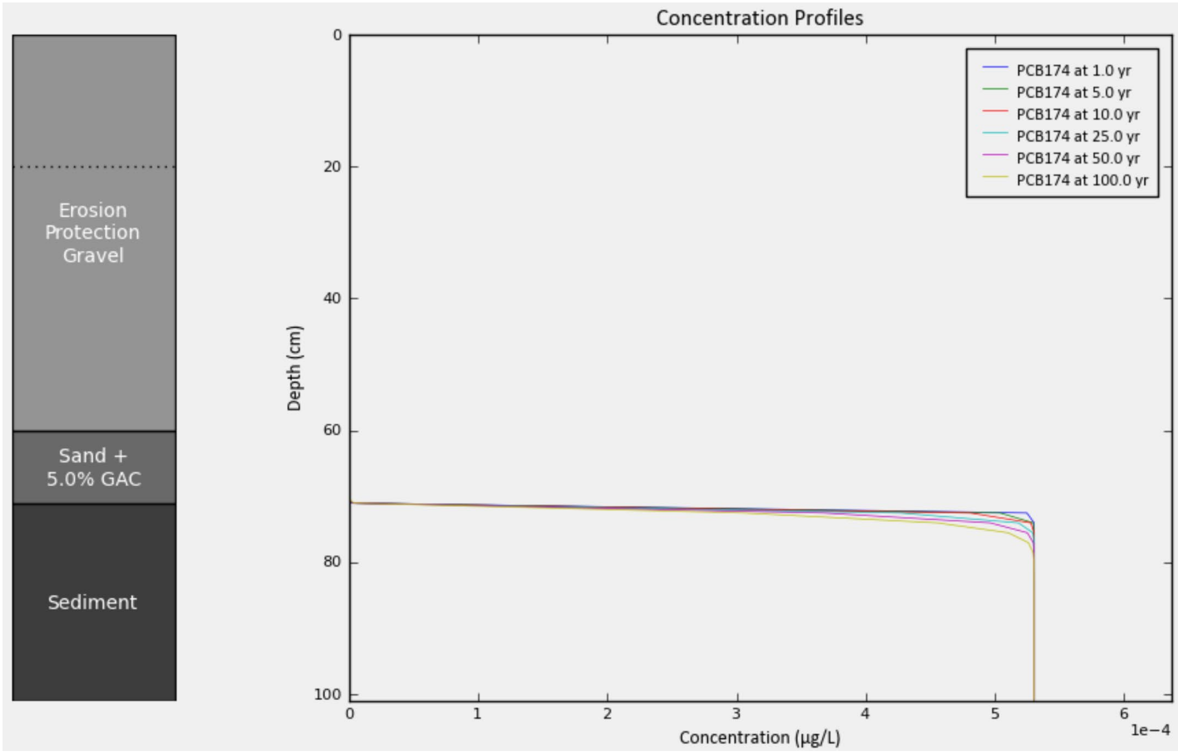

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (μg/L)
1e−8
HxCDF at 1.0 yr
HxCDF at 5.0 yr
HxCDF at 10.0 yr
HxCDF at 25.0 yr
HxCDF at 50.0 yr
HxCDF at 100.0 yr

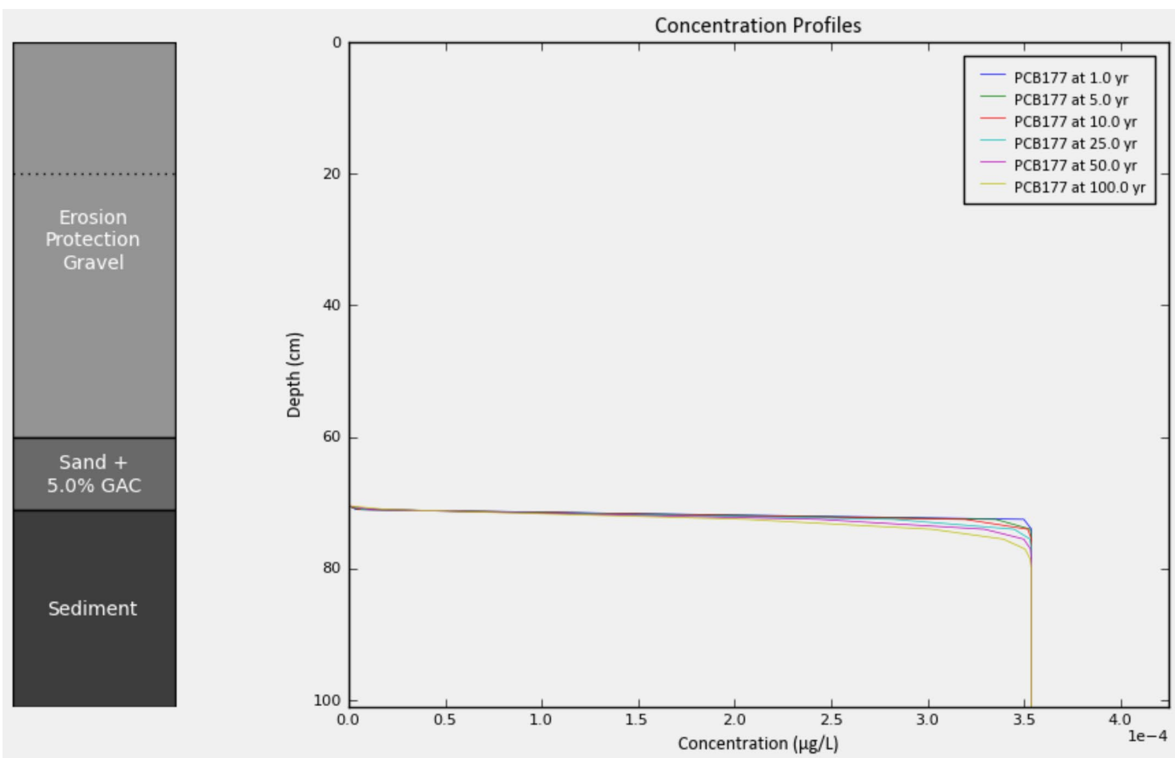

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Indeno(1,2,3-c,d)pyrene at 1.0 yr
Indeno(1,2,3-c,d)pyrene at 5.0 yr
Indeno(1,2,3-c,d)pyrene at 10.0 yr
Indeno(1,2,3-c,d)pyrene at 25.0 yr
Indeno(1,2,3-c,d)pyrene at 50.0 yr
Indeno(1,2,3-c,d)pyrene at 100.0 yr
0
20
40
60
80
100
0.0000
0.0005
0.0010
0.0015
0.0020
0.0025
0.0030
0.0035
0.0040

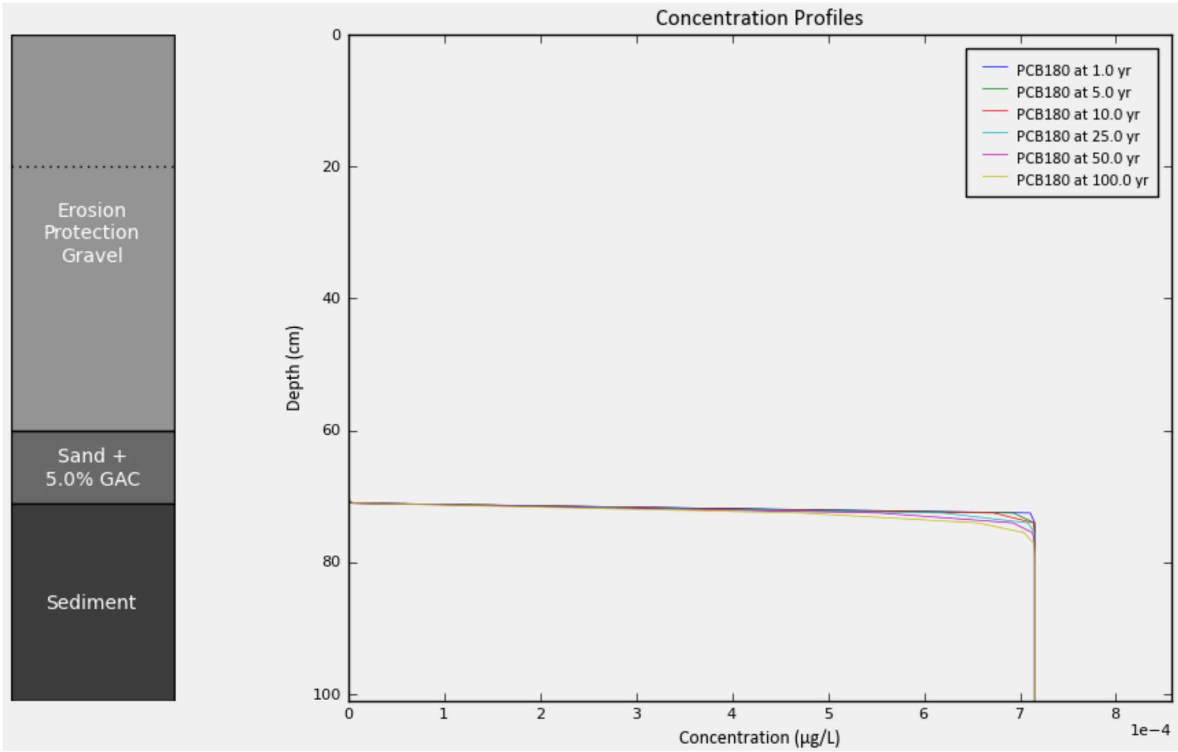

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Naphthalene at 1.0 yr
Naphthalene at 5.0 yr
Naphthalene at 10.0 yr
Naphthalene at 25.0 yr
Naphthalene at 50.0 yr
Naphthalene at 100.0 yr
0
20
40
60
80
100
0.0
0.5
1.0
1.5
2.0
2.5
3.0

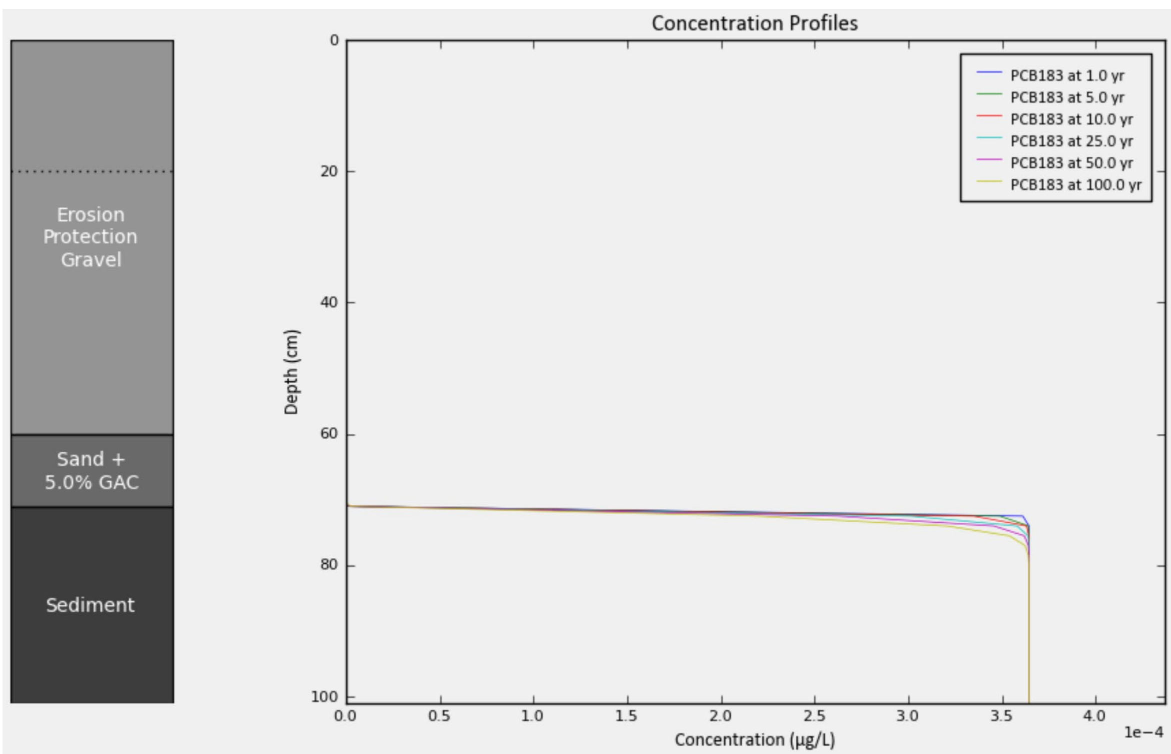

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
1e−4
PCB141 at 1.0 yr
PCB141 at 5.0 yr
PCB141 at 10.0 yr
PCB141 at 25.0 yr
PCB141 at 50.0 yr
PCB141 at 100.0 yr

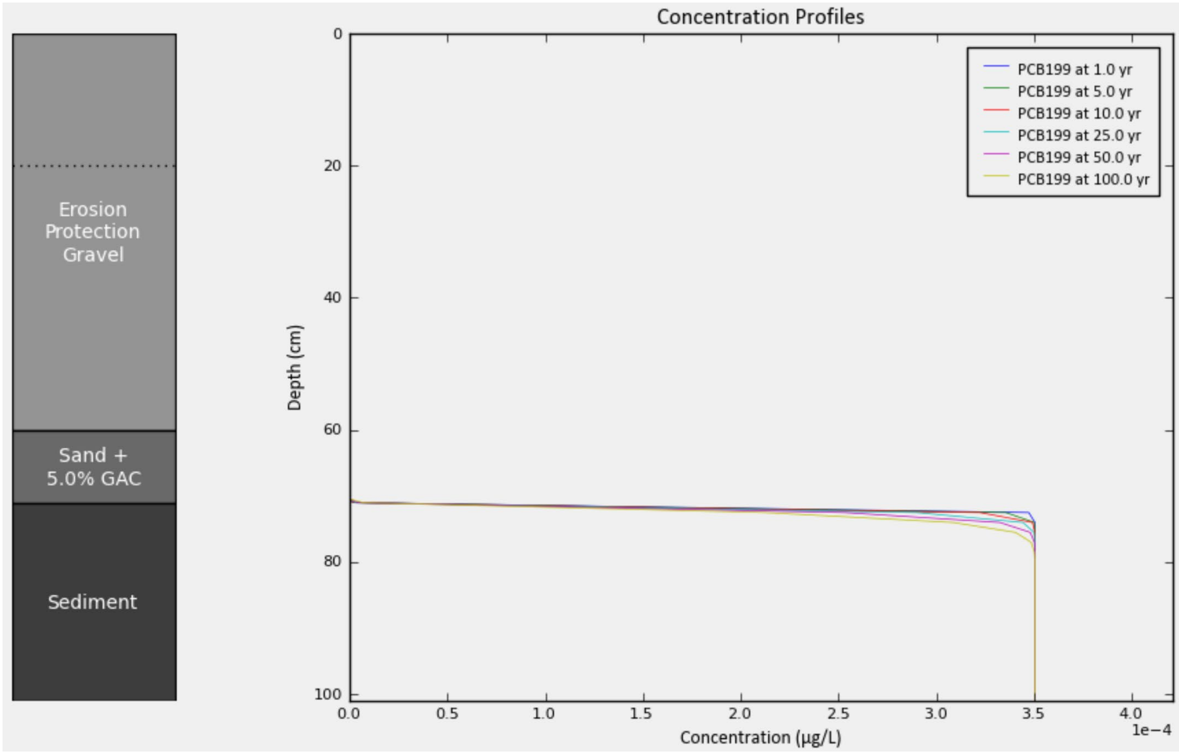

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
PCB153 at 1.0 yr
PCB153 at 5.0 yr
PCB153 at 10.0 yr
PCB153 at 25.0 yr
PCB153 at 50.0 yr
PCB153 at 100.0 yr

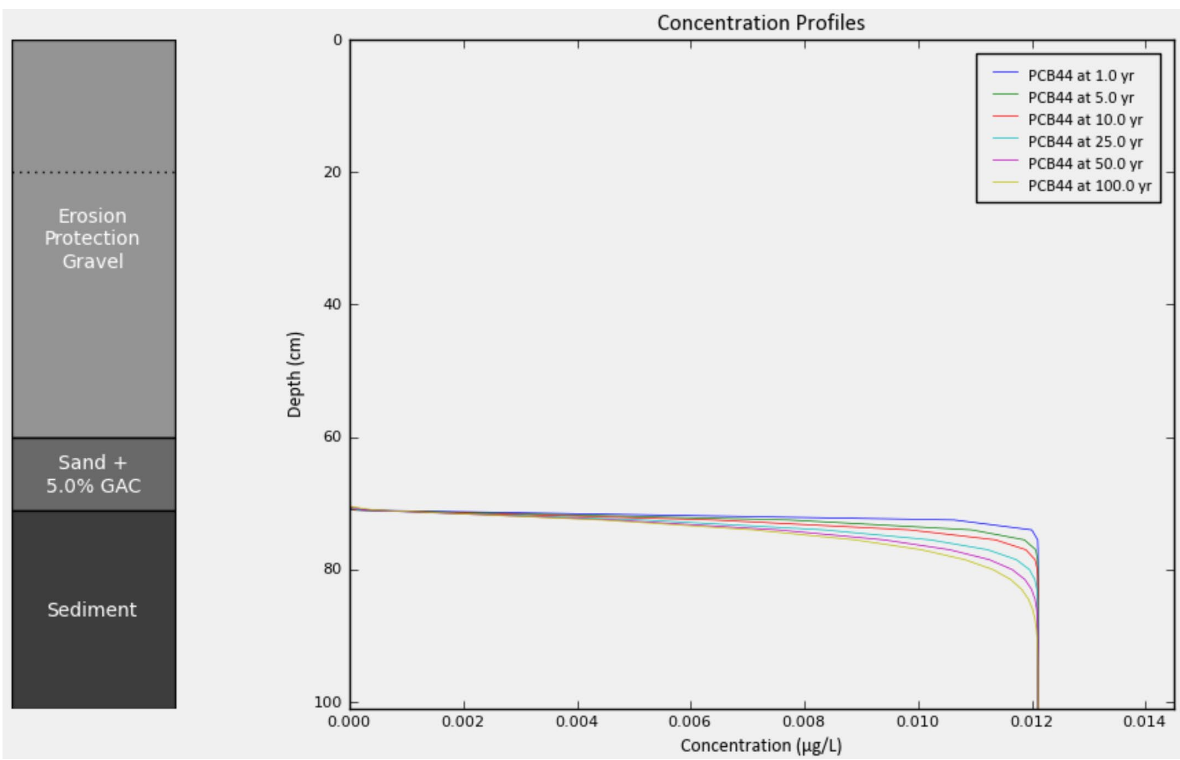

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Profiles
PCB174 at 1.0 yr
PCB174 at 5.0 yr
PCB174 at 10.0 yr
PCB174 at 25.0 yr
PCB174 at 50.0 yr
PCB174 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

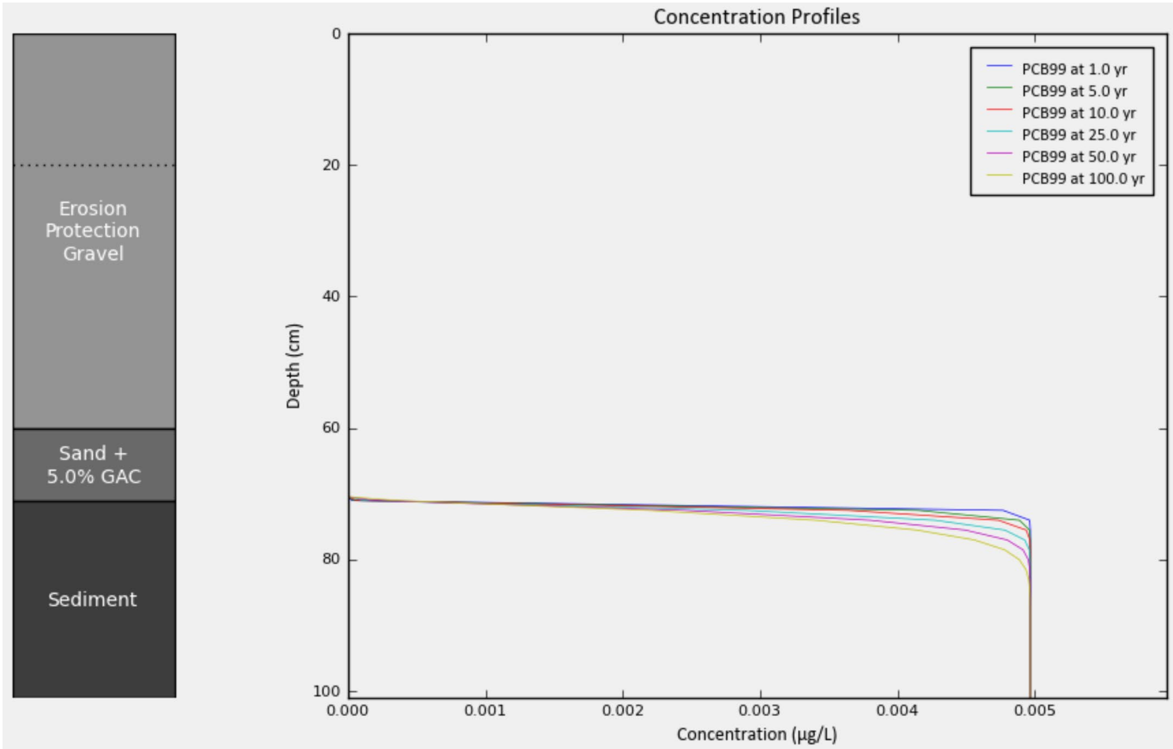

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Profiles
PCB177 at 1.0 yr
PCB177 at 5.0 yr
PCB177 at 10.0 yr
PCB177 at 25.0 yr
PCB177 at 50.0 yr
PCB177 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

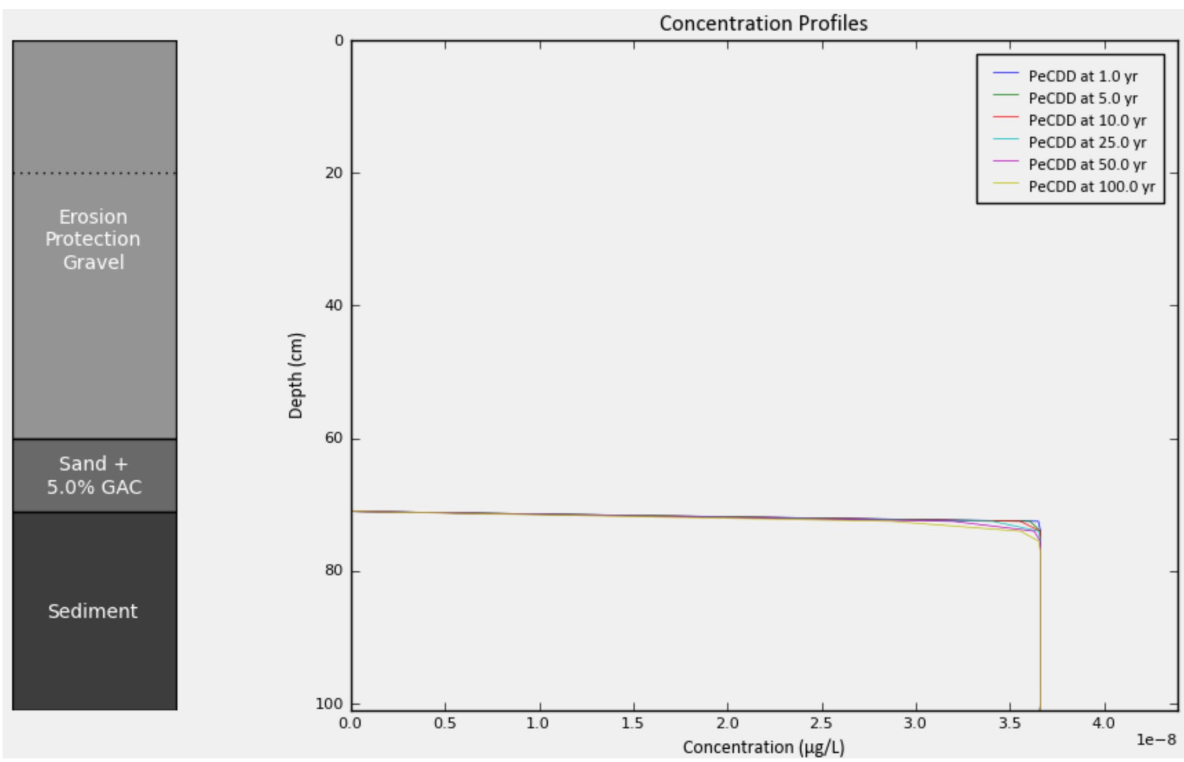

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB180 at 1.0 yr
PCB180 at 5.0 yr
PCB180 at 10.0 yr
PCB180 at 25.0 yr
PCB180 at 50.0 yr
PCB180 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

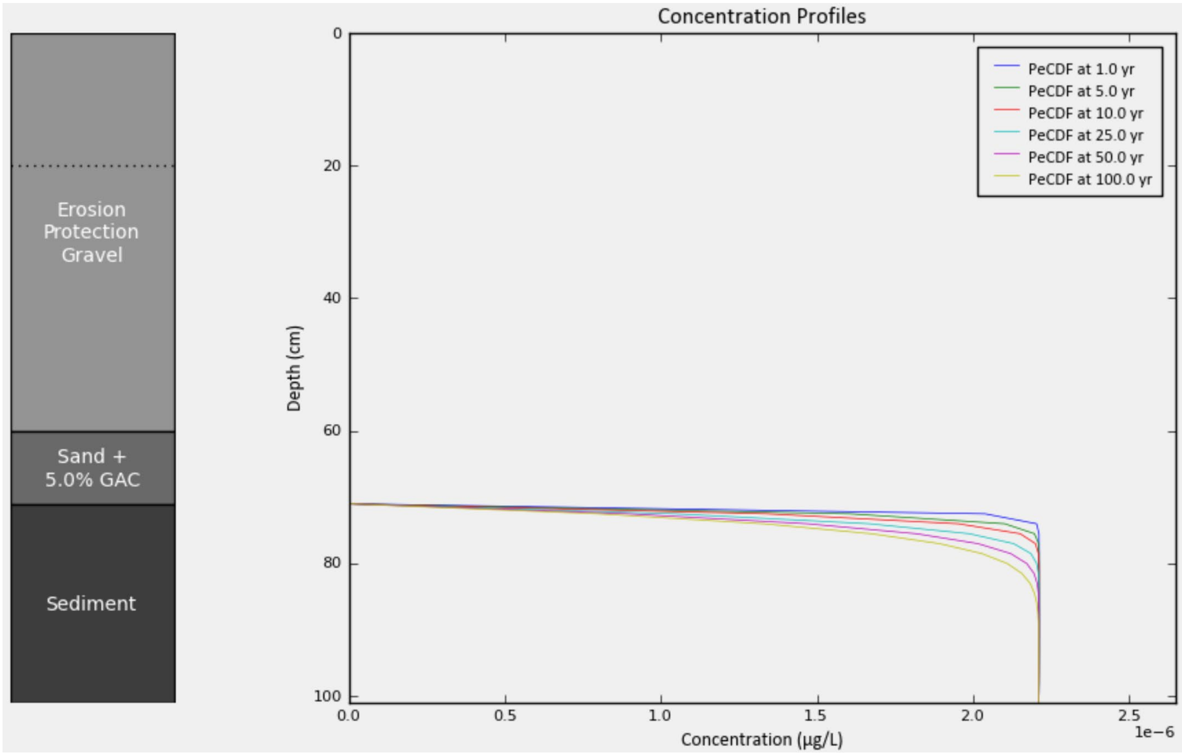

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB183 at 1.0 yr
PCB183 at 5.0 yr
PCB183 at 10.0 yr
PCB183 at 25.0 yr
PCB183 at 50.0 yr
PCB183 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

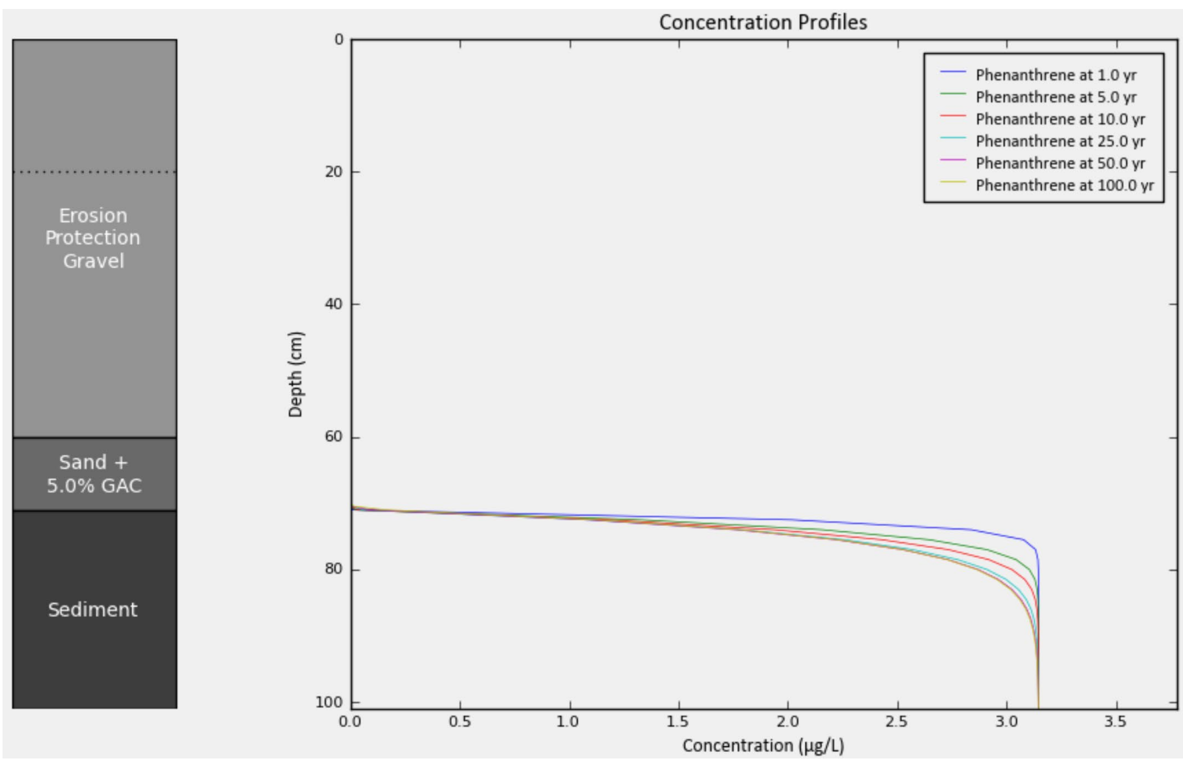

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
PCB199 at 1.0 yr
PCB199 at 5.0 yr
PCB199 at 10.0 yr
PCB199 at 25.0 yr
PCB199 at 50.0 yr
PCB199 at 100.0 yr
Depth (cm)
0
20
40
60
80
100
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
1e−4
Concentration (µg/L)

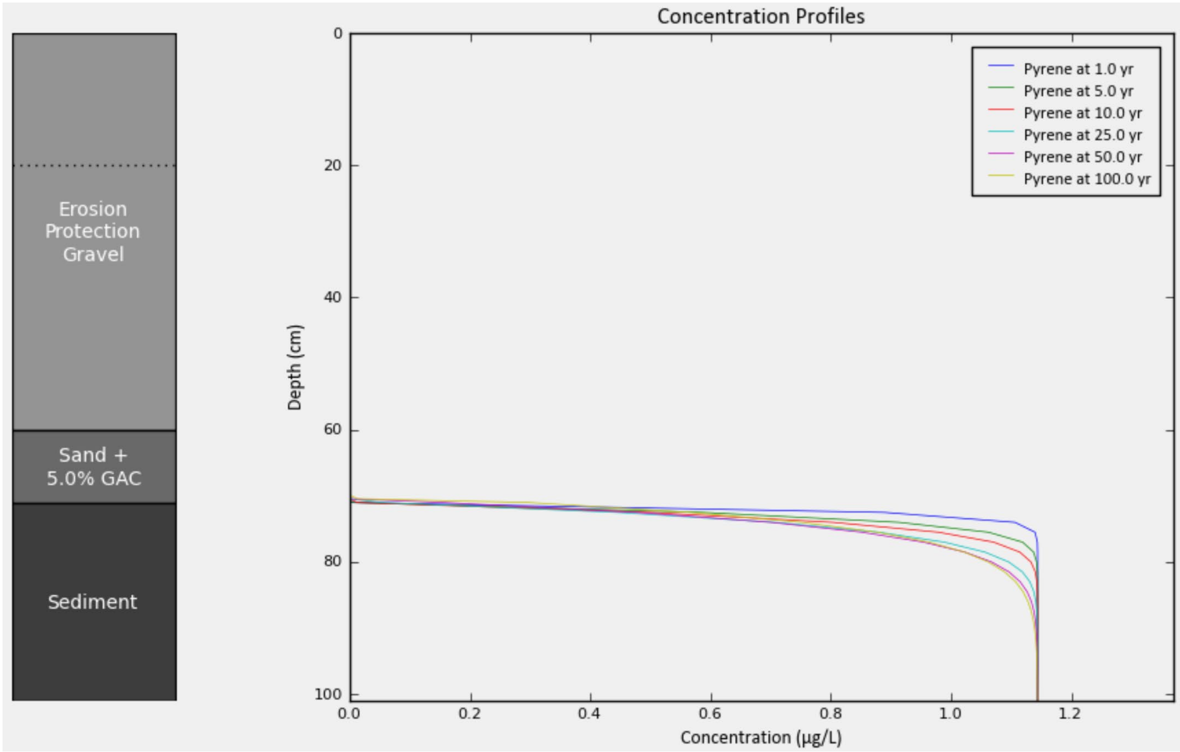

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
PCB44 at 1.0 yr
PCB44 at 5.0 yr
PCB44 at 10.0 yr
PCB44 at 25.0 yr
PCB44 at 50.0 yr
PCB44 at 100.0 yr
Depth (cm)
0
20
40
60
80
100
0.000
0.002
0.004
0.006
0.008
0.010
0.012
0.014
Concentration (µg/L)

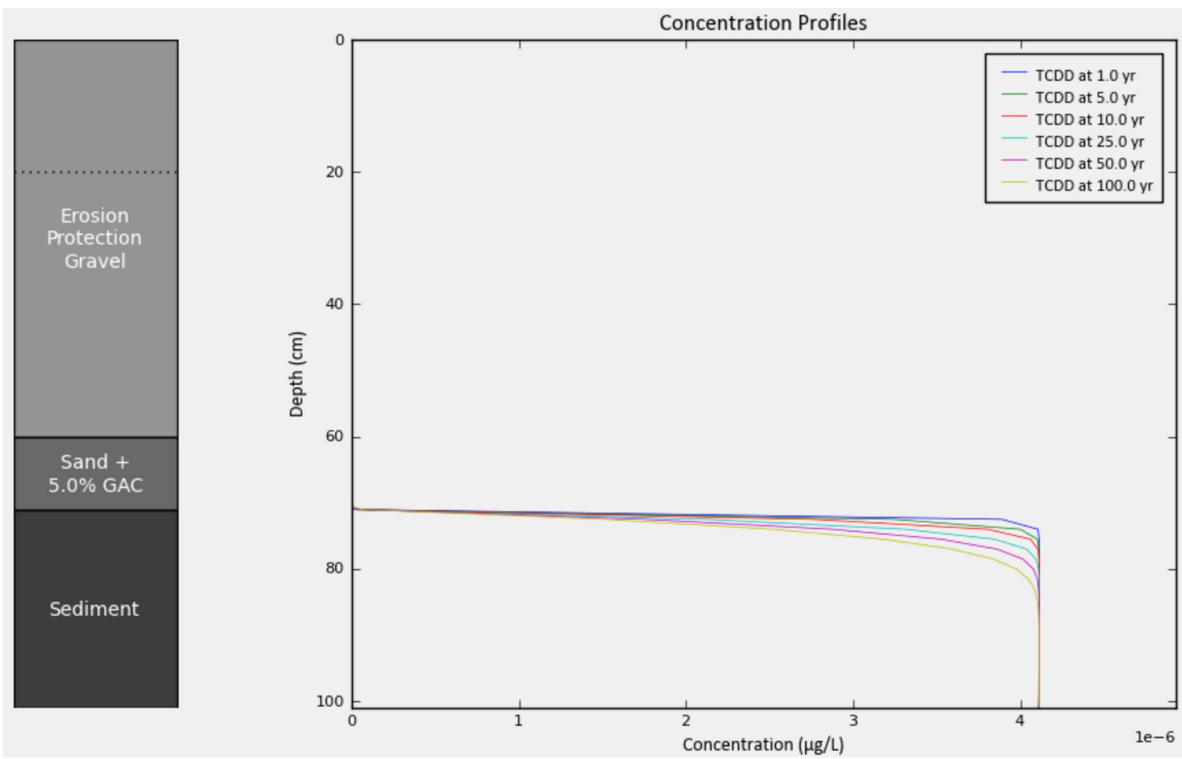

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
PCB99 at 1.0 yr
PCB99 at 5.0 yr
PCB99 at 10.0 yr
PCB99 at 25.0 yr
PCB99 at 50.0 yr
PCB99 at 100.0 yr
Depth (cm)
0
20
40
60
80
100
0.000
0.001
0.002
0.003
0.004
0.005
Concentration (μg/L)

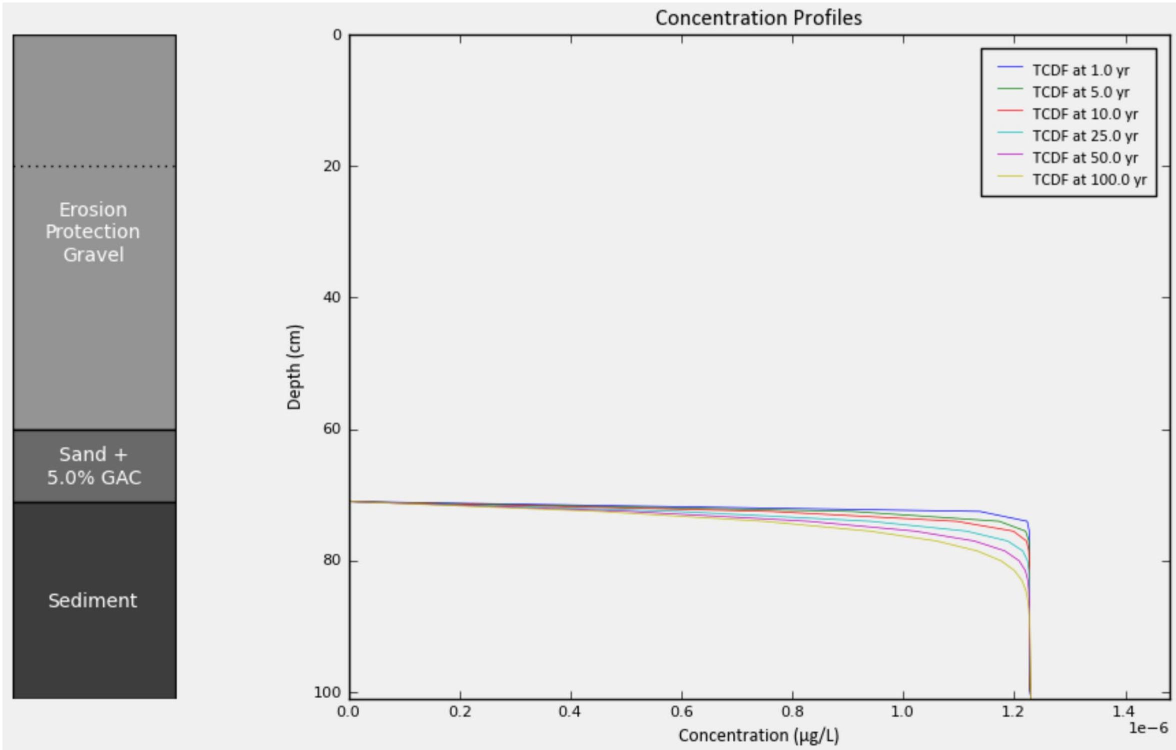

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
PeCDD at 1.0 yr
PeCDD at 5.0 yr
PeCDD at 10.0 yr
PeCDD at 25.0 yr
PeCDD at 50.0 yr
PeCDD at 100.0 yr
Depth (cm)
0
20
40
60
80
100
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
1e−8
Concentration (μg/L)


Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
PeCDF at 1.0 yr
PeCDF at 5.0 yr
PeCDF at 10.0 yr
PeCDF at 25.0 yr
PeCDF at 50.0 yr
PeCDF at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−6

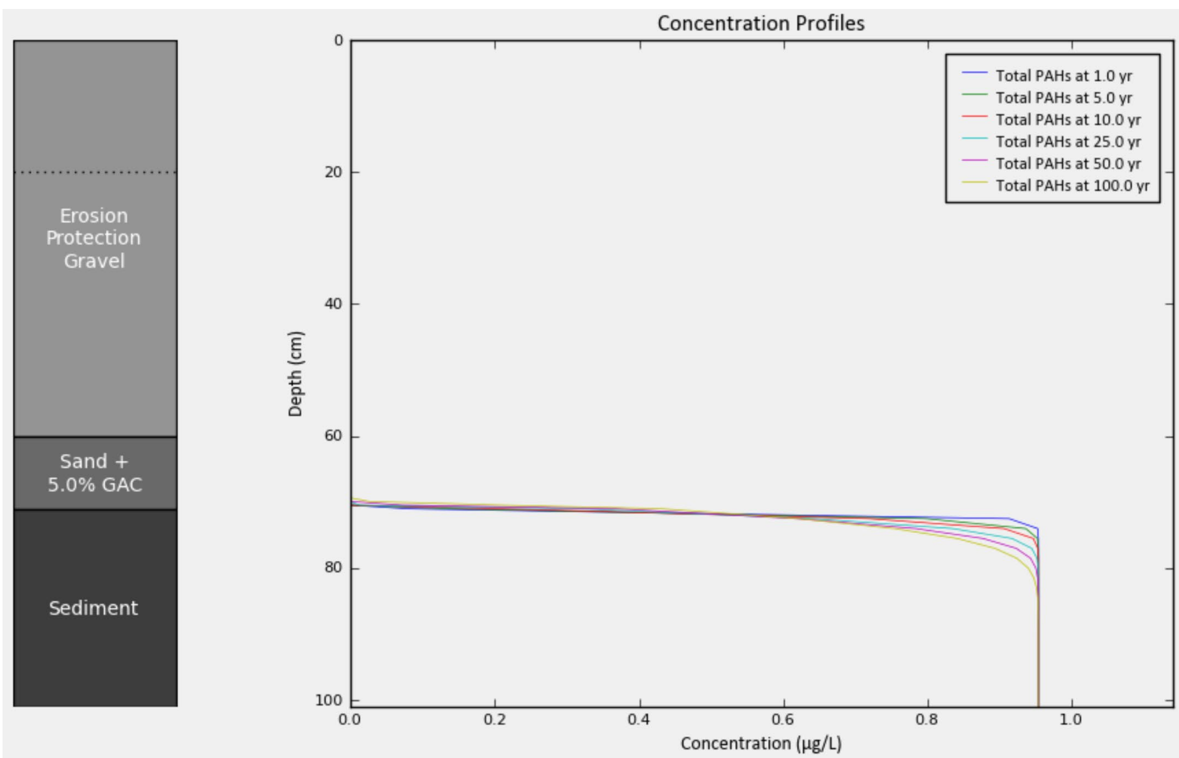

Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Phenanthrene at 1.0 yr
Phenanthrene at 5.0 yr
Phenanthrene at 10.0 yr
Phenanthrene at 25.0 yr
Phenanthrene at 50.0 yr
Phenanthrene at 100.0 yr
Depth (cm)
Concentration (μg/L)


Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Profiles
Pyrene at 1.0 yr
Pyrene at 5.0 yr
Pyrene at 10.0 yr
Pyrene at 25.0 yr
Pyrene at 50.0 yr
Pyrene at 100.0 yr
Depth (cm)
Concentration (μg/L)

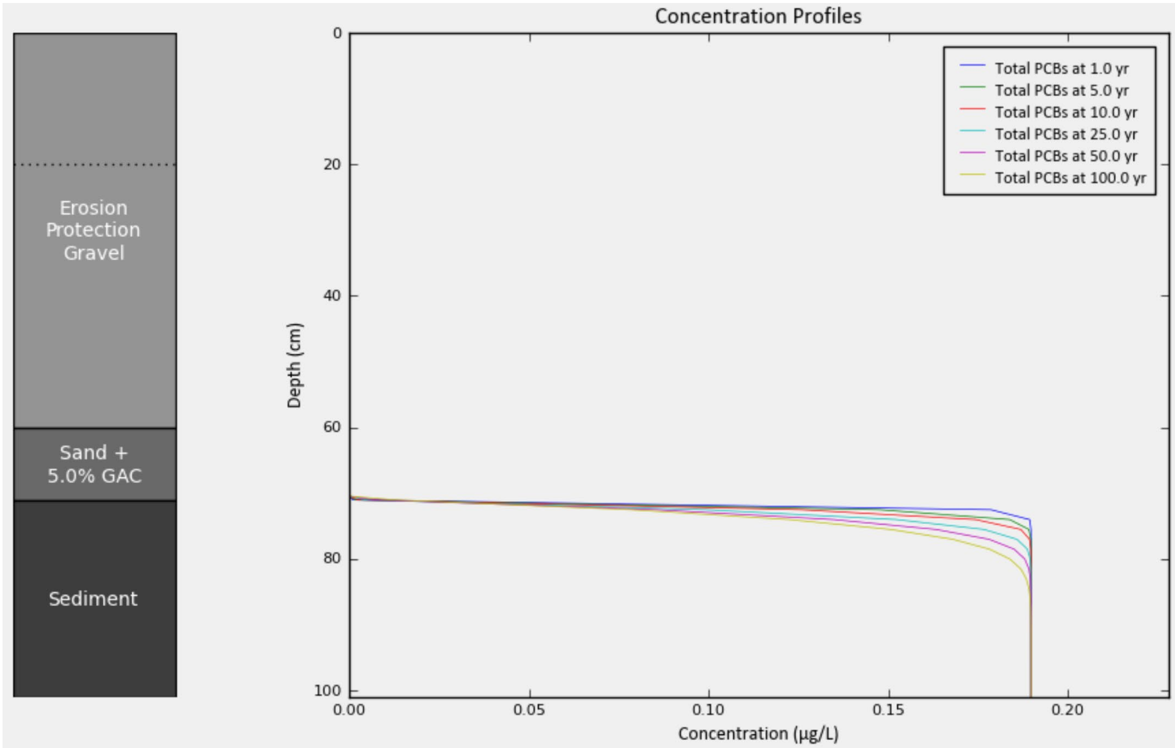

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Profiles
TCDD at 1.0 yr
TCDD at 5.0 yr
TCDD at 10.0 yr
TCDD at 25.0 yr
TCDD at 50.0 yr
TCDD at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−6

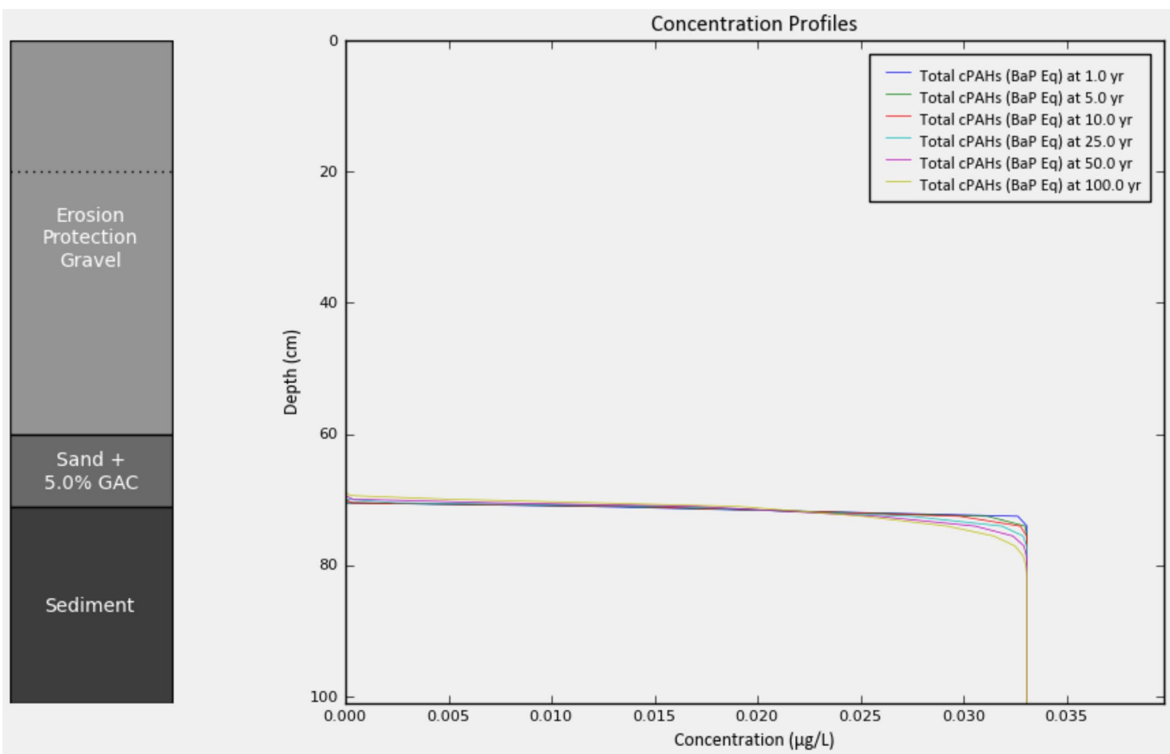


Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
1e−6
TCDF at 1.0 yr
TCDF at 5.0 yr
TCDF at 10.0 yr
TCDF at 25.0 yr
TCDF at 50.0 yr
TCDF at 100.0 yr

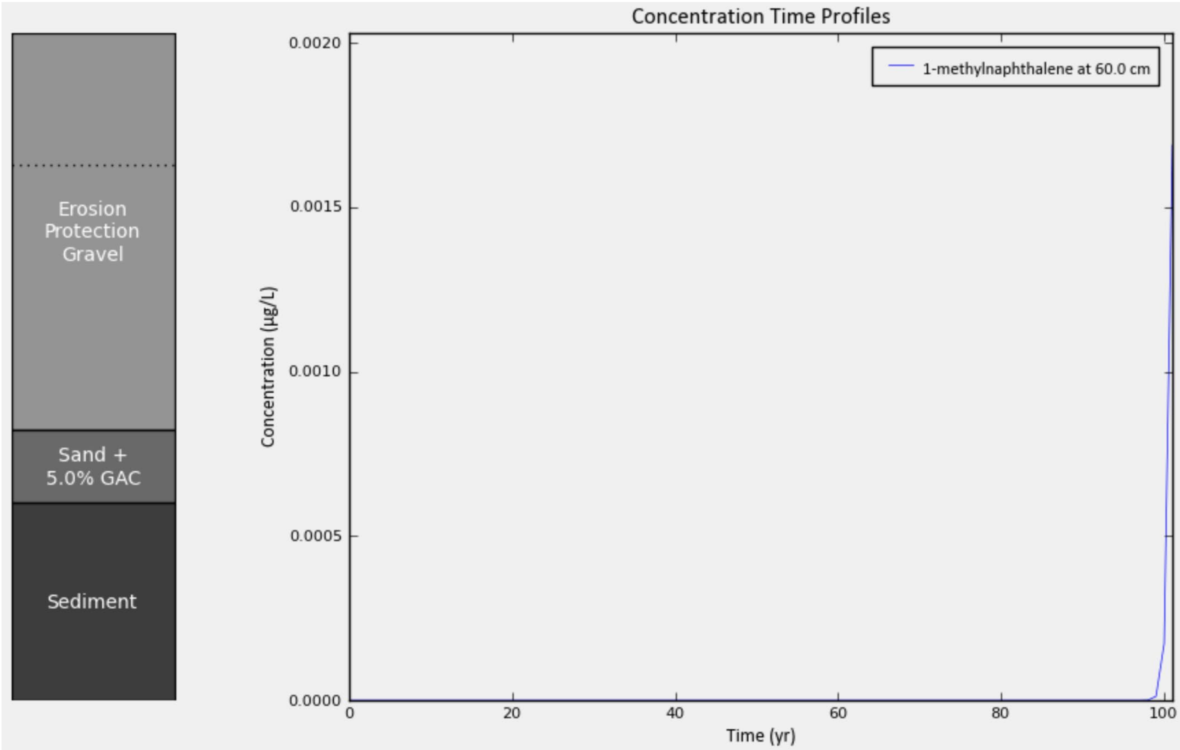


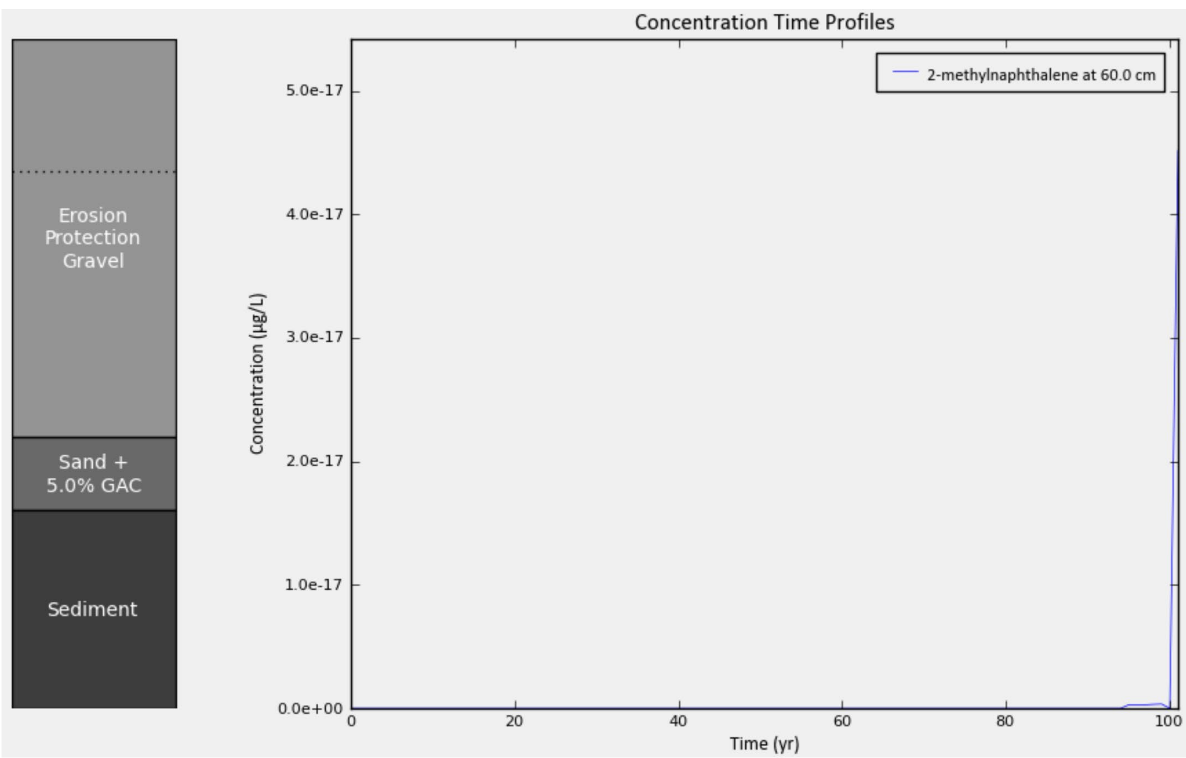
Concentration Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Total PAHs at 1.0 yr
Total PAHs at 5.0 yr
Total PAHs at 10.0 yr
Total PAHs at 25.0 yr
Total PAHs at 50.0 yr
Total PAHs at 100.0 yr

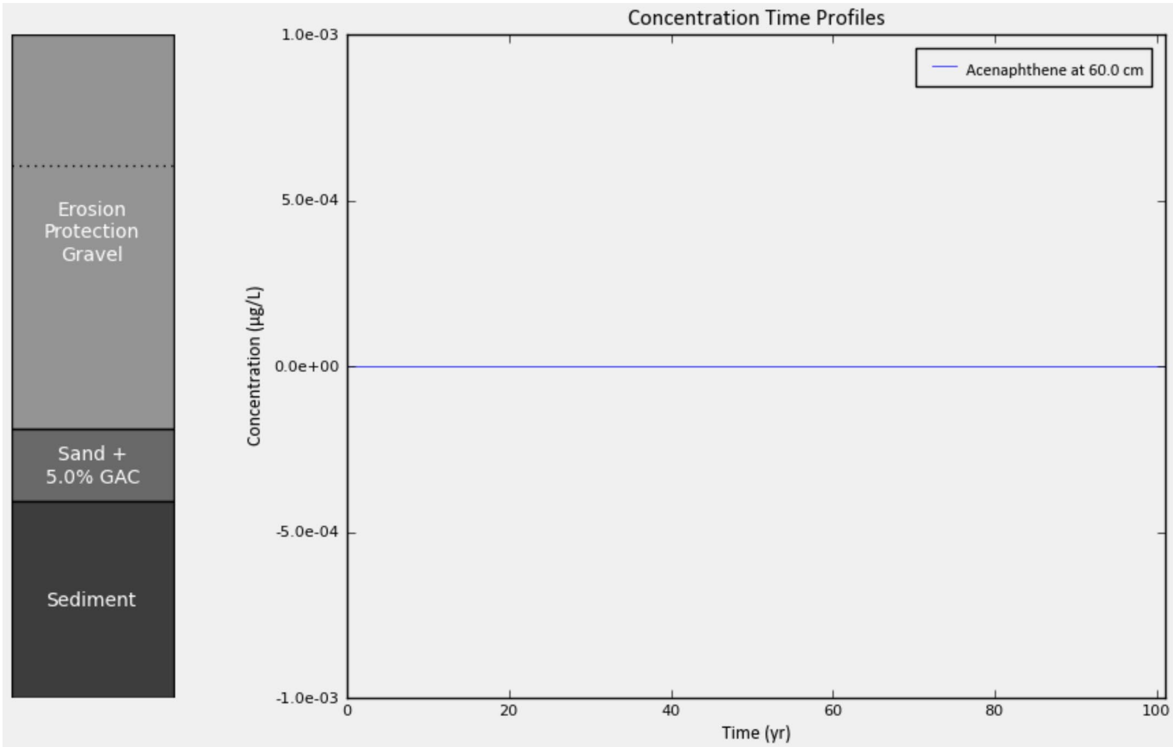

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Profiles
Total PCBs at 1.0 yr
Total PCBs at 5.0 yr
Total PCBs at 10.0 yr
Total PCBs at 25.0 yr
Total PCBs at 50.0 yr
Total PCBs at 100.0 yr
Depth (cm)
0
20
40
60
80
100
0.00
0.05
0.10
0.15
0.20
Concentration (µg/L)

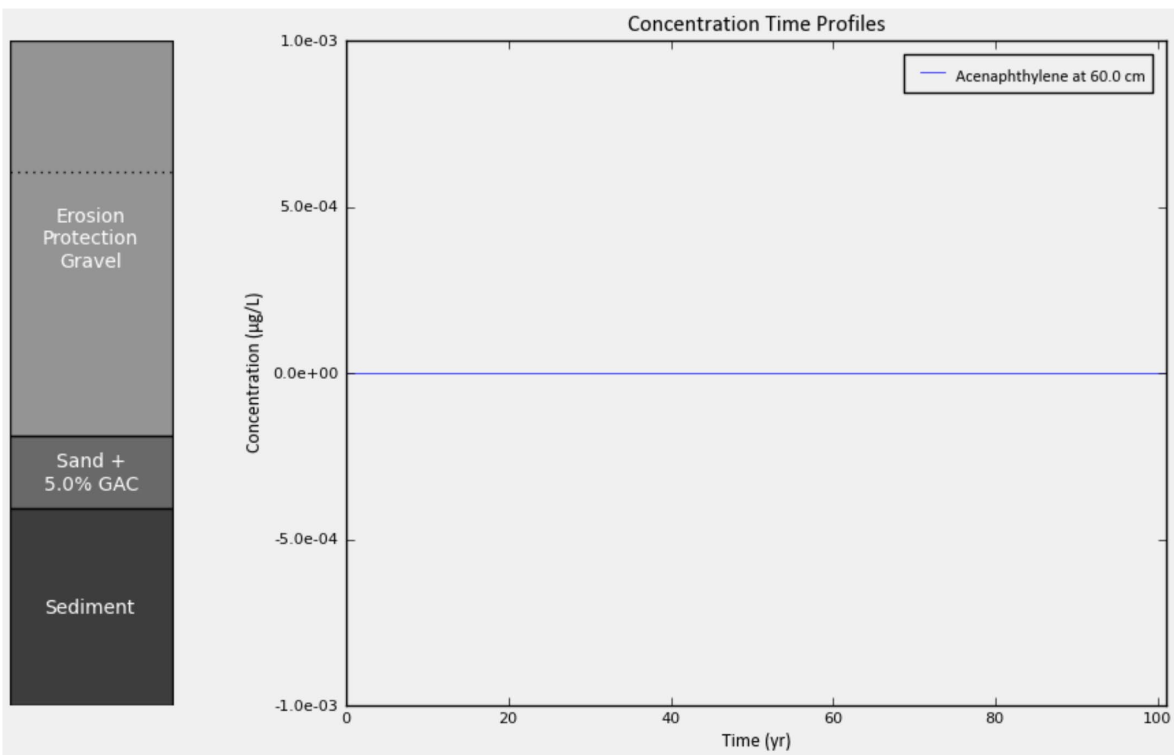

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Profiles
Total cPAHs (BaP Eq) at 1.0 yr
Total cPAHs (BaP Eq) at 5.0 yr
Total cPAHs (BaP Eq) at 10.0 yr
Total cPAHs (BaP Eq) at 25.0 yr
Total cPAHs (BaP Eq) at 50.0 yr
Total cPAHs (BaP Eq) at 100.0 yr
Depth (cm)
0
20
40
60
80
100
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
Concentration (µg/L)

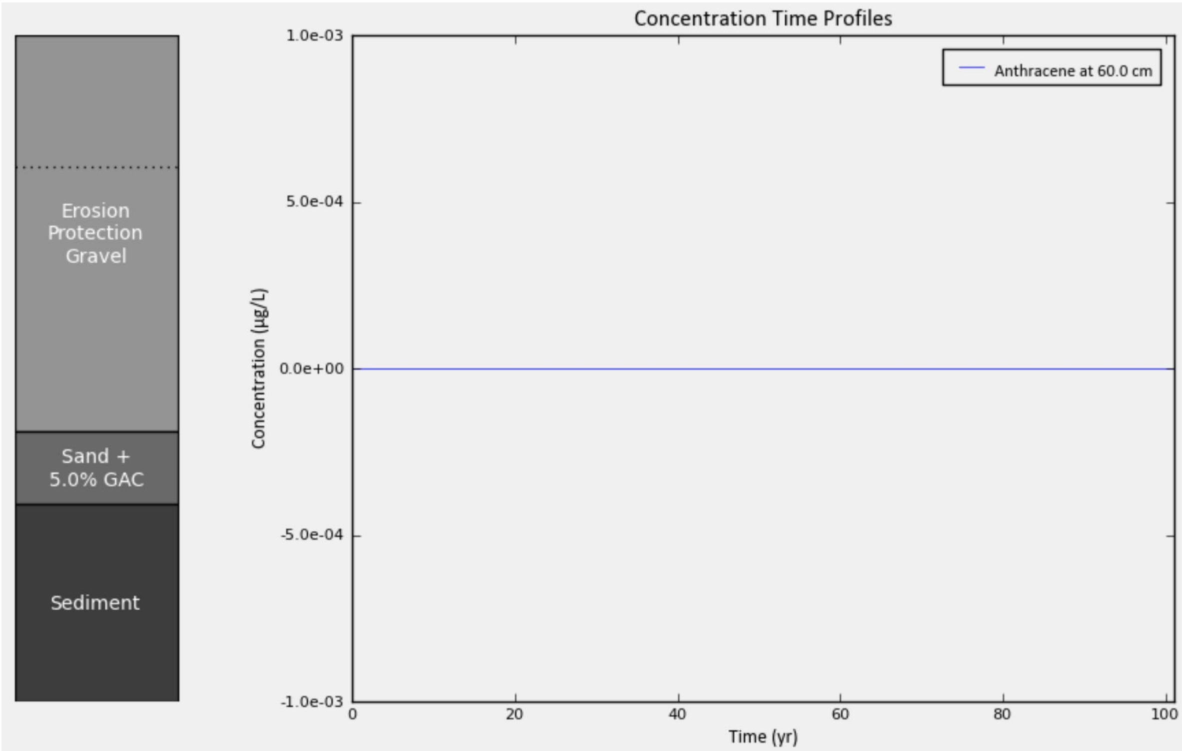
Porewater Concentration – Time

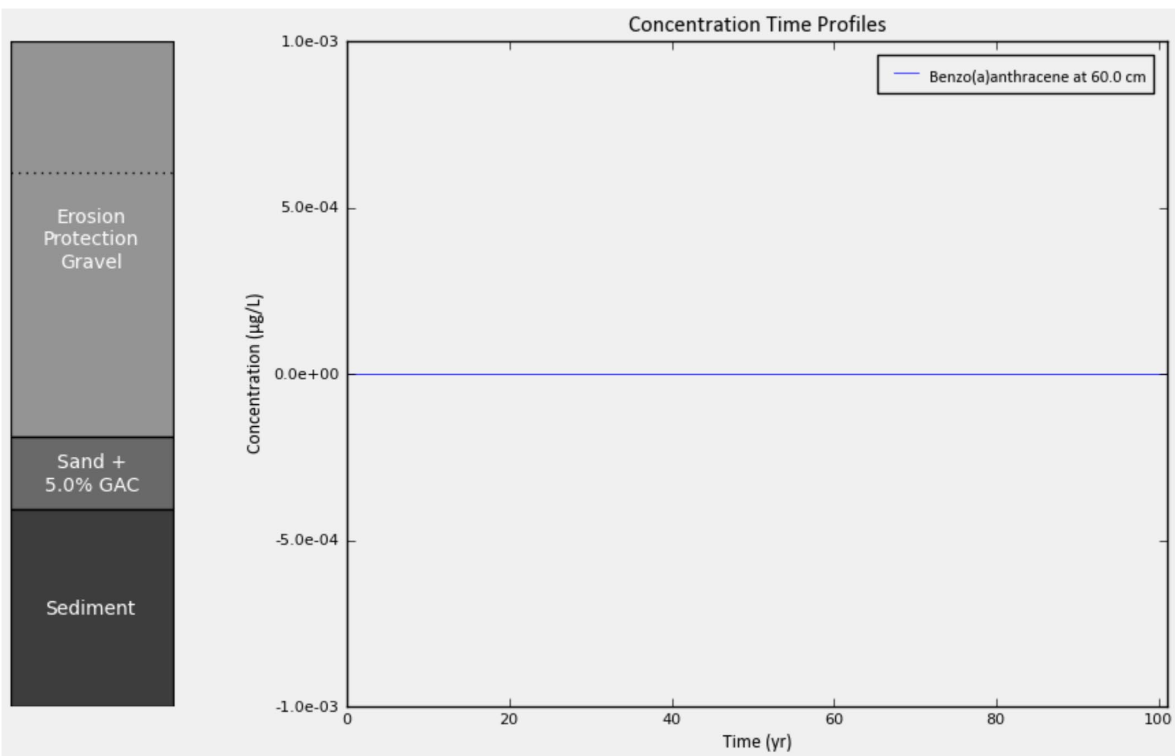


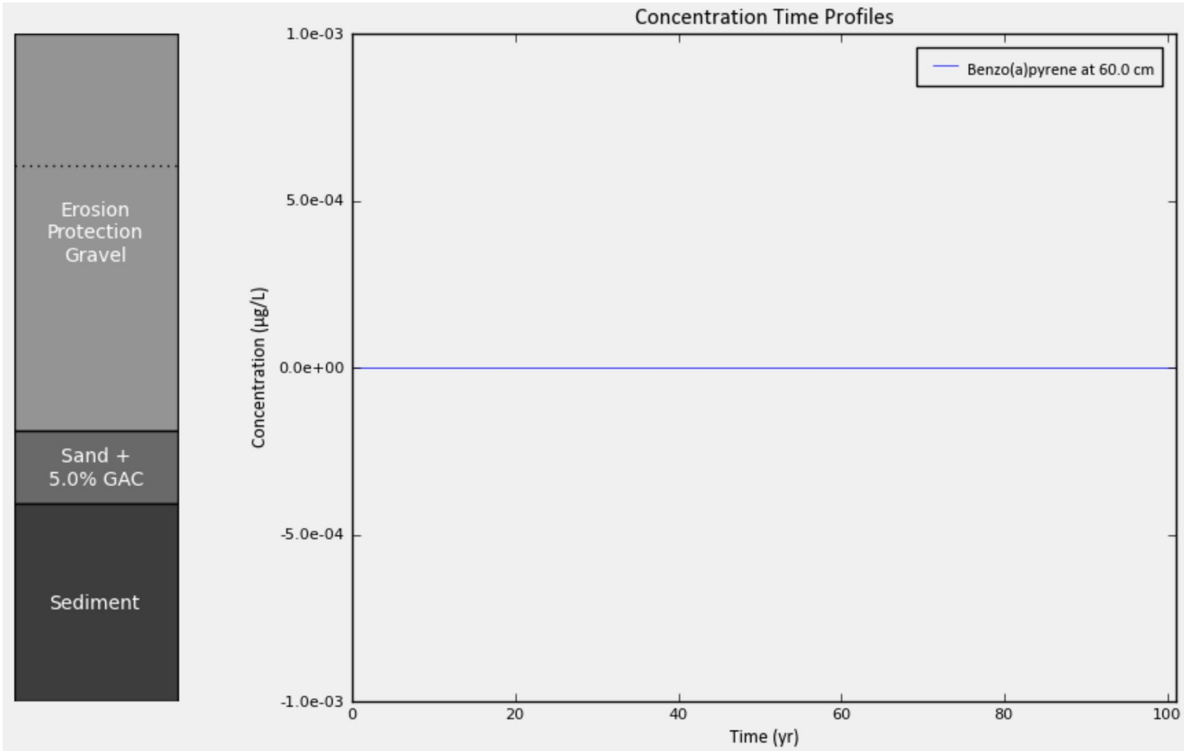


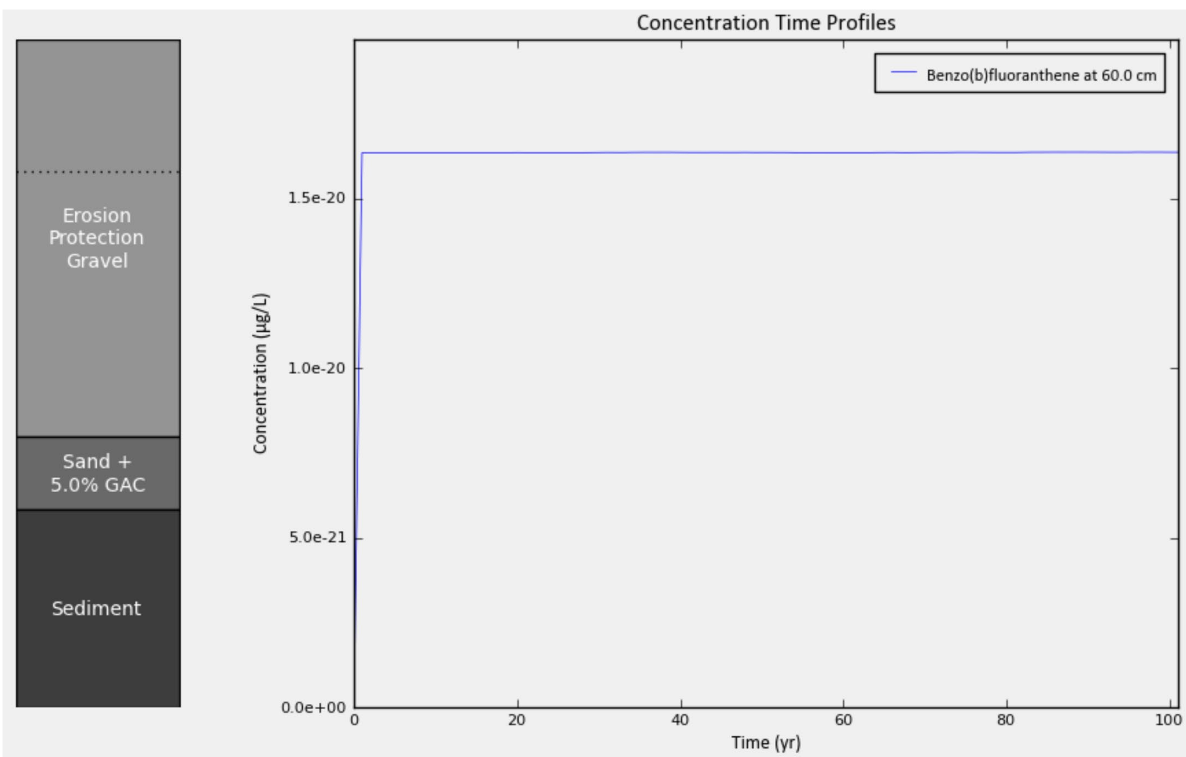

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Acenaphthene at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

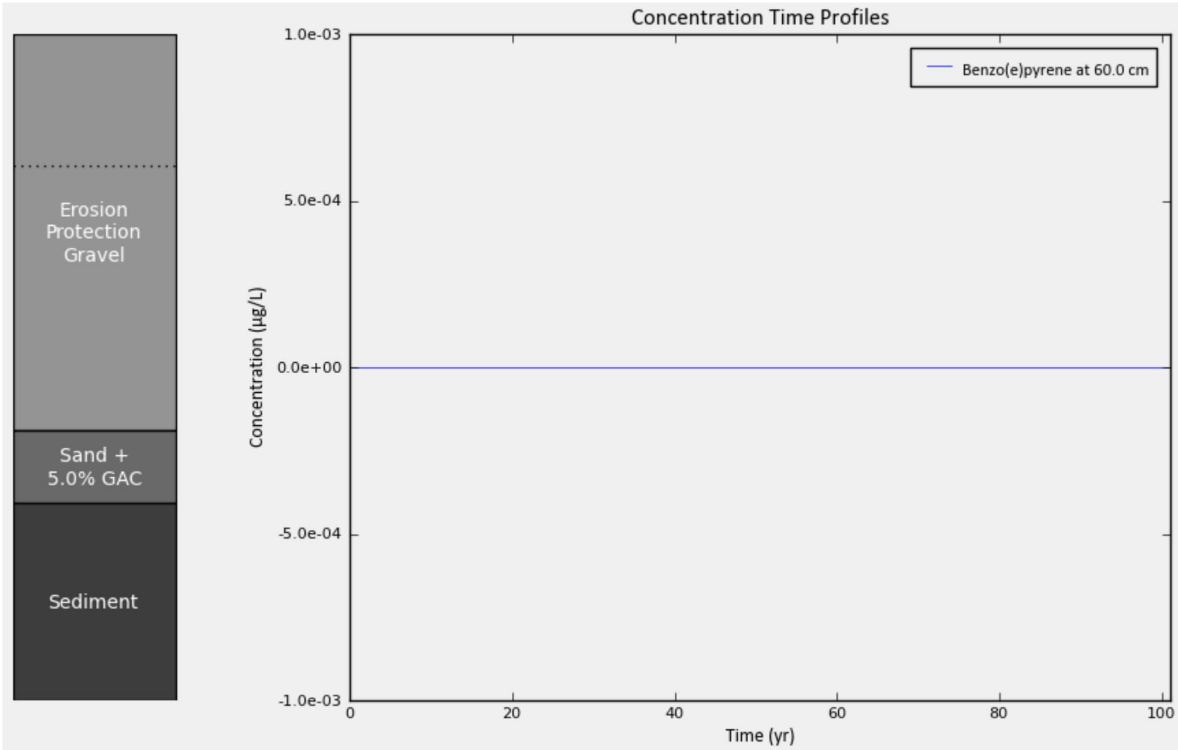

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Acenaphthylene at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

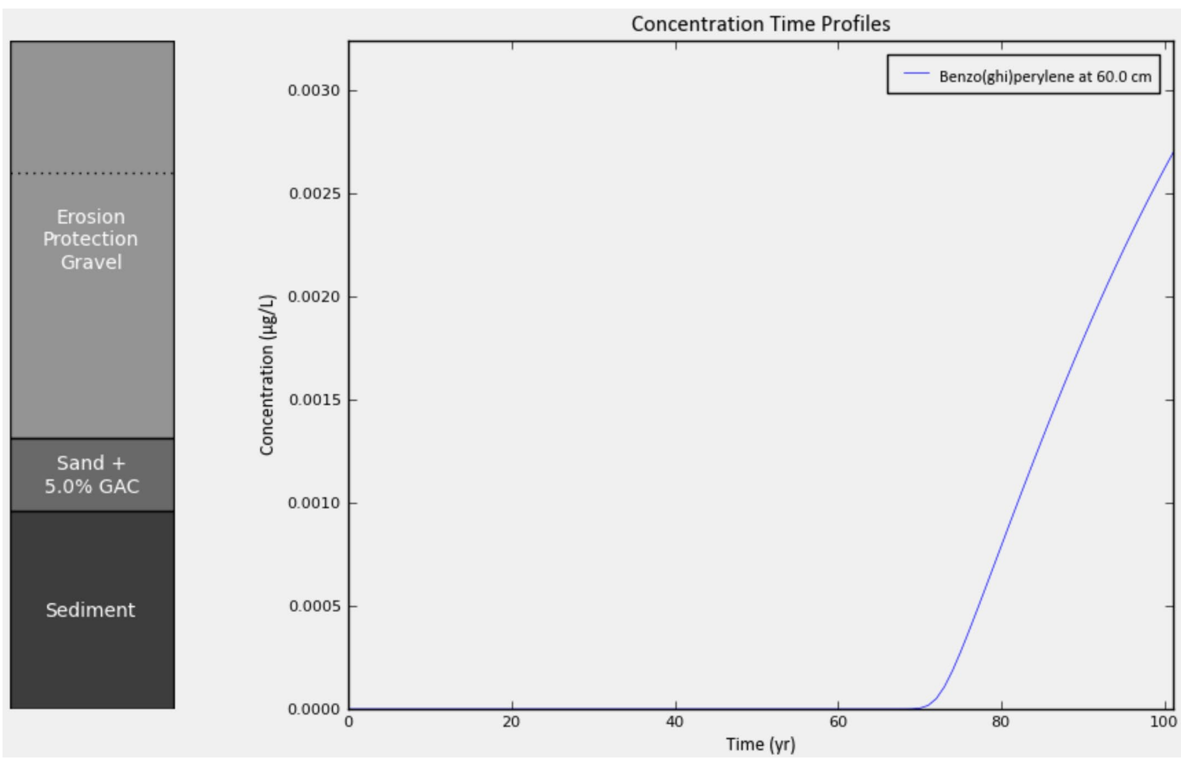

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Anthracene at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

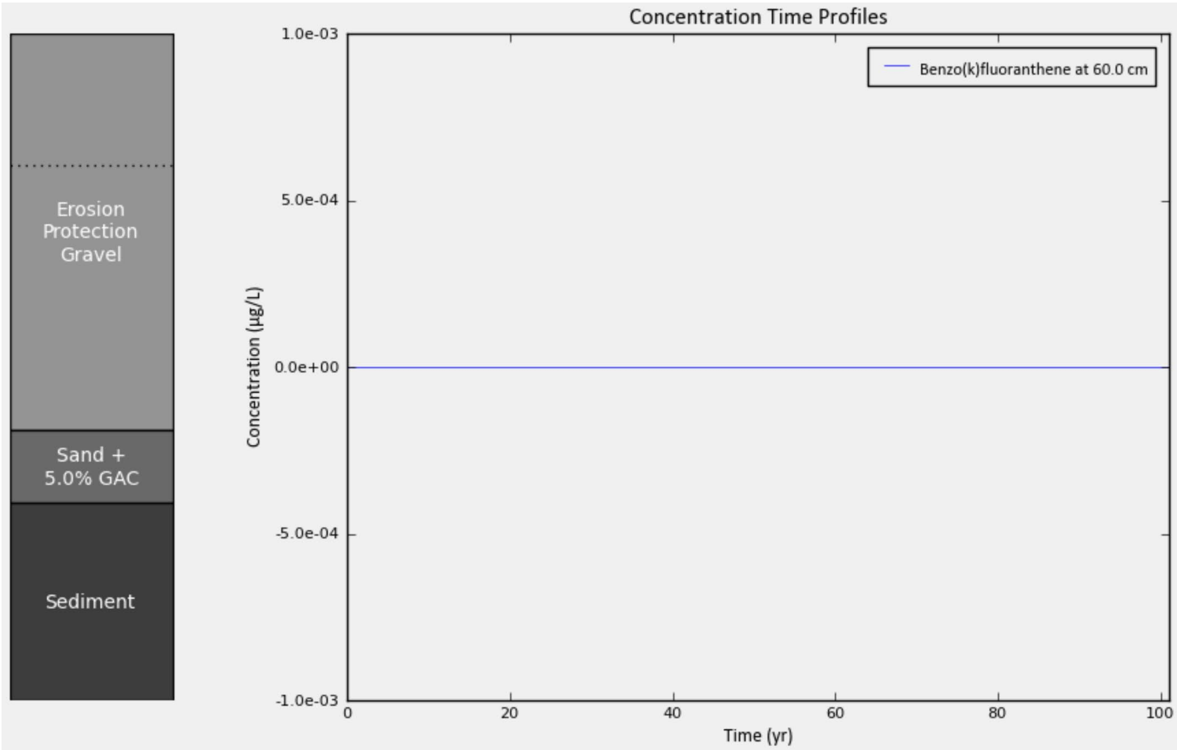

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Benzo(a)anthracene at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

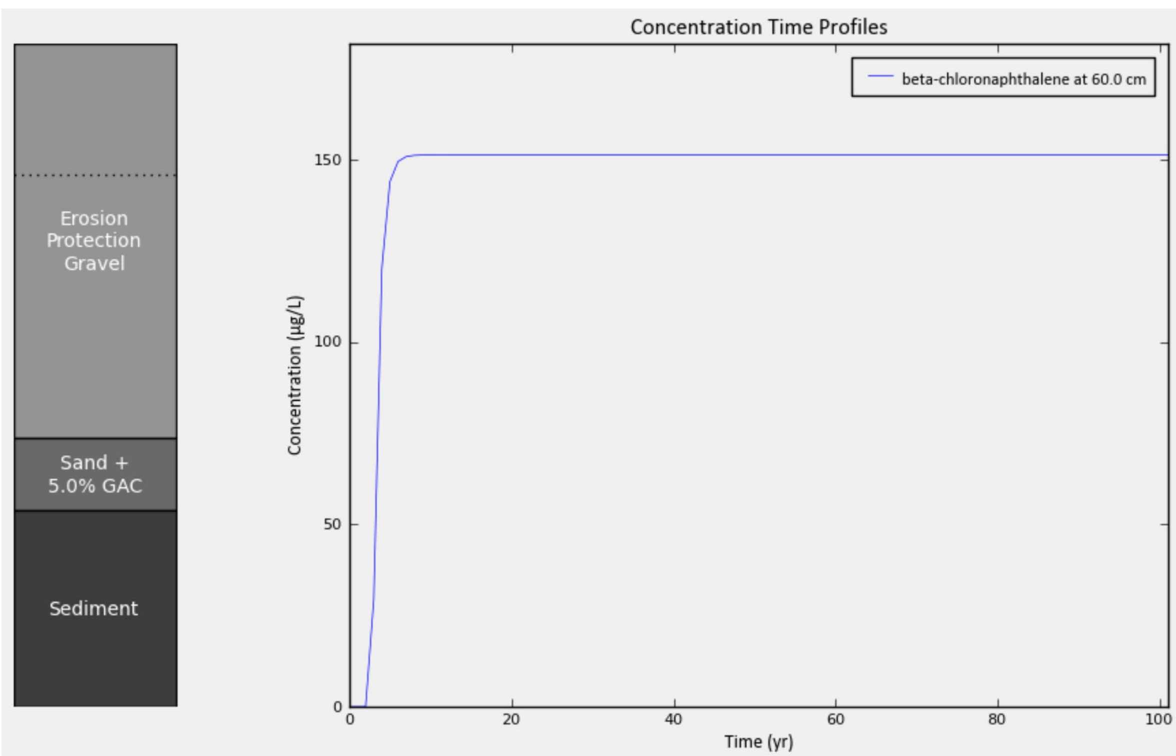

Concentration Time Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Benzo(a)pyrene at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

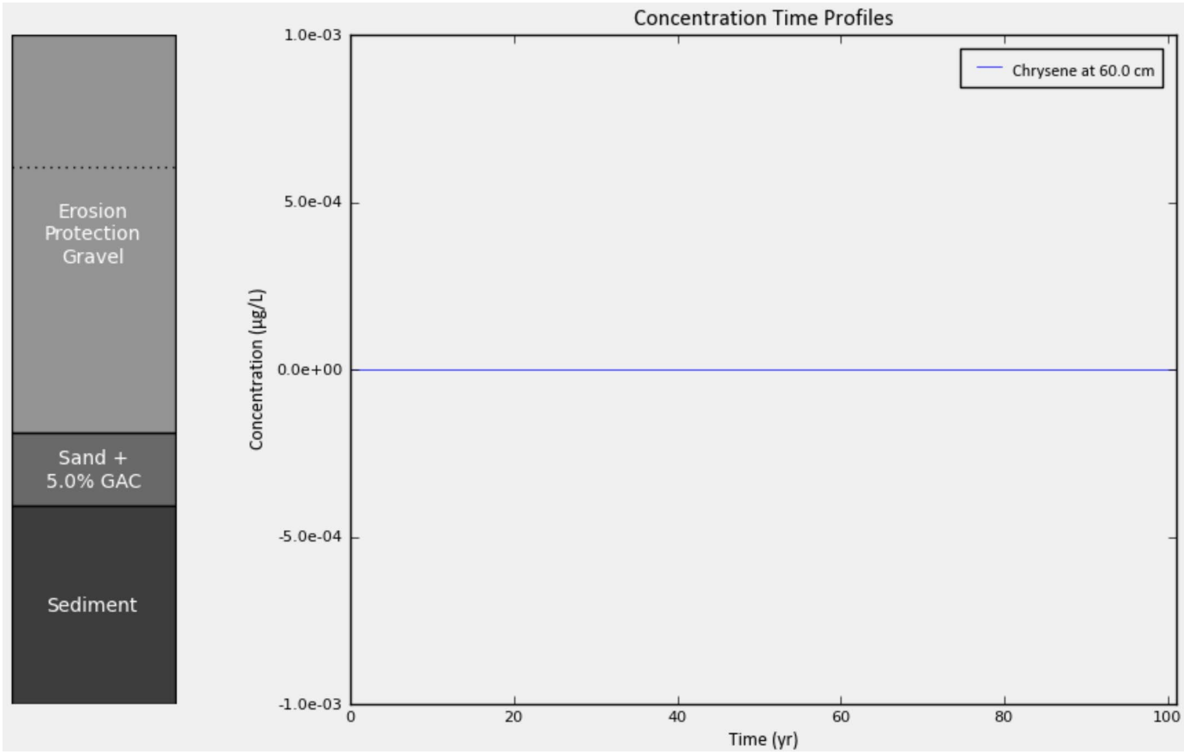

Concentration Time Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Benzo(b)fluoranthene at 60.0 cm
Concentration (µg/L)
1.5e-20
1.0e-20
5.0e-21
0.0e+00
0
20
40
60
80
100
Time (yr)

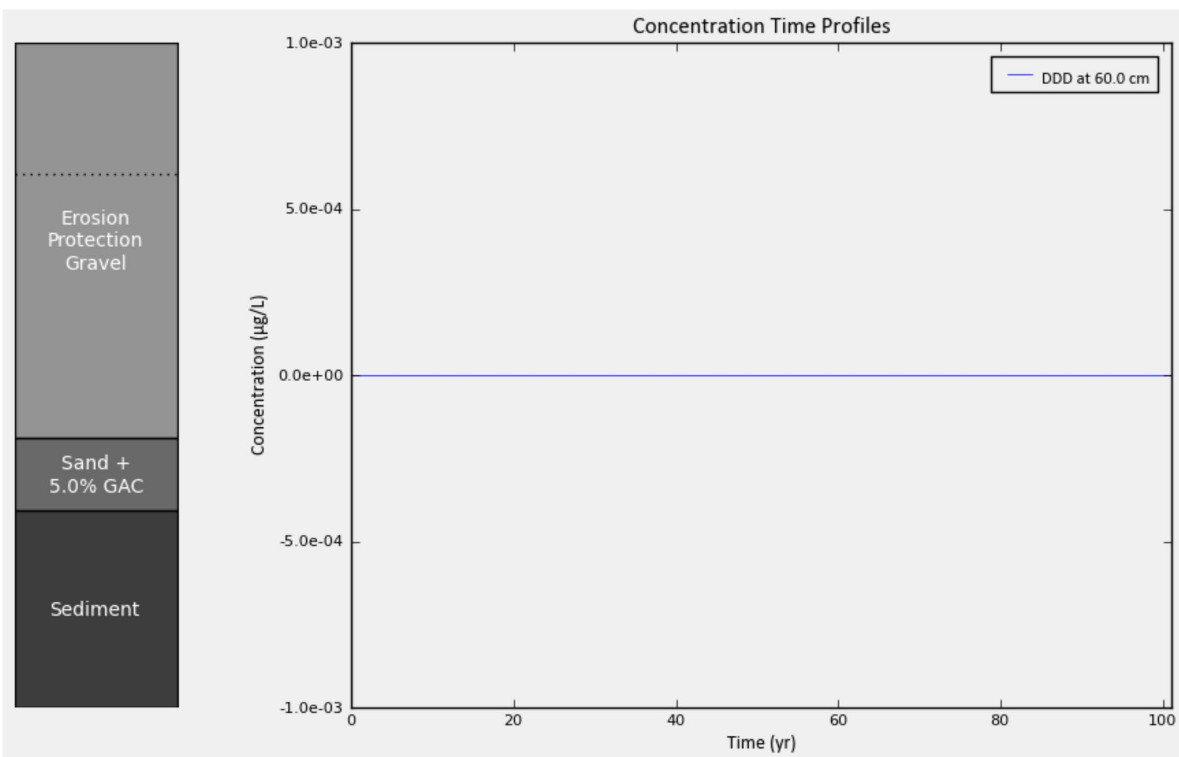

Concentration Time Profiles
Benzo(e)pyrene at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100

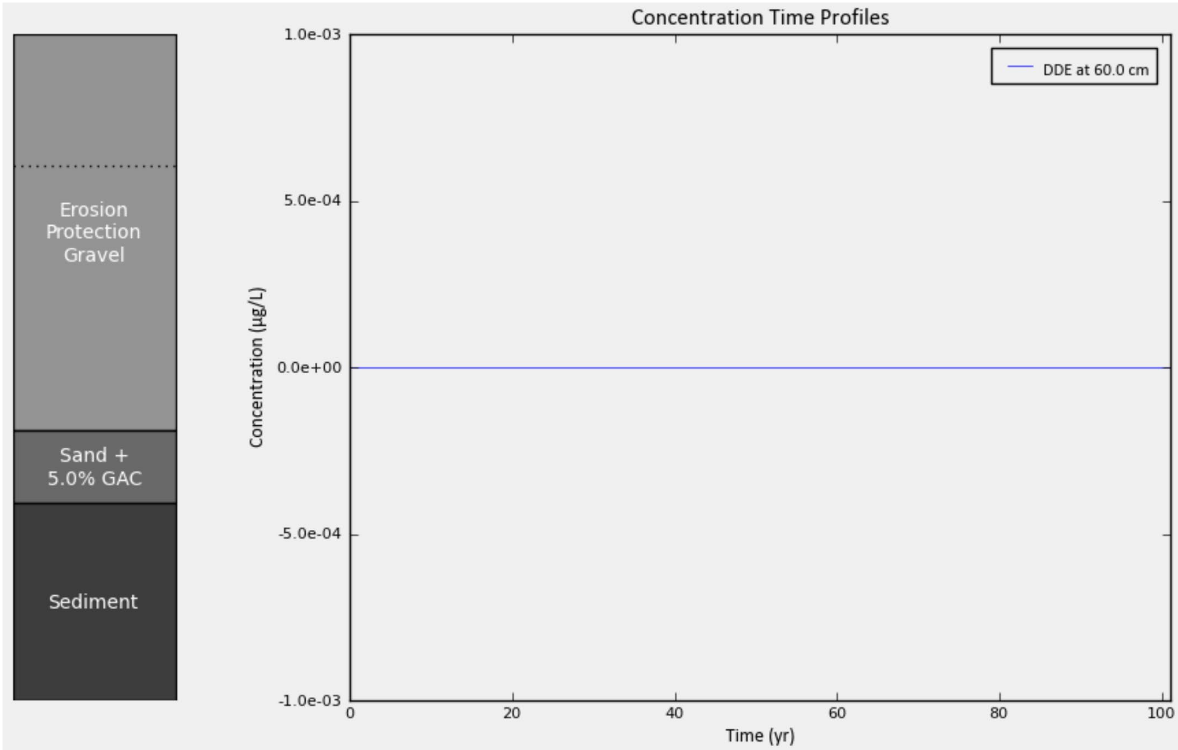

Concentration Time Profiles
Benzo(ghi)perylene at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
Time (yr)
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
0
20
40
60
80
100

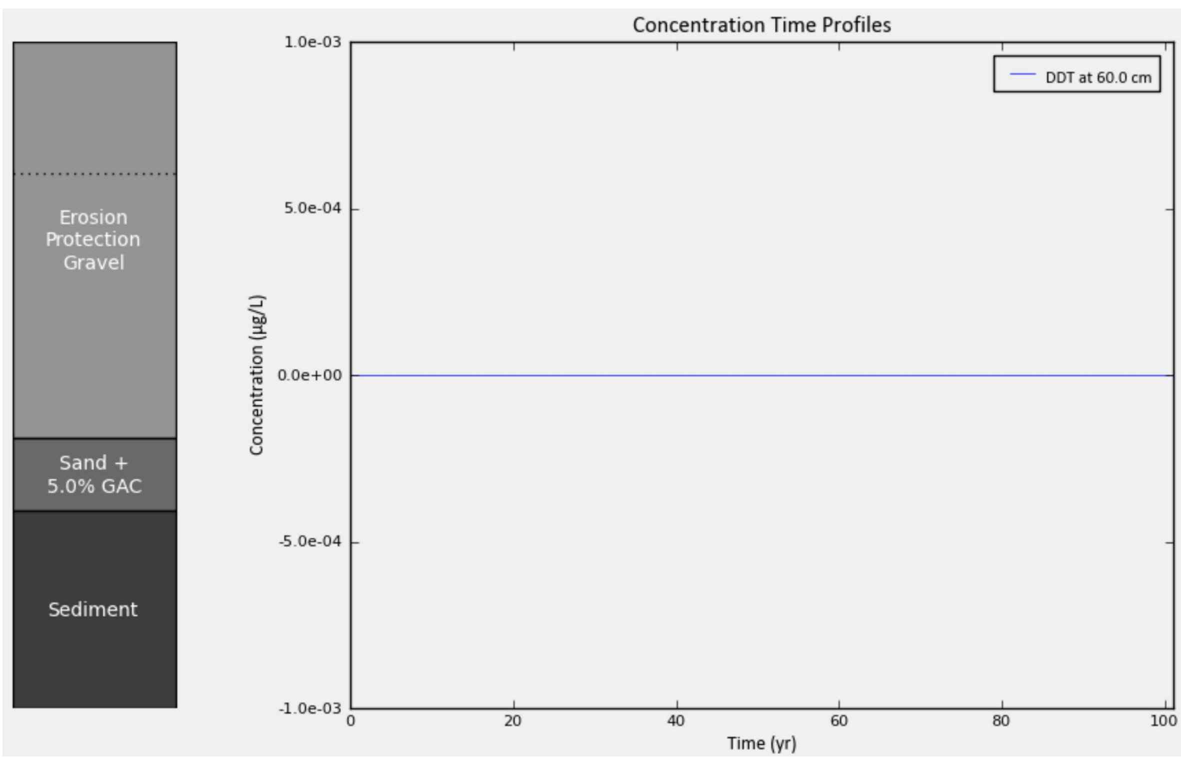

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Time Profiles
Benzo(k)fluoranthene at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

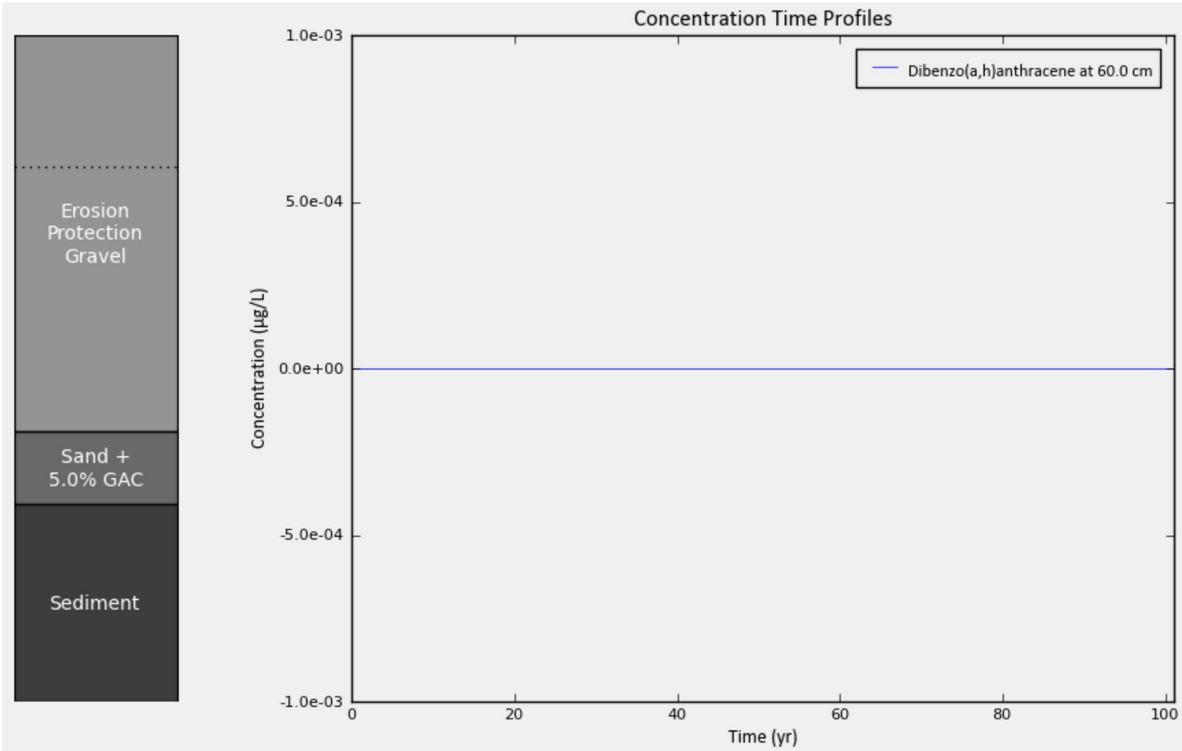

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Time Profiles
beta-chloronaphthalene at 60.0 cm
Concentration (µg/L)
150
100
50
0
0
20
40
60
80
100
Time (yr)

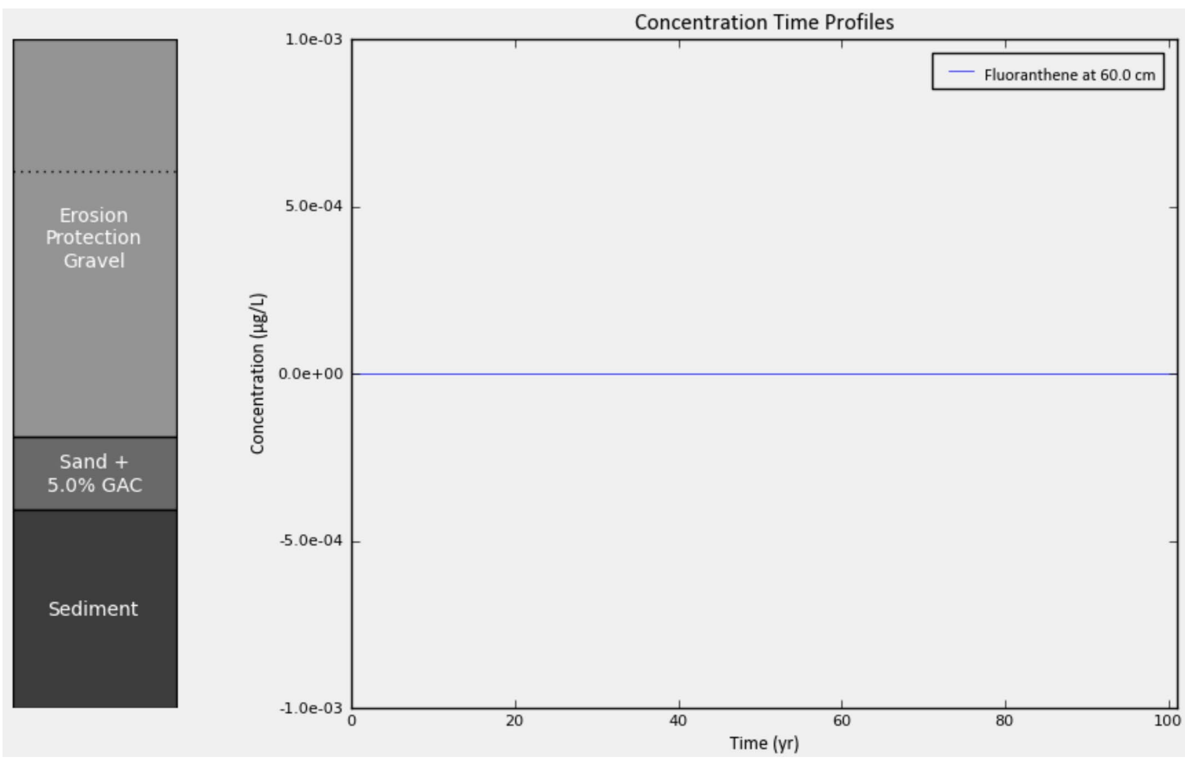

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Time Profiles
Chrysene at 60.0 cm
Concentration (µg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100

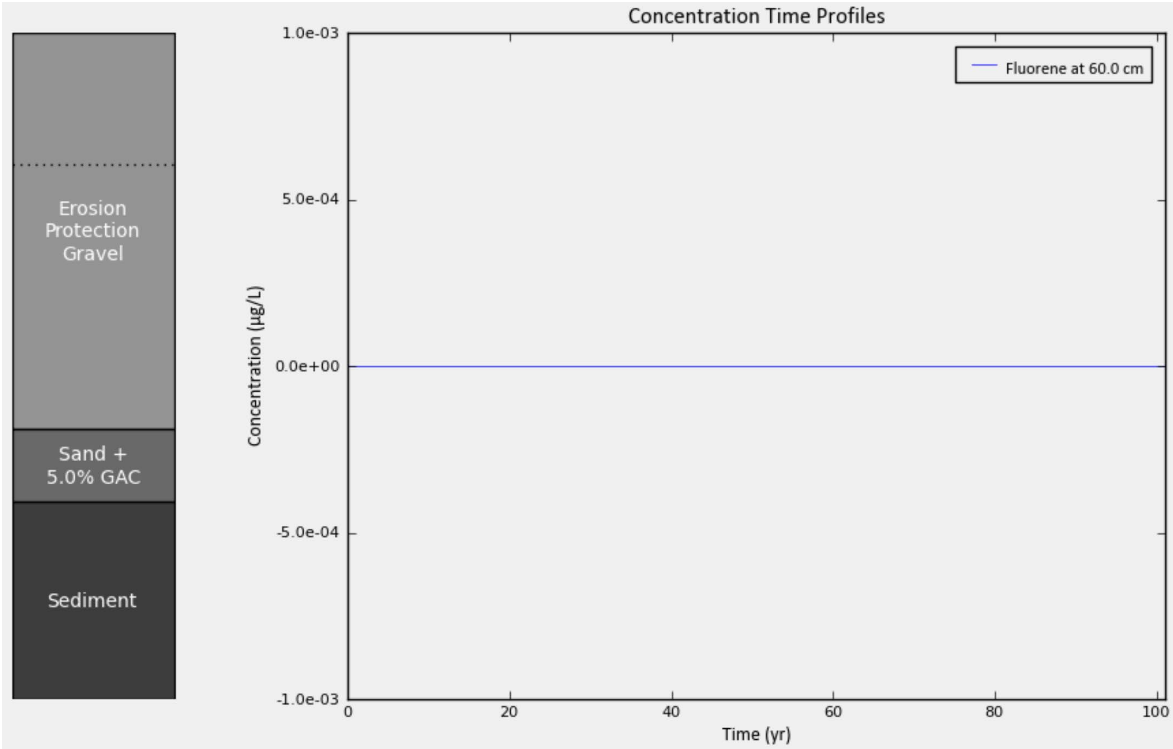

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Time Profiles
DDD at 60.0 cm
Concentration (µg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100

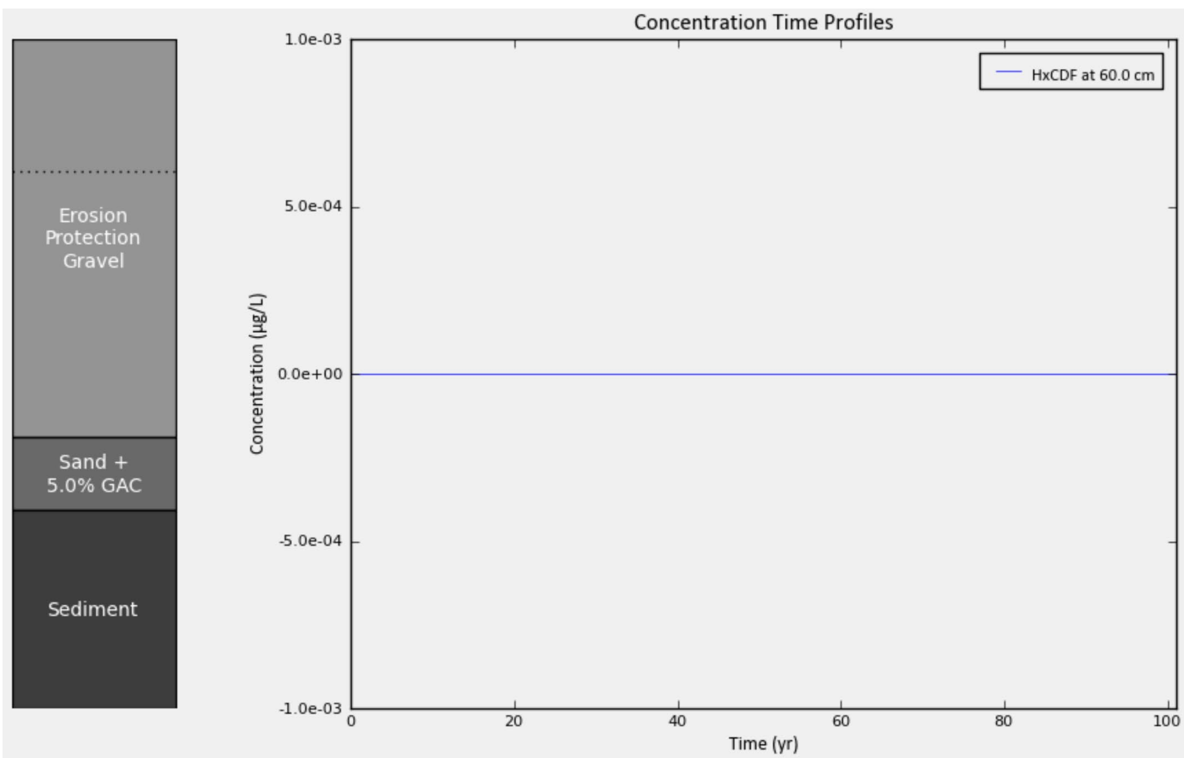

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
DDE at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

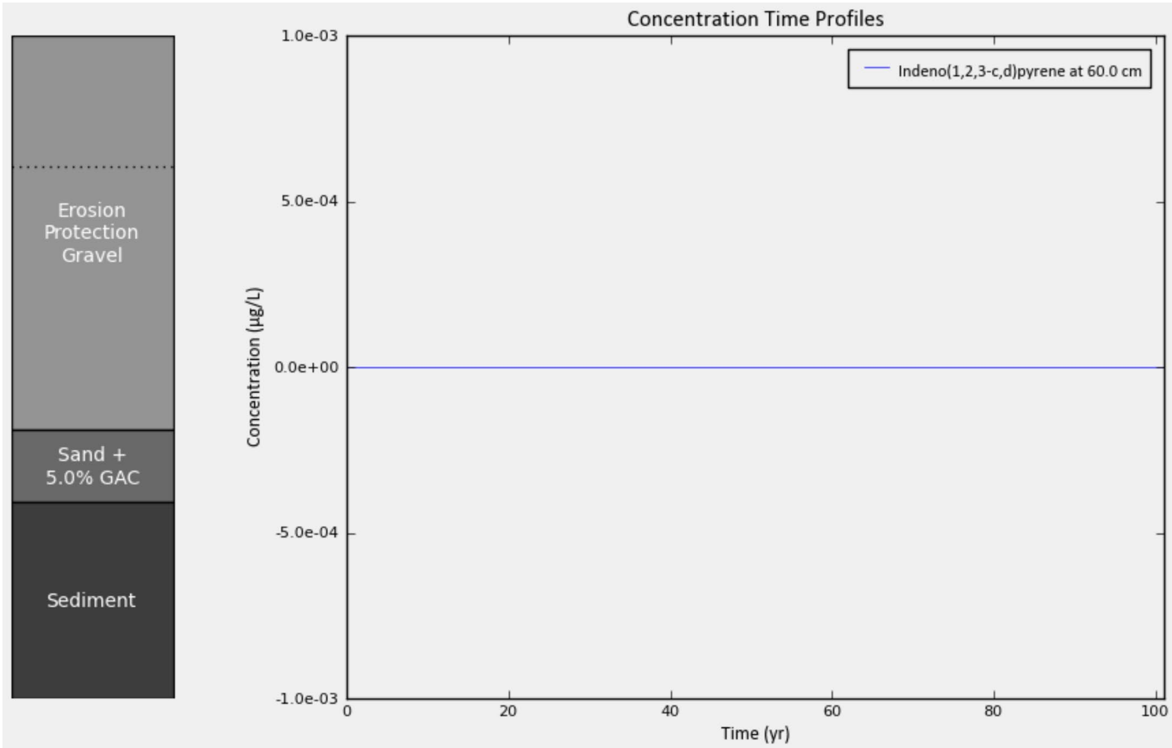

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
DDT at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

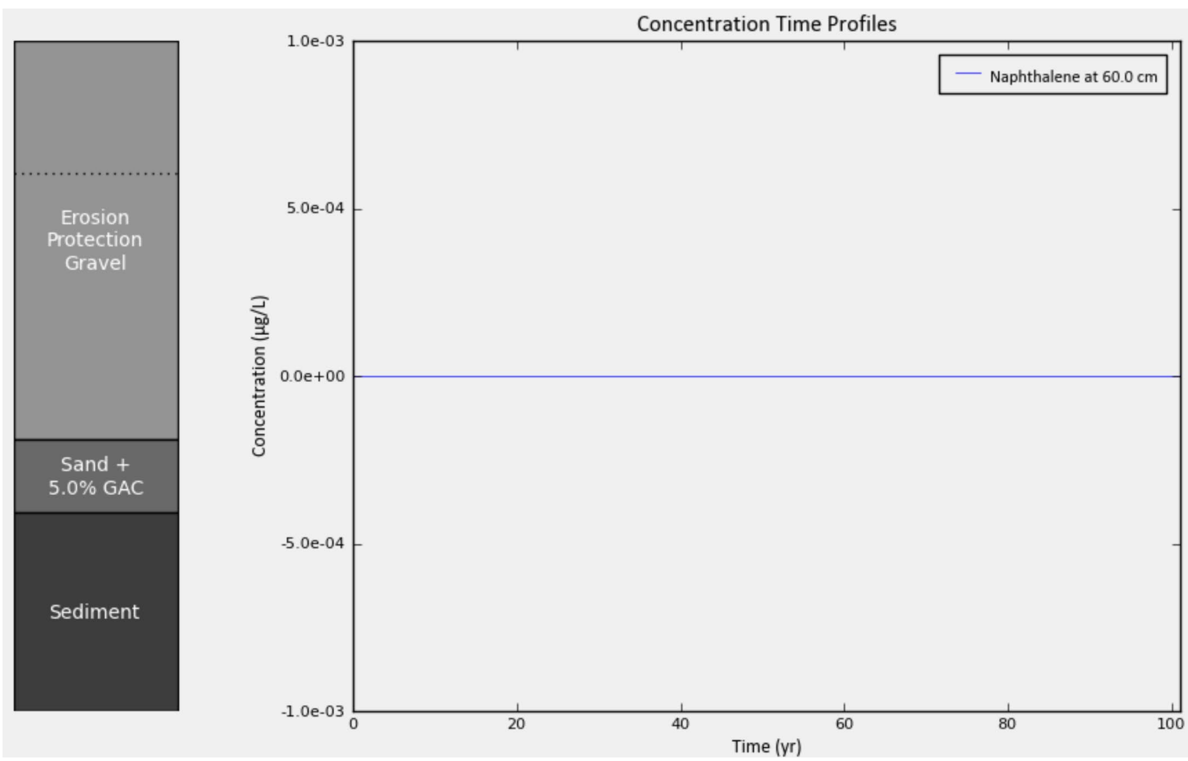

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Dibenzo(a,h)anthracene at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

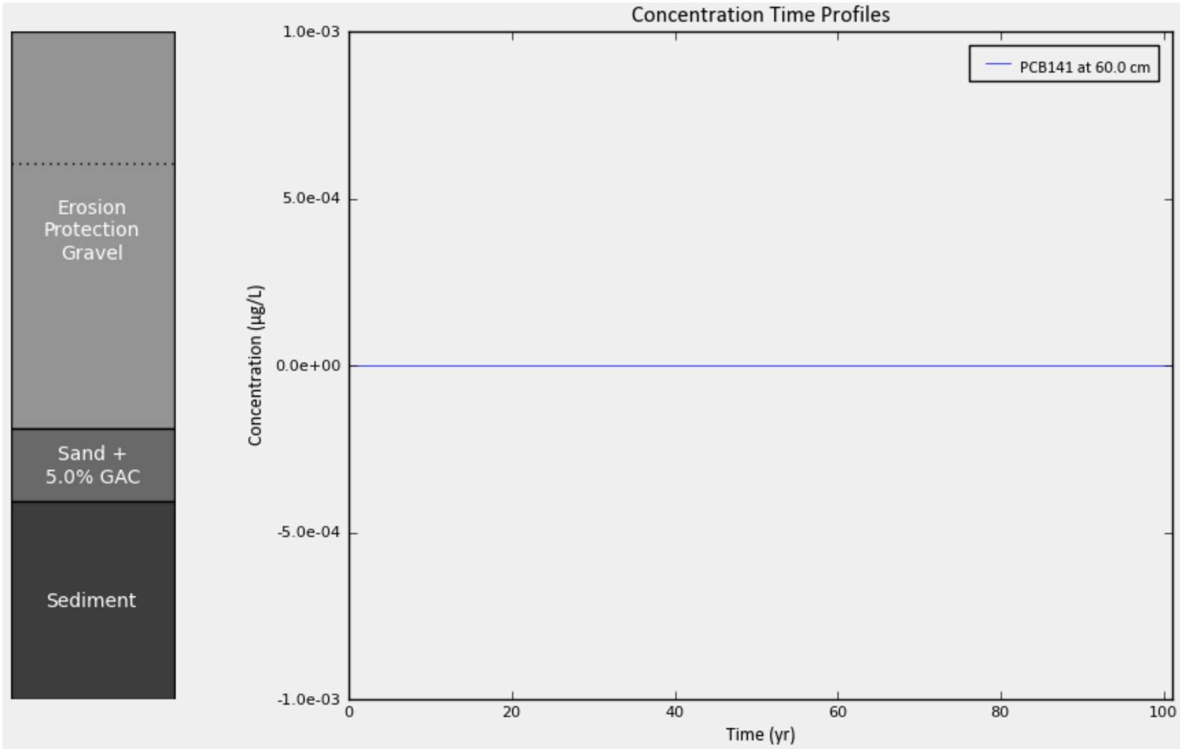

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Fluoranthene at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

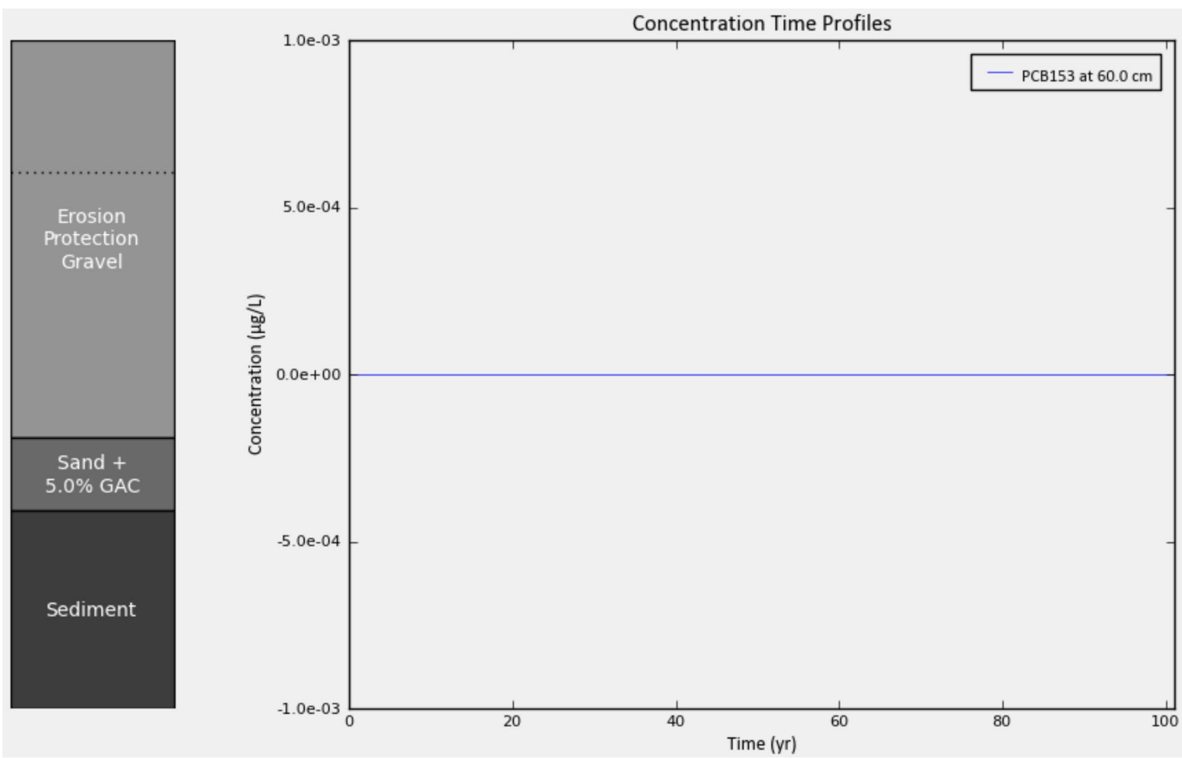

Concentration Time Profiles
Fluorene at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (μg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

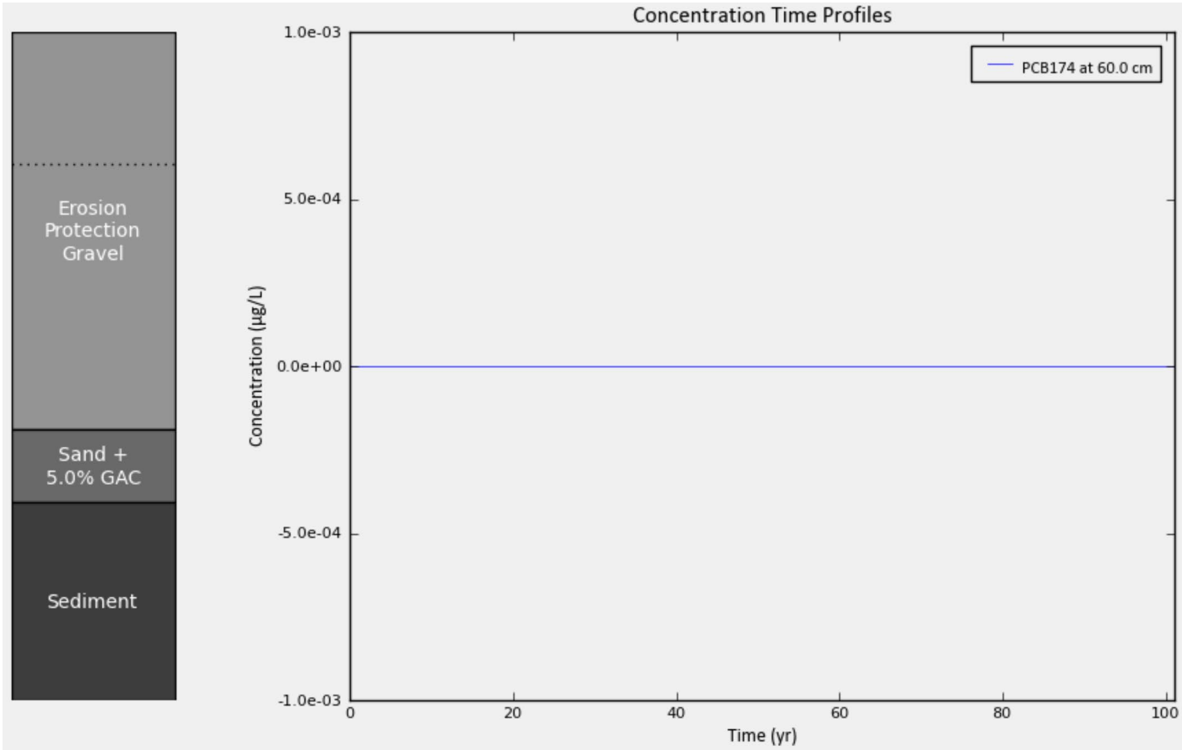

Concentration Time Profiles
HxCDF at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (μg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

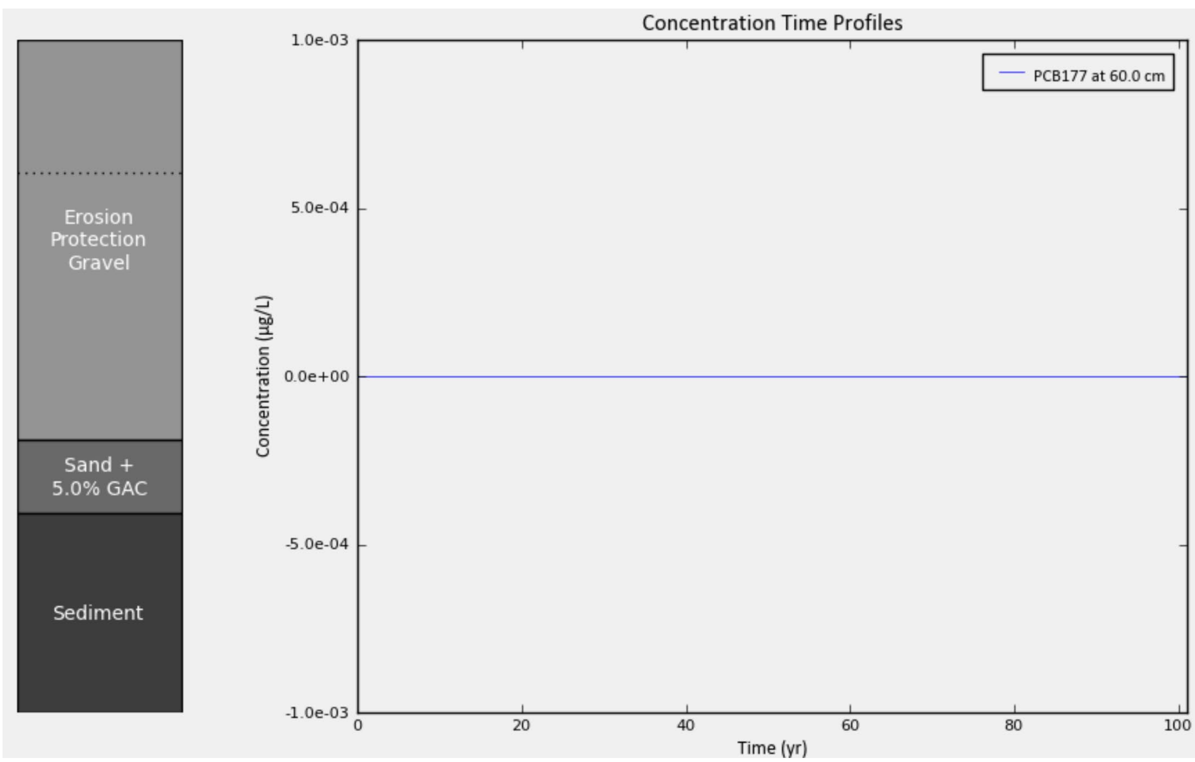

Concentration Time Profiles
Indeno(1,2,3-c,d)pyrene at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

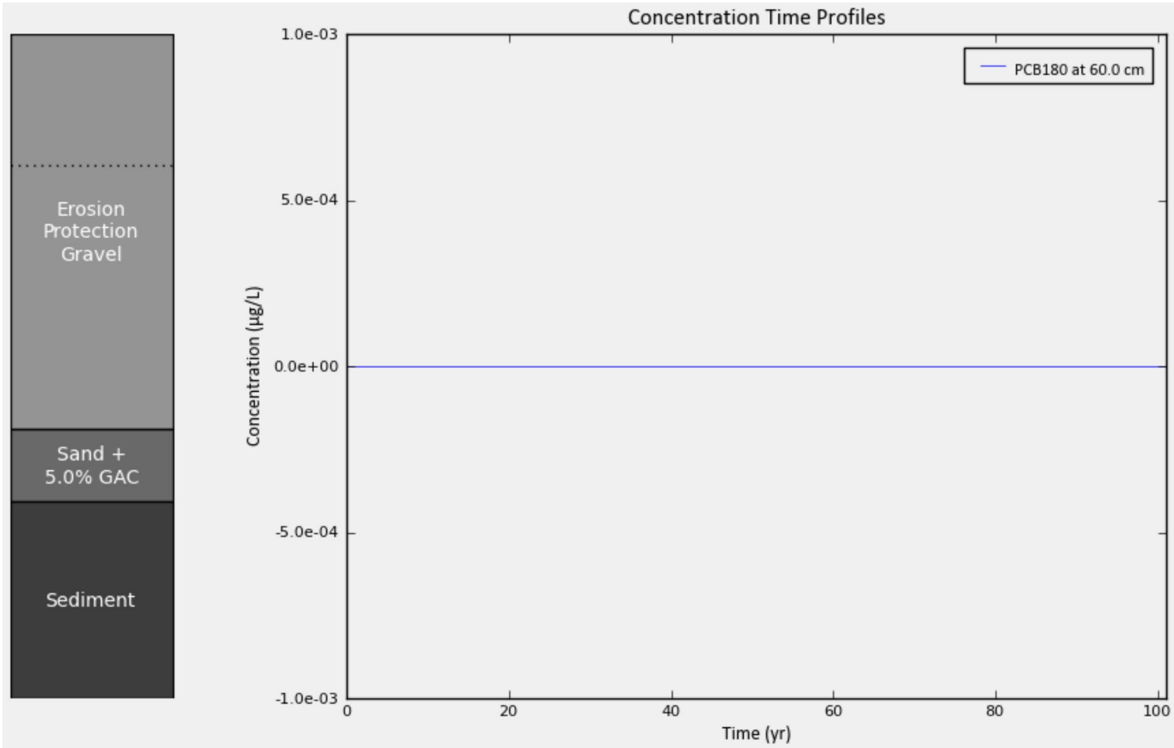

Concentration Time Profiles
Naphthalene at 60.0 cm
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

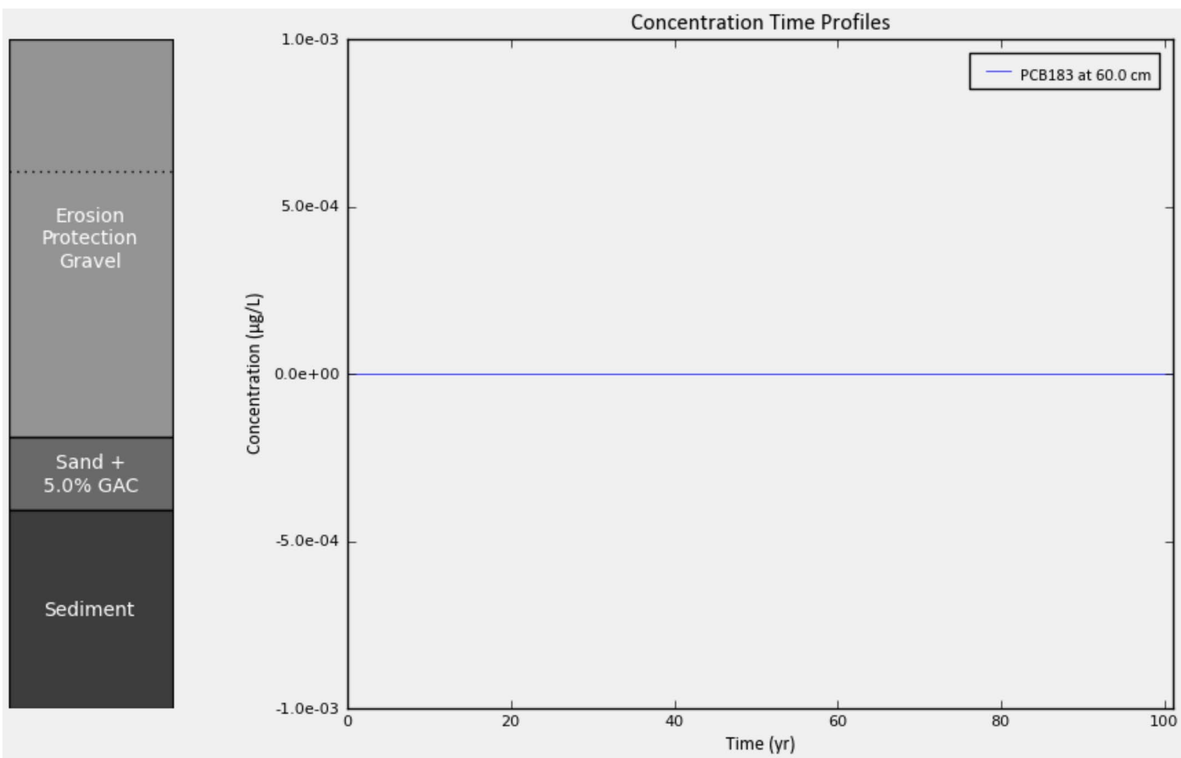

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Time Profiles
PCB141 at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

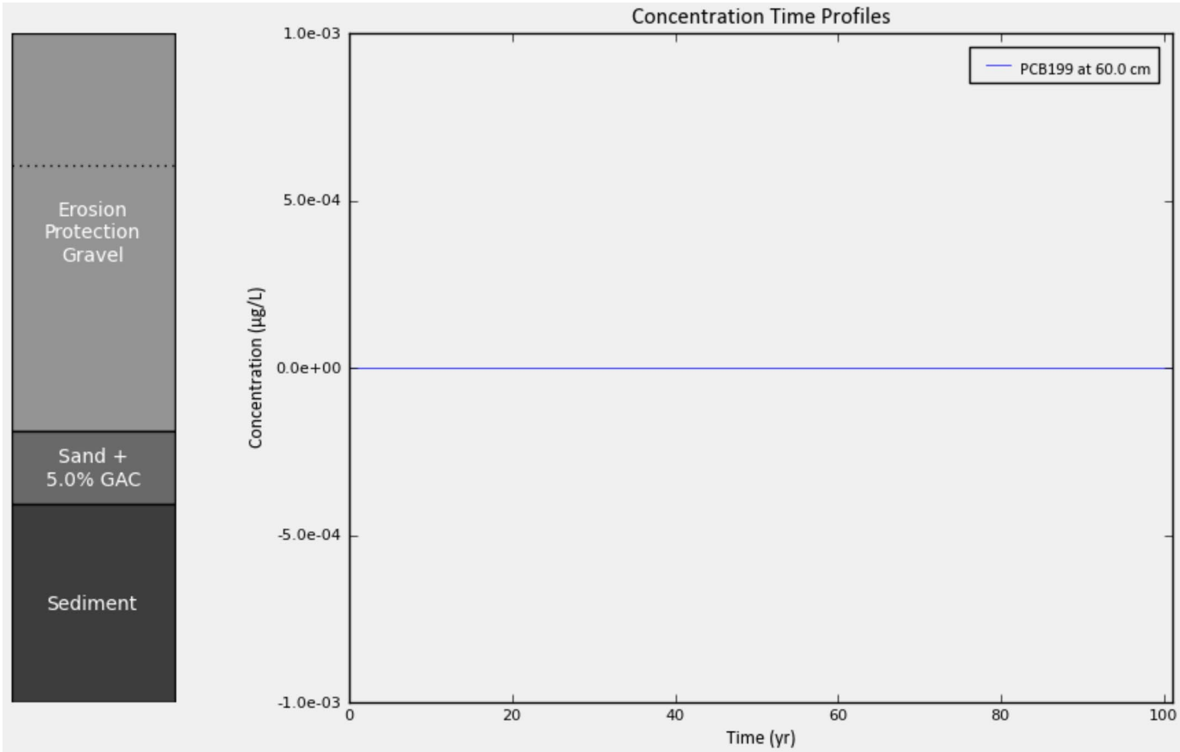

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Time Profiles
PCB153 at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

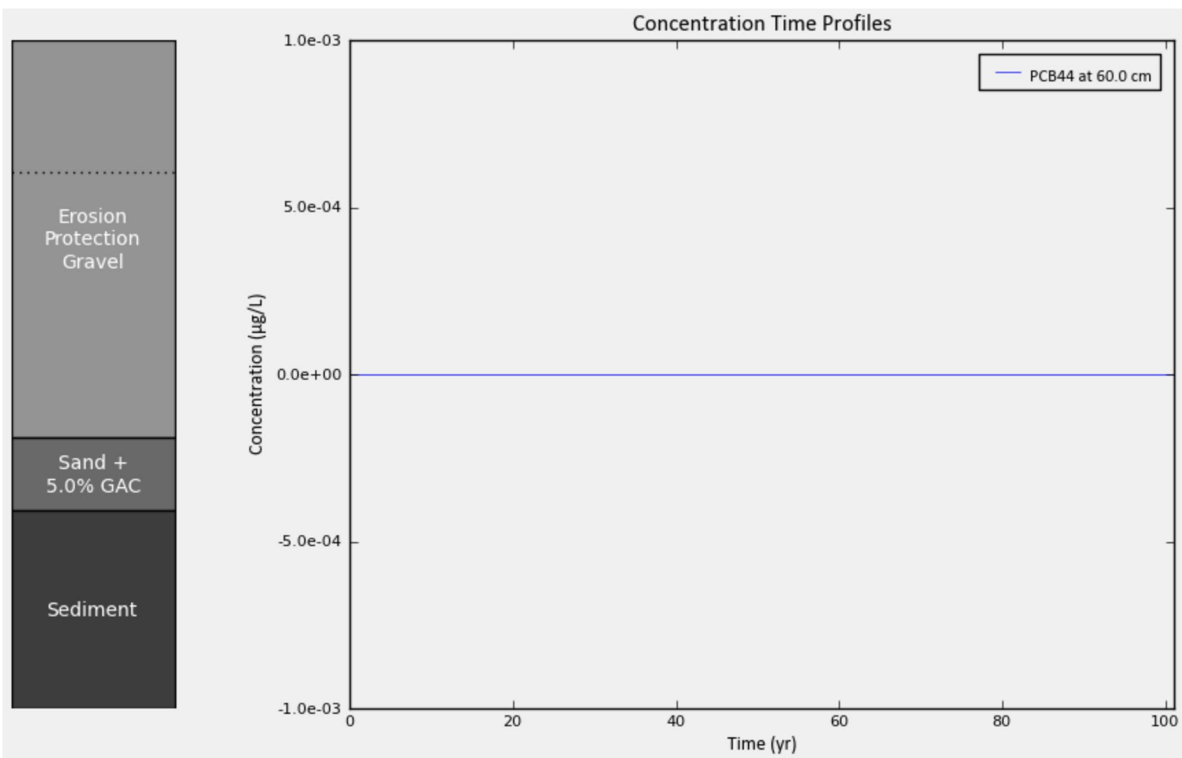

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB174 at 60.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

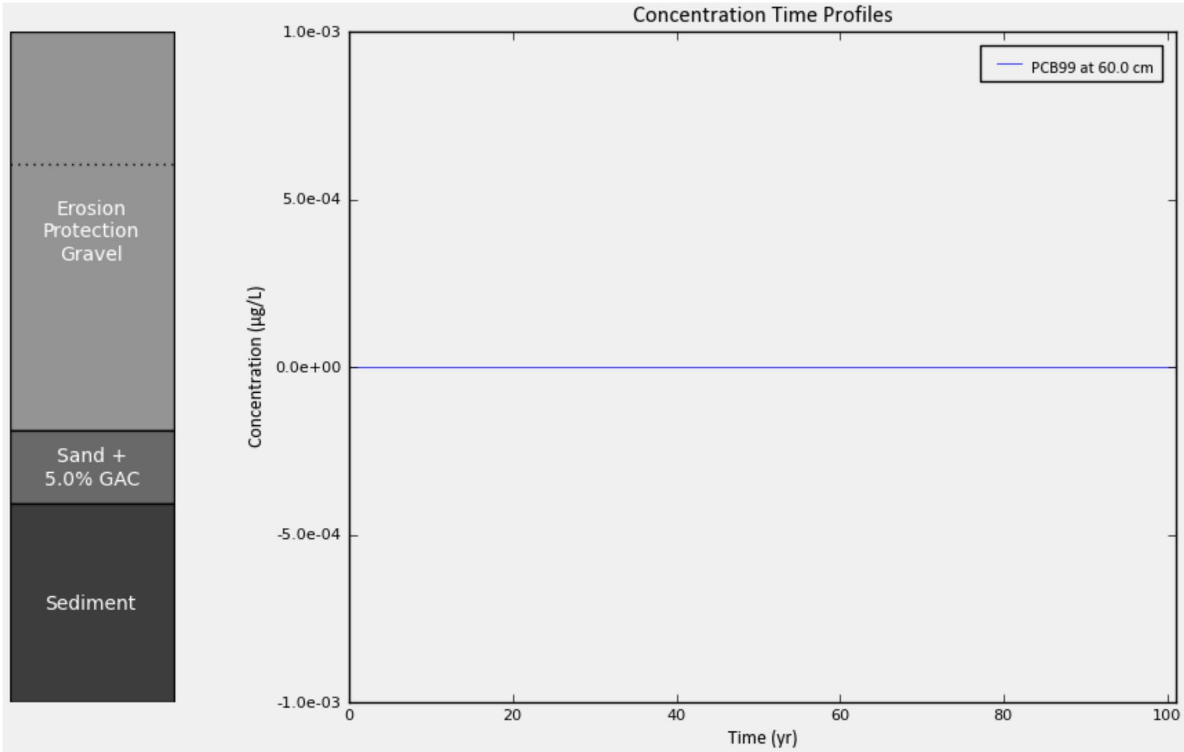

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB177 at 60.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

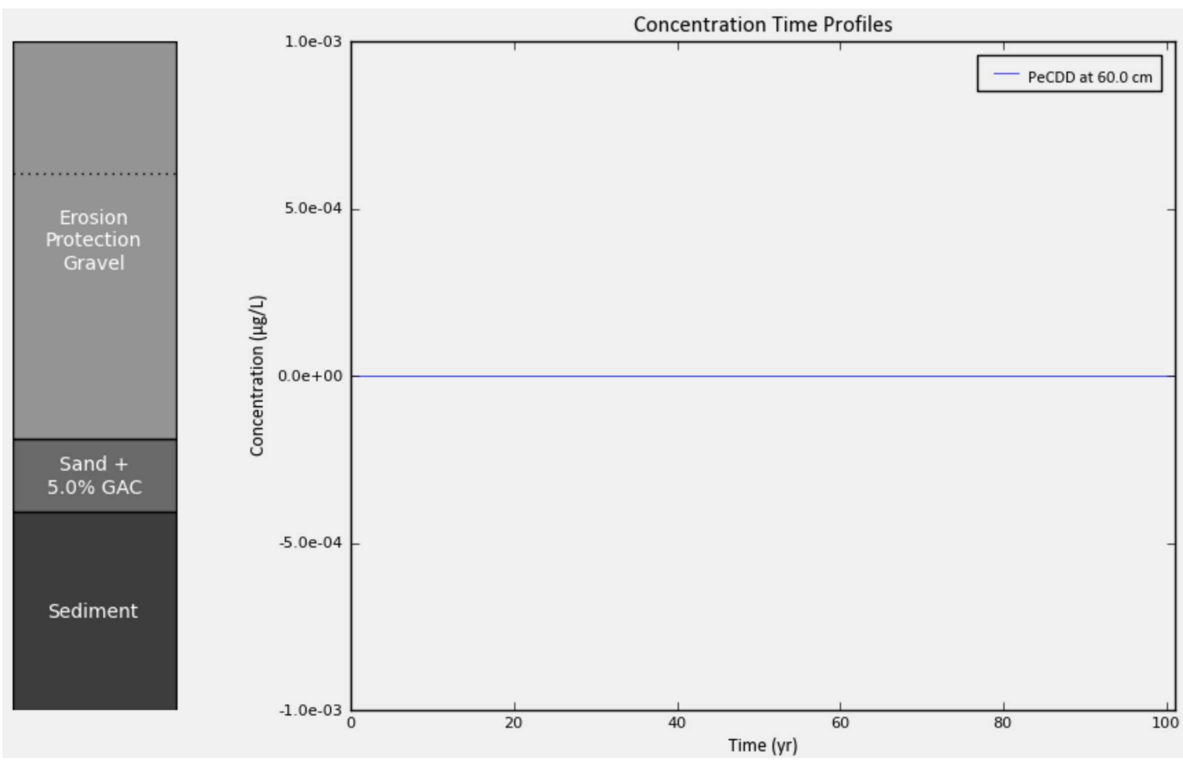

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB180 at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

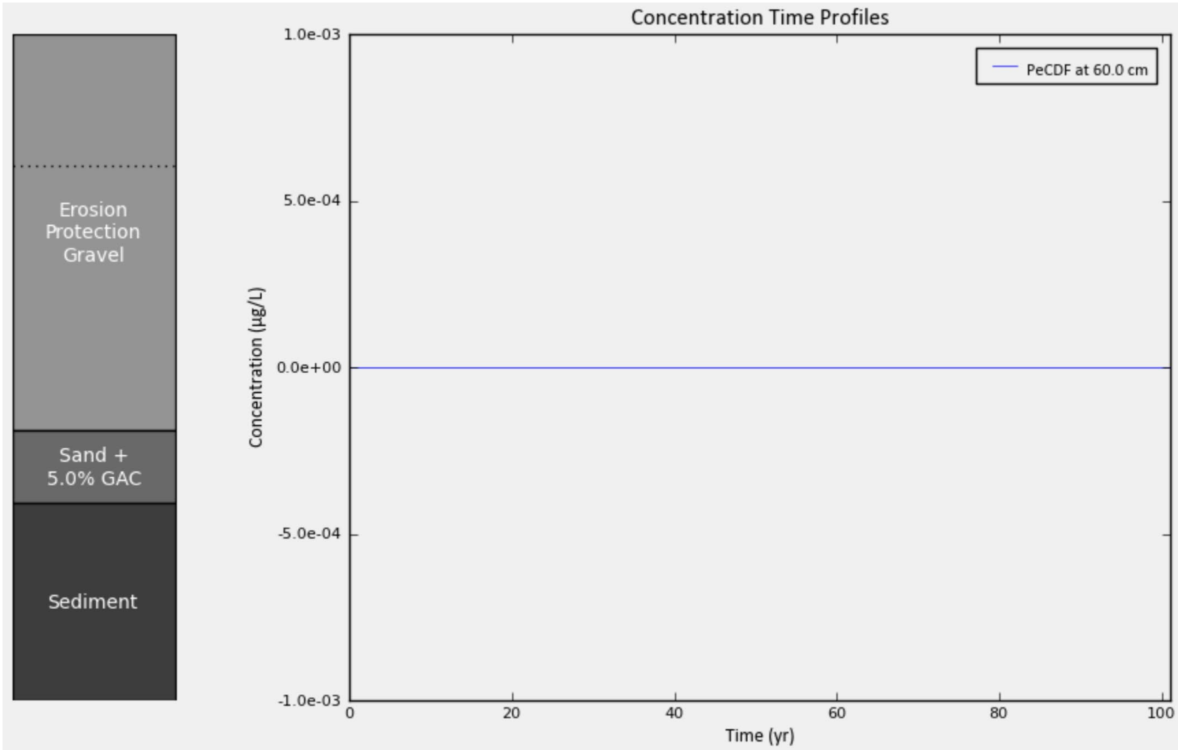

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB183 at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

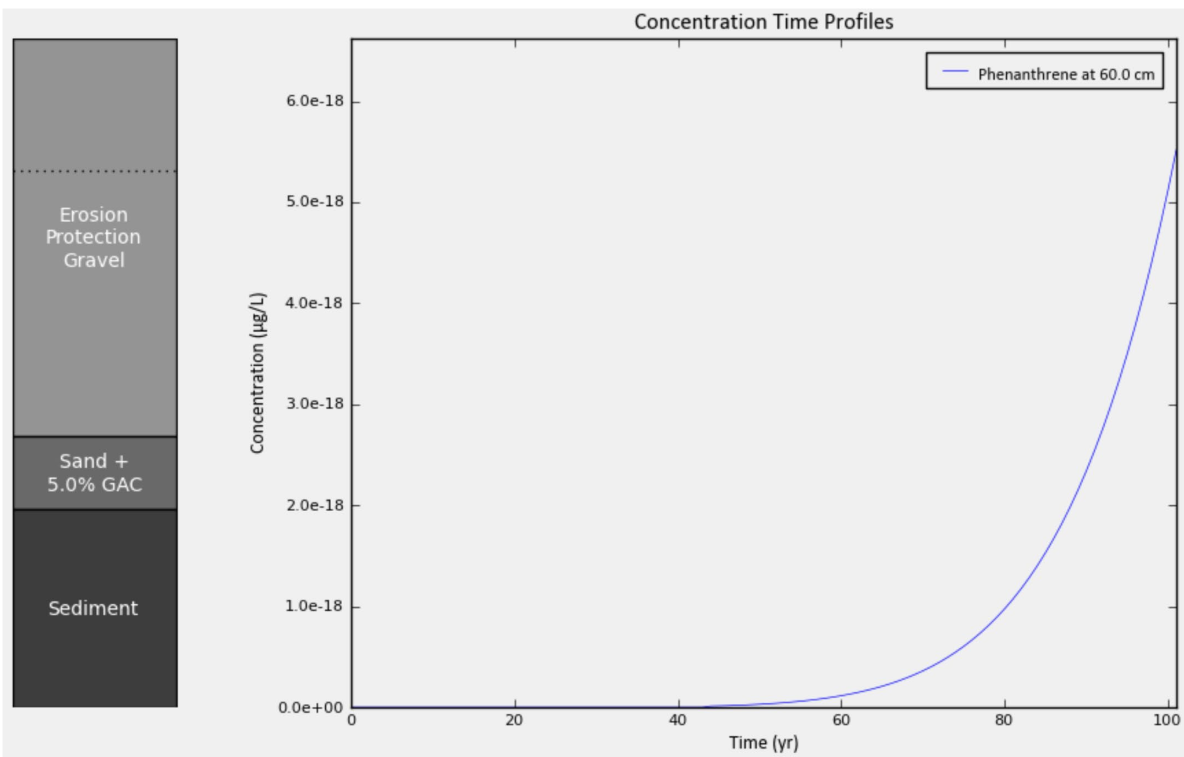

Concentration Time Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
PCB199 at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

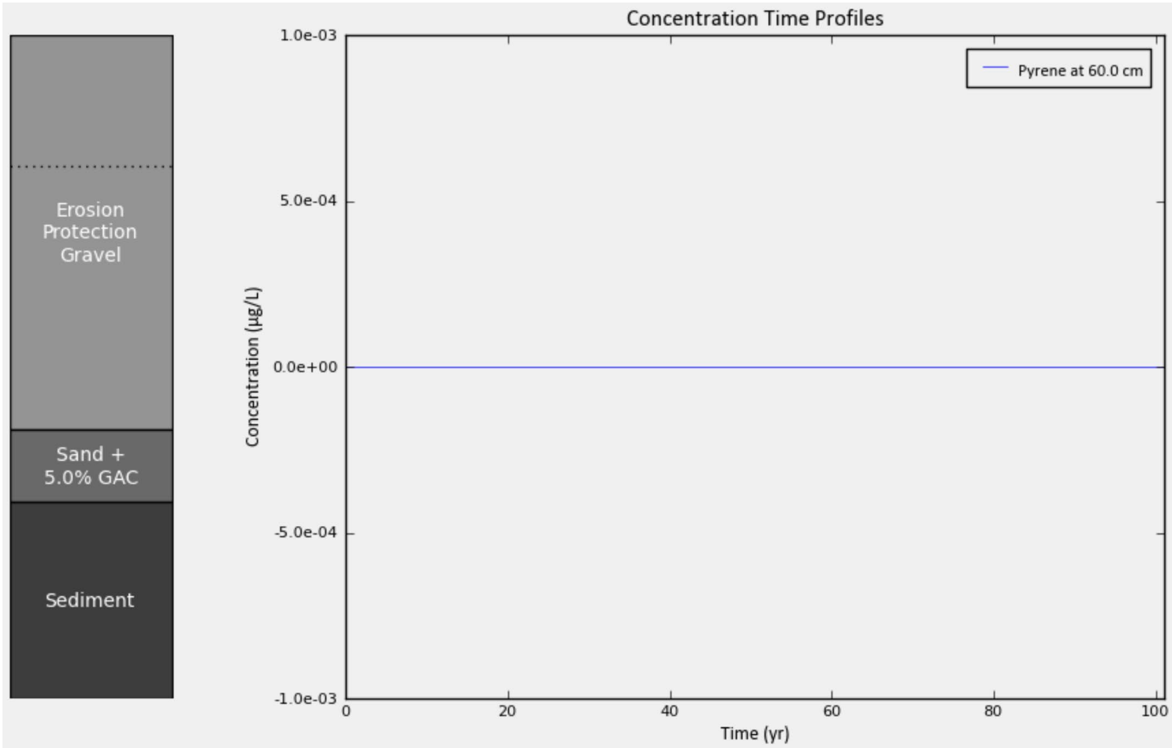

Concentration Time Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
PCB44 at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

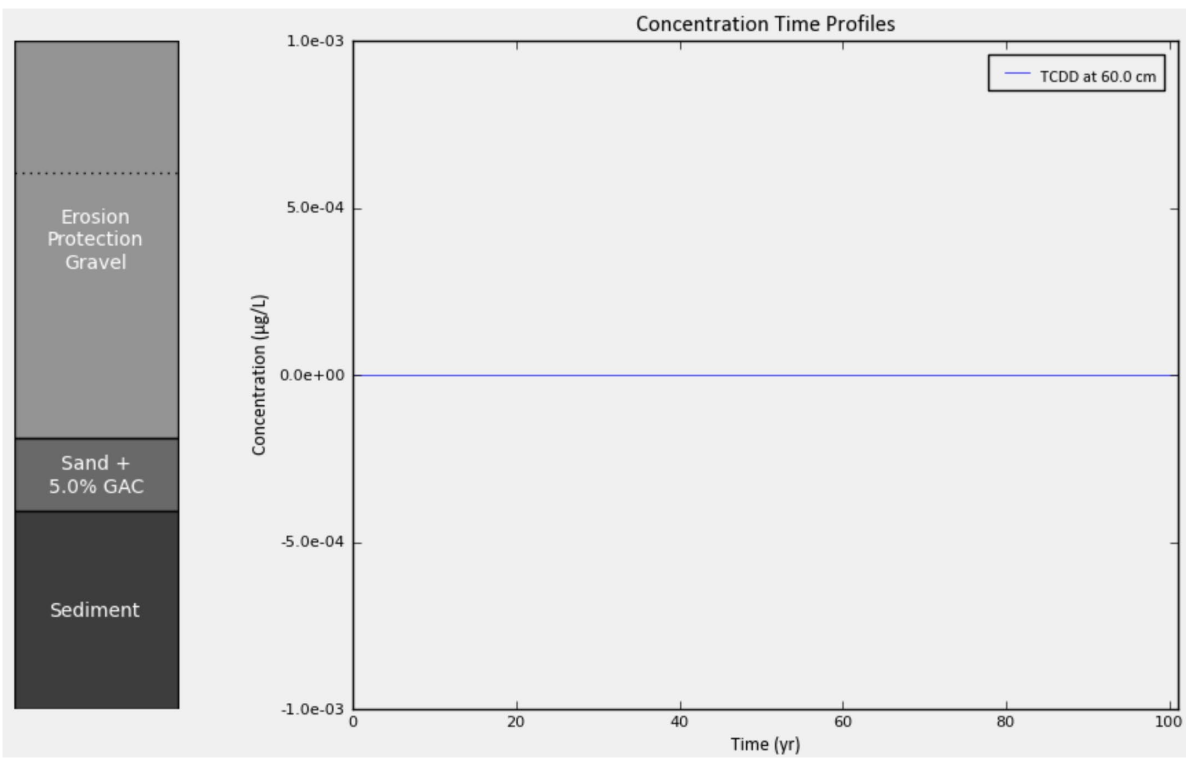

Concentration Time Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
PCB99 at 60.0 cm
Concentration (μg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100

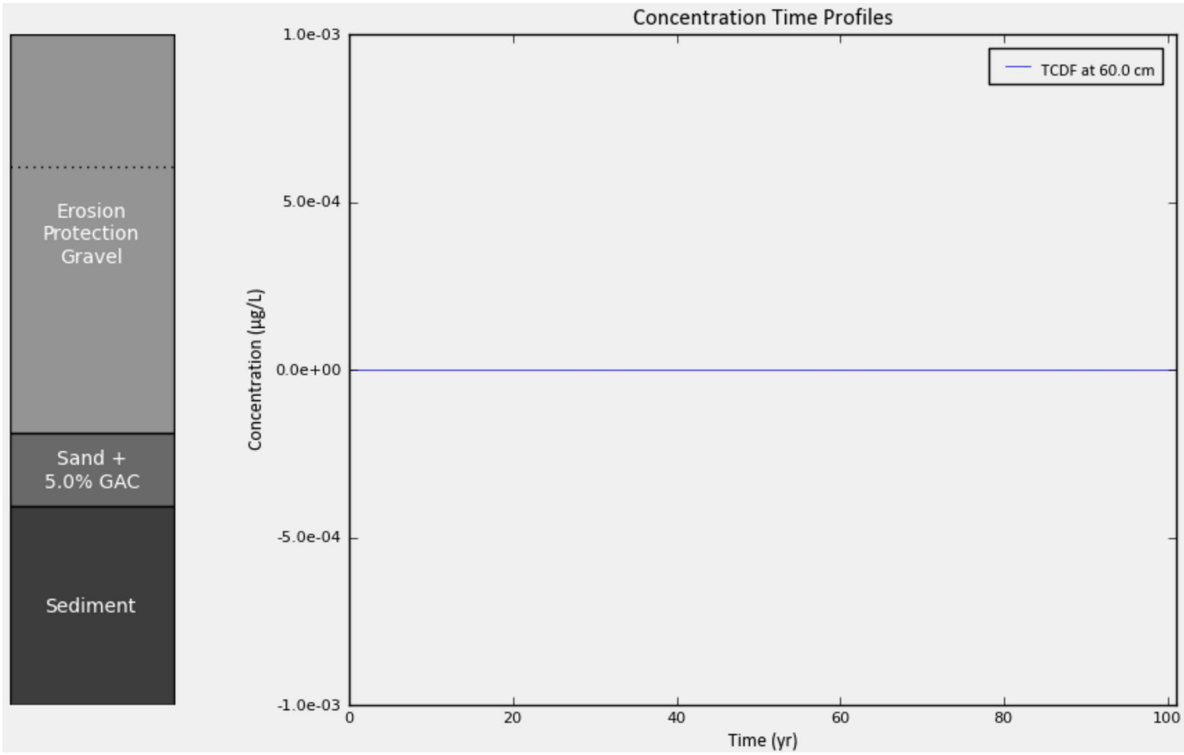

Concentration Time Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
PeCDD at 60.0 cm
Concentration (μg/L)
Time (yr)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100

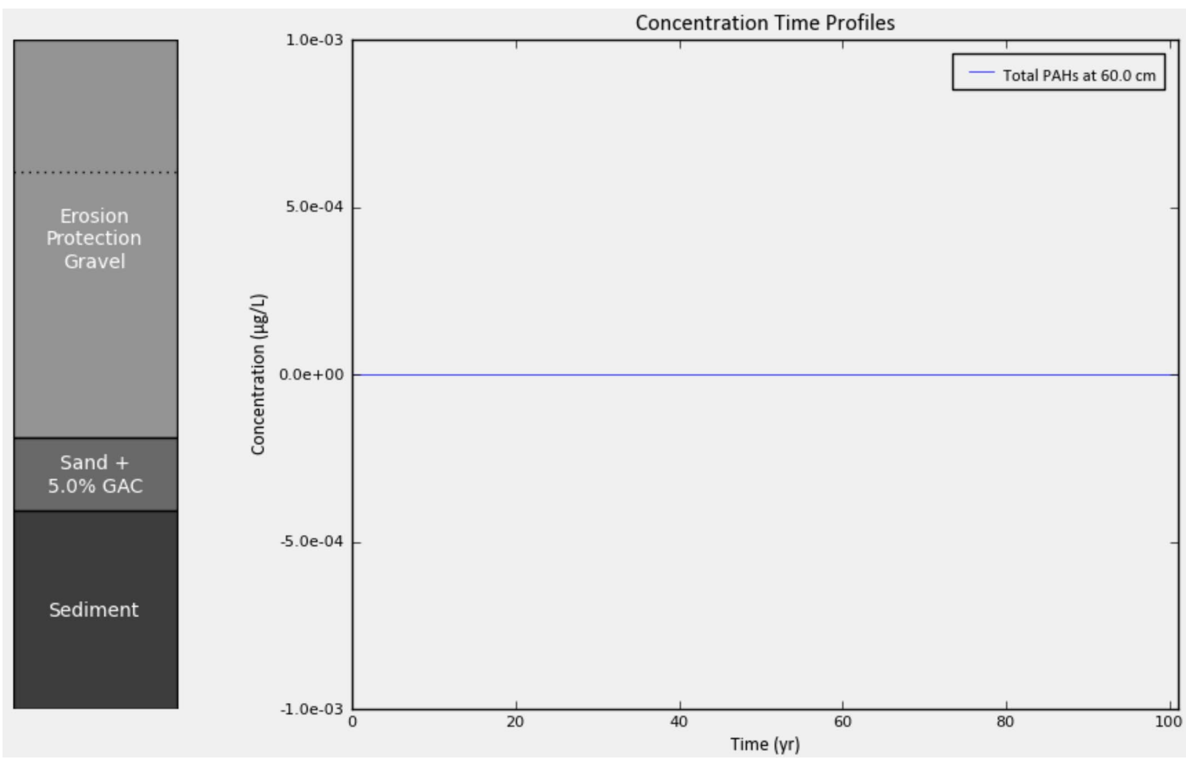

Concentration Time Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
PeCDF at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

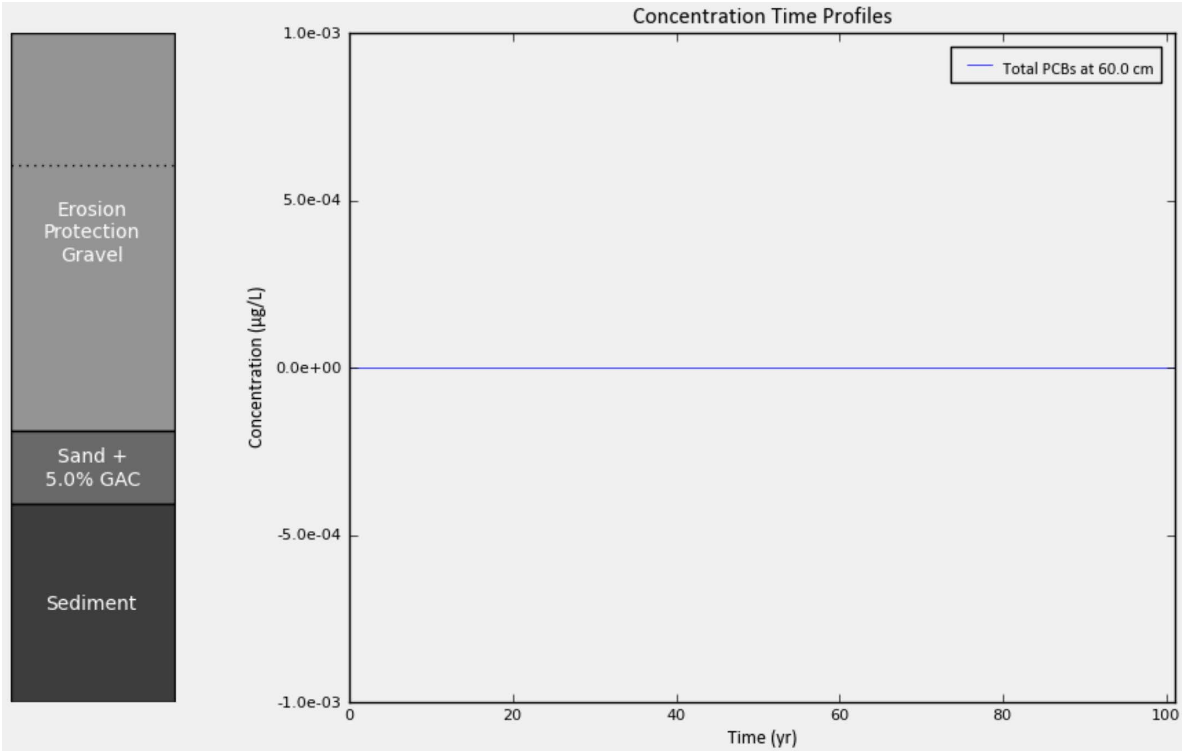

Concentration Time Profiles
Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Phenanthrene at 60.0 cm
Concentration (µg/L)
6.0e-18
5.0e-18
4.0e-18
3.0e-18
2.0e-18
1.0e-18
0.0e+00
0
20
40
60
80
100
Time (yr)

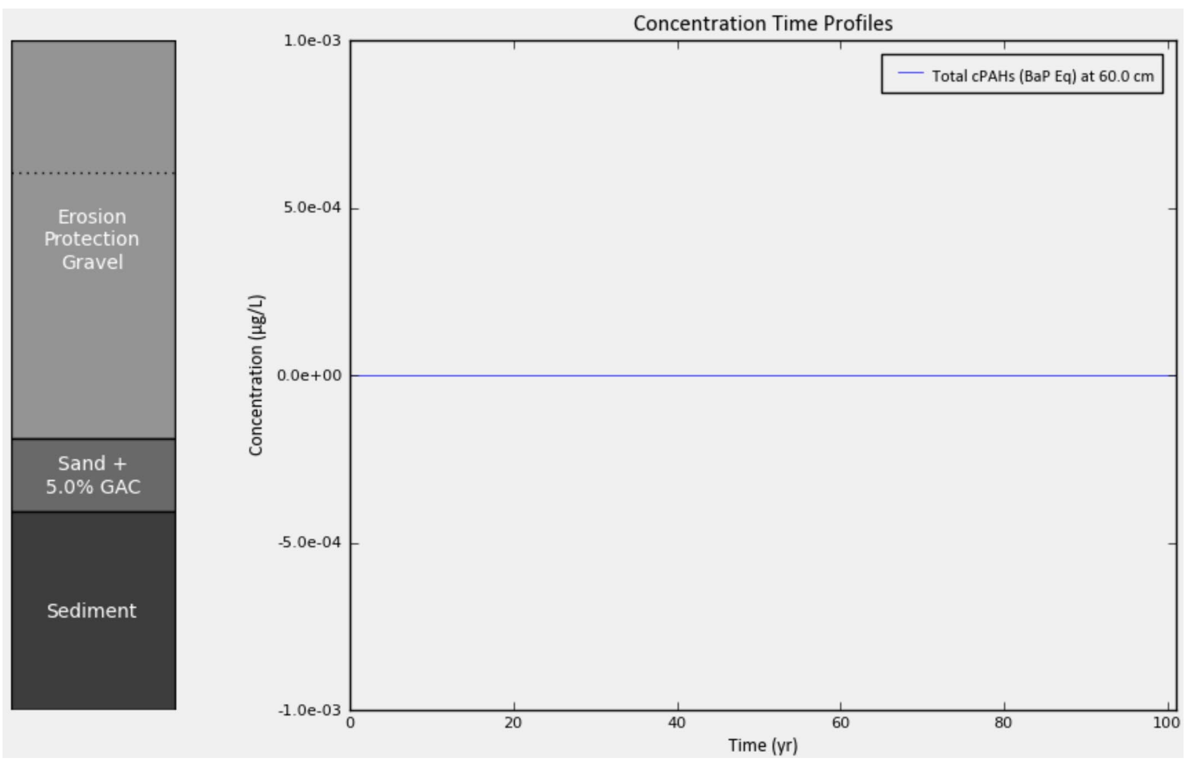

Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Time Profiles
Pyrene at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Erosion Protection Gravel
Sand + 5.0% GAC
Sediment
Concentration Time Profiles
TCDD at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
TCDF at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

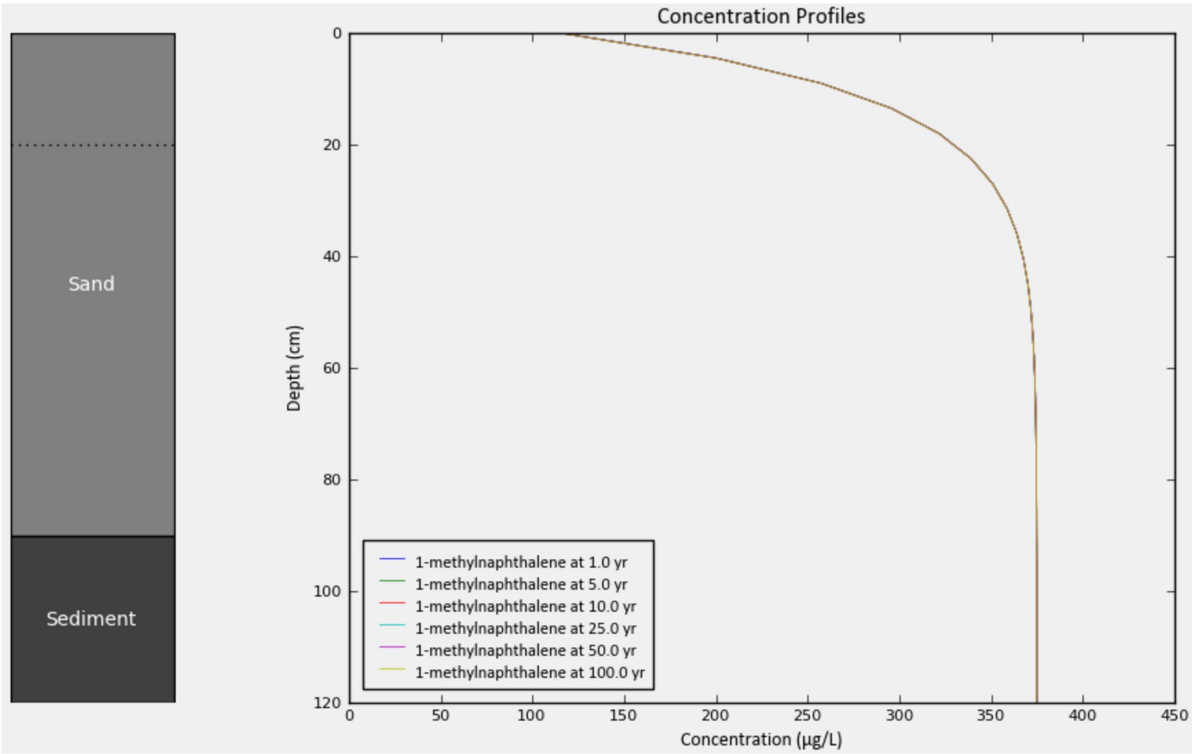

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Total PAHs at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

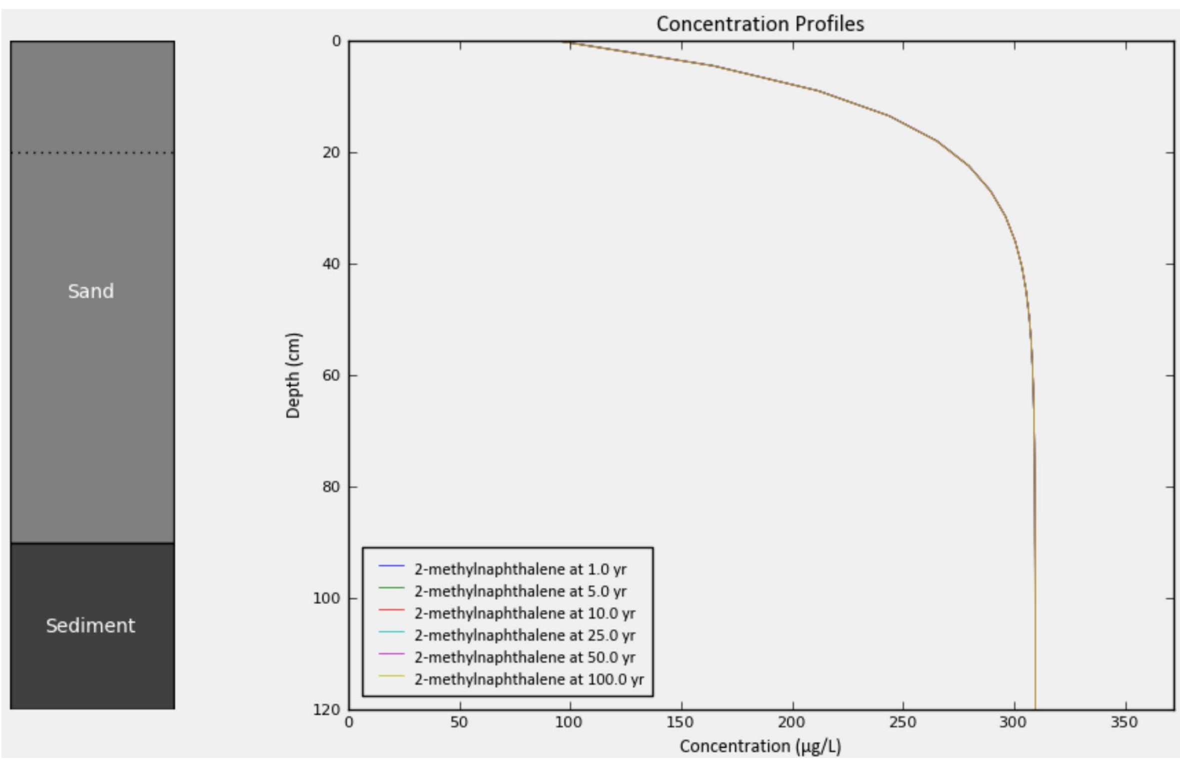

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Total PCBs at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

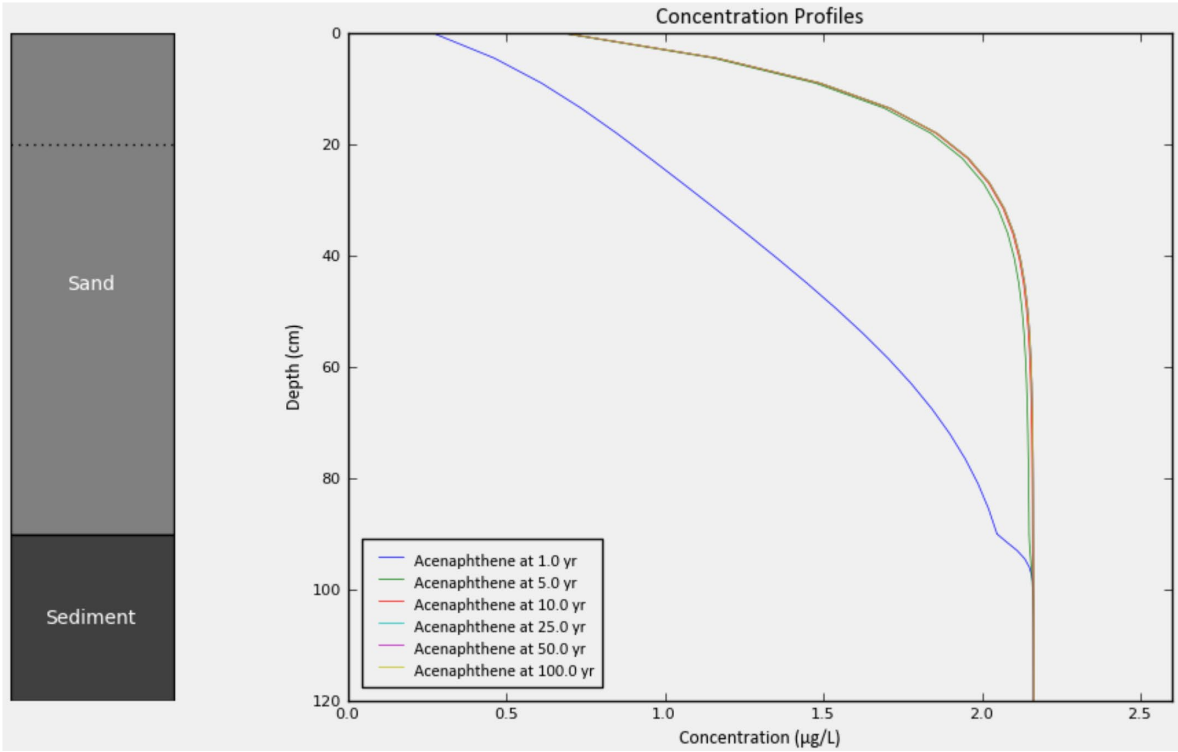

Erosion
Protection
Gravel
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Total cPAHs (BaP Eq) at 60.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

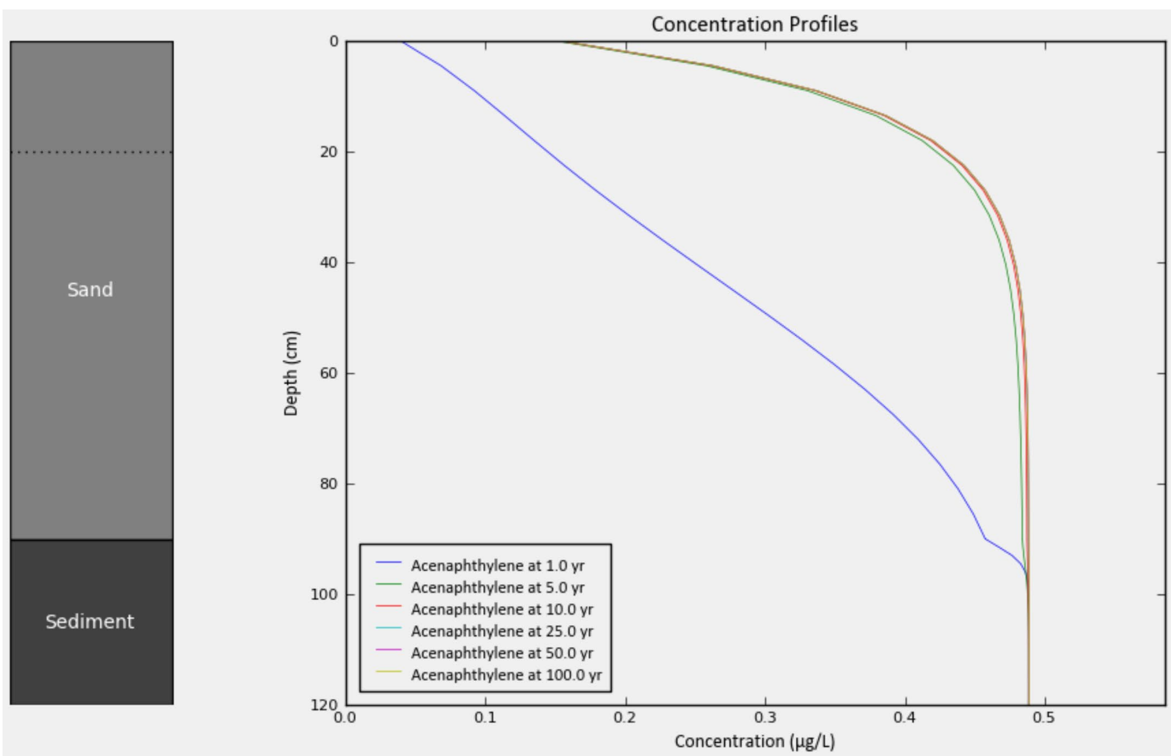
Cap Alternative 3: 90 cm of unamended sand

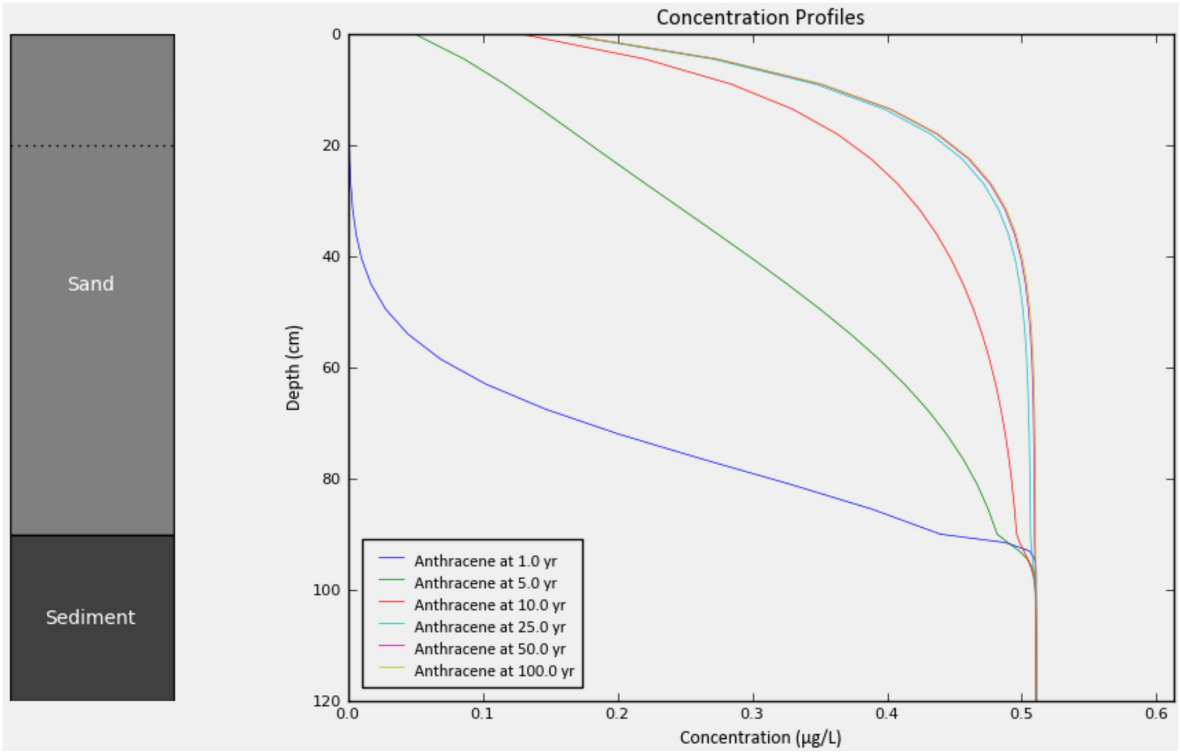
Porewater Concentration – Depth

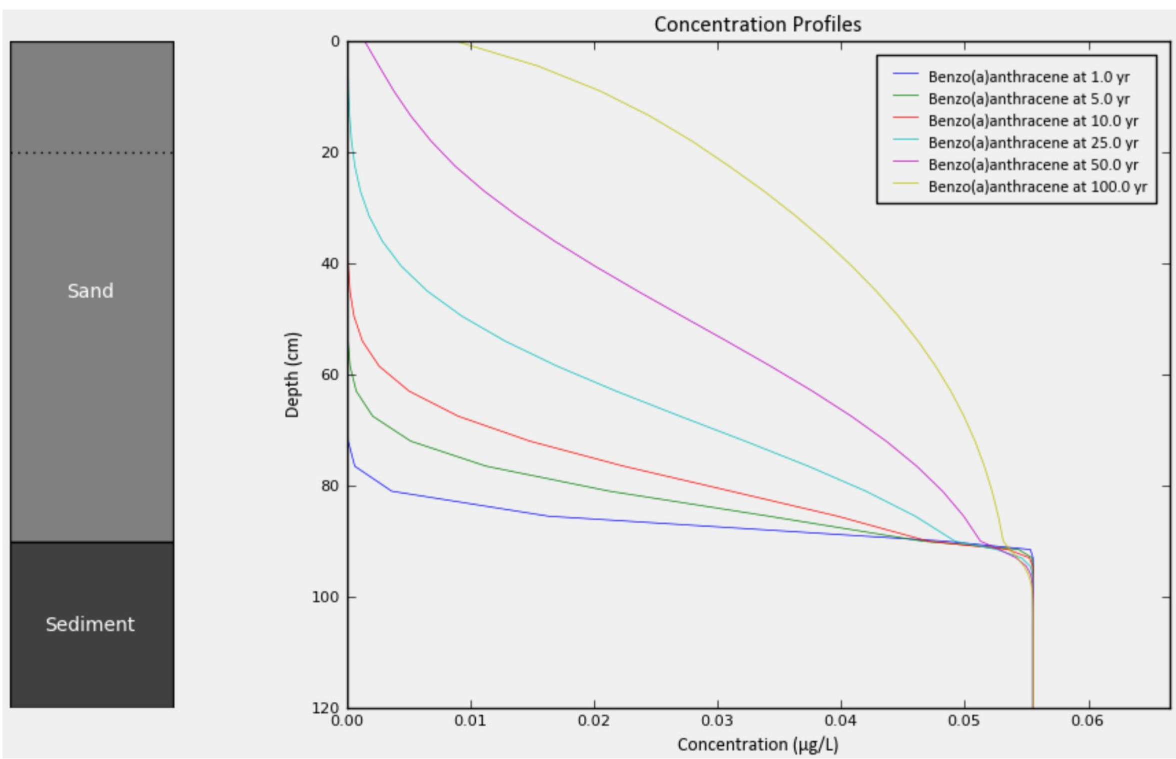


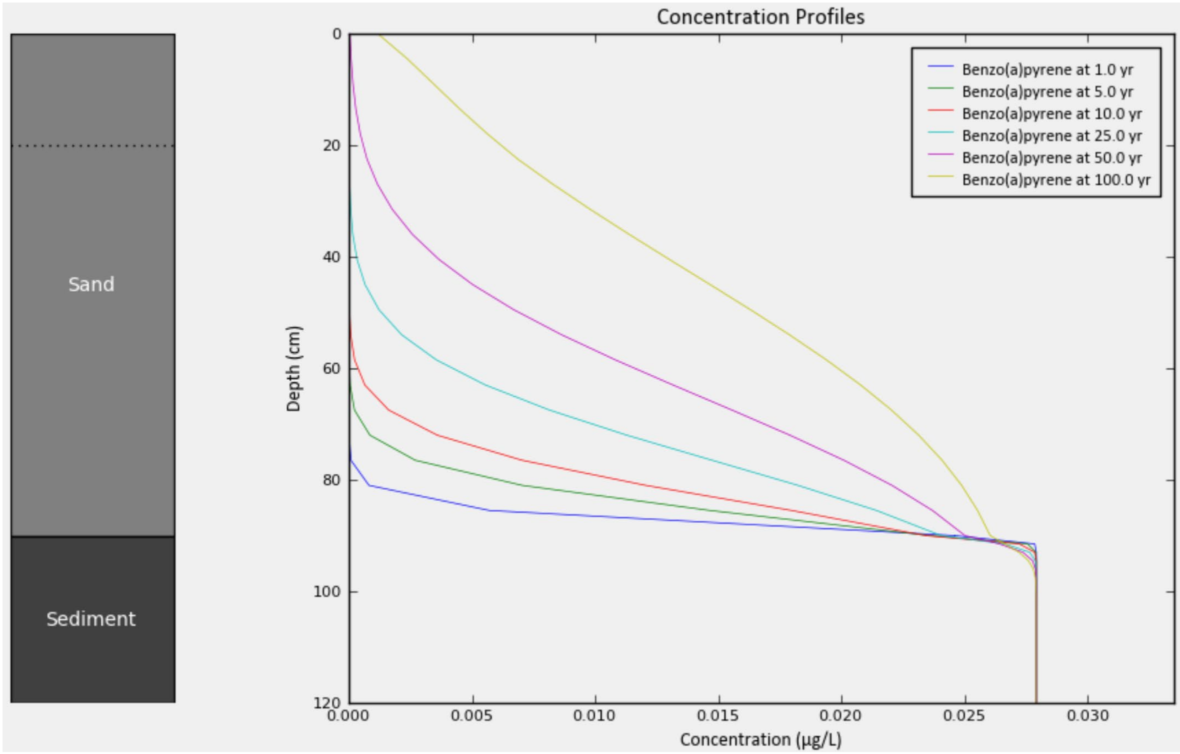


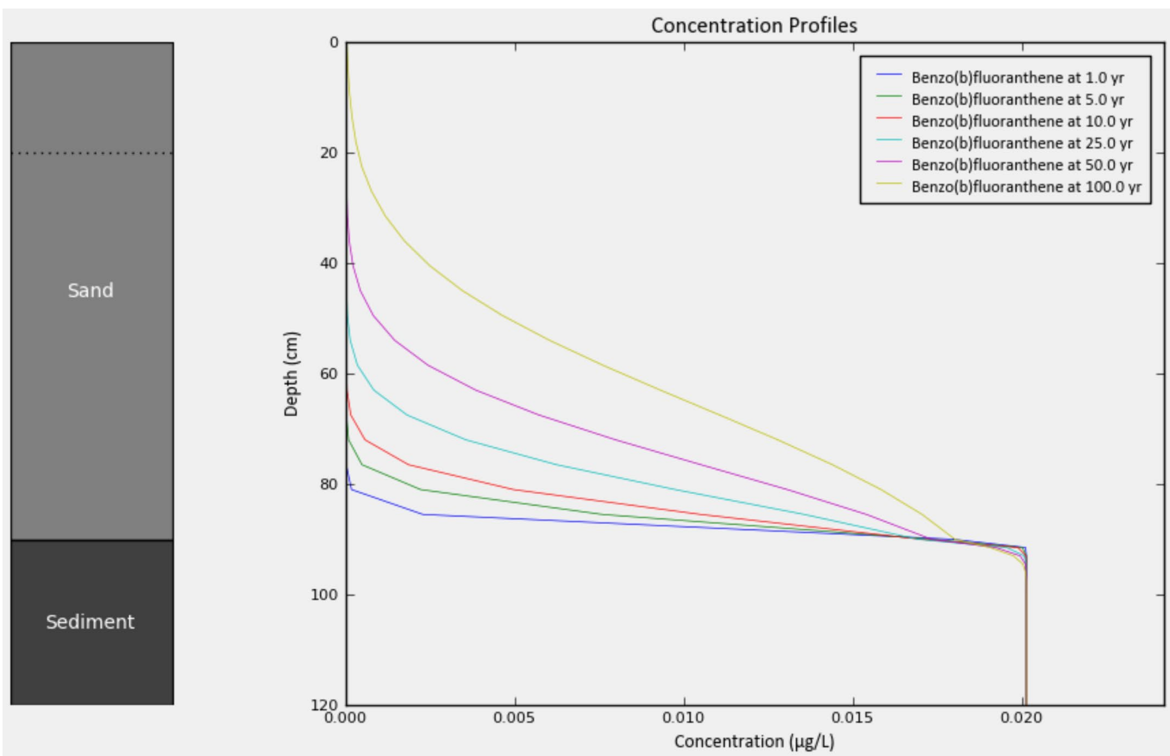

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
0
20
40
60
80
100
120
0.0
0.5
1.0
1.5
2.0
2.5
Acenaphthene at 1.0 yr
Acenaphthene at 5.0 yr
Acenaphthene at 10.0 yr
Acenaphthene at 25.0 yr
Acenaphthene at 50.0 yr
Acenaphthene at 100.0 yr

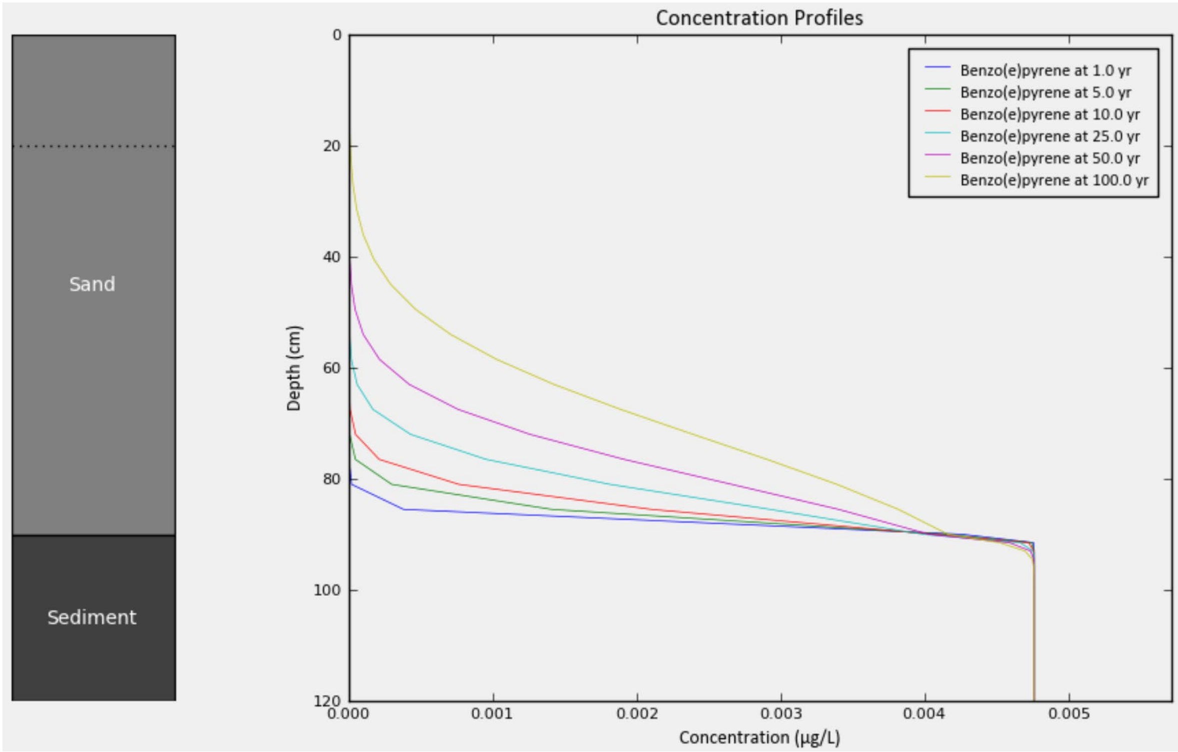

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
0
20
40
60
80
100
120
0.0
0.1
0.2
0.3
0.4
0.5
Acenaphthylene at 1.0 yr
Acenaphthylene at 5.0 yr
Acenaphthylene at 10.0 yr
Acenaphthylene at 25.0 yr
Acenaphthylene at 50.0 yr
Acenaphthylene at 100.0 yr

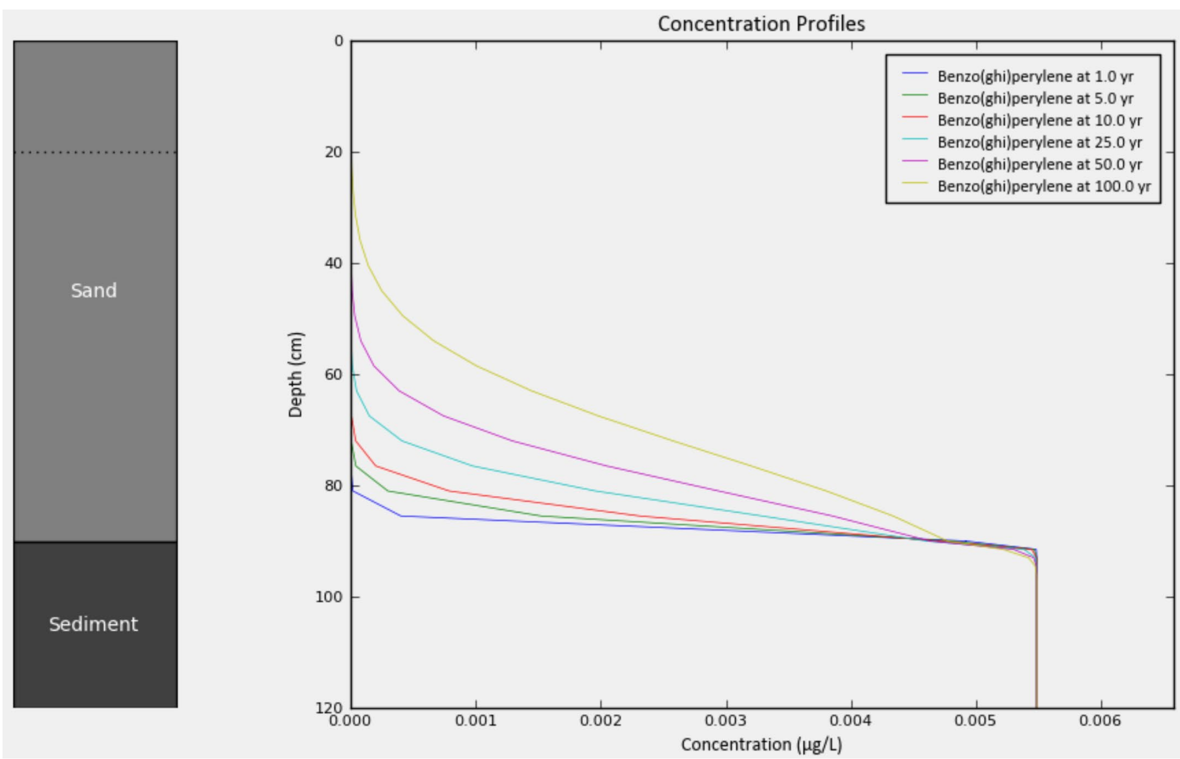

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
0
20
40
60
80
100
120
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Anthracene at 1.0 yr
Anthracene at 5.0 yr
Anthracene at 10.0 yr
Anthracene at 25.0 yr
Anthracene at 50.0 yr
Anthracene at 100.0 yr

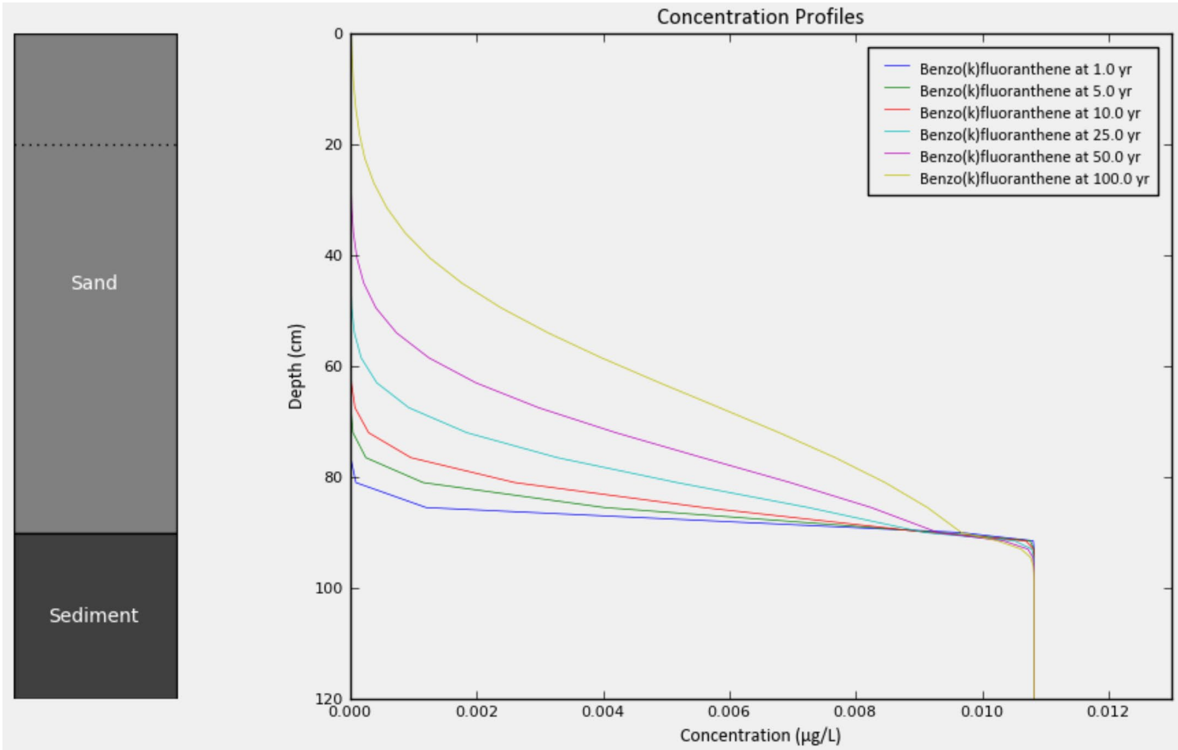

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
0
20
40
60
80
100
120
0.00
0.01
0.02
0.03
0.04
0.05
0.06
Benzo(a)anthracene at 1.0 yr
Benzo(a)anthracene at 5.0 yr
Benzo(a)anthracene at 10.0 yr
Benzo(a)anthracene at 25.0 yr
Benzo(a)anthracene at 50.0 yr
Benzo(a)anthracene at 100.0 yr

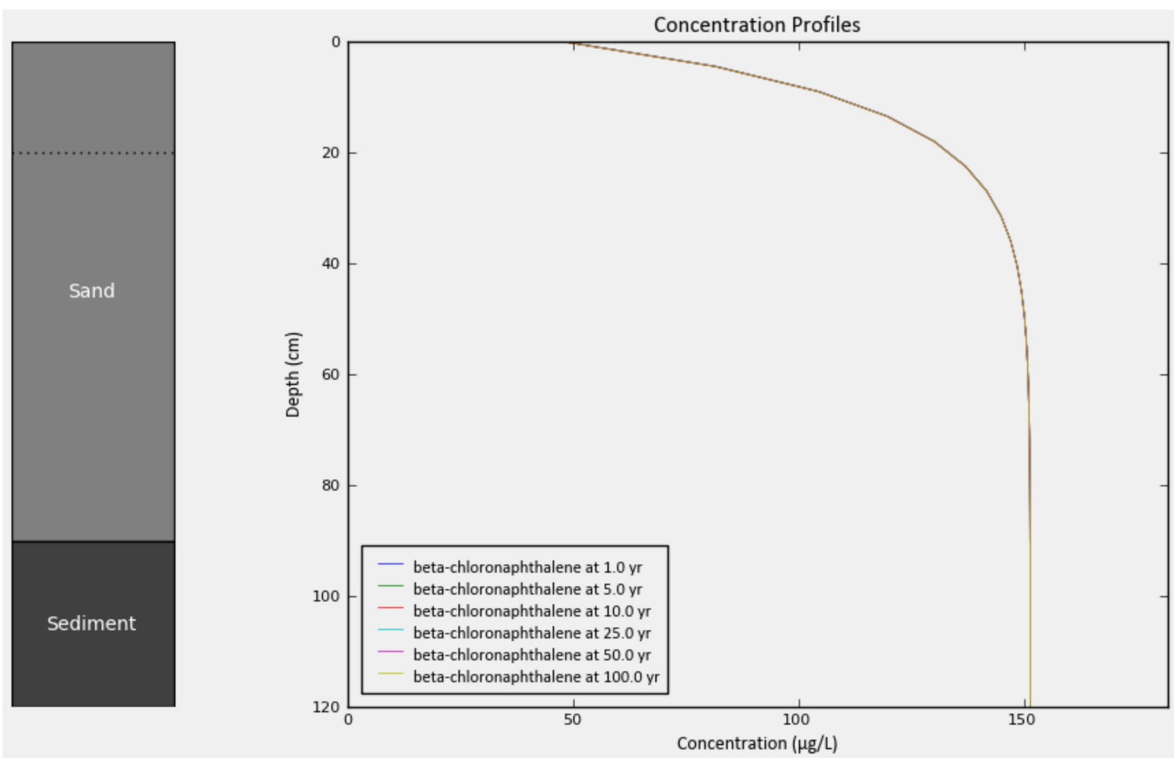

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(a)pyrene at 1.0 yr
Benzo(a)pyrene at 5.0 yr
Benzo(a)pyrene at 10.0 yr
Benzo(a)pyrene at 25.0 yr
Benzo(a)pyrene at 50.0 yr
Benzo(a)pyrene at 100.0 yr
0
20
40
60
80
100
120
0.000
0.005
0.010
0.015
0.020
0.025
0.030

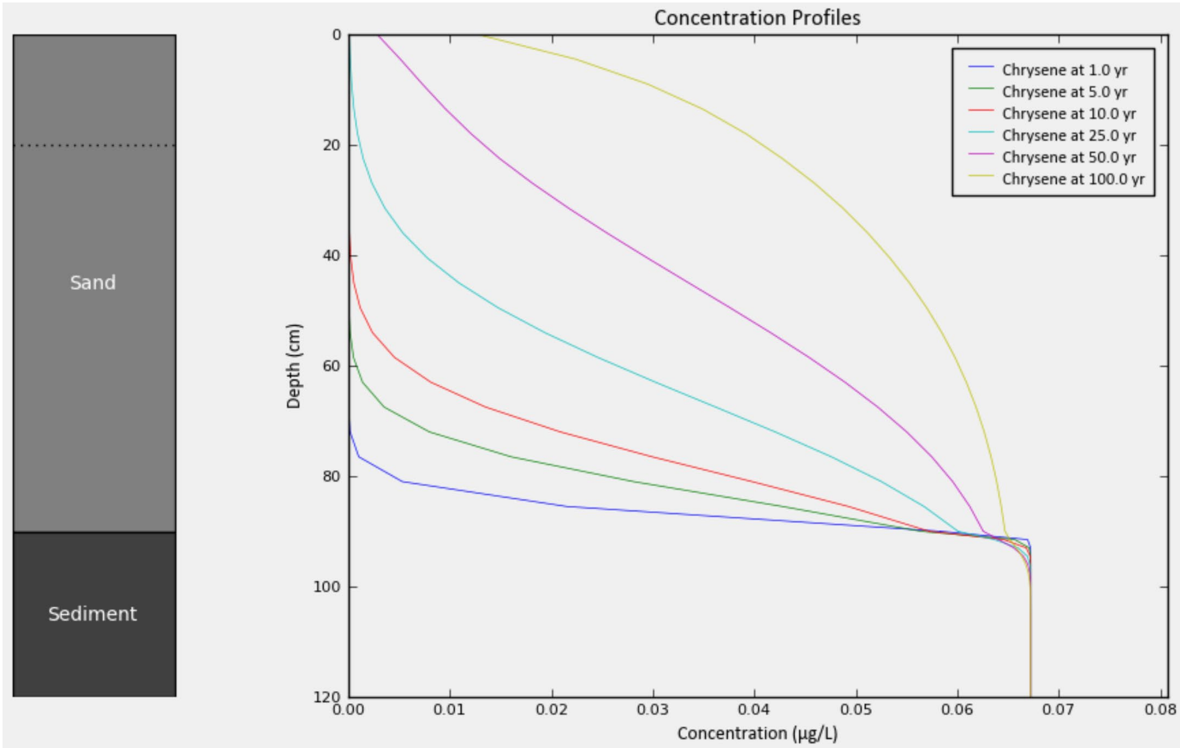

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(b)fluoranthene at 1.0 yr
Benzo(b)fluoranthene at 5.0 yr
Benzo(b)fluoranthene at 10.0 yr
Benzo(b)fluoranthene at 25.0 yr
Benzo(b)fluoranthene at 50.0 yr
Benzo(b)fluoranthene at 100.0 yr
0
20
40
60
80
100
120
0.000
0.005
0.010
0.015
0.020

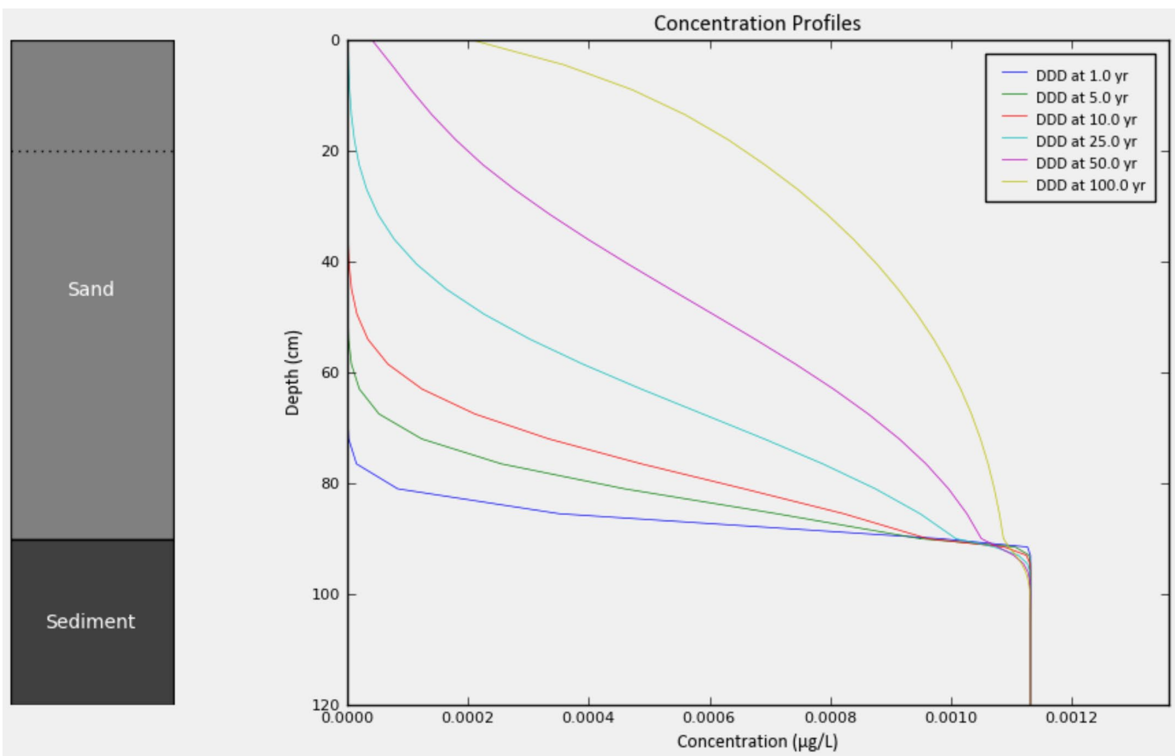

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (μg/L)
Benzo(e)pyrene at 1.0 yr
Benzo(e)pyrene at 5.0 yr
Benzo(e)pyrene at 10.0 yr
Benzo(e)pyrene at 25.0 yr
Benzo(e)pyrene at 50.0 yr
Benzo(e)pyrene at 100.0 yr

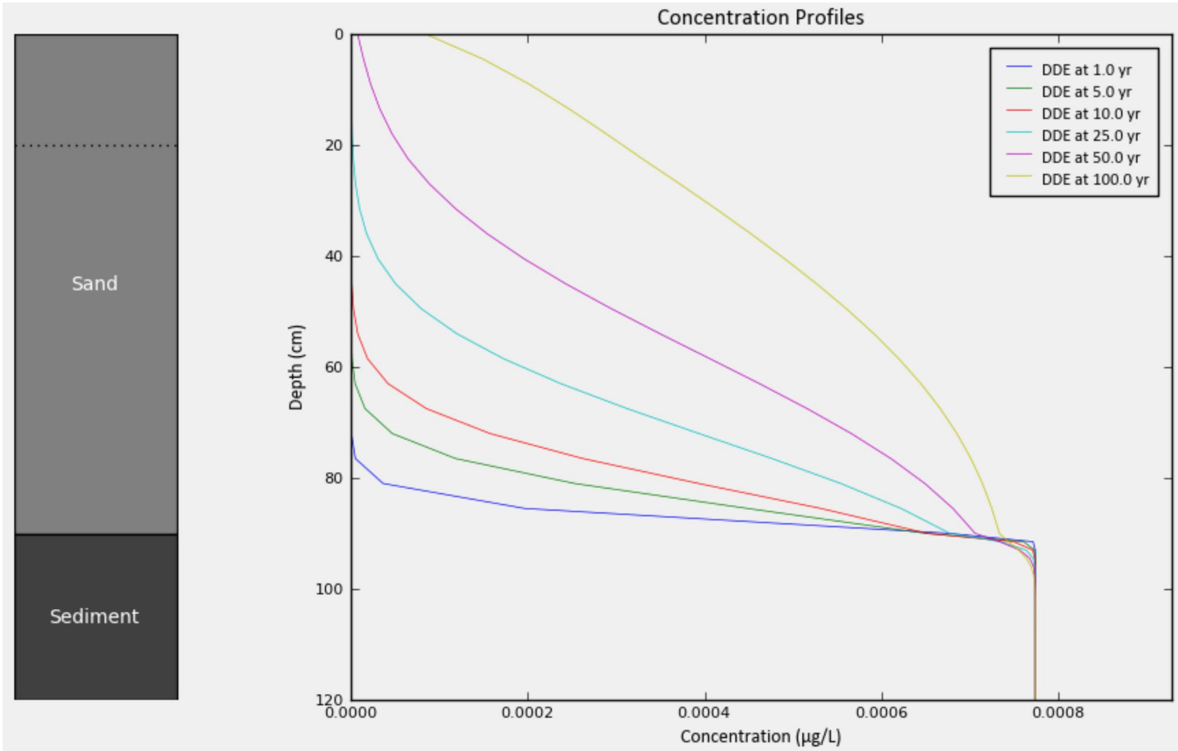

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (μg/L)
Benzo(ghi)perylene at 1.0 yr
Benzo(ghi)perylene at 5.0 yr
Benzo(ghi)perylene at 10.0 yr
Benzo(ghi)perylene at 25.0 yr
Benzo(ghi)perylene at 50.0 yr
Benzo(ghi)perylene at 100.0 yr

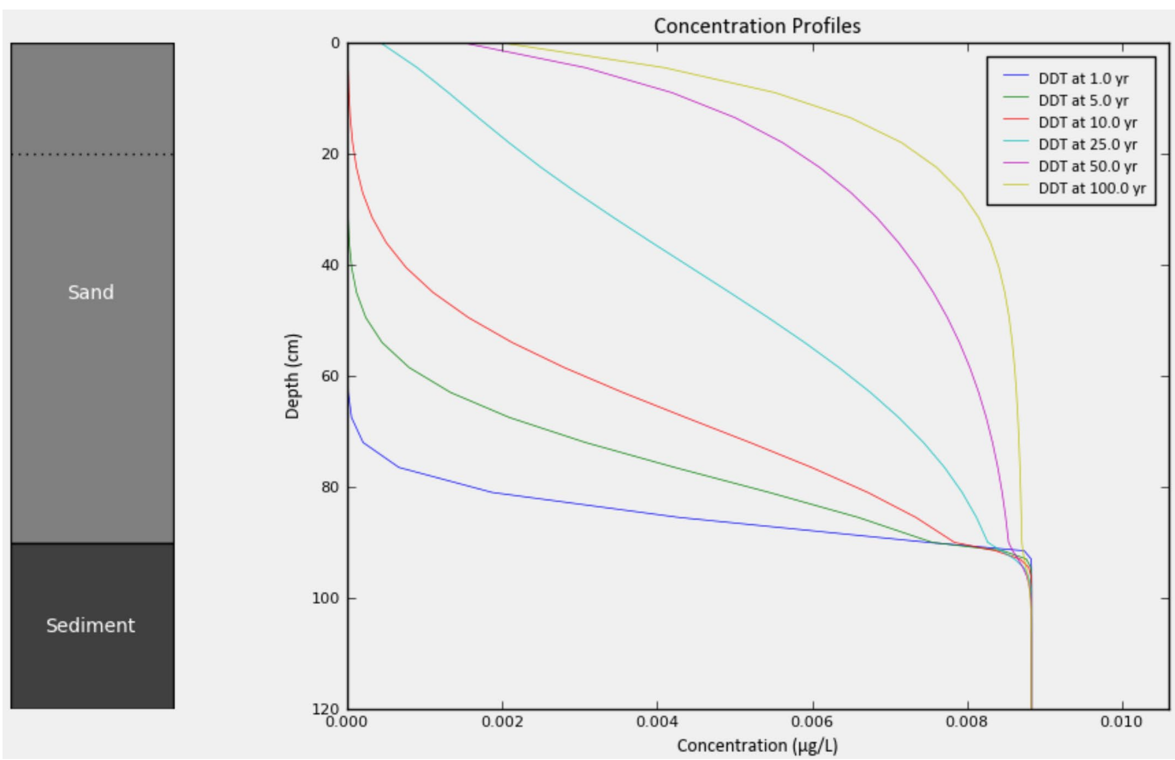

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(k)fluoranthene at 1.0 yr
Benzo(k)fluoranthene at 5.0 yr
Benzo(k)fluoranthene at 10.0 yr
Benzo(k)fluoranthene at 25.0 yr
Benzo(k)fluoranthene at 50.0 yr
Benzo(k)fluoranthene at 100.0 yr

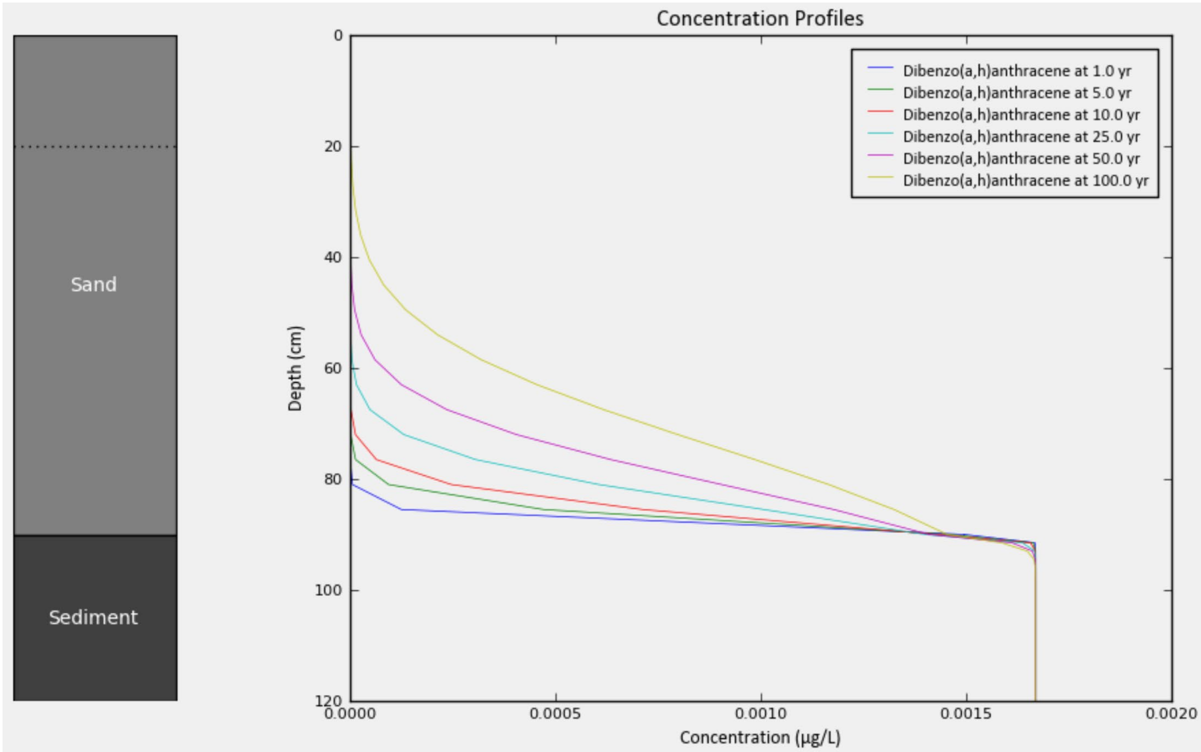

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
beta-chloronaphthalene at 1.0 yr
beta-chloronaphthalene at 5.0 yr
beta-chloronaphthalene at 10.0 yr
beta-chloronaphthalene at 25.0 yr
beta-chloronaphthalene at 50.0 yr
beta-chloronaphthalene at 100.0 yr

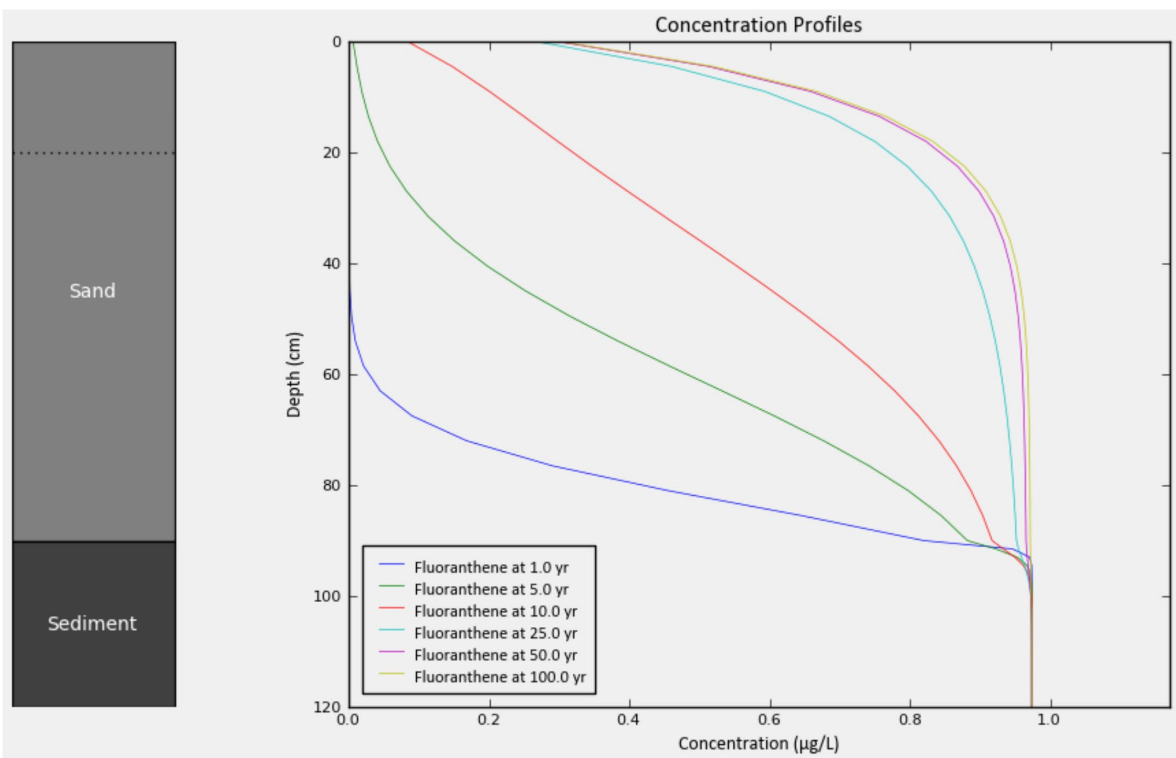

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Chrysene at 1.0 yr
Chrysene at 5.0 yr
Chrysene at 10.0 yr
Chrysene at 25.0 yr
Chrysene at 50.0 yr
Chrysene at 100.0 yr
0
20
40
60
80
100
120
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08

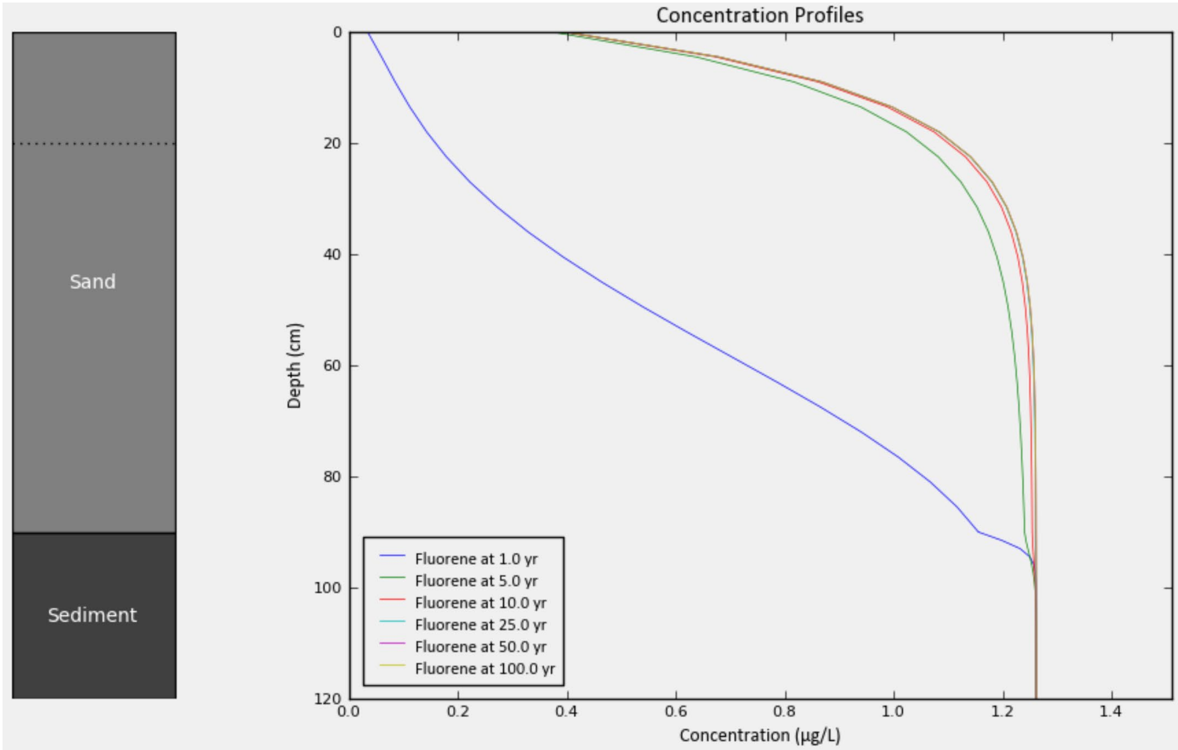

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
DDD at 1.0 yr
DDD at 5.0 yr
DDD at 10.0 yr
DDD at 25.0 yr
DDD at 50.0 yr
DDD at 100.0 yr
0
20
40
60
80
100
120
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010
0.0012

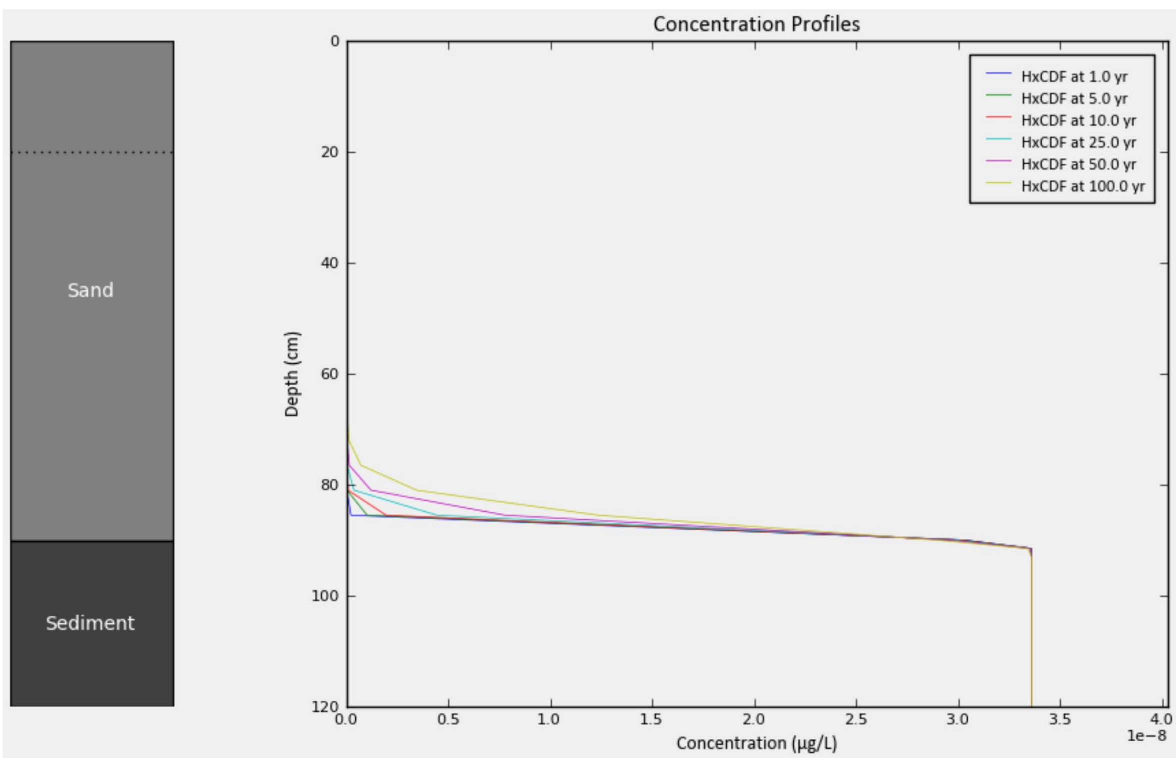

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
DDE at 1.0 yr
DDE at 5.0 yr
DDE at 10.0 yr
DDE at 25.0 yr
DDE at 50.0 yr
DDE at 100.0 yr
0
20
40
60
80
100
120
0.0000
0.0002
0.0004
0.0006
0.0008

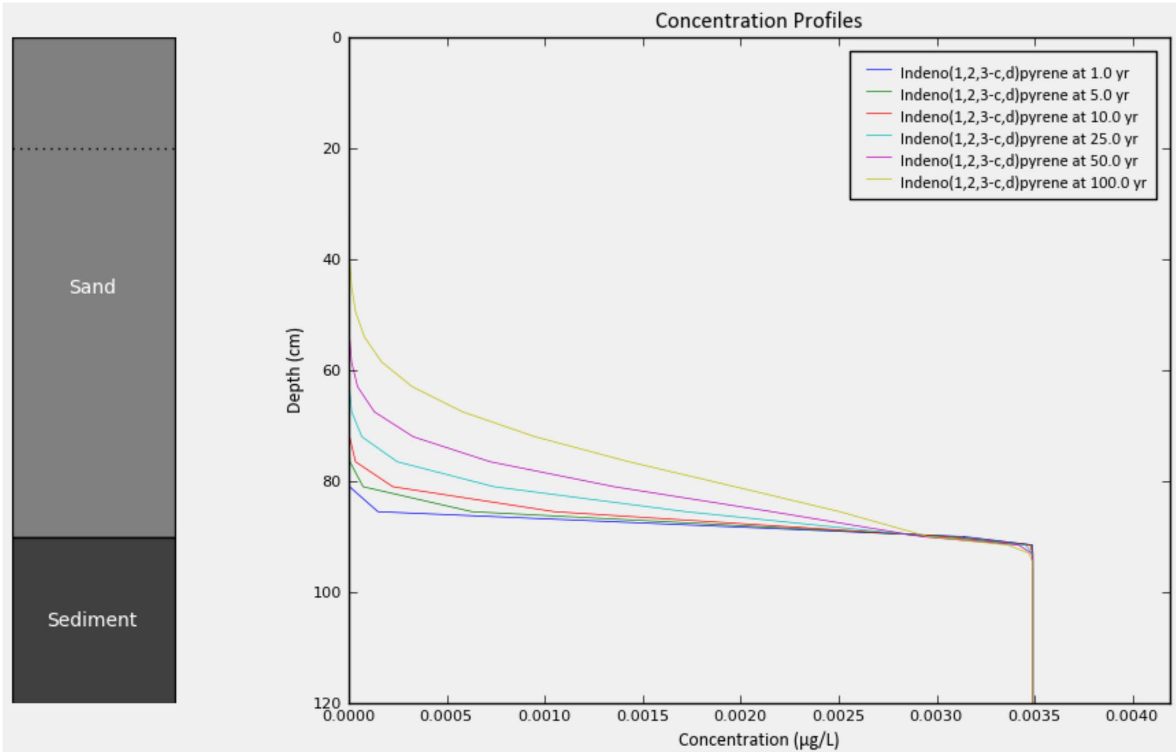

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
DDT at 1.0 yr
DDT at 5.0 yr
DDT at 10.0 yr
DDT at 25.0 yr
DDT at 50.0 yr
DDT at 100.0 yr
0
20
40
60
80
100
120
0.000
0.002
0.004
0.006
0.008
0.010

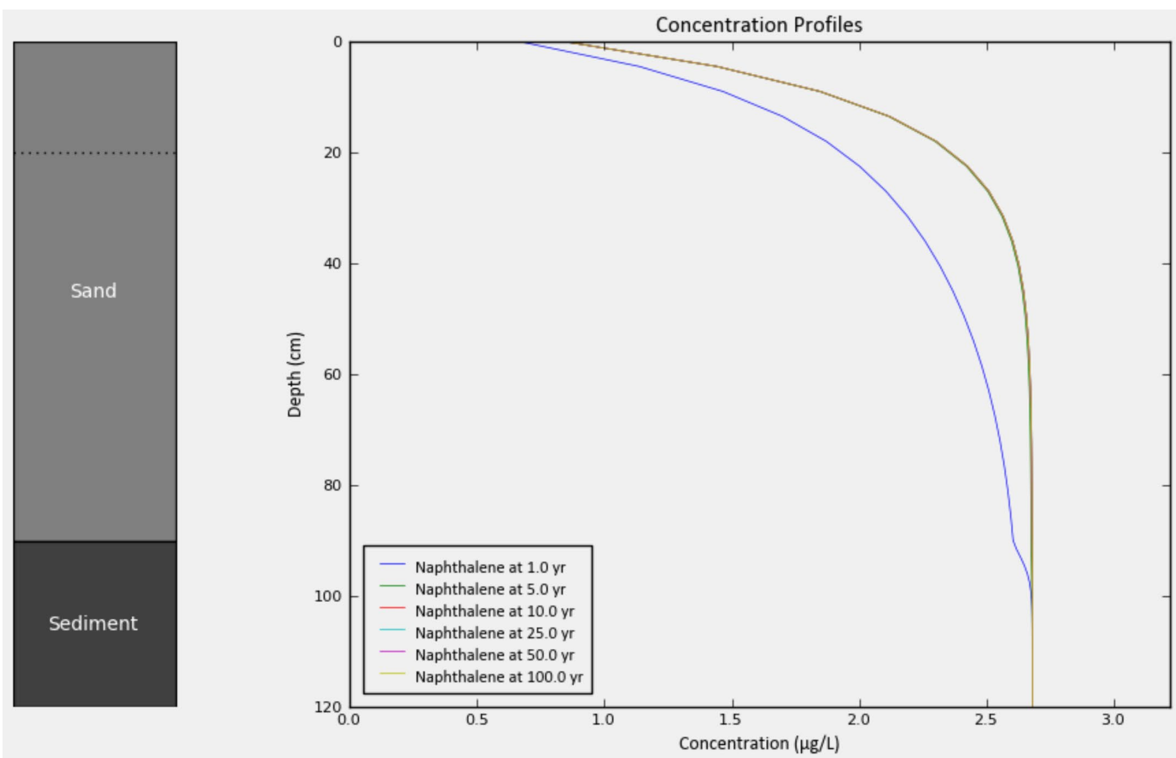

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Dibenzo(a,h)anthracene at 1.0 yr
Dibenzo(a,h)anthracene at 5.0 yr
Dibenzo(a,h)anthracene at 10.0 yr
Dibenzo(a,h)anthracene at 25.0 yr
Dibenzo(a,h)anthracene at 50.0 yr
Dibenzo(a,h)anthracene at 100.0 yr
0
20
40
60
80
100
120
0.0000
0.0005
0.0010
0.0015
0.0020

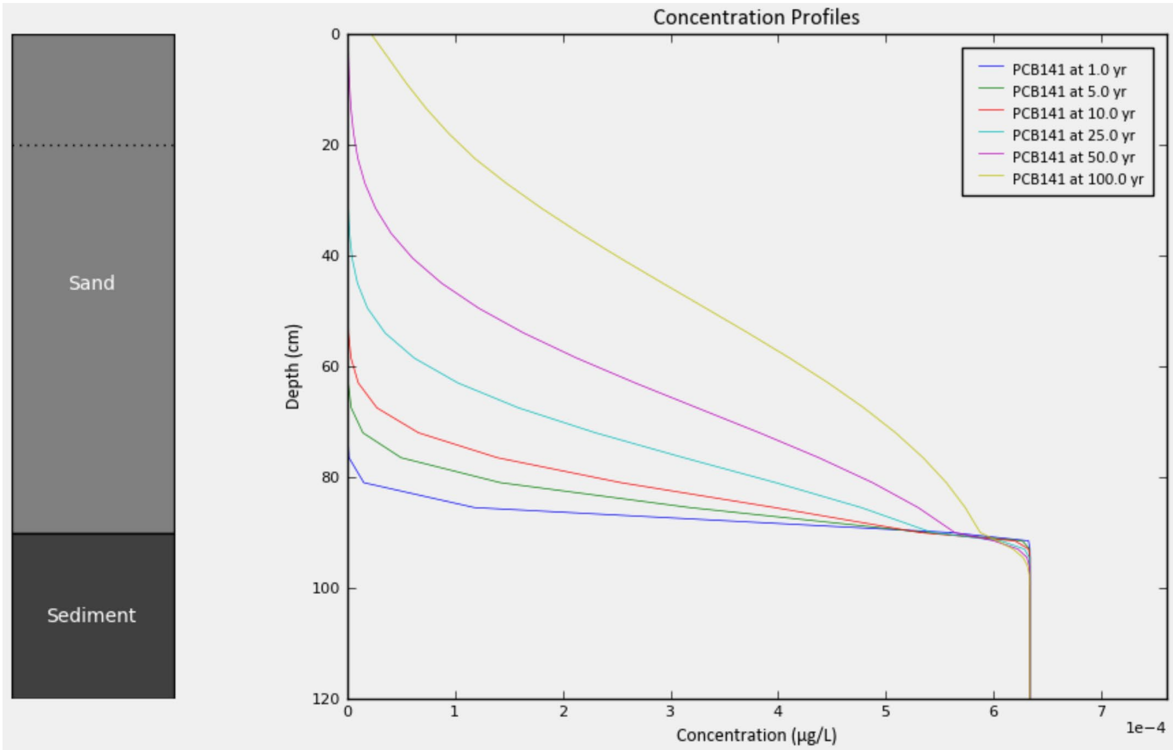

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Fluoranthene at 1.0 yr
Fluoranthene at 5.0 yr
Fluoranthene at 10.0 yr
Fluoranthene at 25.0 yr
Fluoranthene at 50.0 yr
Fluoranthene at 100.0 yr
0
20
40
60
80
100
120
0.0
0.2
0.4
0.6
0.8
1.0

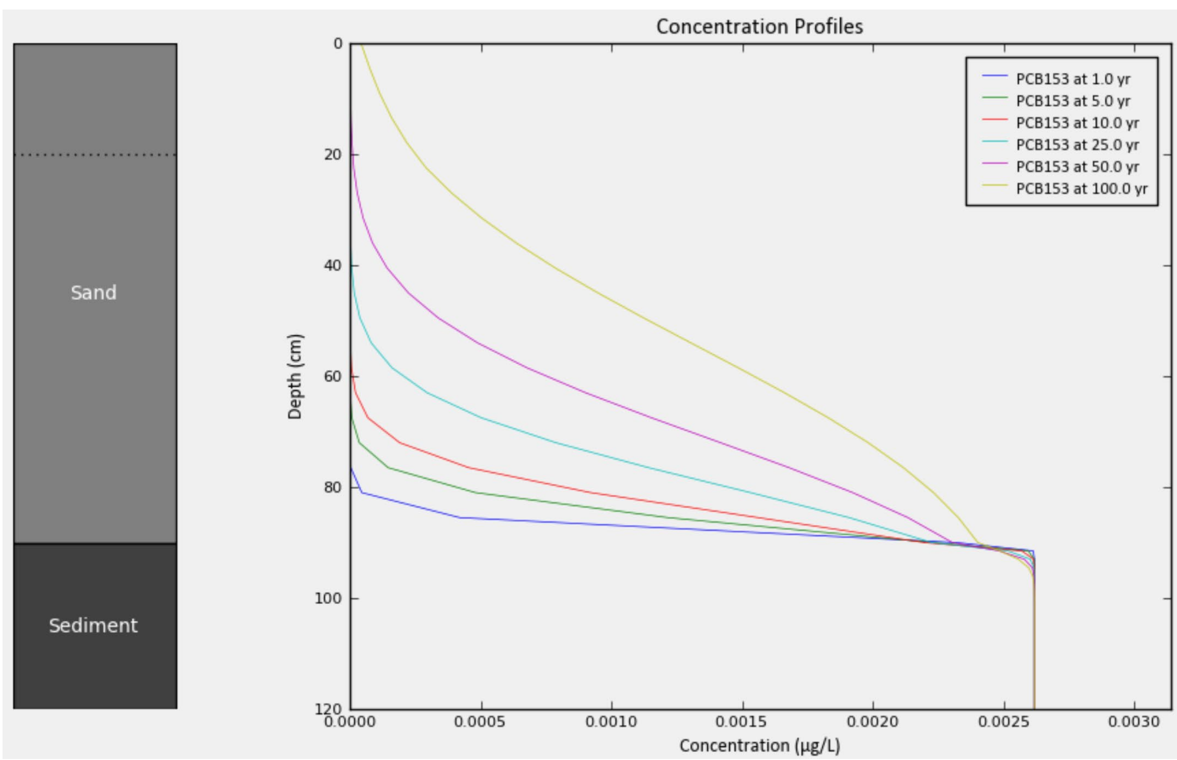

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (μg/L)
Fluorene at 1.0 yr
Fluorene at 5.0 yr
Fluorene at 10.0 yr
Fluorene at 25.0 yr
Fluorene at 50.0 yr
Fluorene at 100.0 yr

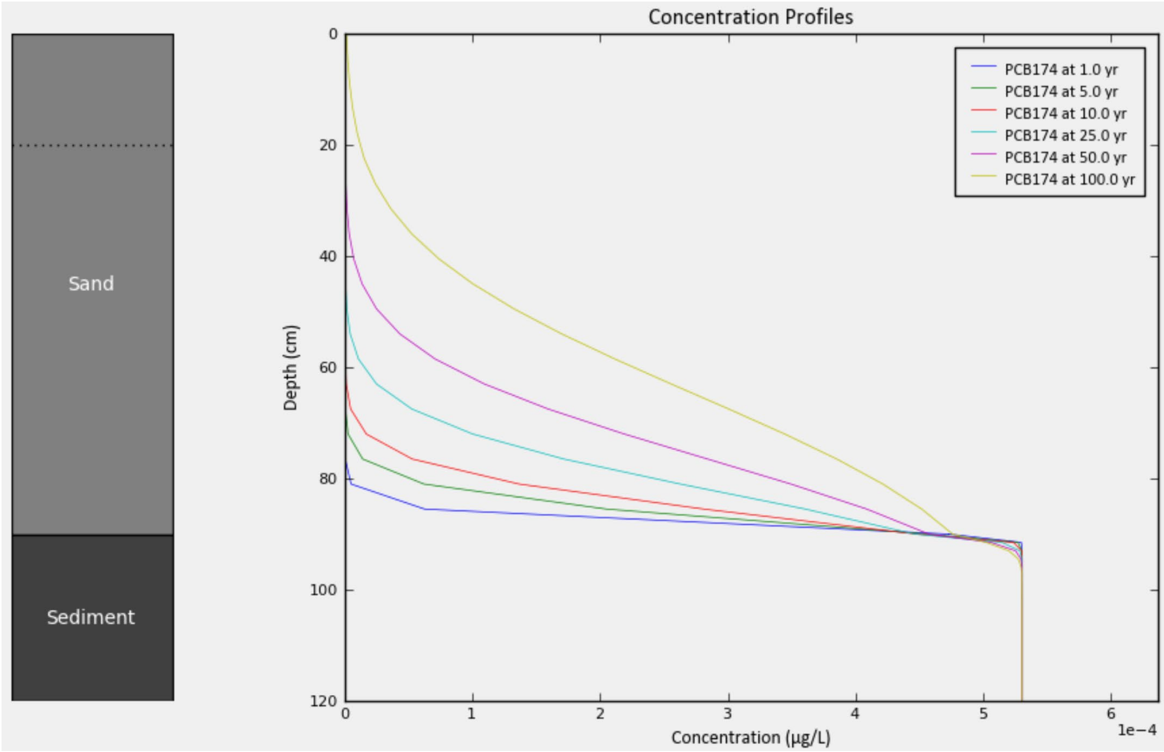

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (μg/L)
1e−8
HxCDF at 1.0 yr
HxCDF at 5.0 yr
HxCDF at 10.0 yr
HxCDF at 25.0 yr
HxCDF at 50.0 yr
HxCDF at 100.0 yr

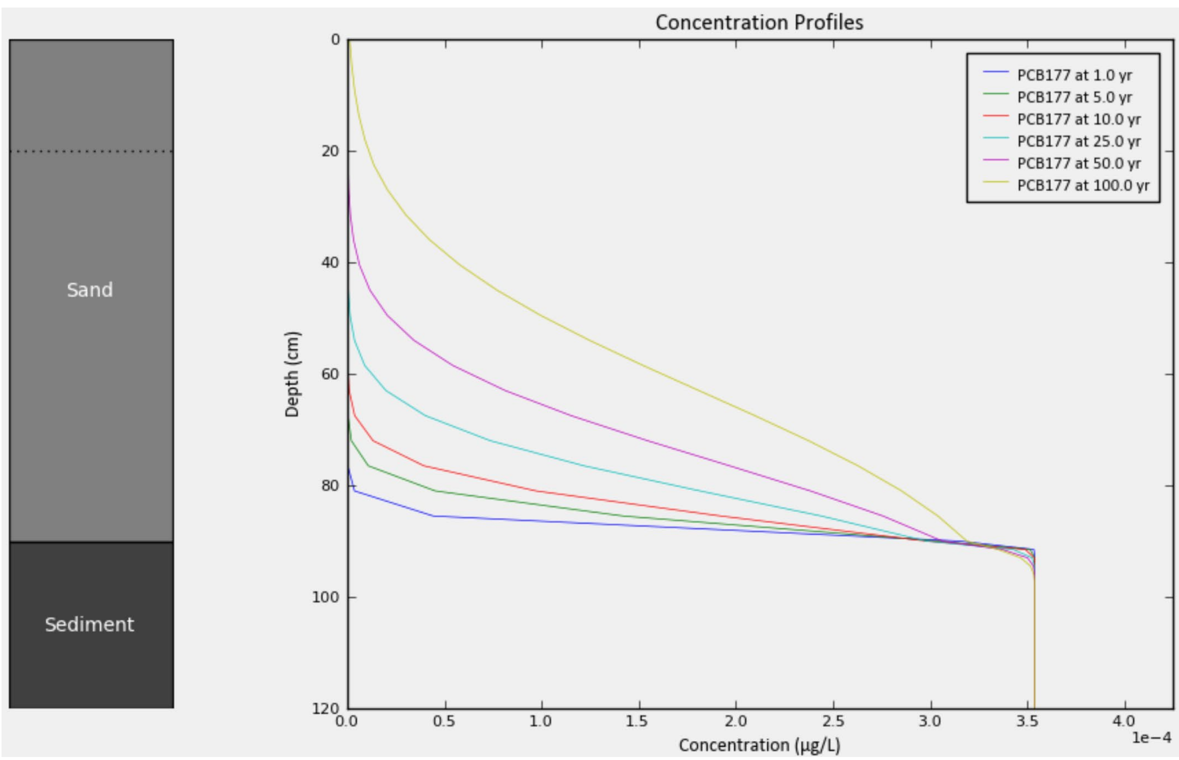

Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Indeno(1,2,3-c,d)pyrene at 1.0 yr
Indeno(1,2,3-c,d)pyrene at 5.0 yr
Indeno(1,2,3-c,d)pyrene at 10.0 yr
Indeno(1,2,3-c,d)pyrene at 25.0 yr
Indeno(1,2,3-c,d)pyrene at 50.0 yr
Indeno(1,2,3-c,d)pyrene at 100.0 yr

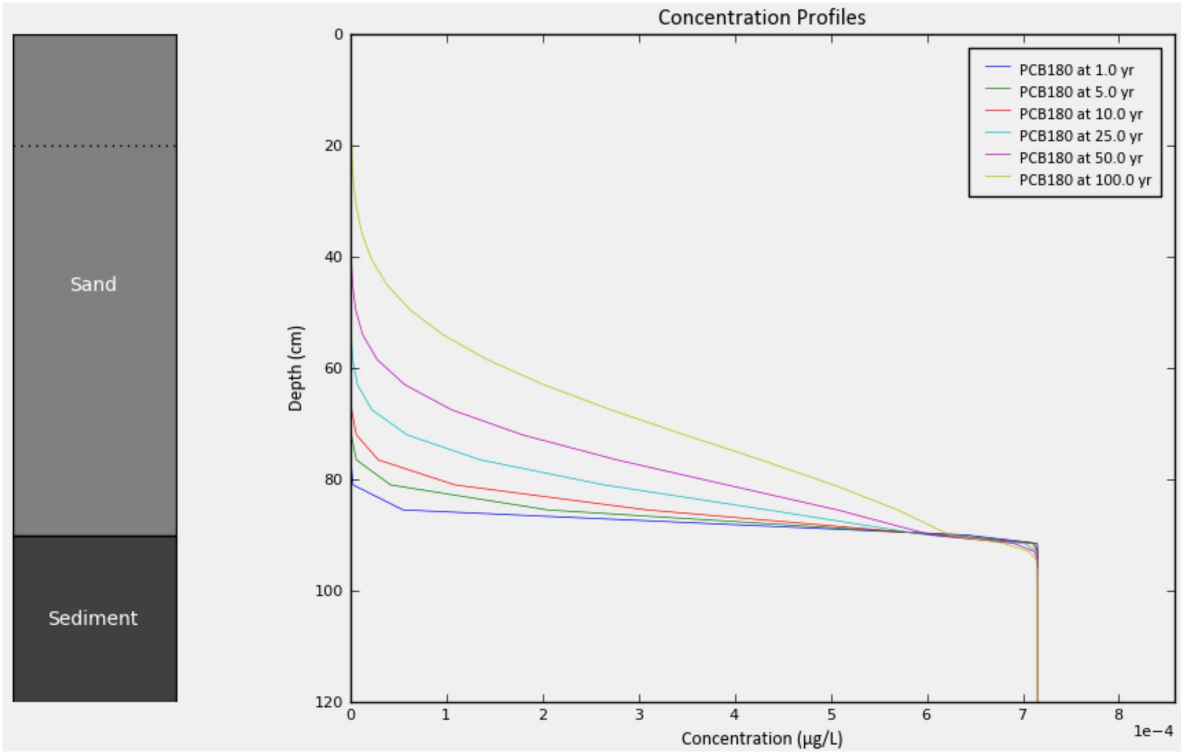

Sand
Sediment
Concentration Profiles
Depth (cm)
Concentration (µg/L)
Naphthalene at 1.0 yr
Naphthalene at 5.0 yr
Naphthalene at 10.0 yr
Naphthalene at 25.0 yr
Naphthalene at 50.0 yr
Naphthalene at 100.0 yr

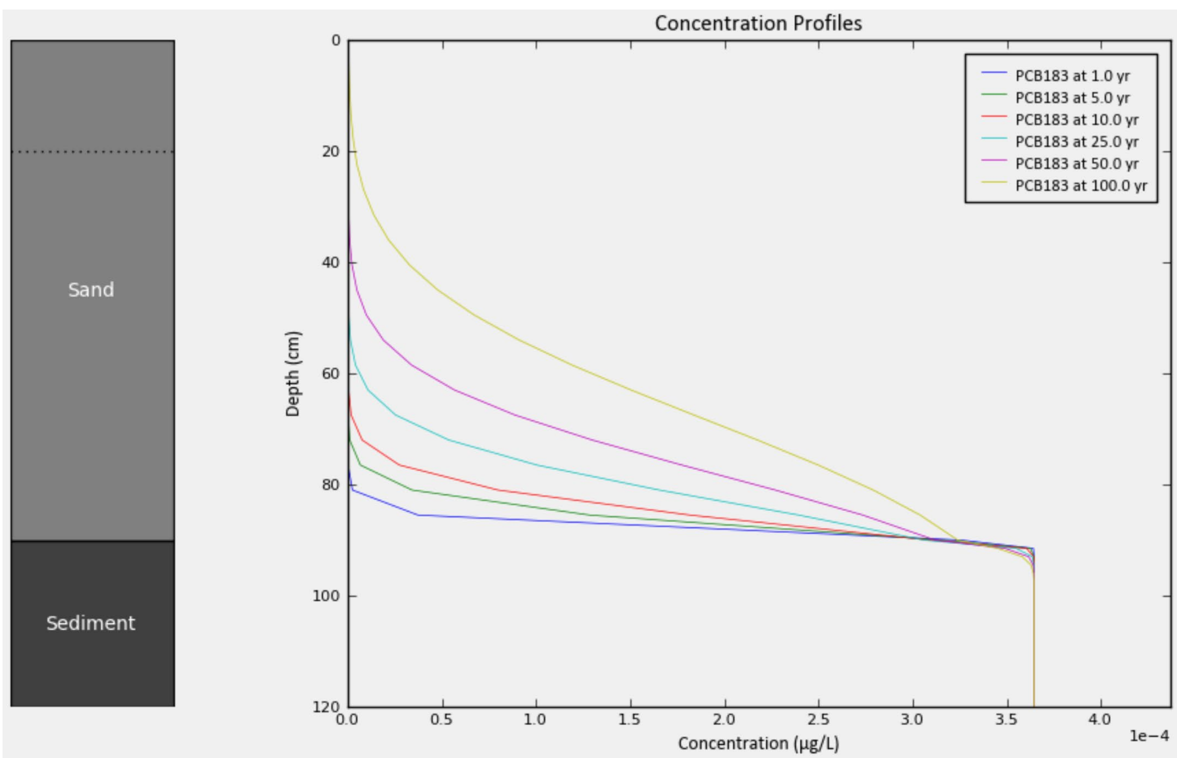

Sand
Sediment
Concentration Profiles
PCB141 at 1.0 yr
PCB141 at 5.0 yr
PCB141 at 10.0 yr
PCB141 at 25.0 yr
PCB141 at 50.0 yr
PCB141 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

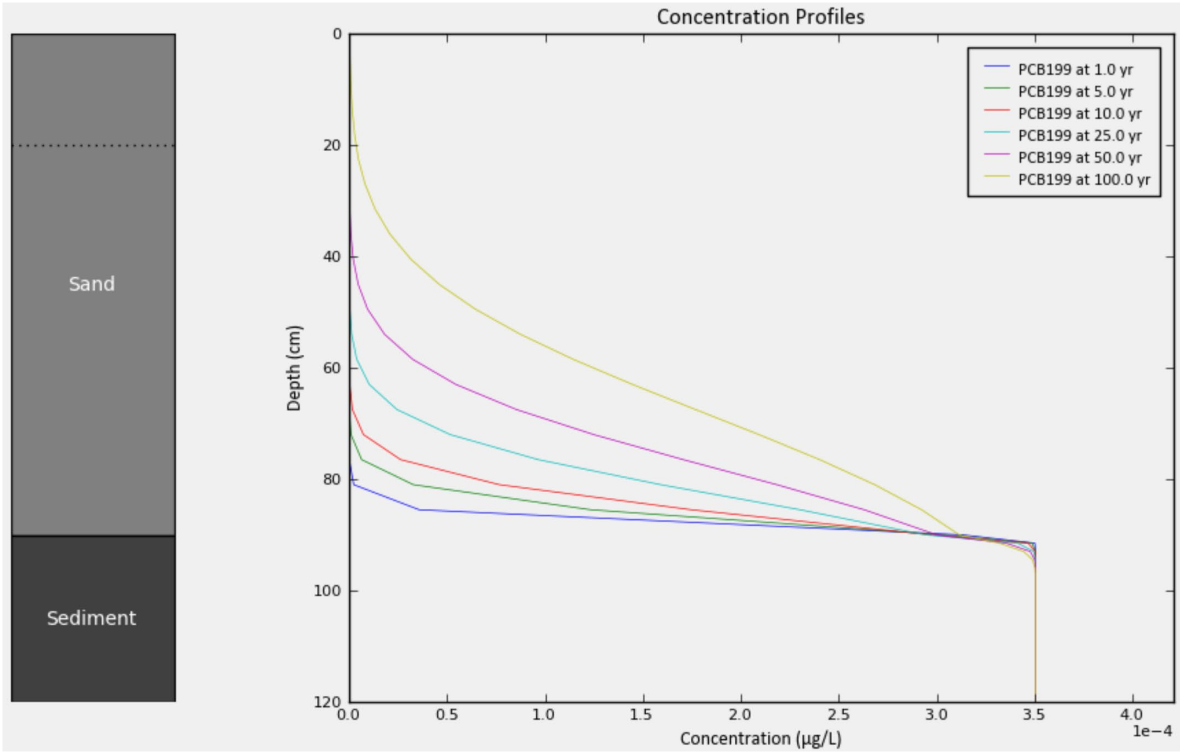

Sand
Sediment
Concentration Profiles
PCB153 at 1.0 yr
PCB153 at 5.0 yr
PCB153 at 10.0 yr
PCB153 at 25.0 yr
PCB153 at 50.0 yr
PCB153 at 100.0 yr
Depth (cm)
Concentration (µg/L)

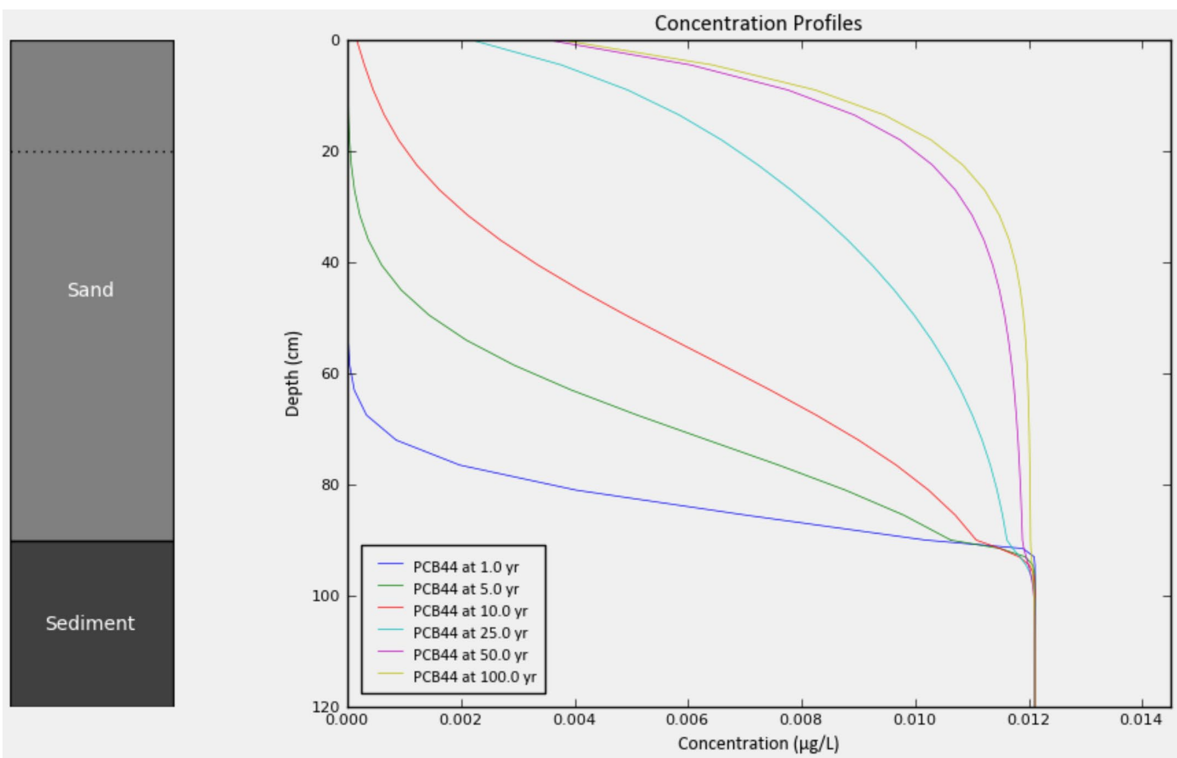

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−4
PCB174 at 1.0 yr
PCB174 at 5.0 yr
PCB174 at 10.0 yr
PCB174 at 25.0 yr
PCB174 at 50.0 yr
PCB174 at 100.0 yr

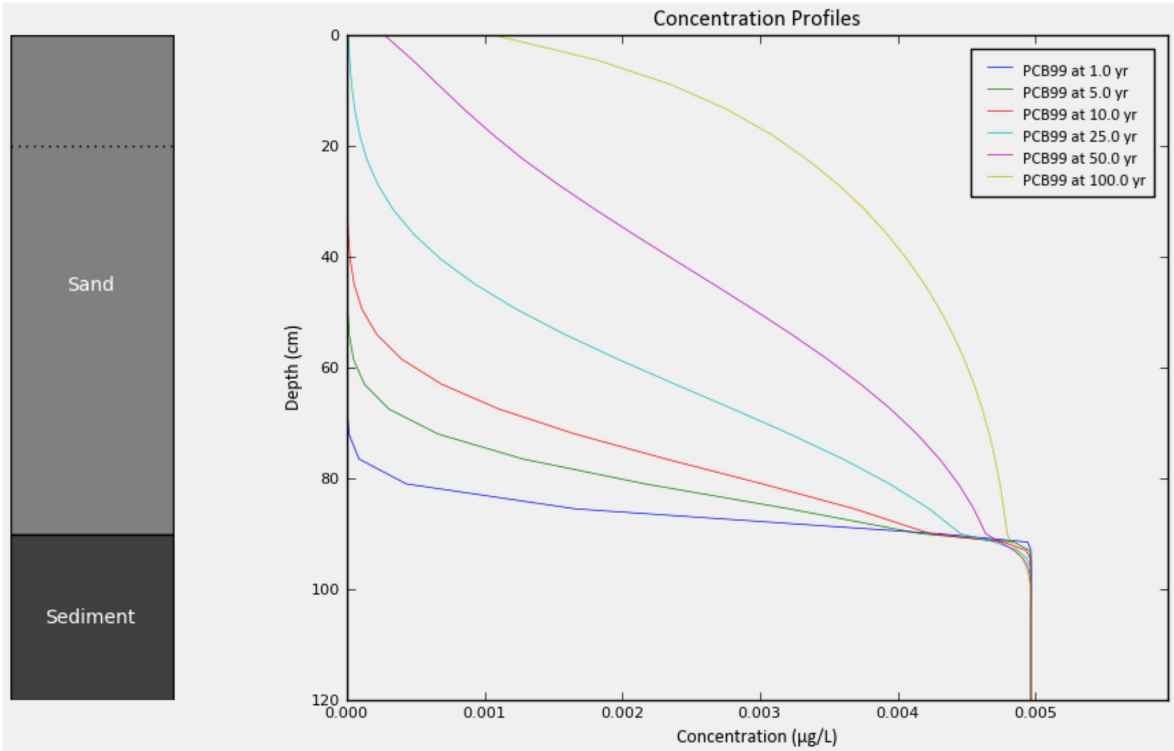

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−4
PCB177 at 1.0 yr
PCB177 at 5.0 yr
PCB177 at 10.0 yr
PCB177 at 25.0 yr
PCB177 at 50.0 yr
PCB177 at 100.0 yr

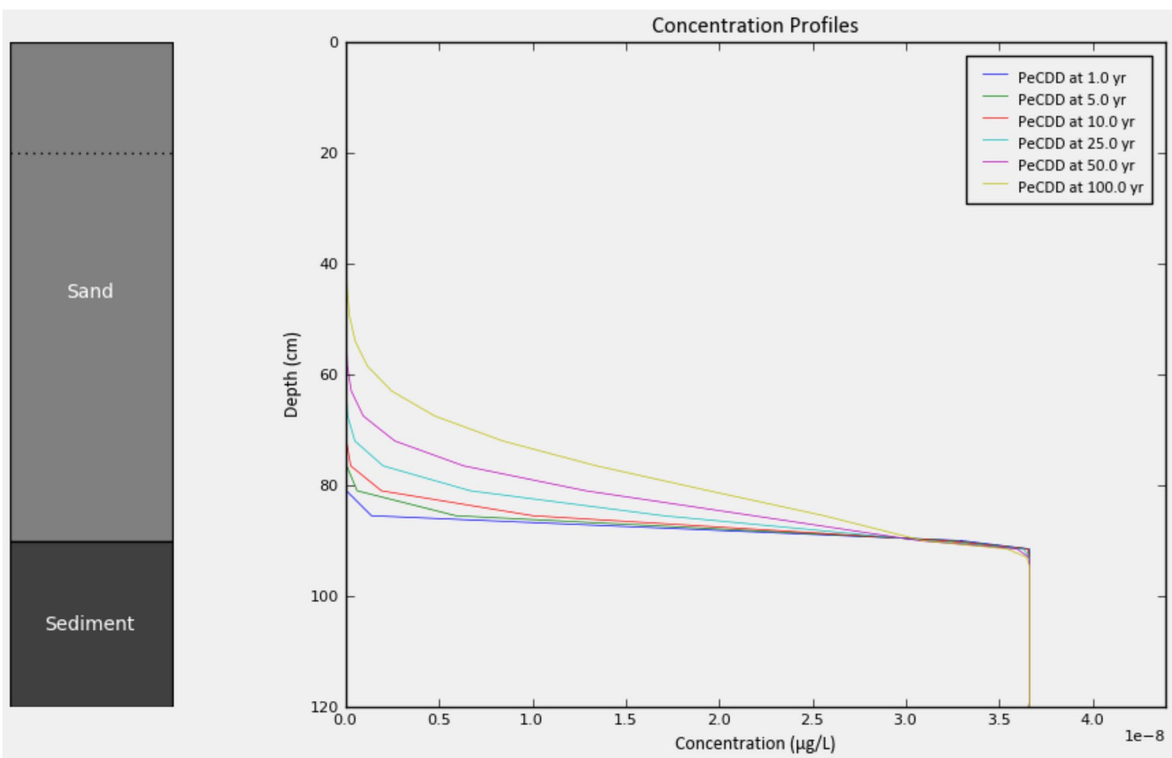

Sand
Sediment
Concentration Profiles
PCB180 at 1.0 yr
PCB180 at 5.0 yr
PCB180 at 10.0 yr
PCB180 at 25.0 yr
PCB180 at 50.0 yr
PCB180 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

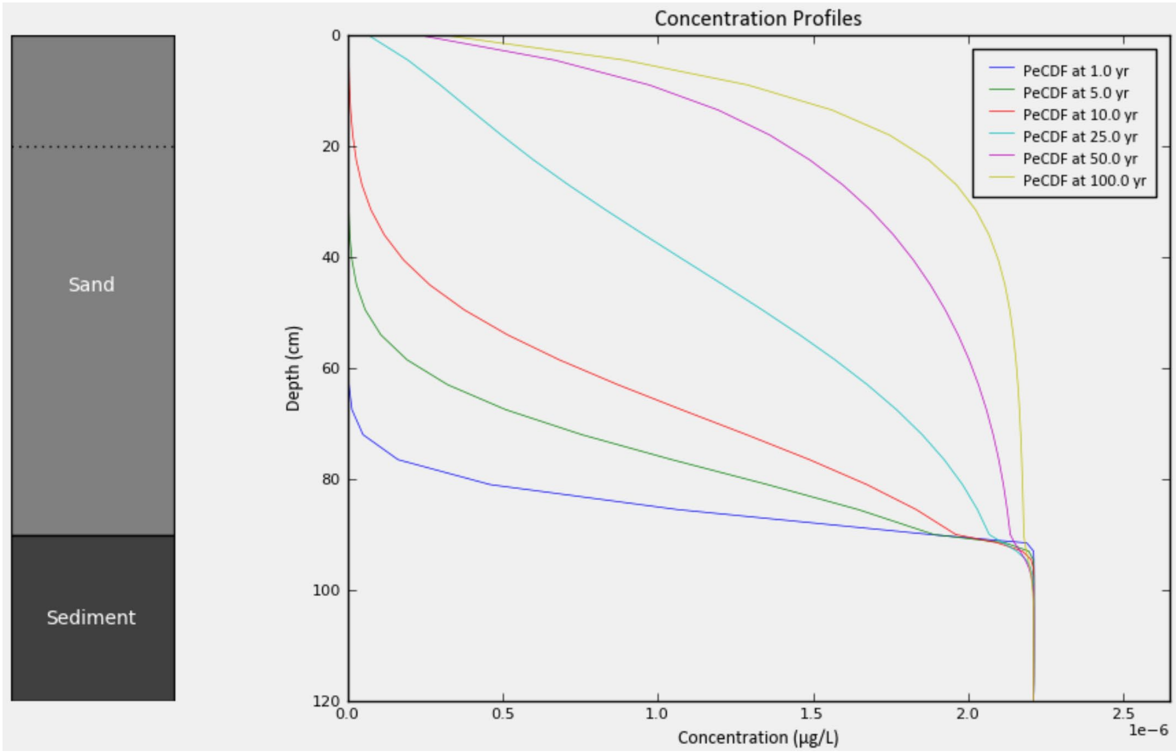

Sand
Sediment
Concentration Profiles
PCB183 at 1.0 yr
PCB183 at 5.0 yr
PCB183 at 10.0 yr
PCB183 at 25.0 yr
PCB183 at 50.0 yr
PCB183 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

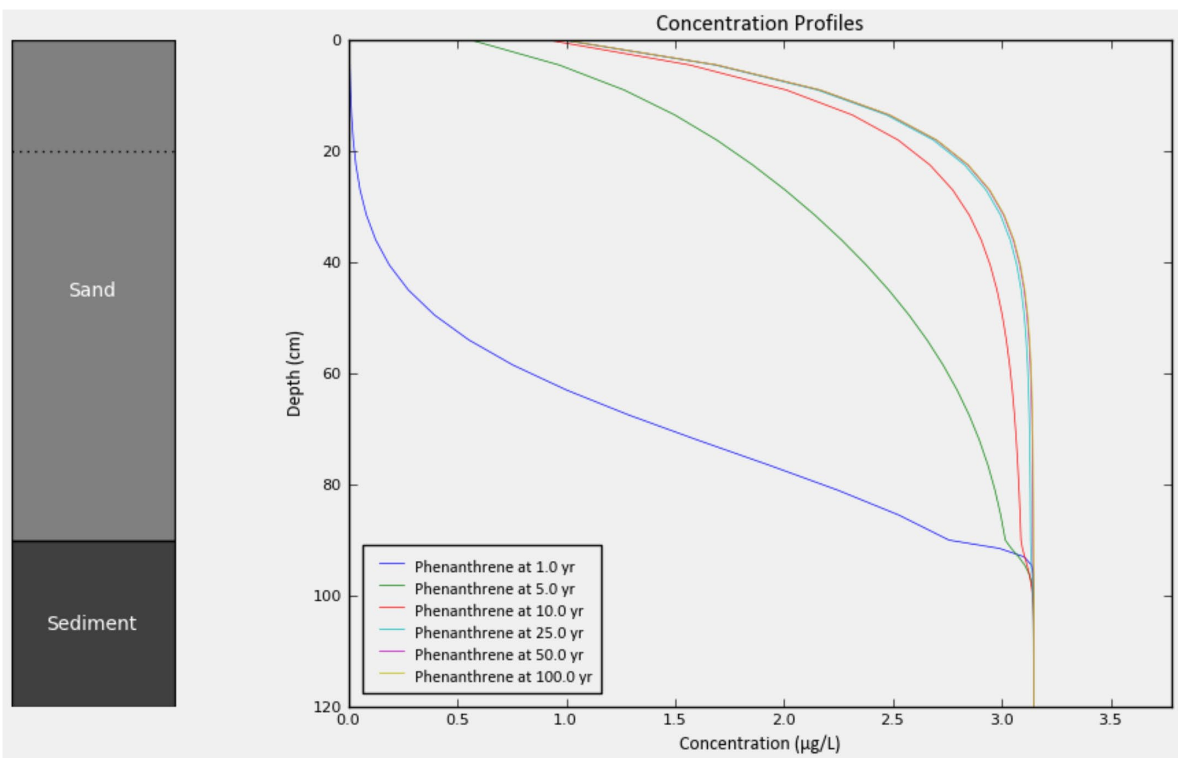

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−4
PCB199 at 1.0 yr
PCB199 at 5.0 yr
PCB199 at 10.0 yr
PCB199 at 25.0 yr
PCB199 at 50.0 yr
PCB199 at 100.0 yr

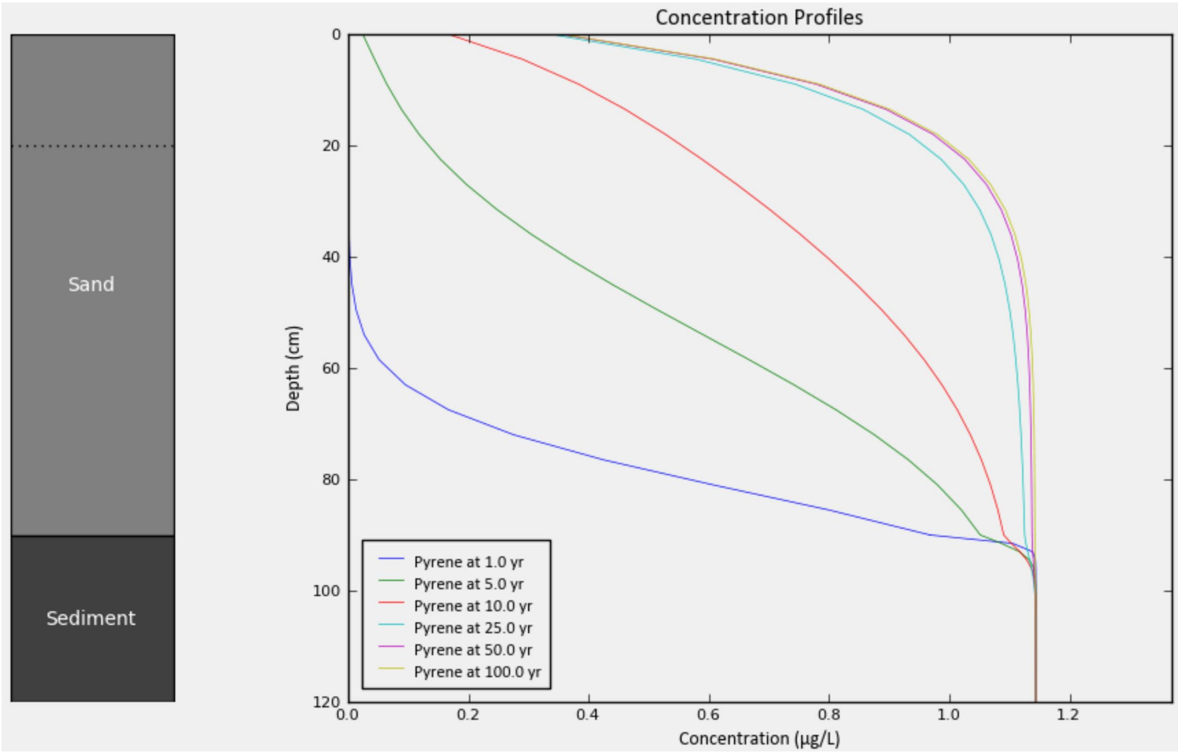

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
PCB44 at 1.0 yr
PCB44 at 5.0 yr
PCB44 at 10.0 yr
PCB44 at 25.0 yr
PCB44 at 50.0 yr
PCB44 at 100.0 yr

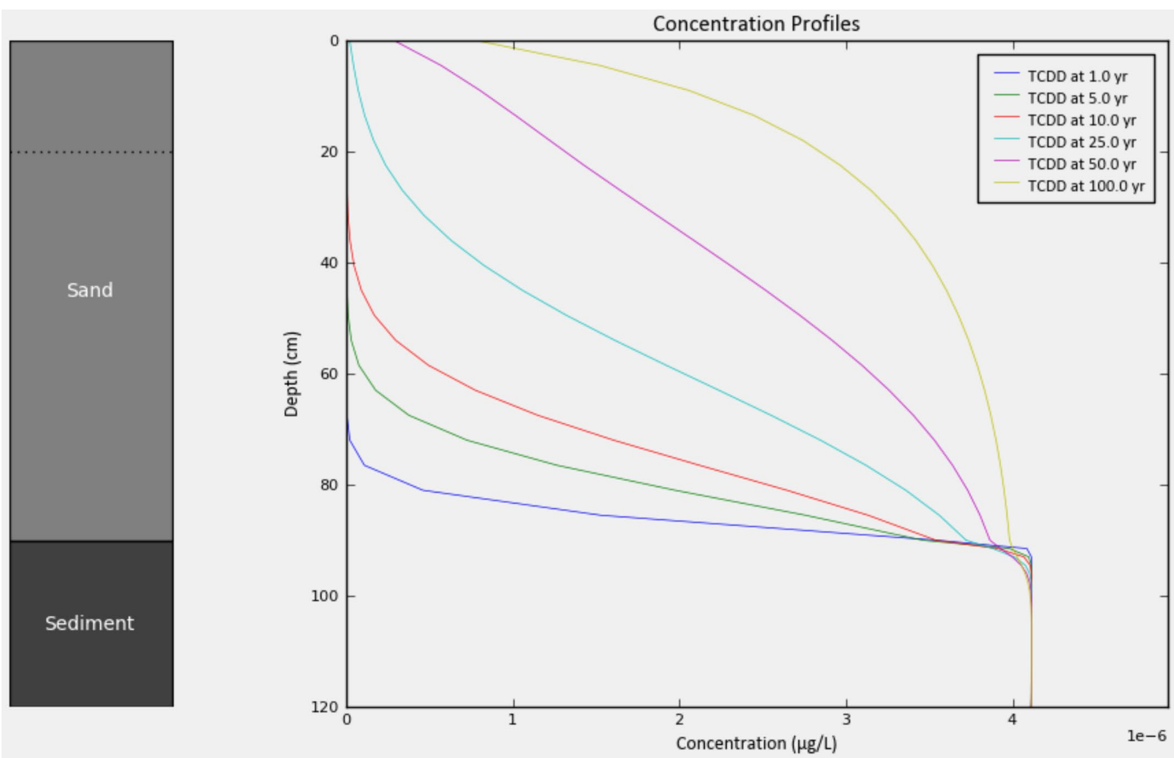

Sand
Sediment
Concentration Profiles
PCB99 at 1.0 yr
PCB99 at 5.0 yr
PCB99 at 10.0 yr
PCB99 at 25.0 yr
PCB99 at 50.0 yr
PCB99 at 100.0 yr
Depth (cm)
0
20
40
60
80
100
120
0.000
0.001
0.002
0.003
0.004
0.005
Concentration (μg/L)

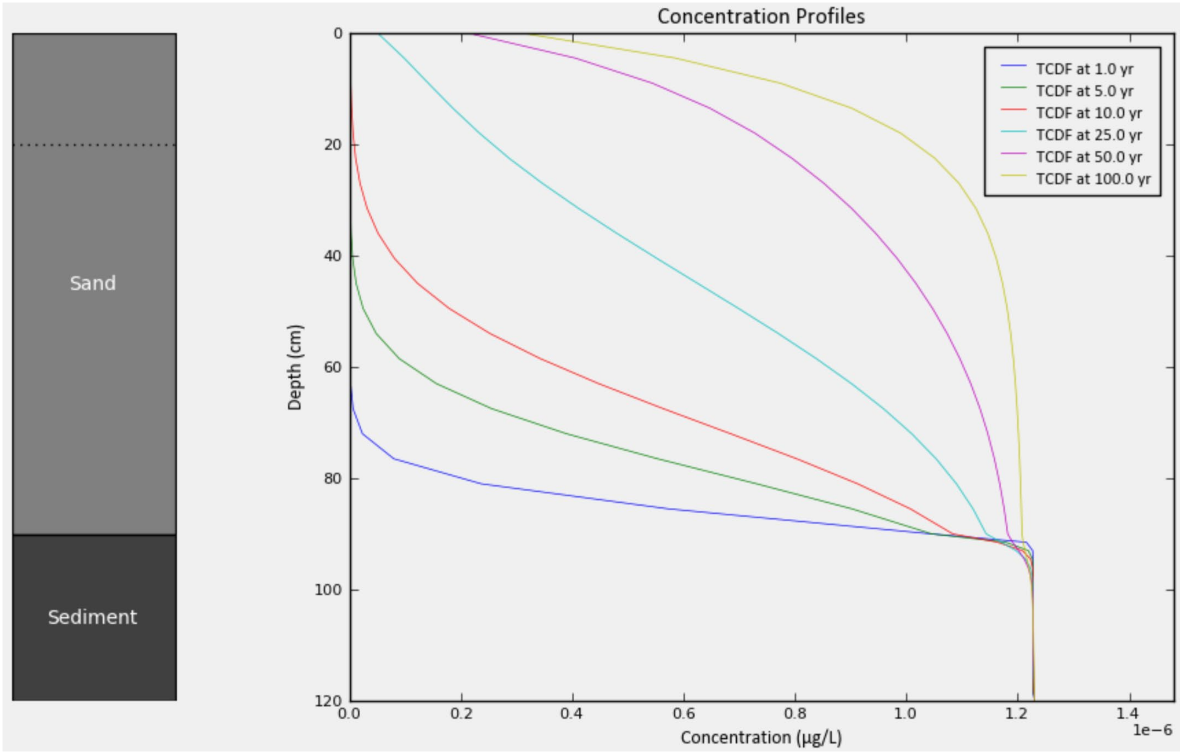

Sand
Sediment
Concentration Profiles
PeCDD at 1.0 yr
PeCDD at 5.0 yr
PeCDD at 10.0 yr
PeCDD at 25.0 yr
PeCDD at 50.0 yr
PeCDD at 100.0 yr
Depth (cm)
0
20
40
60
80
100
120
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
1e−8
Concentration (μg/L)

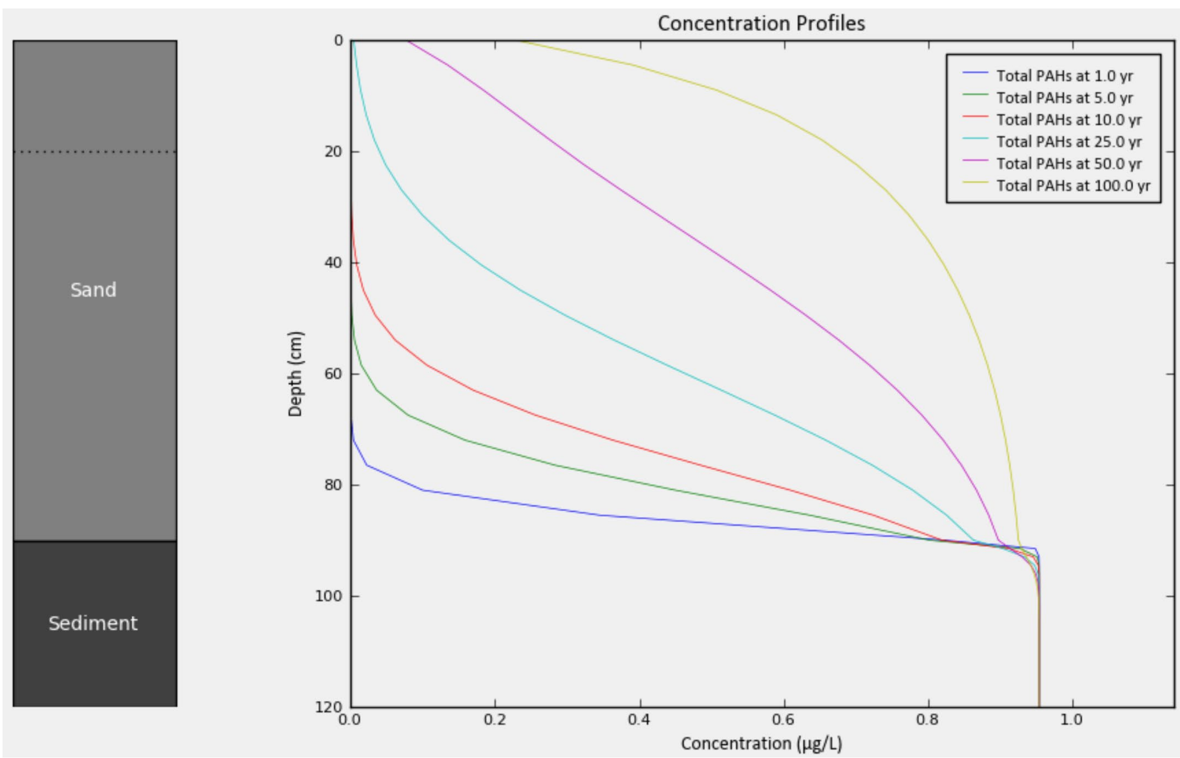

Sand
Sediment
Concentration Profiles
PeCDF at 1.0 yr
PeCDF at 5.0 yr
PeCDF at 10.0 yr
PeCDF at 25.0 yr
PeCDF at 50.0 yr
PeCDF at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−6

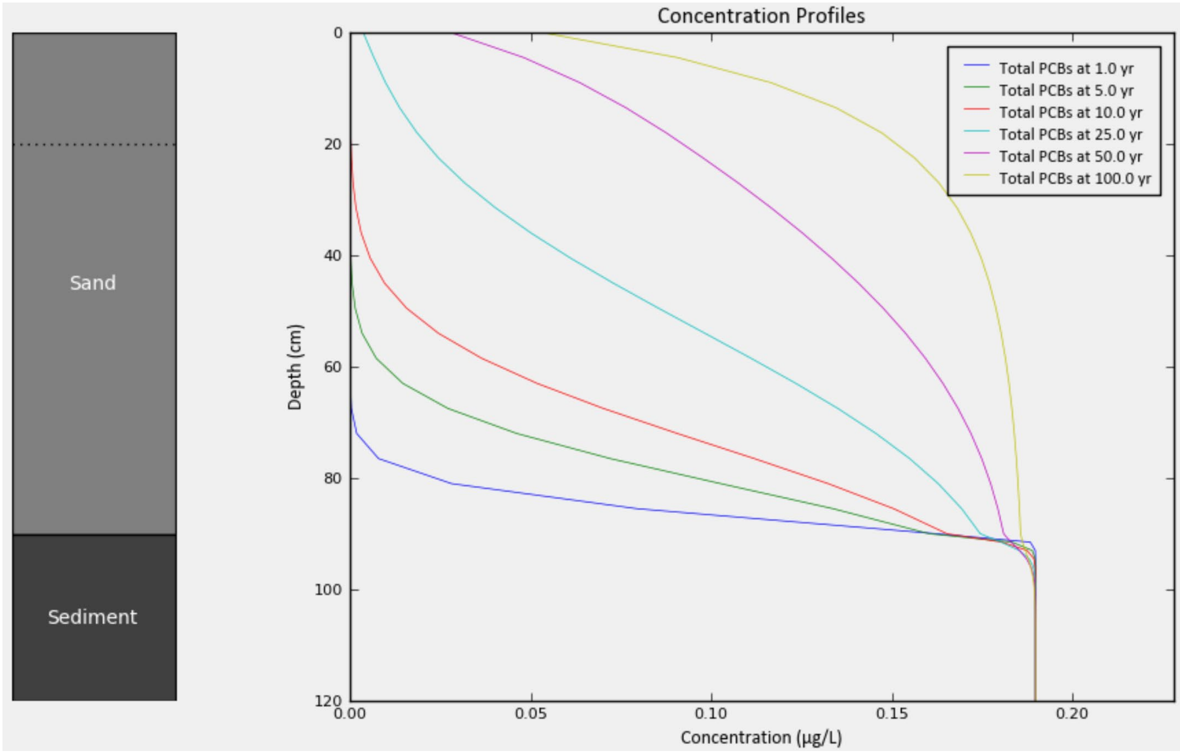

Sand
Sediment
Concentration Profiles
Phenanthrene at 1.0 yr
Phenanthrene at 5.0 yr
Phenanthrene at 10.0 yr
Phenanthrene at 25.0 yr
Phenanthrene at 50.0 yr
Phenanthrene at 100.0 yr
Depth (cm)
Concentration (µg/L)

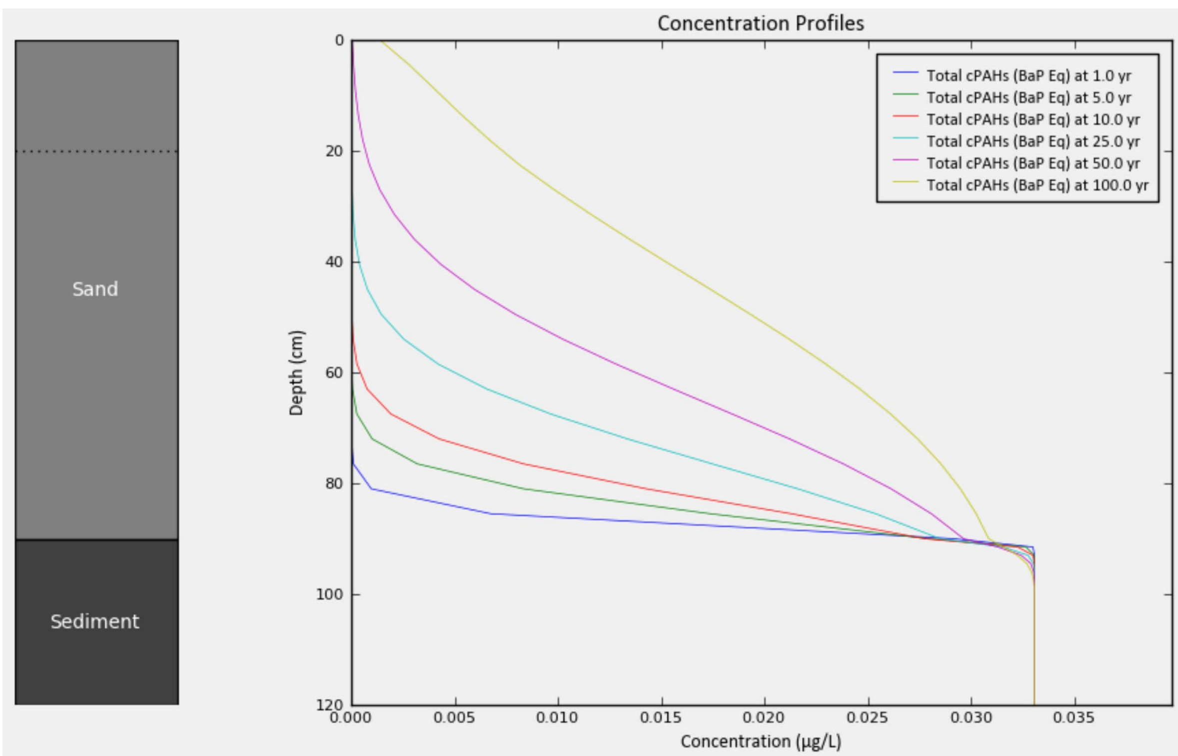

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Pyrene at 1.0 yr
Pyrene at 5.0 yr
Pyrene at 10.0 yr
Pyrene at 25.0 yr
Pyrene at 50.0 yr
Pyrene at 100.0 yr
0
20
40
60
80
100
120
0.0
0.2
0.4
0.6
0.8
1.0
1.2


Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−6
TCDD at 1.0 yr
TCDD at 5.0 yr
TCDD at 10.0 yr
TCDD at 25.0 yr
TCDD at 50.0 yr
TCDD at 100.0 yr
0
20
40
60
80
100
120
0
1
2
3
4

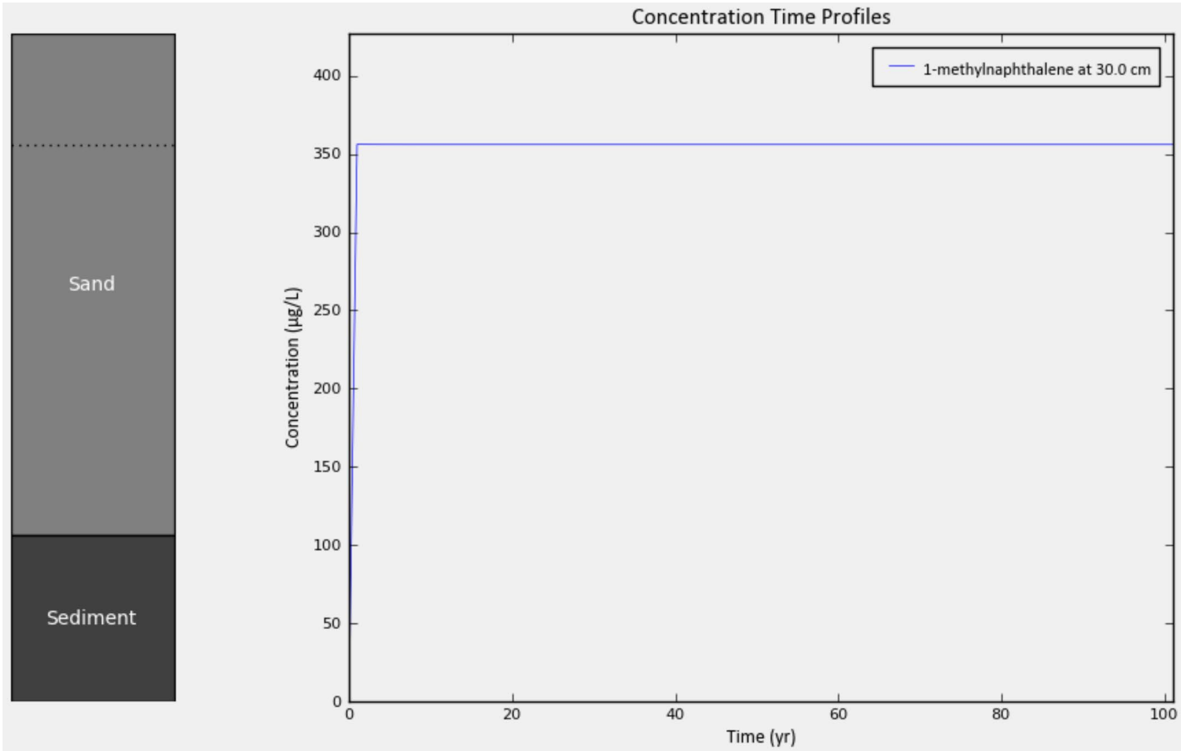

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
1e−6
TCDF at 1.0 yr
TCDF at 5.0 yr
TCDF at 10.0 yr
TCDF at 25.0 yr
TCDF at 50.0 yr
TCDF at 100.0 yr

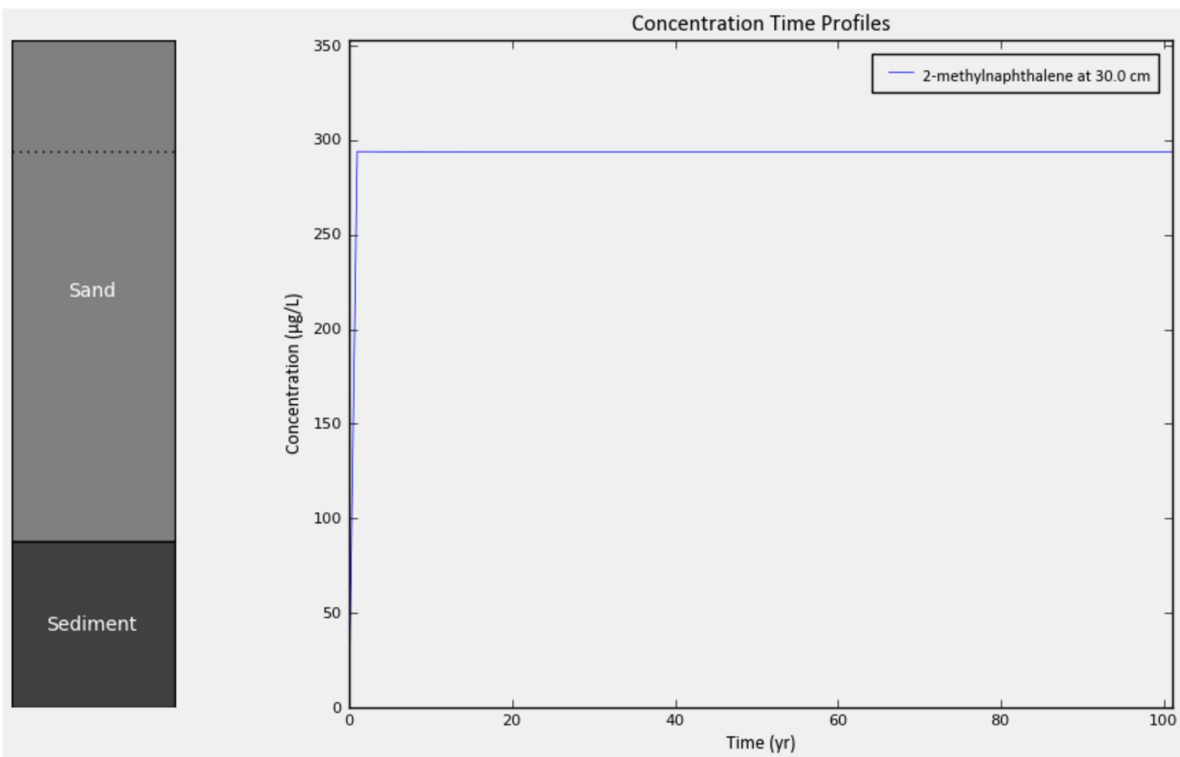

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Total PAHs at 1.0 yr
Total PAHs at 5.0 yr
Total PAHs at 10.0 yr
Total PAHs at 25.0 yr
Total PAHs at 50.0 yr
Total PAHs at 100.0 yr

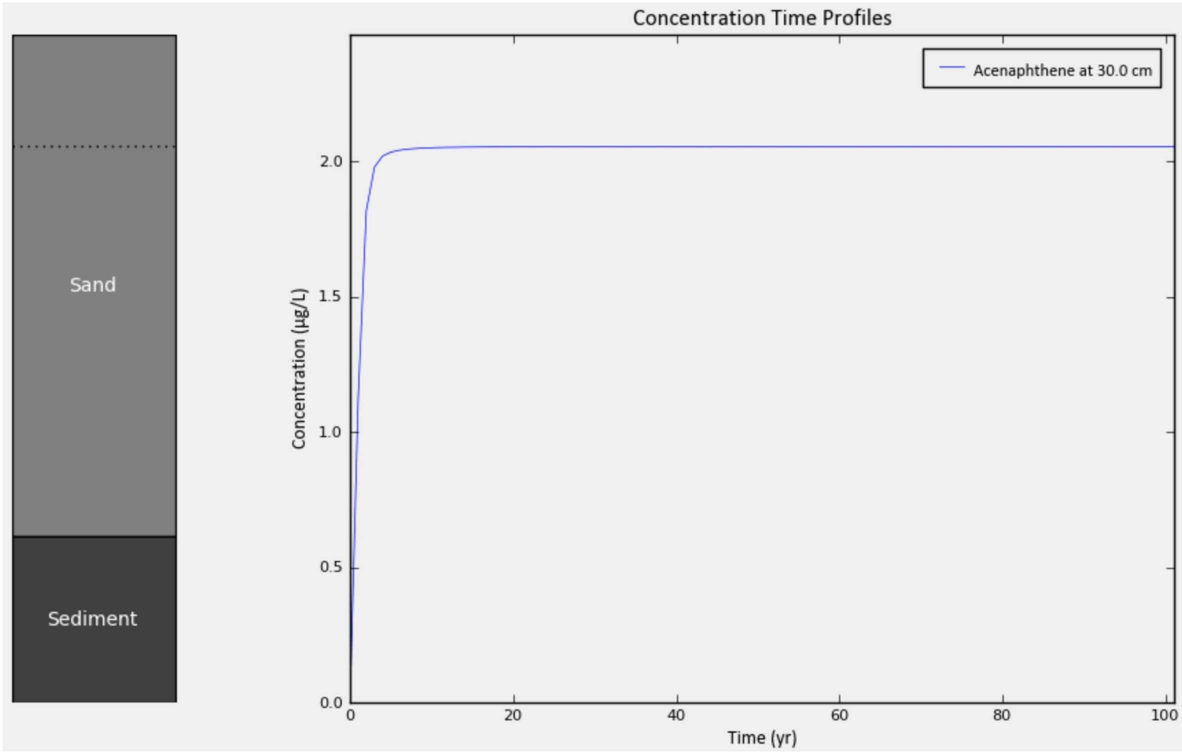

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Total PCBs at 1.0 yr
Total PCBs at 5.0 yr
Total PCBs at 10.0 yr
Total PCBs at 25.0 yr
Total PCBs at 50.0 yr
Total PCBs at 100.0 yr

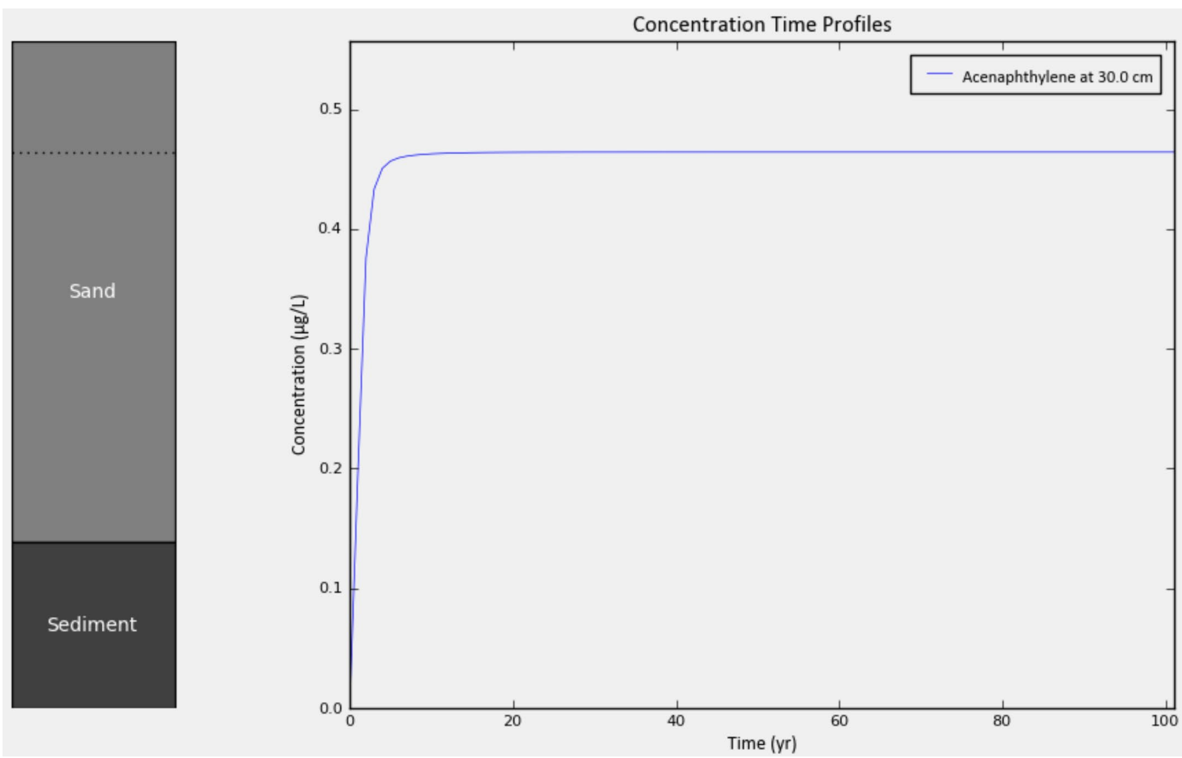

Concentration Profiles
Sand
Sediment
Depth (cm)
Concentration (µg/L)
Total cPAHs (BaP Eq) at 1.0 yr
Total cPAHs (BaP Eq) at 5.0 yr
Total cPAHs (BaP Eq) at 10.0 yr
Total cPAHs (BaP Eq) at 25.0 yr
Total cPAHs (BaP Eq) at 50.0 yr
Total cPAHs (BaP Eq) at 100.0 yr

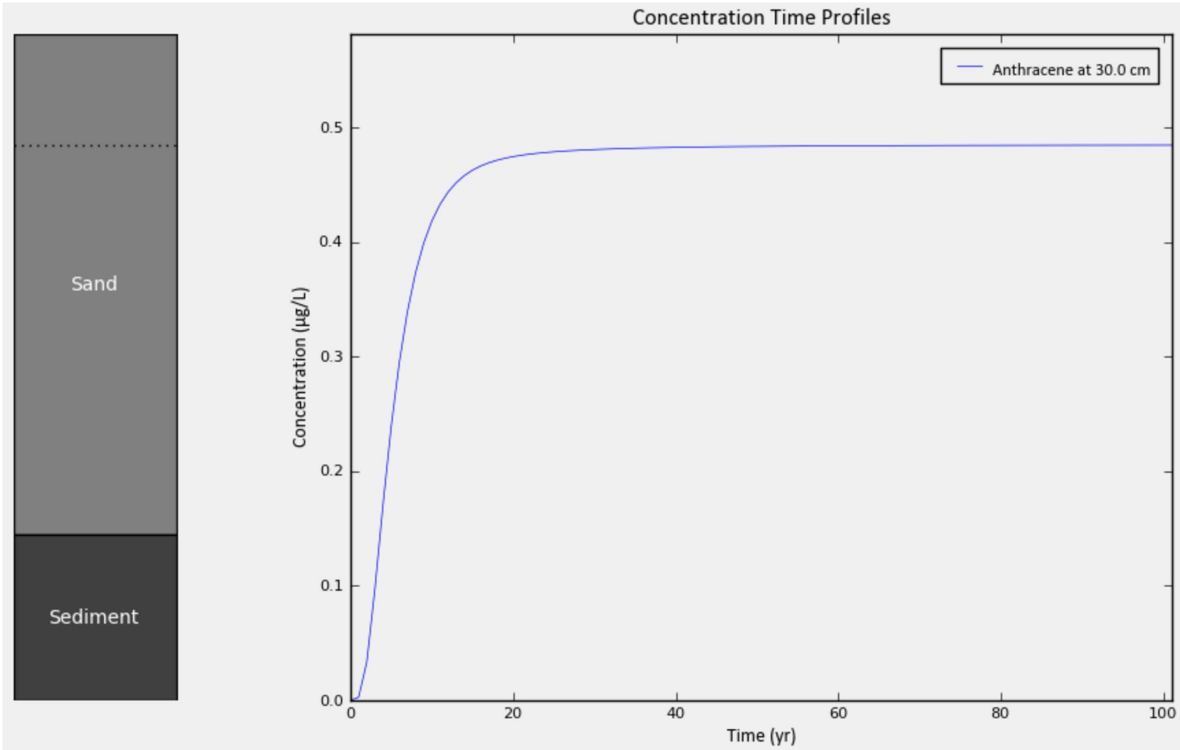
Porewater Concentration – Time

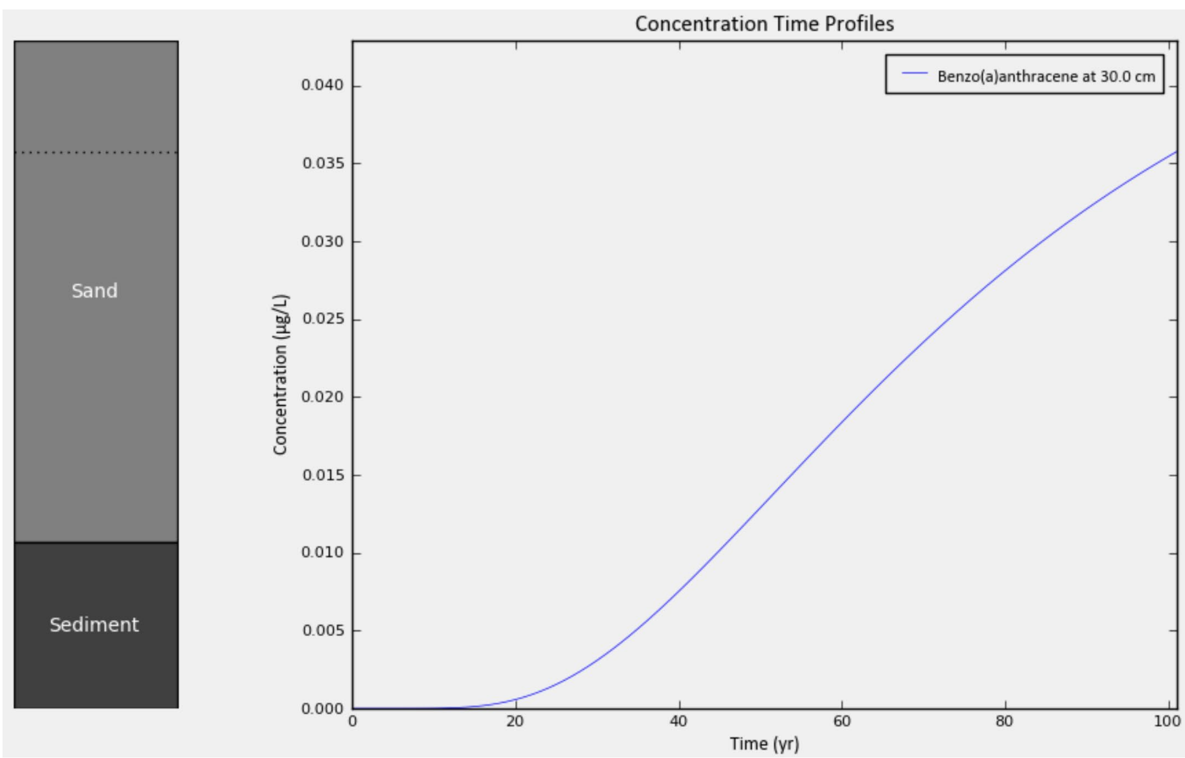


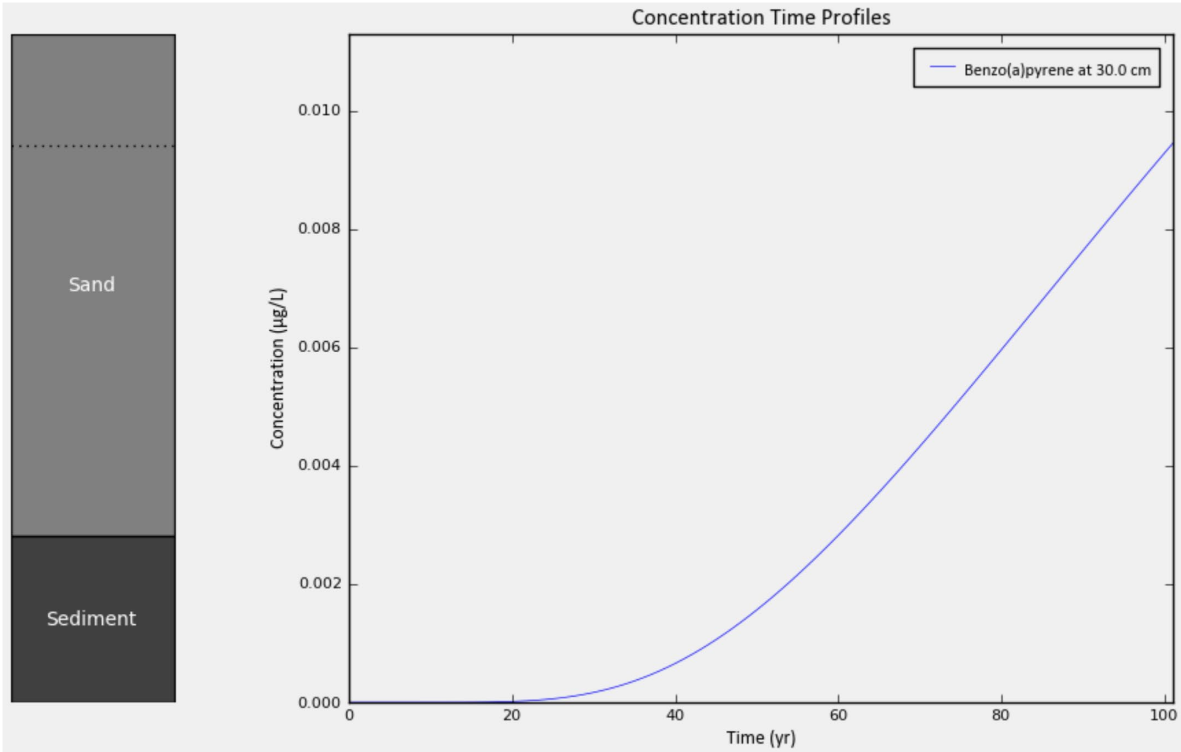


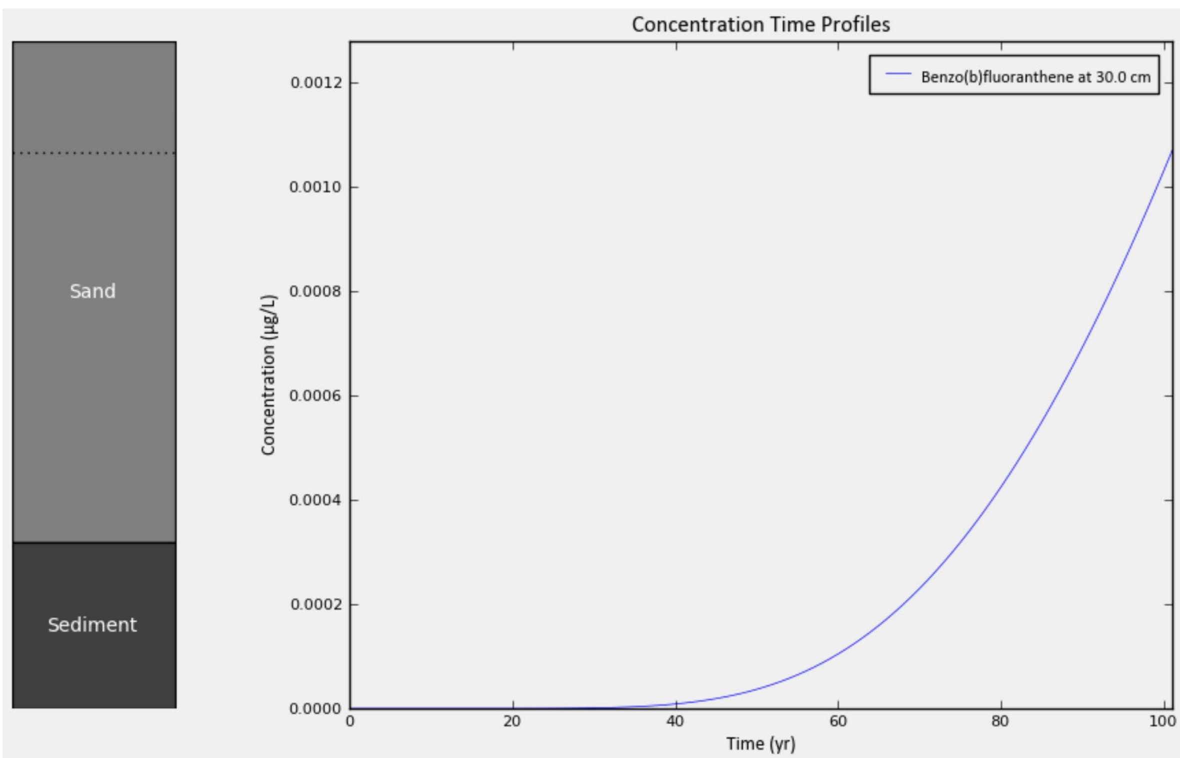

Concentration Time Profiles
Acenaphthene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
0.0
0.5
1.0
1.5
2.0
0
20
40
60
80
100
Time (yr)

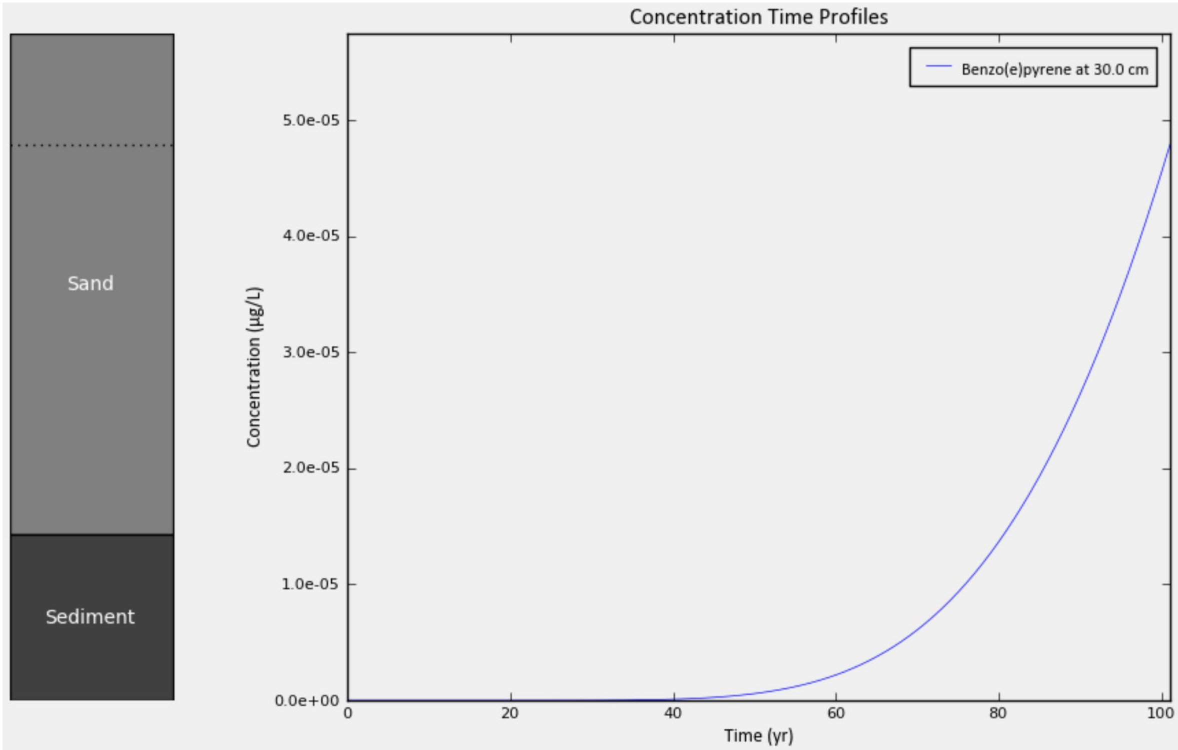

Concentration Time Profiles
Acenaphthylene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
0.0
0.1
0.2
0.3
0.4
0.5
0
20
40
60
80
100
Time (yr)

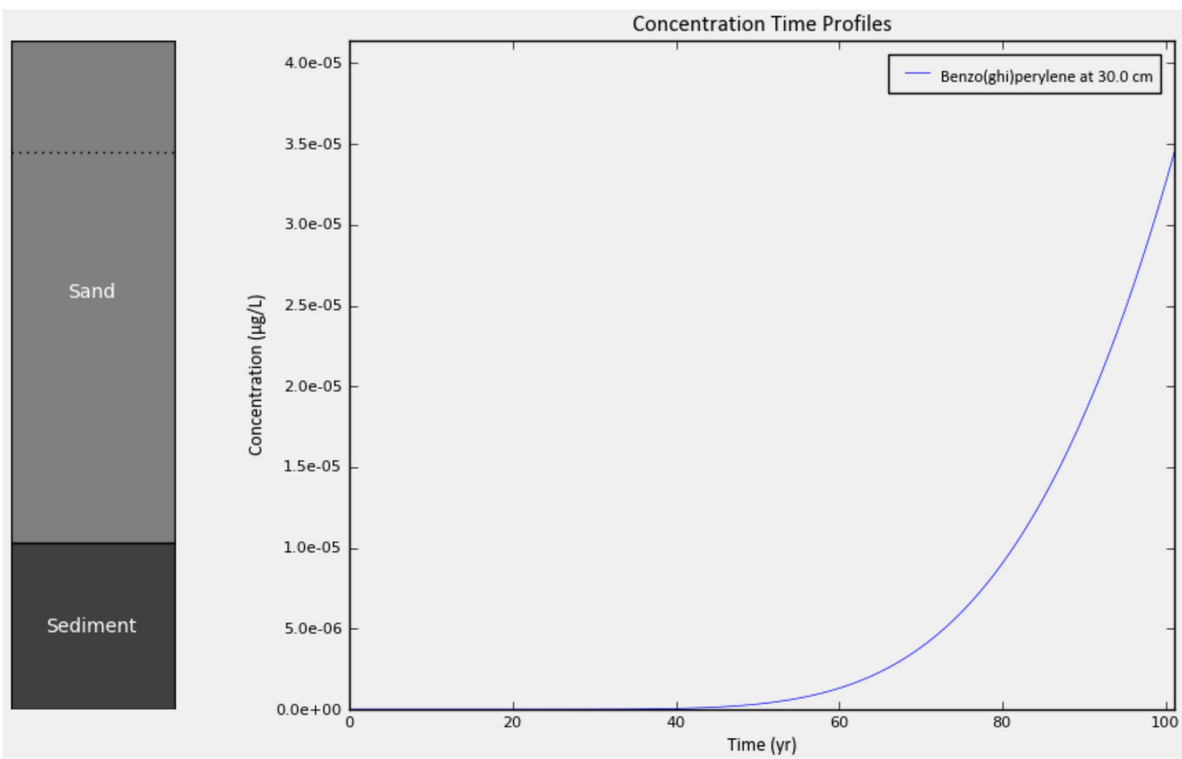

Concentration Time Profiles
Anthracene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
0.0
0.1
0.2
0.3
0.4
0.5
Time (yr)
0
20
40
60
80
100

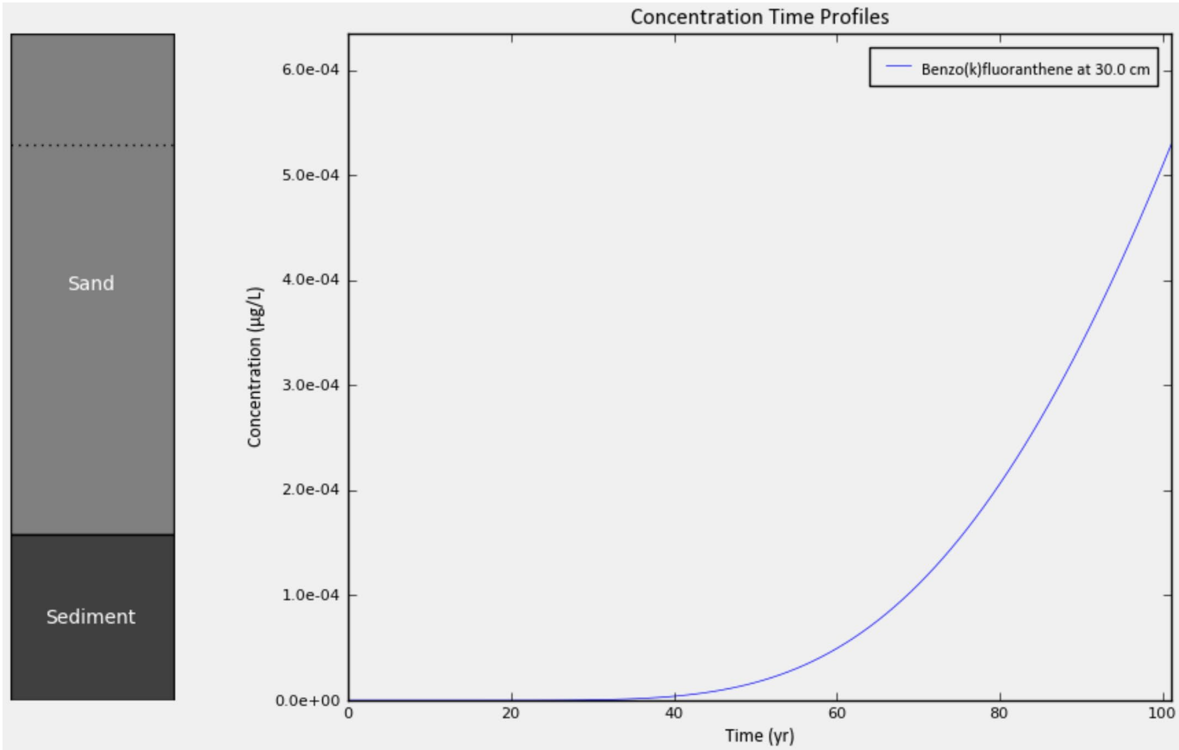

Concentration Time Profiles
Benzo(a)anthracene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
Time (yr)
0
20
40
60
80
100

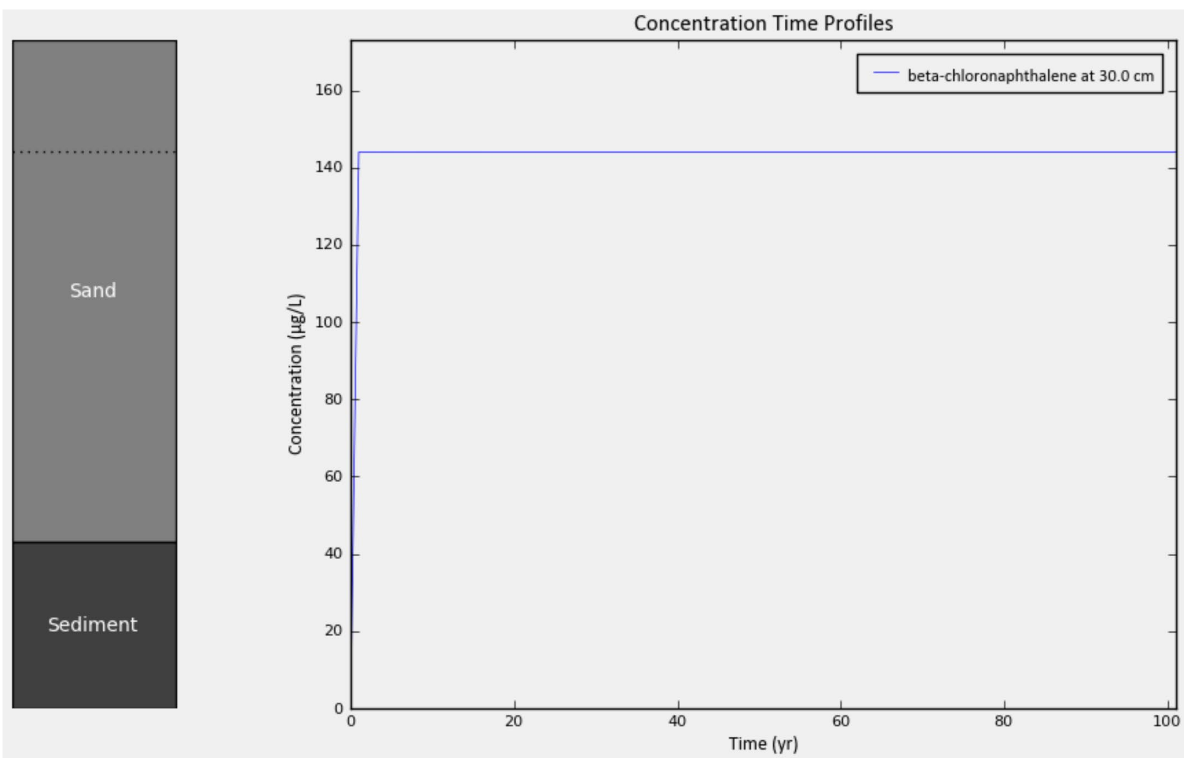

Concentration Time Profiles
Sand
Sediment
Benzo(a)pyrene at 30.0 cm
Concentration (µg/L)
0.000
0.002
0.004
0.006
0.008
0.010
Time (yr)
0
20
40
60
80
100

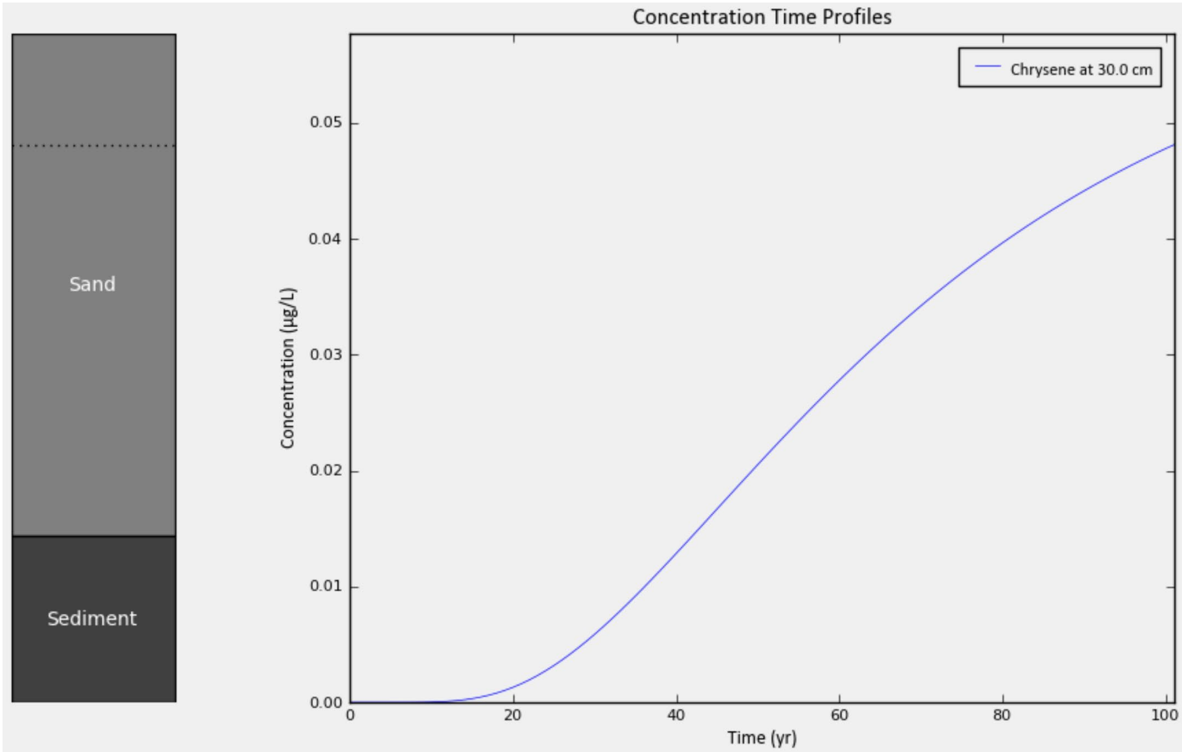

Concentration Time Profiles
Sand
Sediment
Benzo(b)fluoranthene at 30.0 cm
Concentration (µg/L)
0.0000
0.0002
0.0004
0.0006
0.0008
0.0010
0.0012
Time (yr)
0
20
40
60
80
100

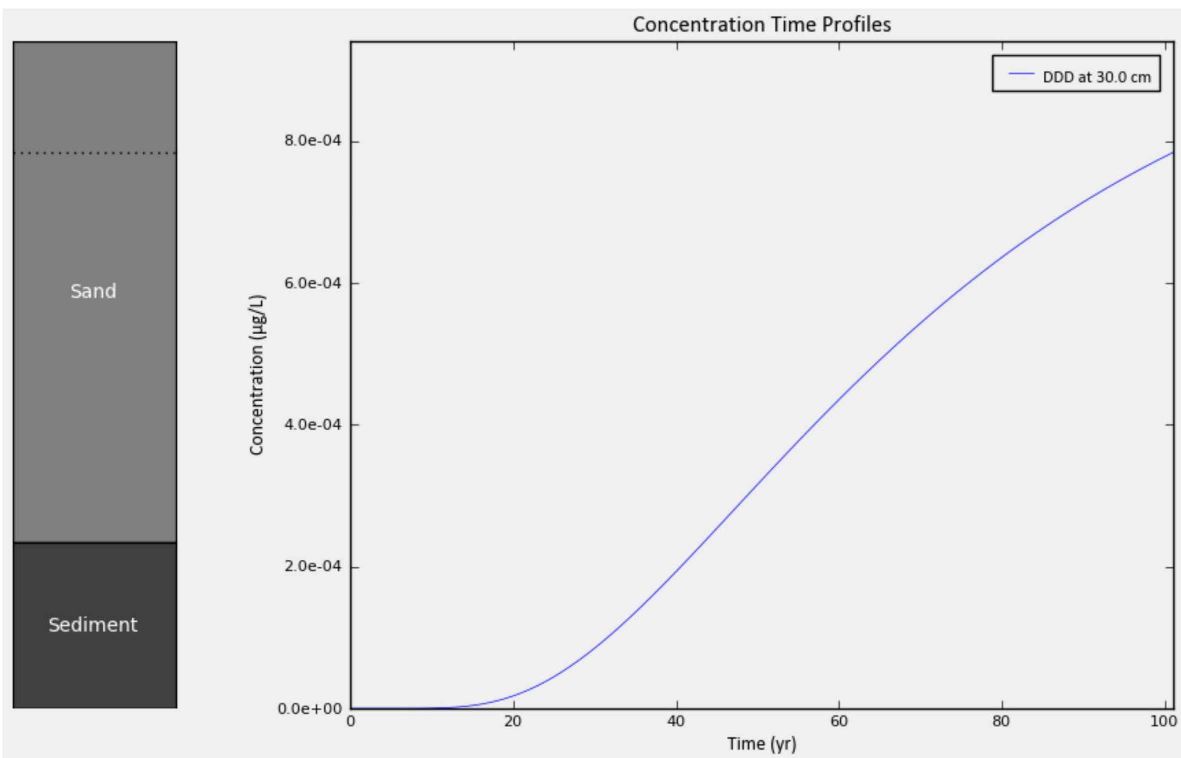

Concentration Time Profiles
Benzo(e)pyrene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
0.0e+00
1.0e-05
2.0e-05
3.0e-05
4.0e-05
5.0e-05
0
20
40
60
80
100

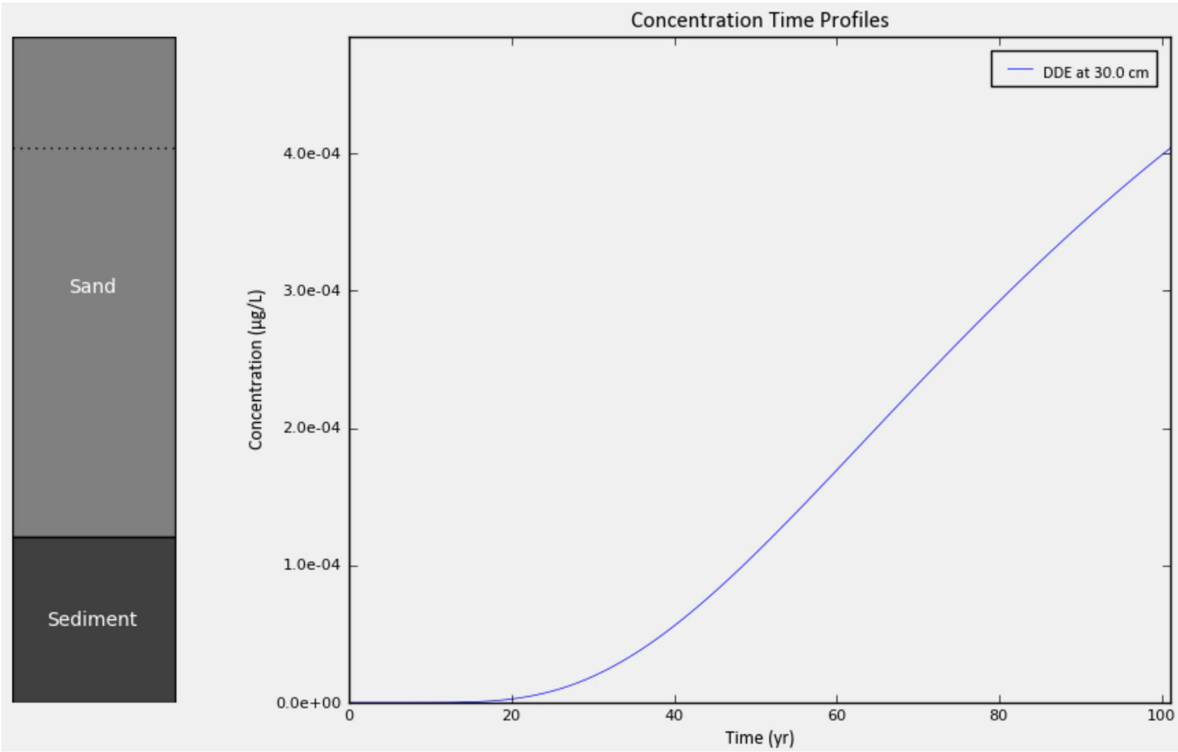

Concentration Time Profiles
Benzo(ghi)perylene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
0.0e+00
5.0e-06
1.0e-05
1.5e-05
2.0e-05
2.5e-05
3.0e-05
3.5e-05
4.0e-05
0
20
40
60
80
100

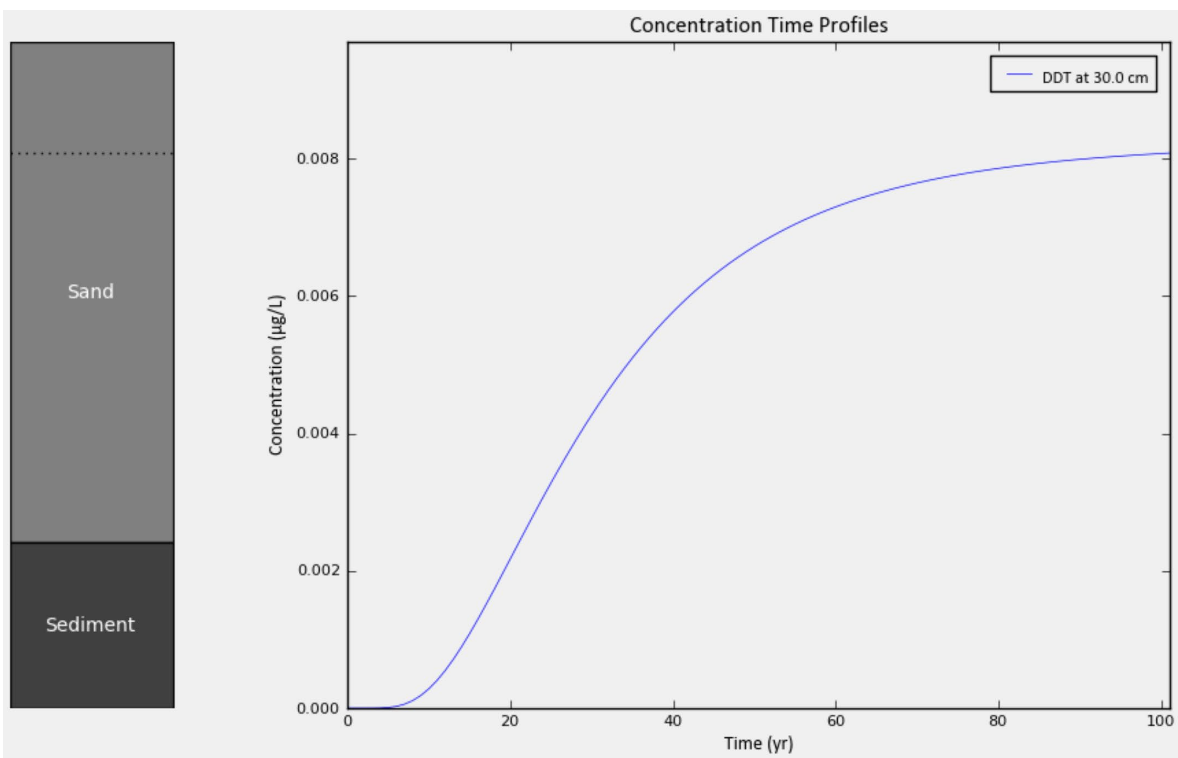

Concentration Time Profiles
Benzo(k)fluoranthene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
6.0e-04
5.0e-04
4.0e-04
3.0e-04
2.0e-04
1.0e-04
0.0e+00
0
20
40
60
80
100
Time (yr)

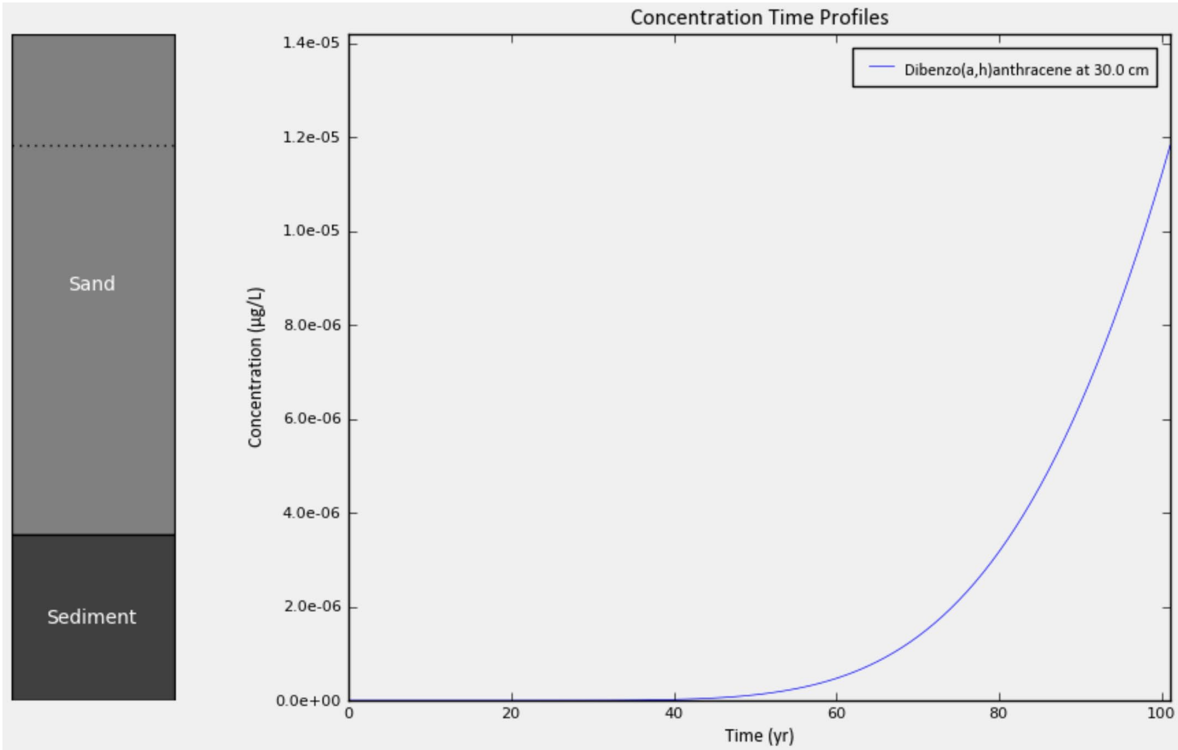

Concentration Time Profiles
beta-chloronaphthalene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
160
140
120
100
80
60
40
20
0
0
20
40
60
80
100
Time (yr)

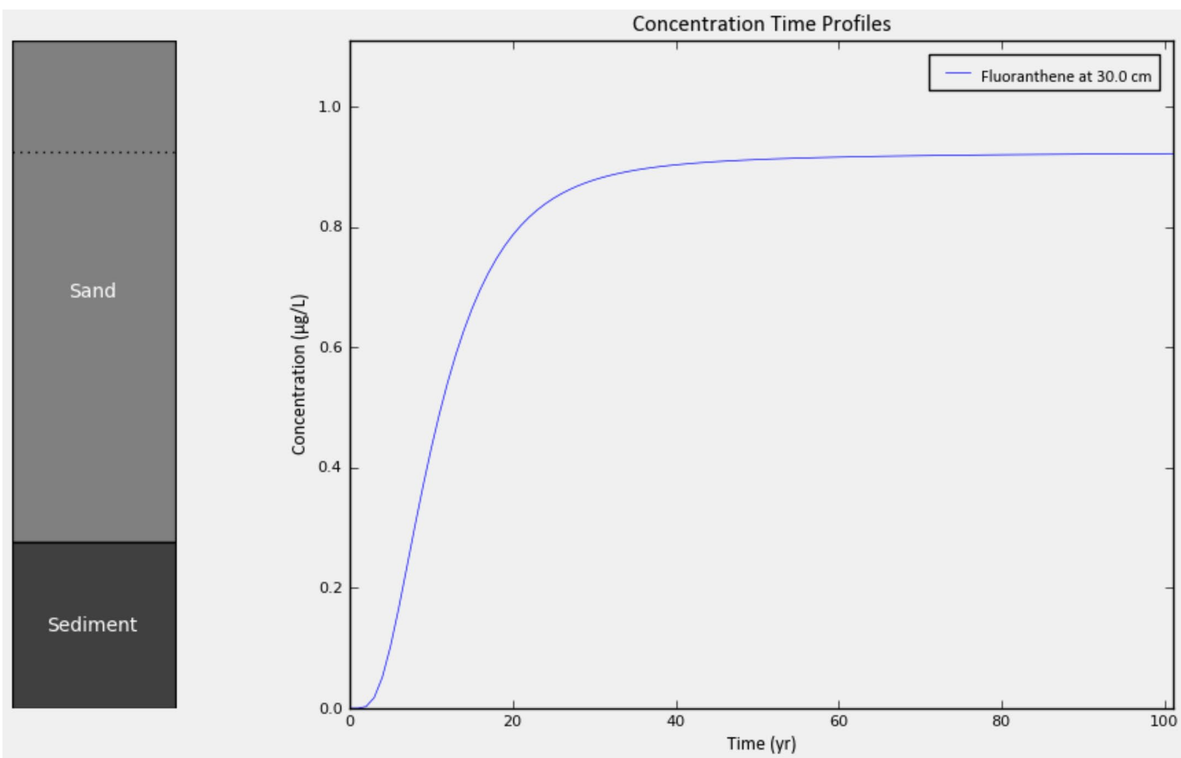

Concentration Time Profiles
Chrysene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
0.00
0.01
0.02
0.03
0.04
0.05
Time (yr)
0
20
40
60
80
100

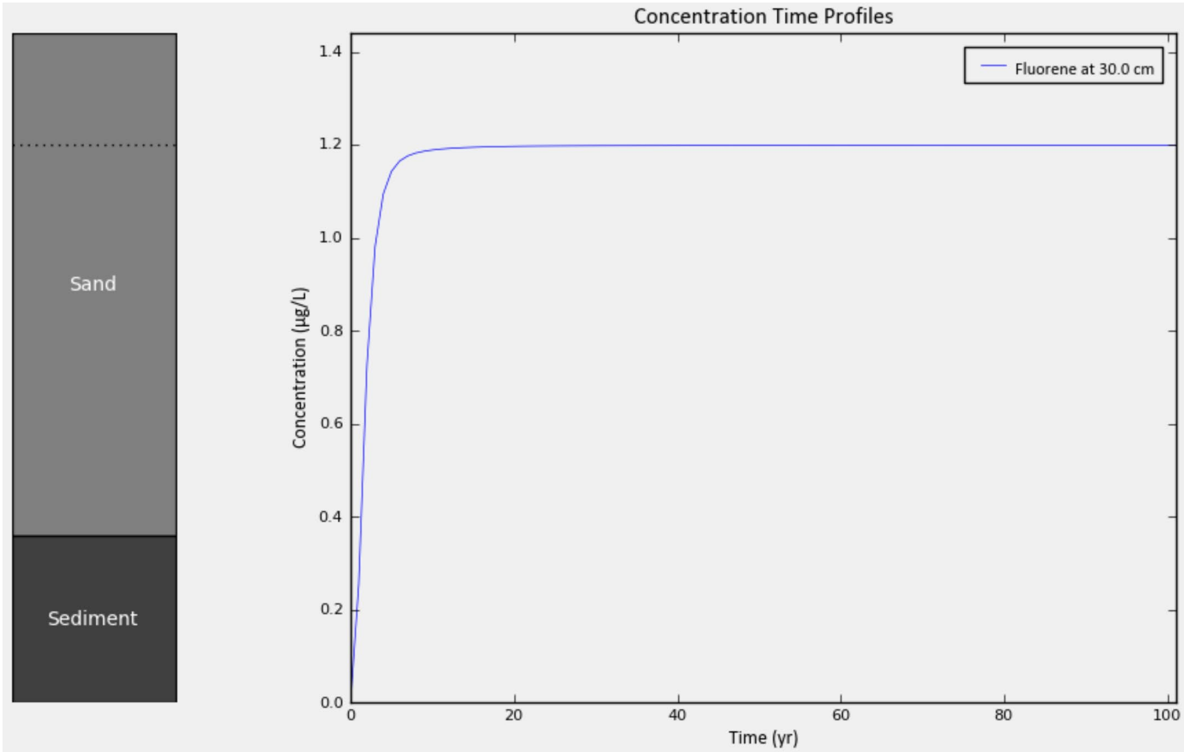

Concentration Time Profiles
DDD at 30.0 cm
Sand
Sediment
Concentration (µg/L)
0.0e+00
2.0e-04
4.0e-04
6.0e-04
8.0e-04
Time (yr)
0
20
40
60
80
100

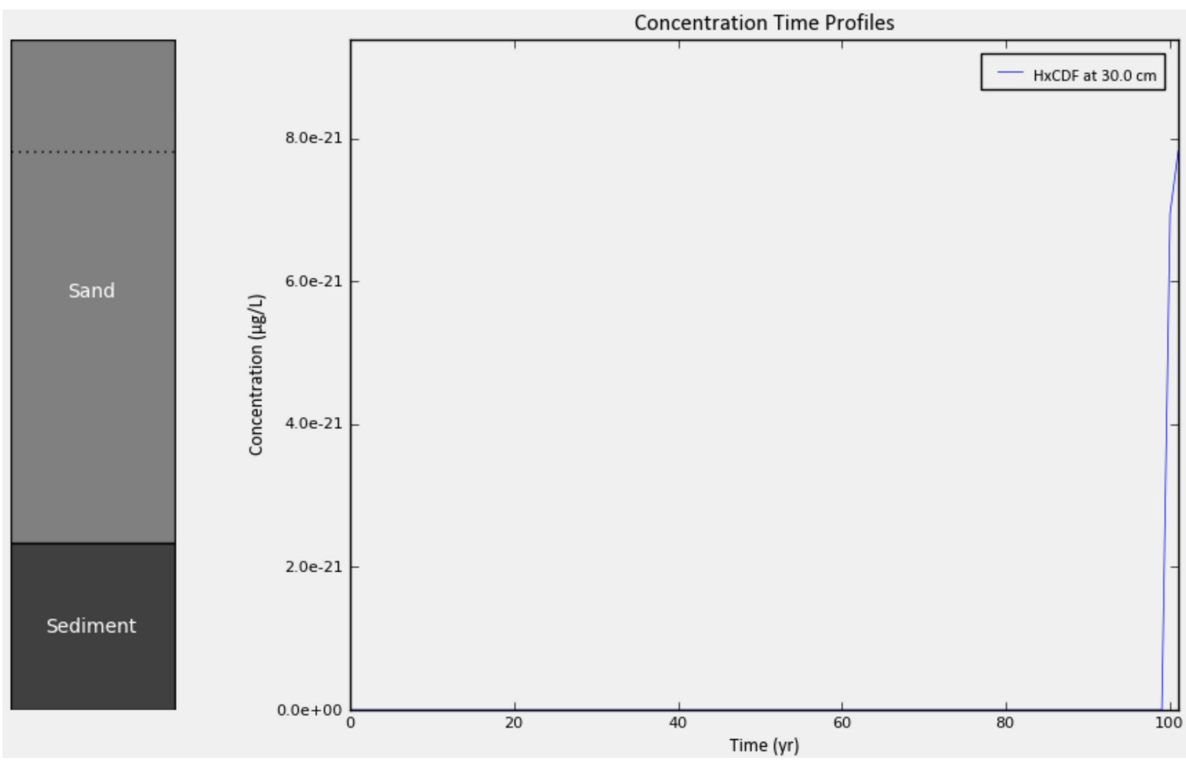

Sand
Sediment
Concentration Time Profiles
DDE at 30.0 cm
Concentration (µg/L)
4.0e-04
3.0e-04
2.0e-04
1.0e-04
0.0e+00
0
20
40
60
80
100
Time (yr)

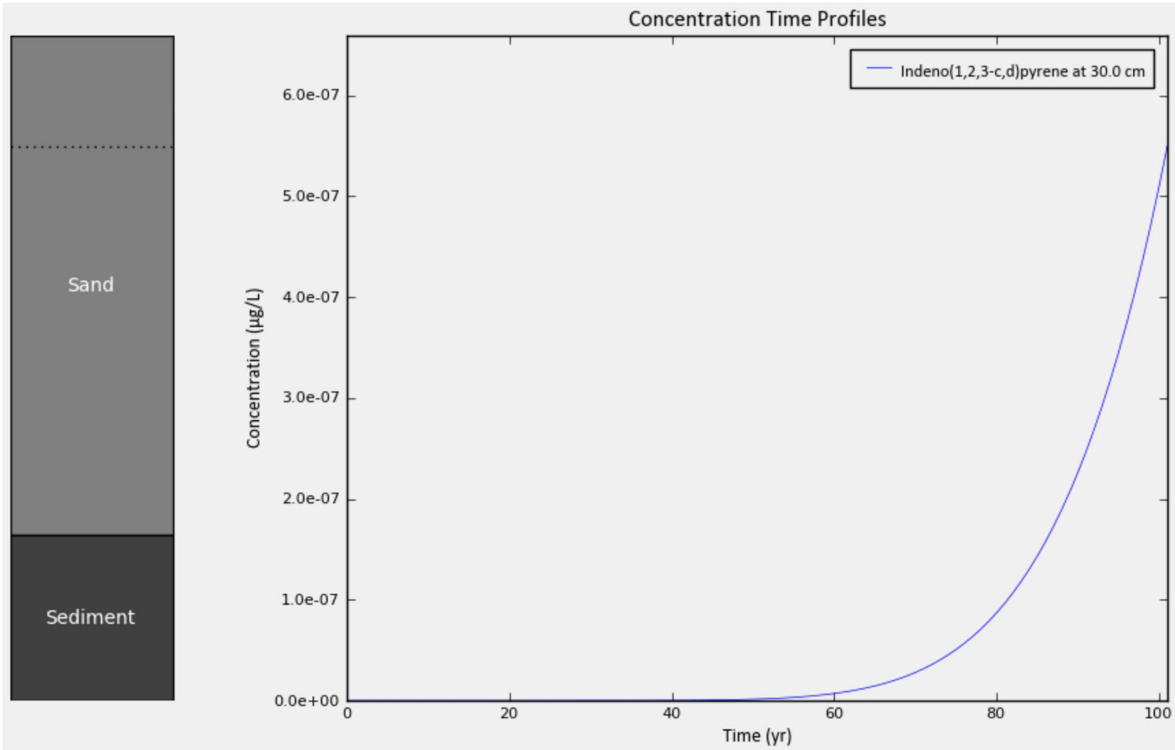

Sand
Sediment
Concentration Time Profiles
DDT at 30.0 cm
Concentration (µg/L)
0.008
0.006
0.004
0.002
0.000
0
20
40
60
80
100
Time (yr)

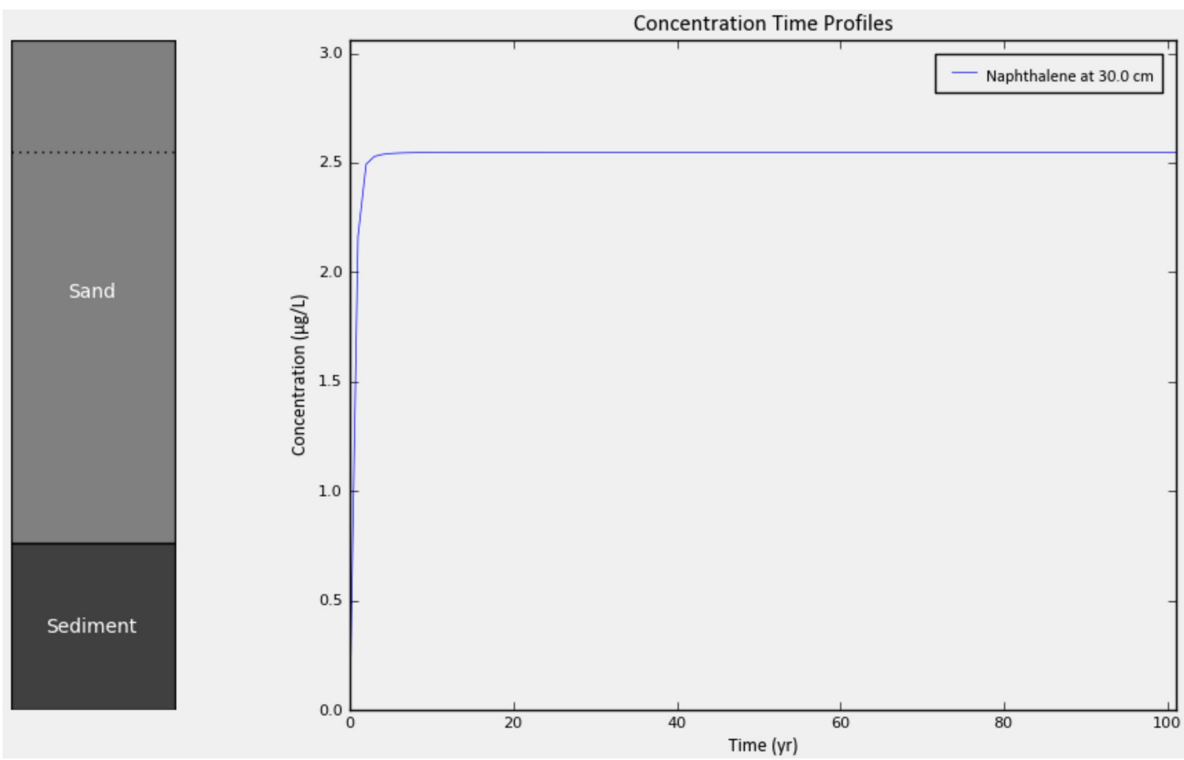

Sand
Sediment
Concentration Time Profiles
Dibenzo(a,h)anthracene at 30.0 cm
Concentration (µg/L)
Time (yr)
1.4e-05
1.2e-05
1.0e-05
8.0e-06
6.0e-06
4.0e-06
2.0e-06
0.0e+00
0
20
40
60
80
100

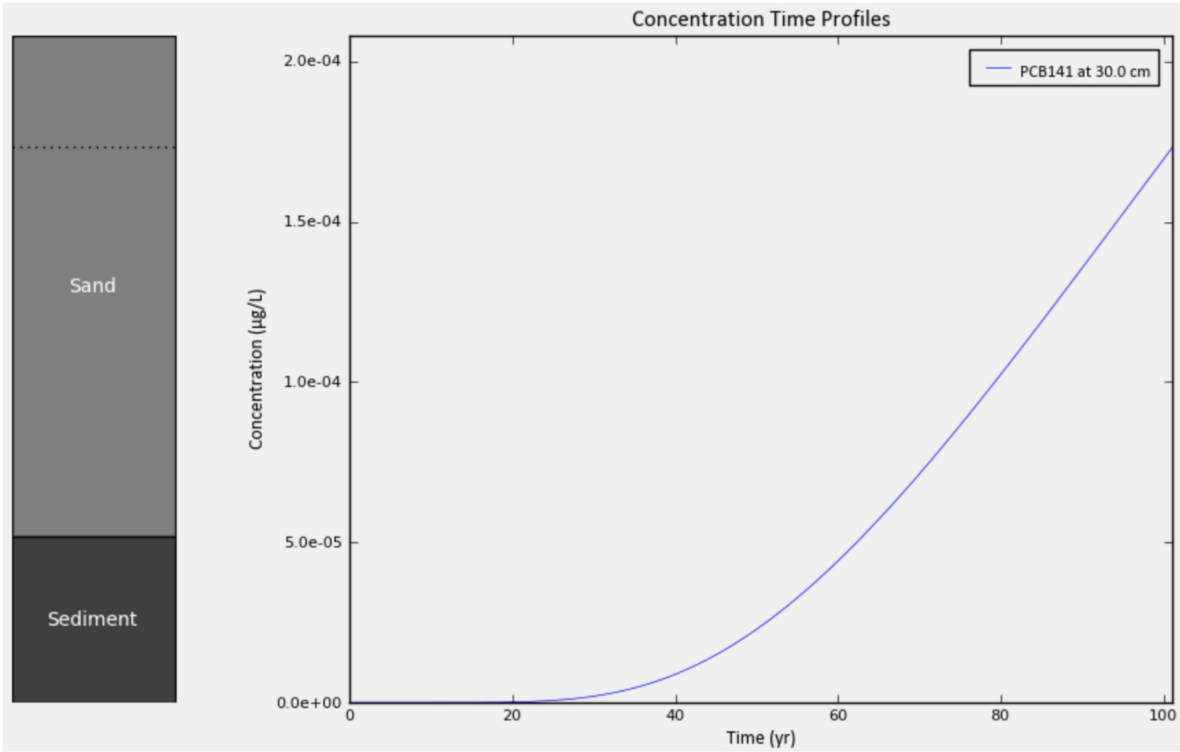

Sand
Sediment
Concentration Time Profiles
Fluoranthene at 30.0 cm
Concentration (µg/L)
Time (yr)
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100

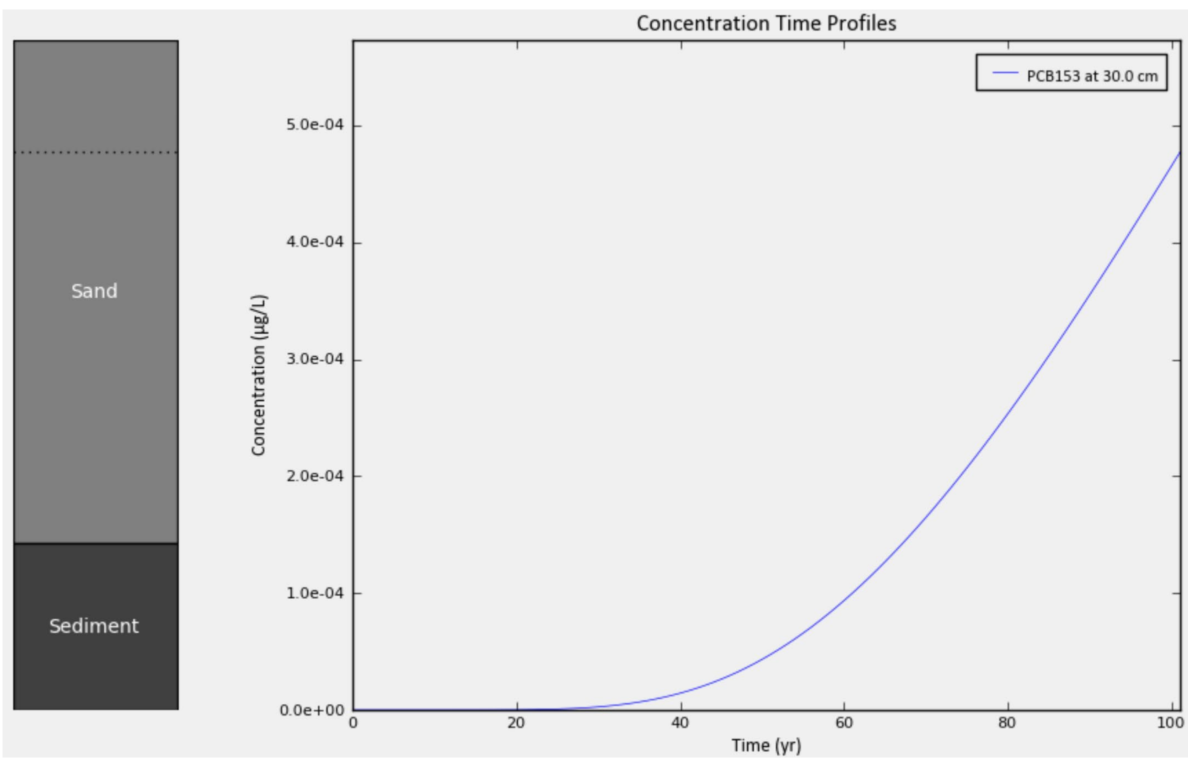

Concentration Time Profiles
Sand
Sediment
Fluorene at 30.0 cm
Concentration (µg/L)
Time (yr)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0
20
40
60
80
100

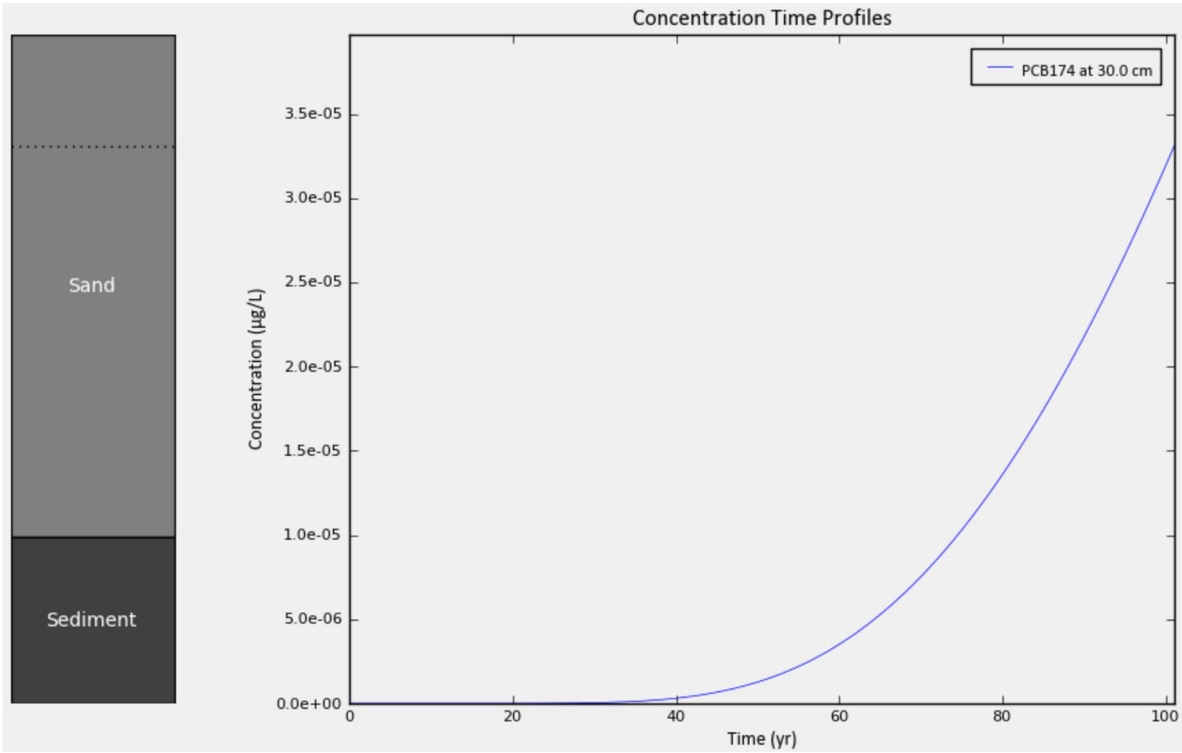

Concentration Time Profiles
Sand
Sediment
HxCDF at 30.0 cm
Concentration (µg/L)
Time (yr)
0.0e+00
2.0e-21
4.0e-21
6.0e-21
8.0e-21
0
20
40
60
80
100

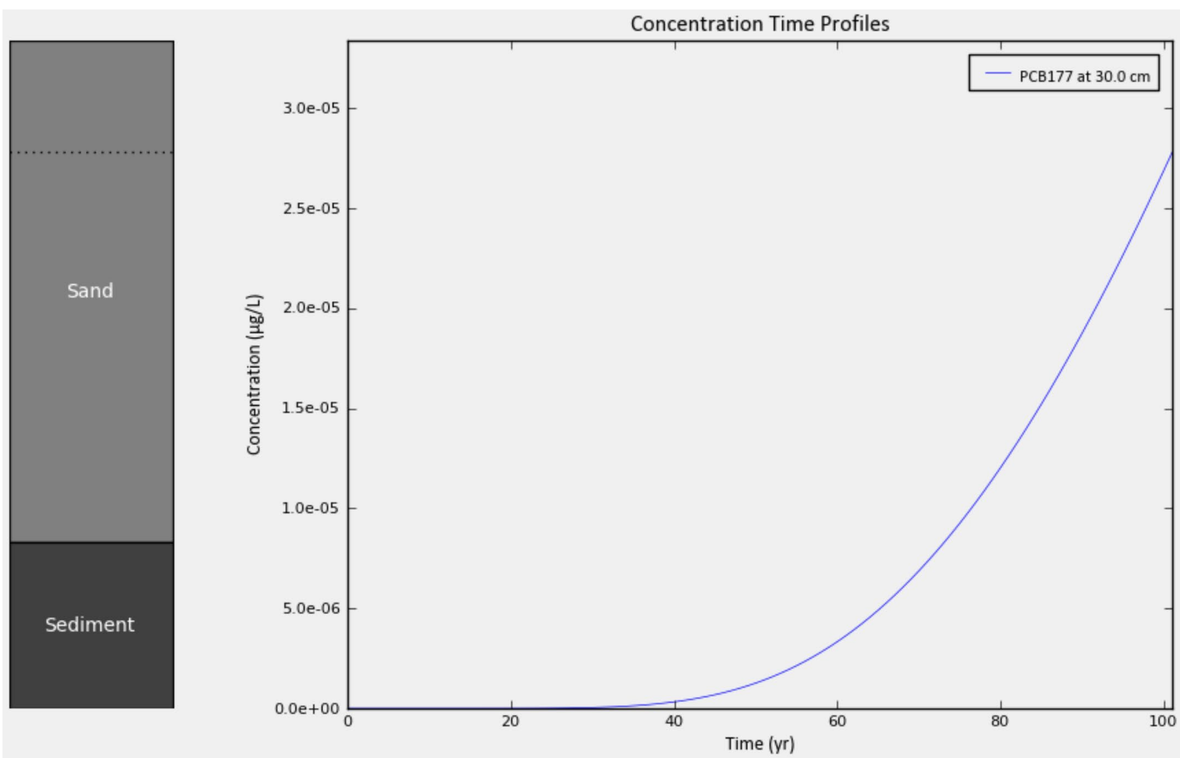

Concentration Time Profiles
Indeno(1,2,3-c,d)pyrene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
0.0e+00
1.0e-07
2.0e-07
3.0e-07
4.0e-07
5.0e-07
6.0e-07
0
20
40
60
80
100

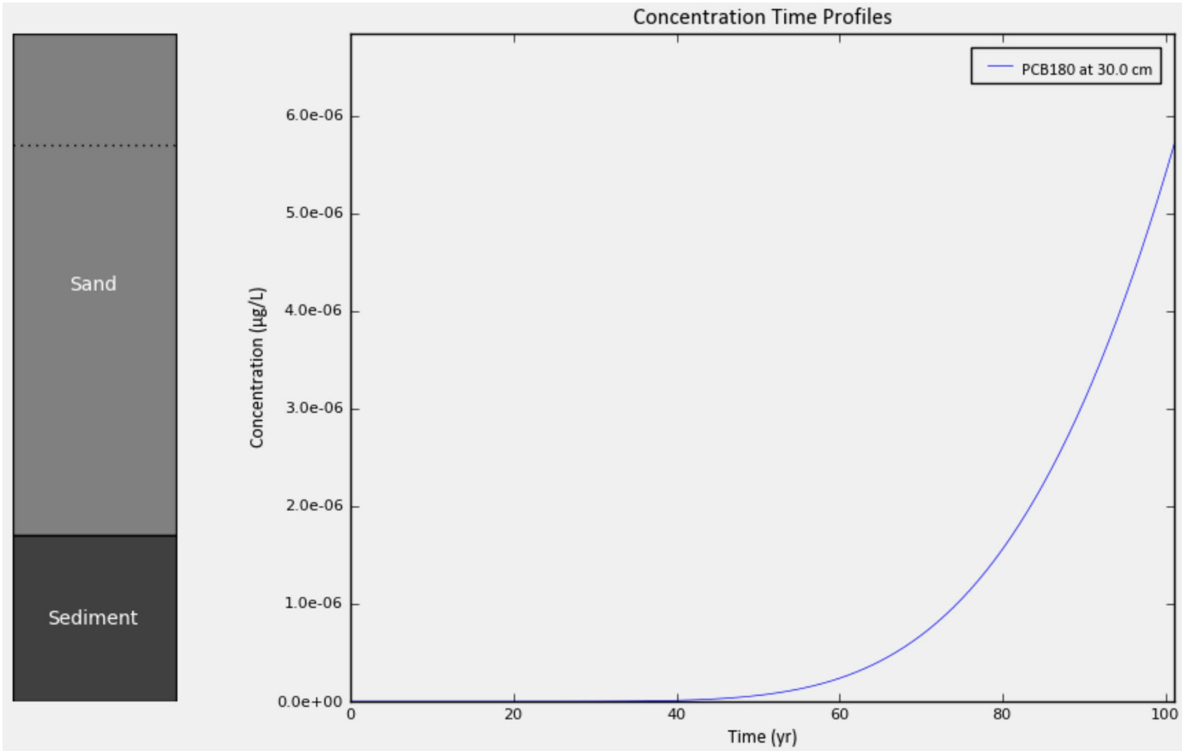

Concentration Time Profiles
Naphthalene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
20
40
60
80
100

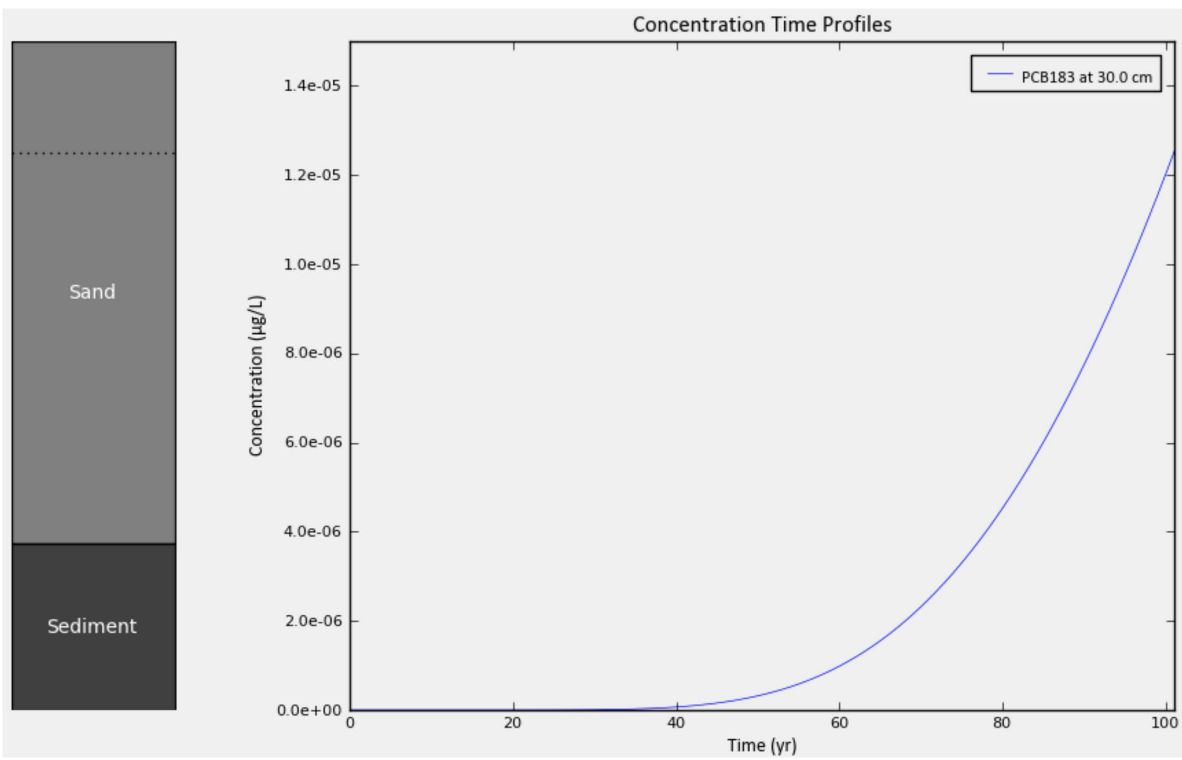

Concentration Time Profiles
PCB141 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
2.0e-04
1.5e-04
1.0e-04
5.0e-05
0.0e+00
0
20
40
60
80
100
Time (yr)

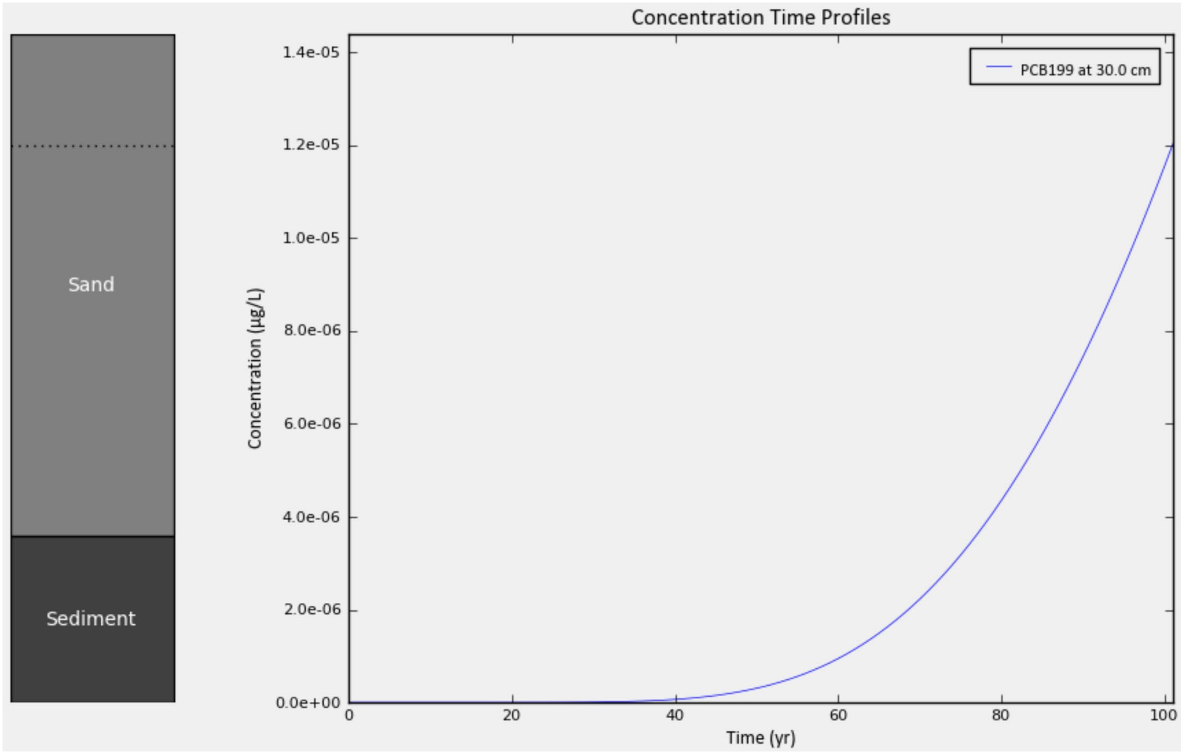

Concentration Time Profiles
PCB153 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
5.0e-04
4.0e-04
3.0e-04
2.0e-04
1.0e-04
0.0e+00
0
20
40
60
80
100
Time (yr)

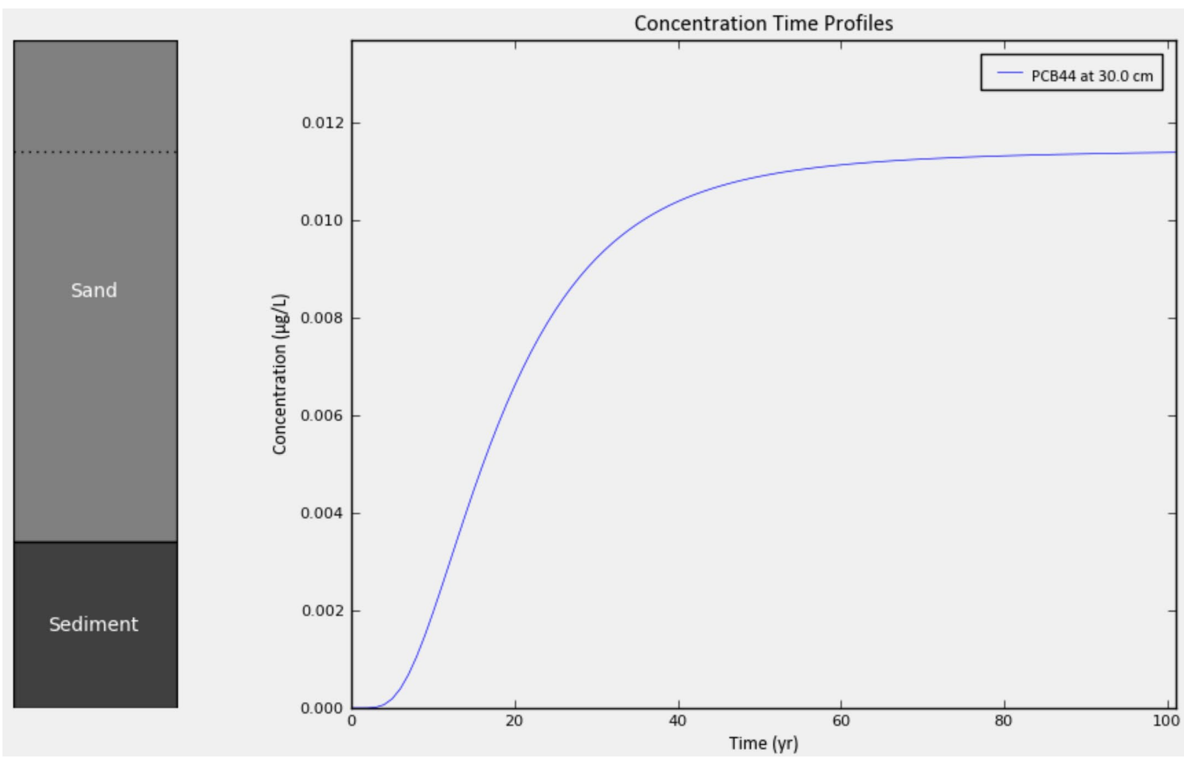

Concentration Time Profiles
PCB174 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
0.0e+00
5.0e-06
1.0e-05
1.5e-05
2.0e-05
2.5e-05
3.0e-05
3.5e-05
0
20
40
60
80
100

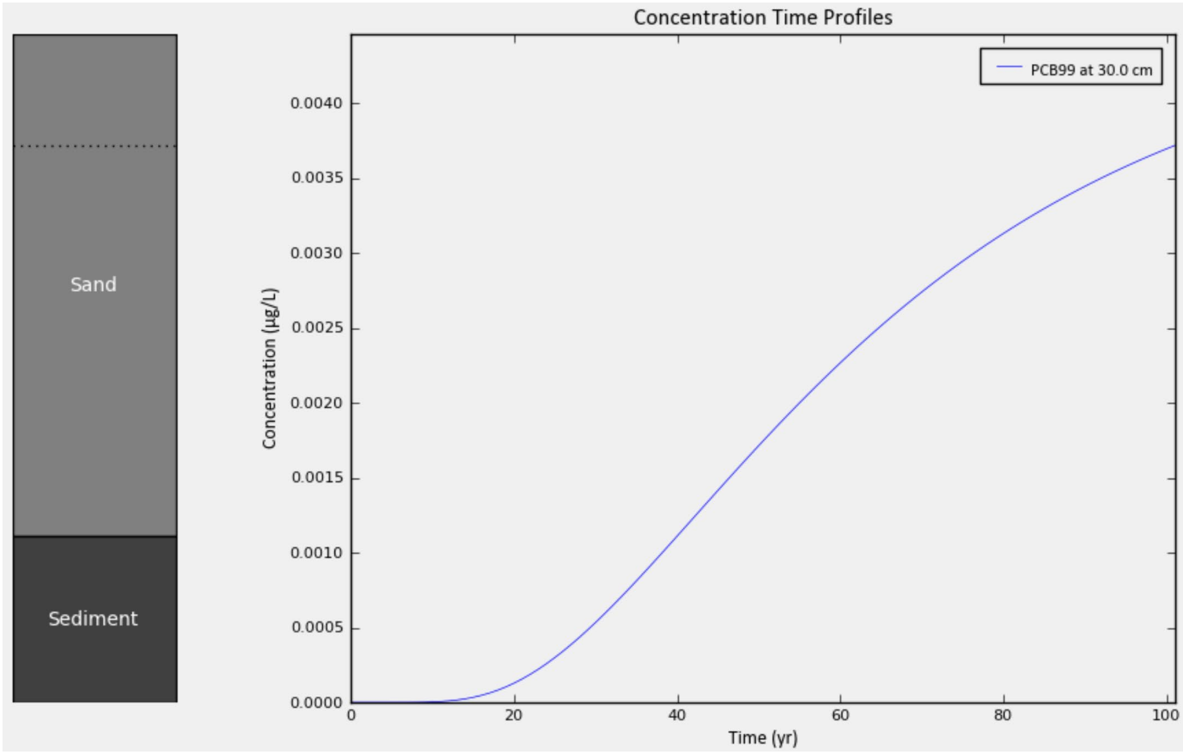

Concentration Time Profiles
PCB177 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
0.0e+00
5.0e-06
1.0e-05
1.5e-05
2.0e-05
2.5e-05
3.0e-05
0
20
40
60
80
100

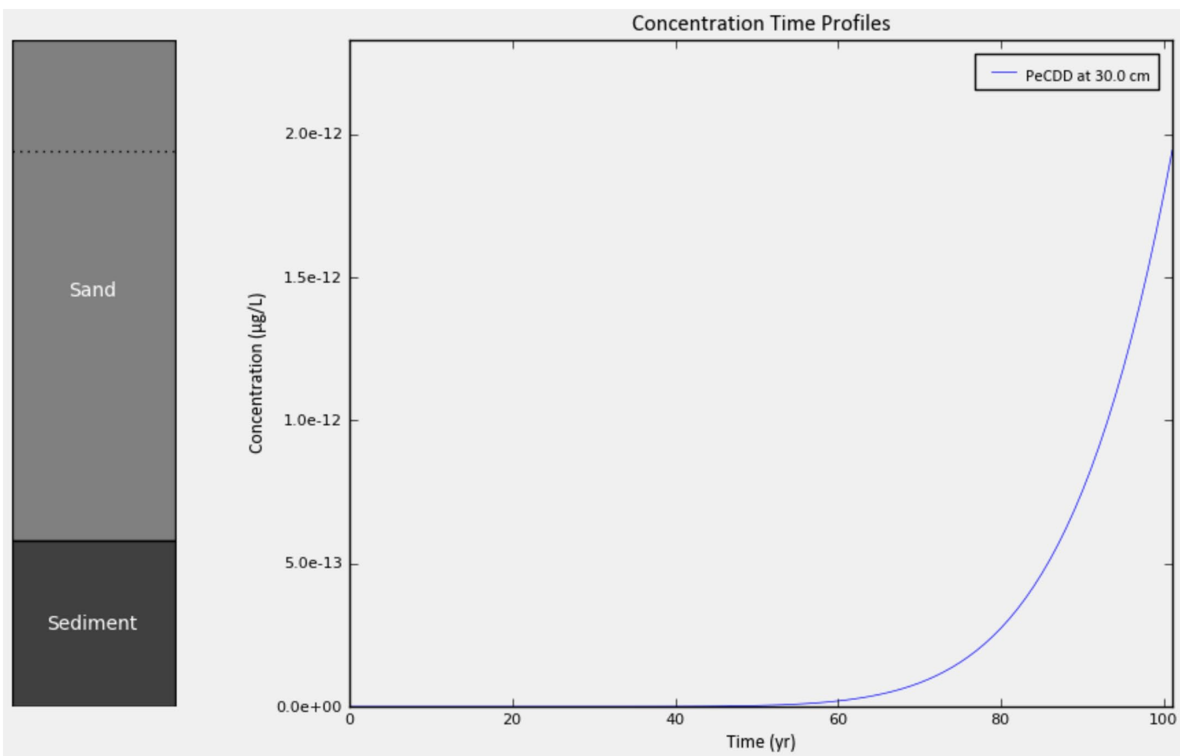

Concentration Time Profiles
PCB180 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
6.0e-06
5.0e-06
4.0e-06
3.0e-06
2.0e-06
1.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

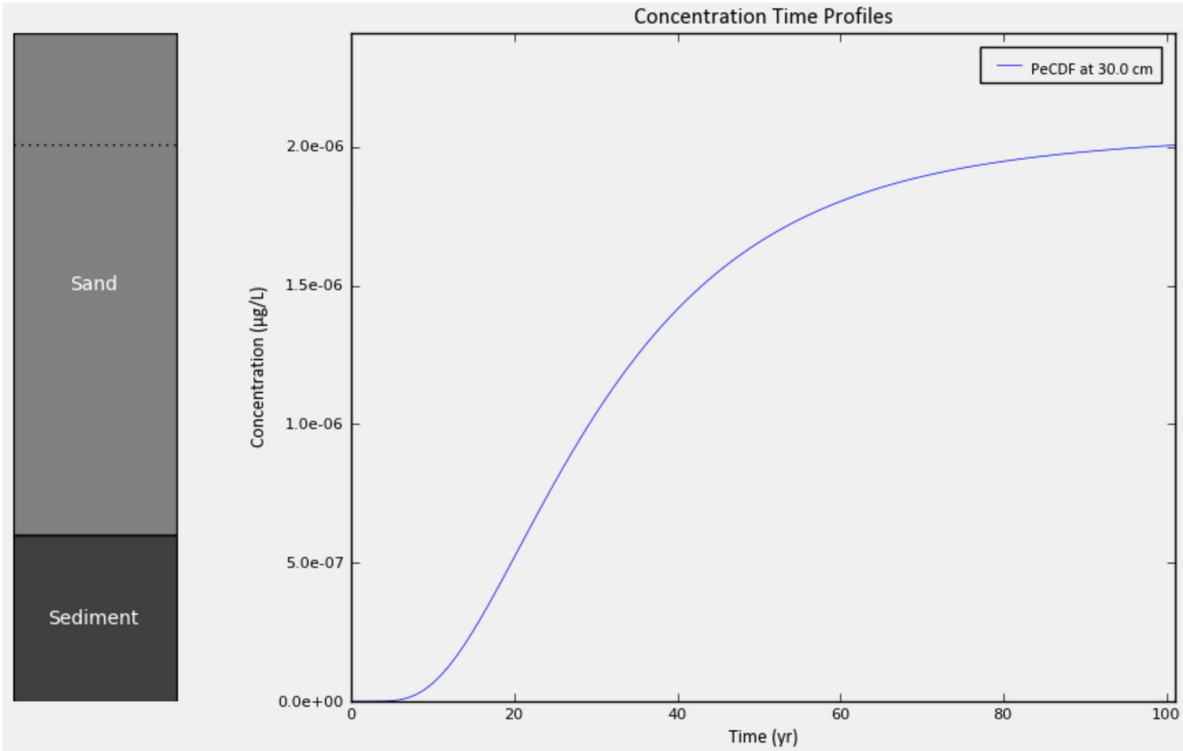

Concentration Time Profiles
PCB183 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
1.4e-05
1.2e-05
1.0e-05
8.0e-06
6.0e-06
4.0e-06
2.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

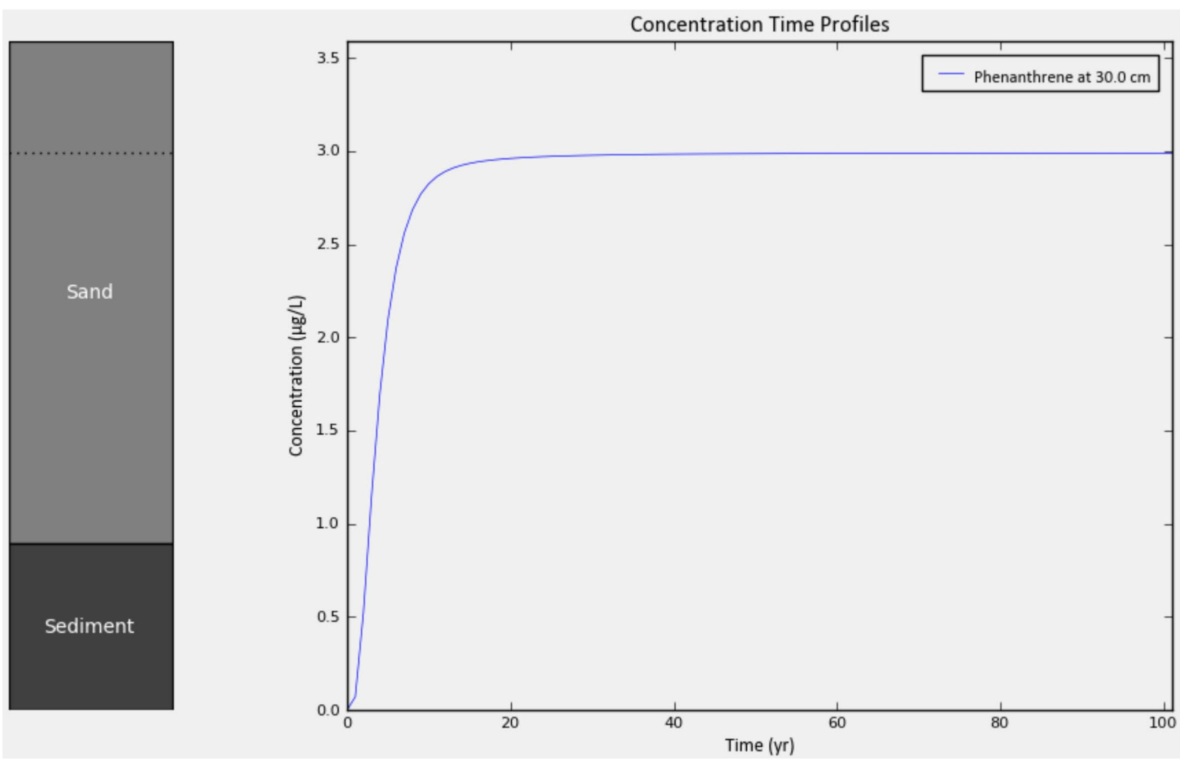

Concentration Time Profiles
Sand
Sediment
PCB199 at 30.0 cm
Concentration (μg/L)
1.4e-05
1.2e-05
1.0e-05
8.0e-06
6.0e-06
4.0e-06
2.0e-06
0.0e+00
0
20
40
60
80
100
Time (yr)

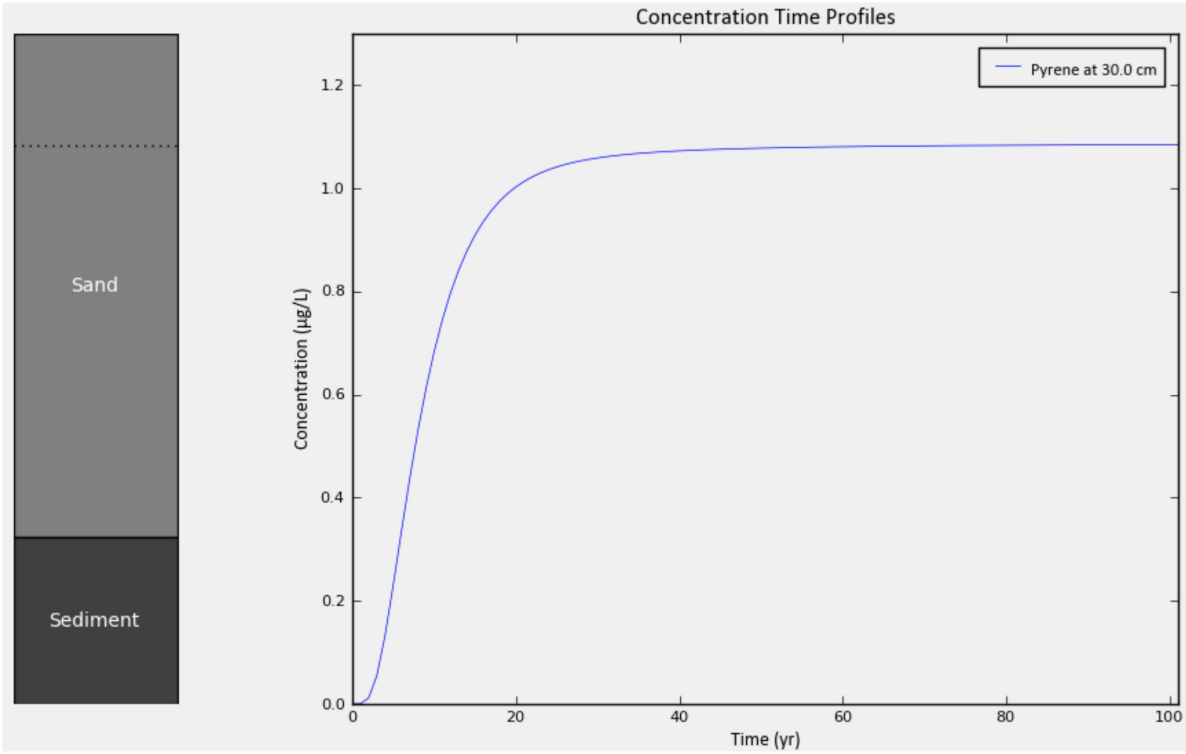

Concentration Time Profiles
Sand
Sediment
PCB44 at 30.0 cm
Concentration (μg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0
20
40
60
80
100
Time (yr)

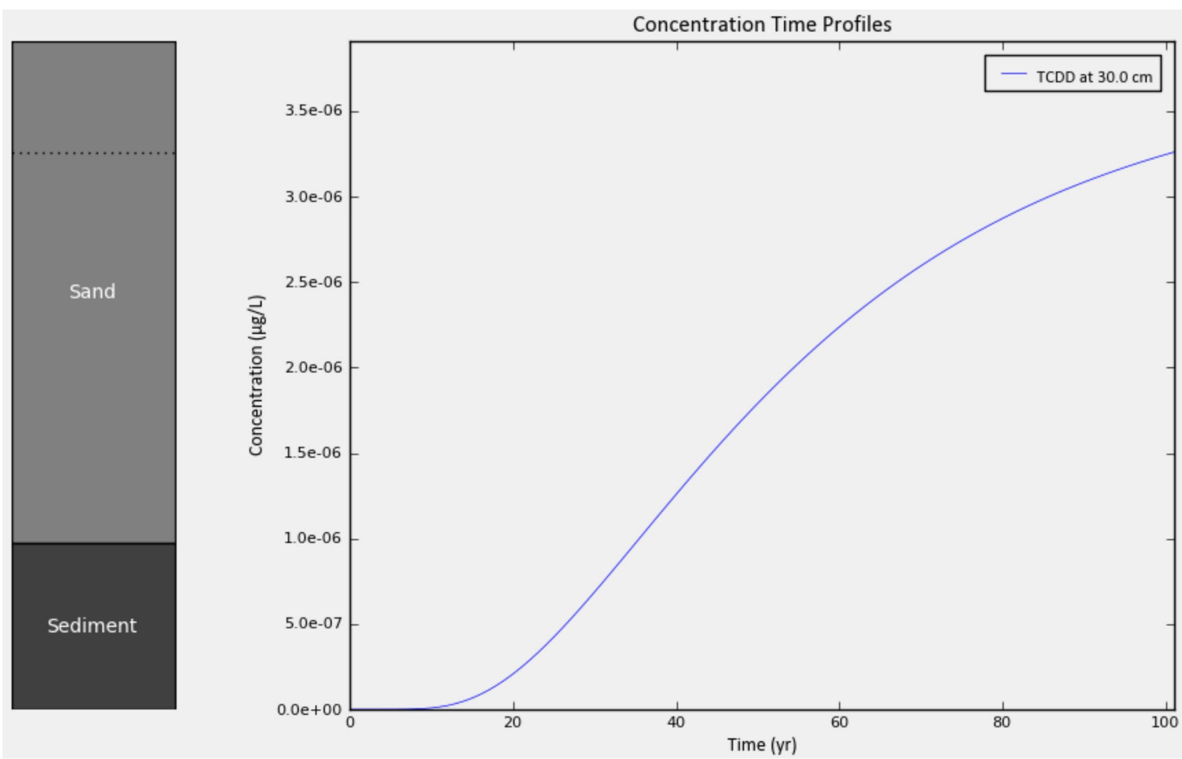

Concentration Time Profiles
PCB99 at 30.0 cm
Sand
Sediment
Concentration (µg/L)
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
0
20
40
60
80
100
Time (yr)

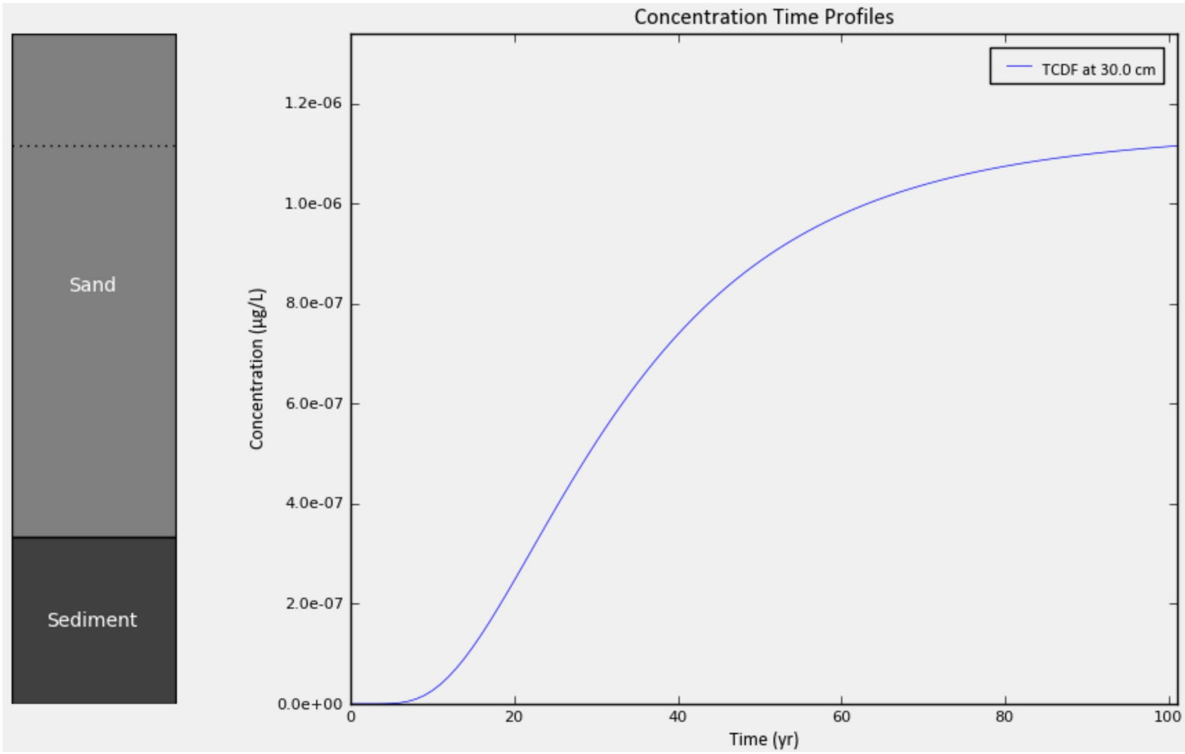

Concentration Time Profiles
PeCDD at 30.0 cm
Sand
Sediment
Concentration (µg/L)
2.0e-12
1.5e-12
1.0e-12
5.0e-13
0.0e+00
0
20
40
60
80
100
Time (yr)

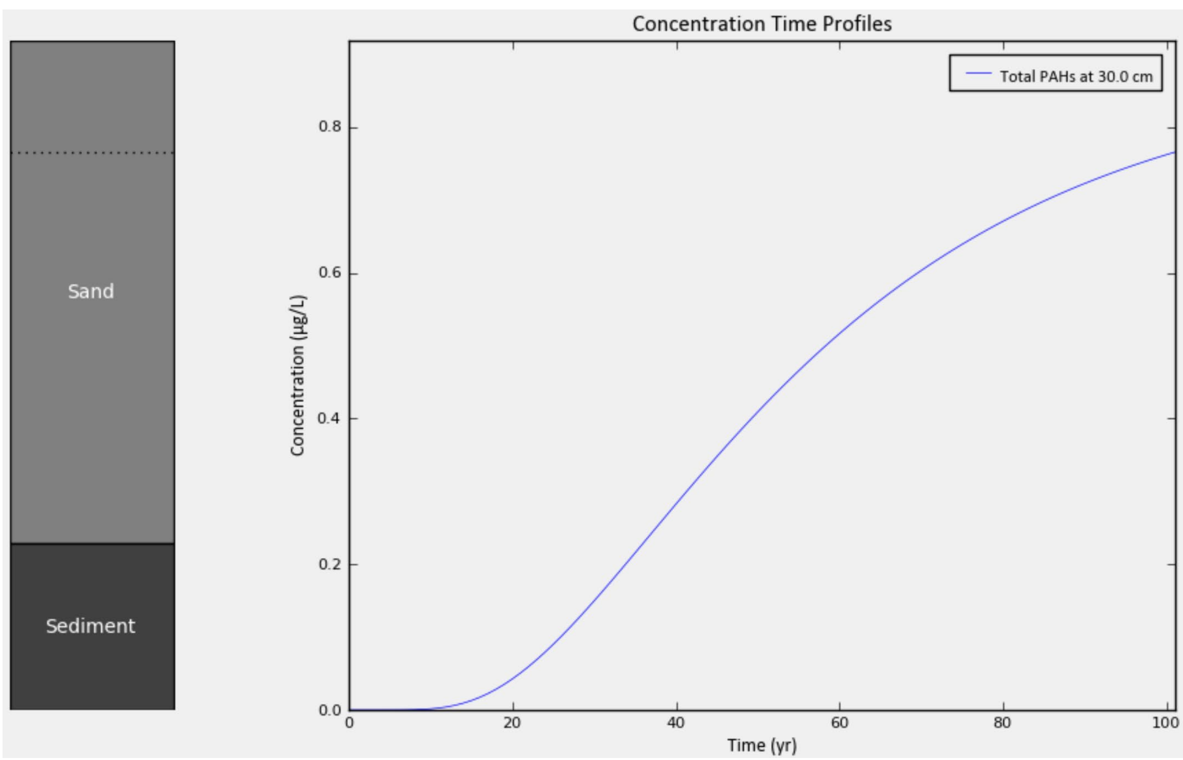

Concentration Time Profiles
PeCDF at 30.0 cm
Sand
Sediment
Concentration (µg/L)
2.0e-06
1.5e-06
1.0e-06
5.0e-07
0.0e+00
0
20
40
60
80
100
Time (yr)

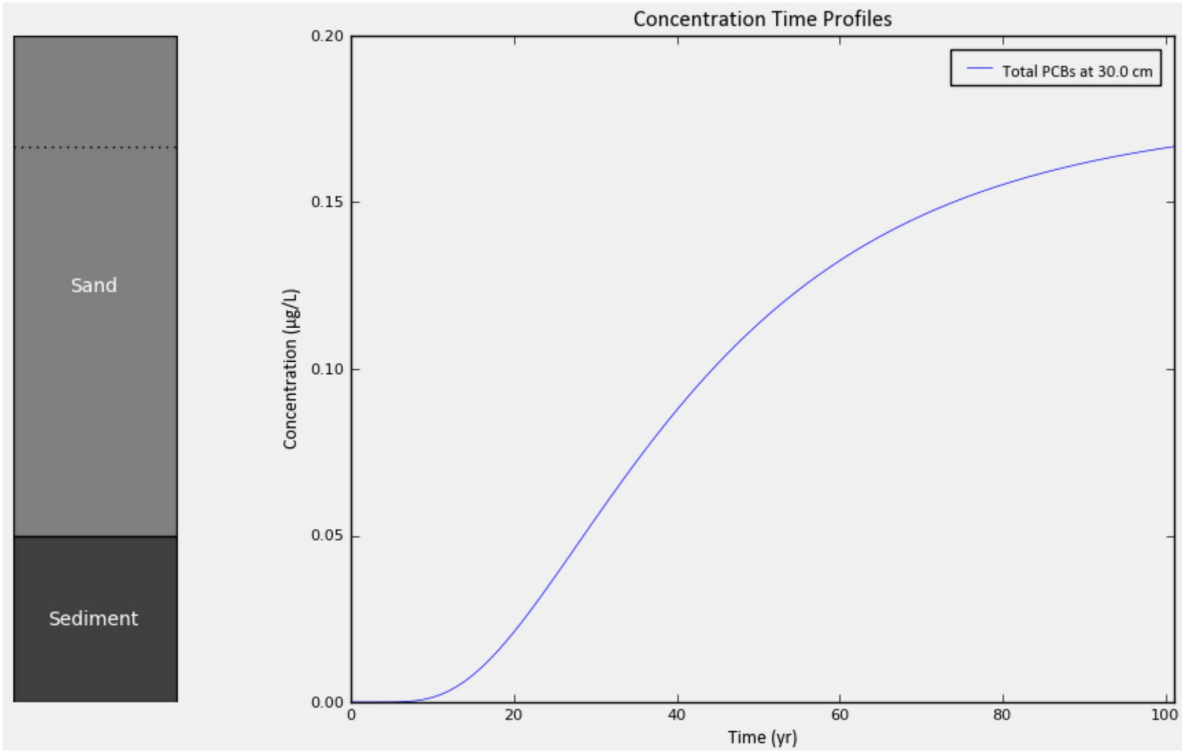

Concentration Time Profiles
Phenanthrene at 30.0 cm
Sand
Sediment
Concentration (µg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
Time (yr)

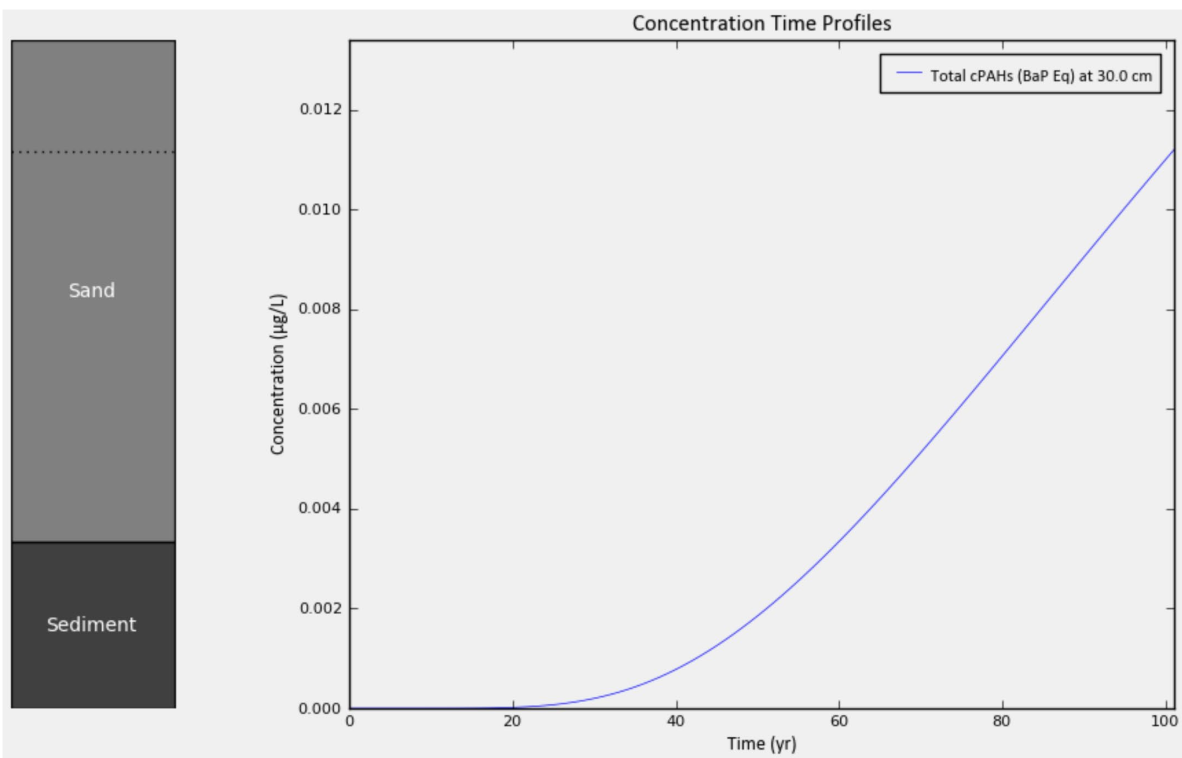

Concentration Time Profiles
Sand
Sediment
Pyrene at 30.0 cm
Concentration (µg/L)
Time (yr)


Concentration Time Profiles
Sand
Sediment
TCDD at 30.0 cm
Concentration (µg/L)
Time (yr)


Concentration Time Profiles
TCDF at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
0.0e+00
2.0e-07
4.0e-07
6.0e-07
8.0e-07
1.0e-06
1.2e-06
0
20
40
60
80
100

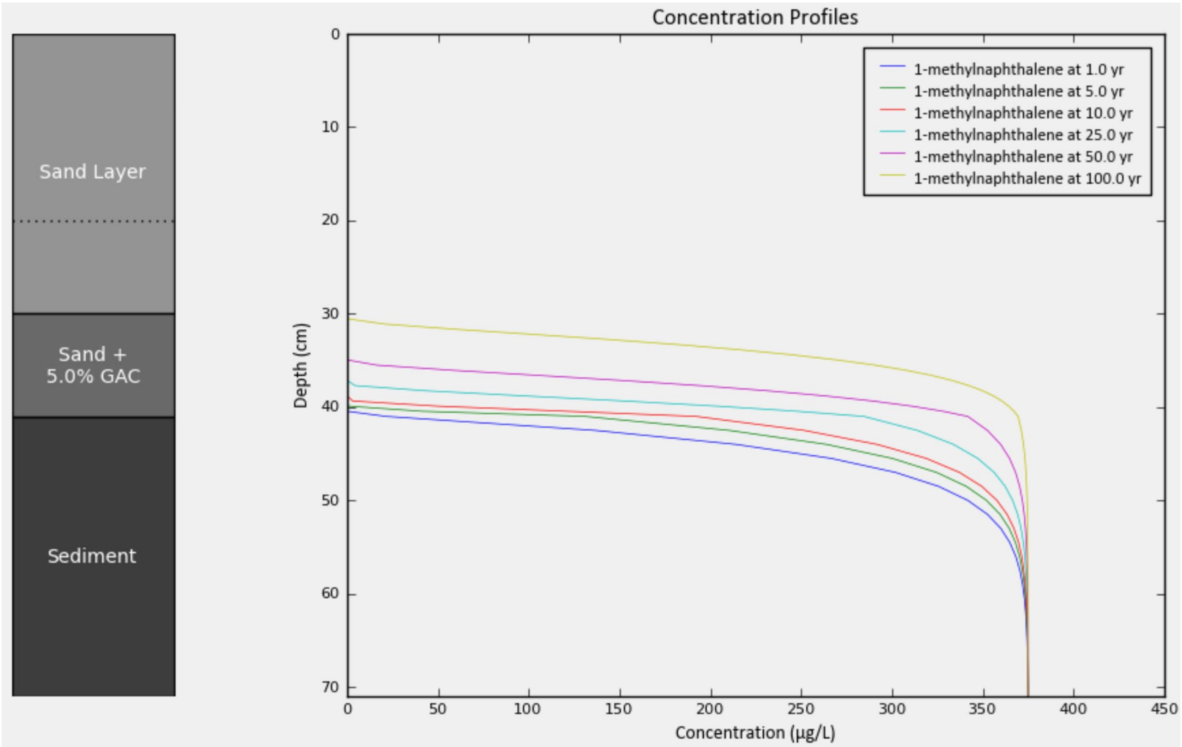

Concentration Time Profiles
Total PAHs at 30.0 cm
Sand
Sediment
Concentration (µg/L)
Time (yr)
0.0
0.2
0.4
0.6
0.8
0
20
40
60
80
100

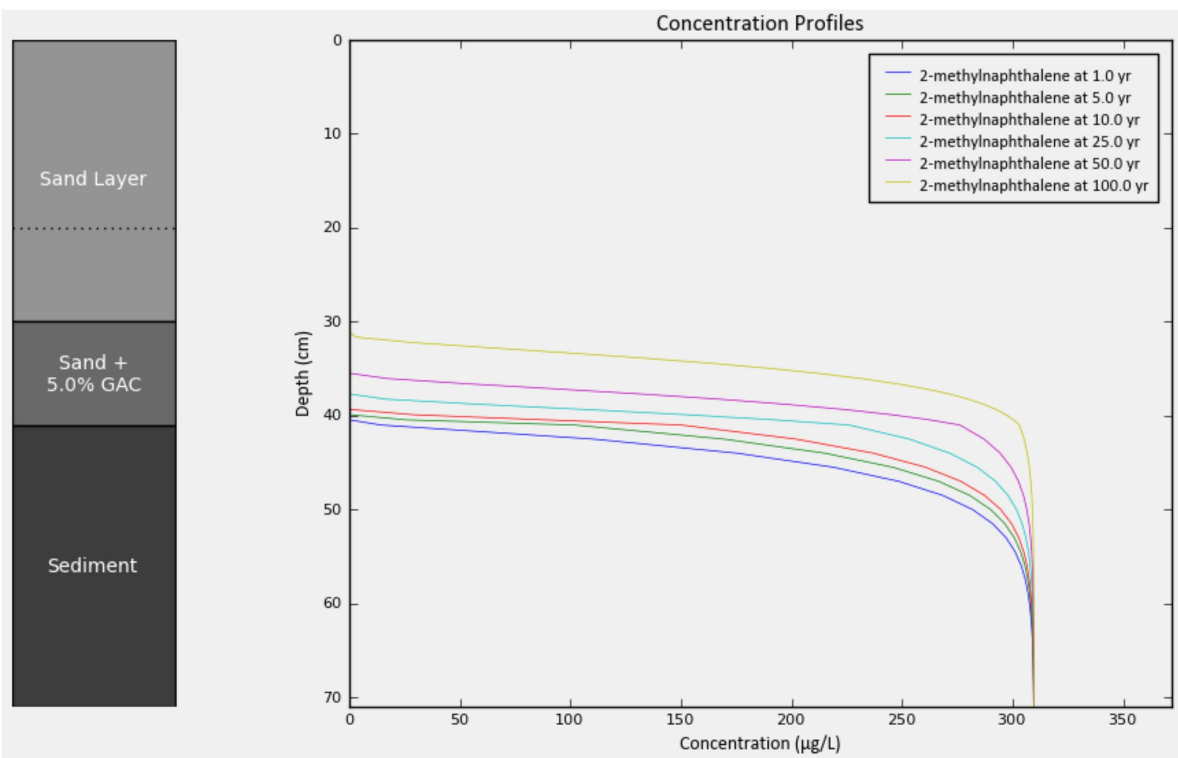

Sand
Sediment
Concentration Time Profiles
Total PCBs at 30.0 cm
Concentration (µg/L)
0.20
0.15
0.10
0.05
0.00
0
20
40
60
80
100
Time (yr)

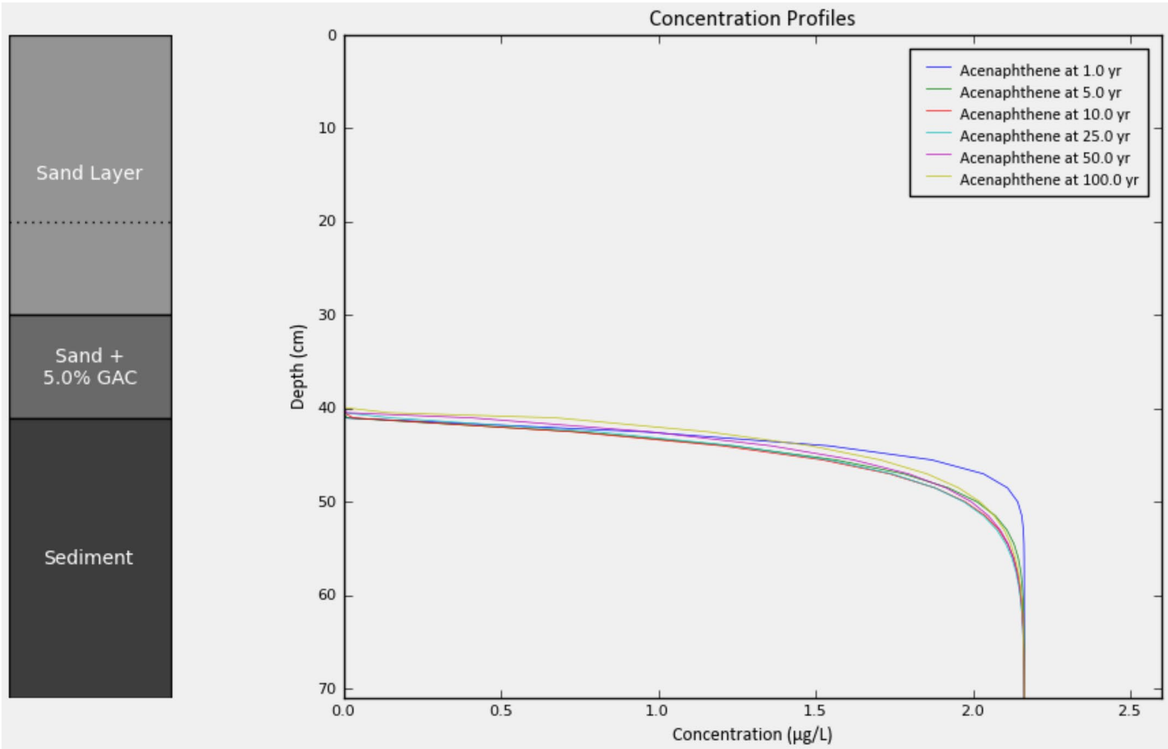

Sand
Sediment
Concentration Time Profiles
Total cPAHs (BaP Eq) at 30.0 cm
Concentration (µg/L)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0
20
40
60
80
100
Time (yr)

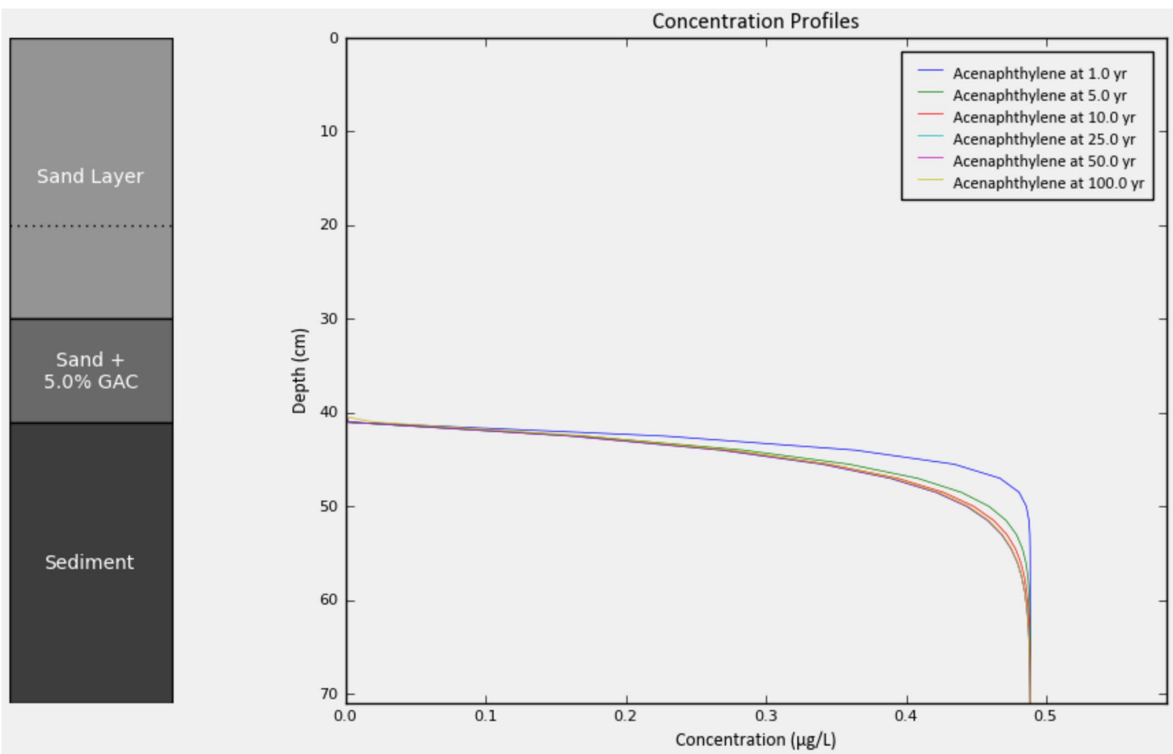
Cap Alternative 4: 11 cm of 5.0% GAC amended sand with 30 cm unamended sand layer

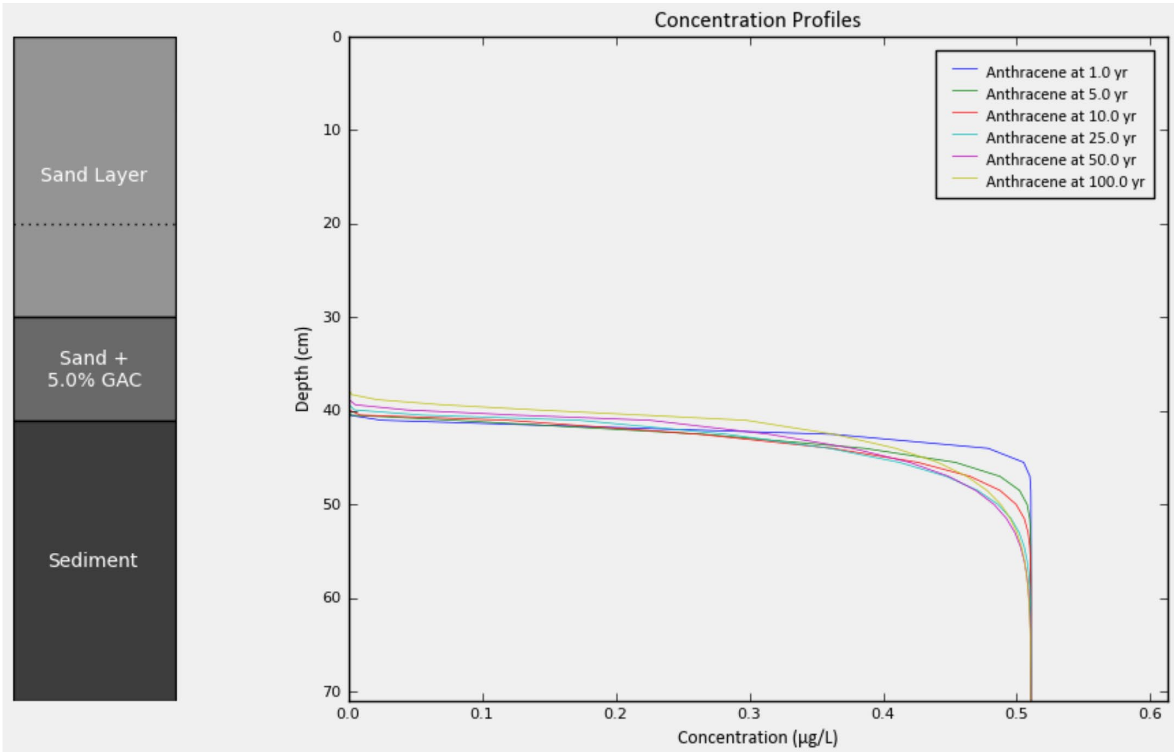
Porewater Concentration – Depth

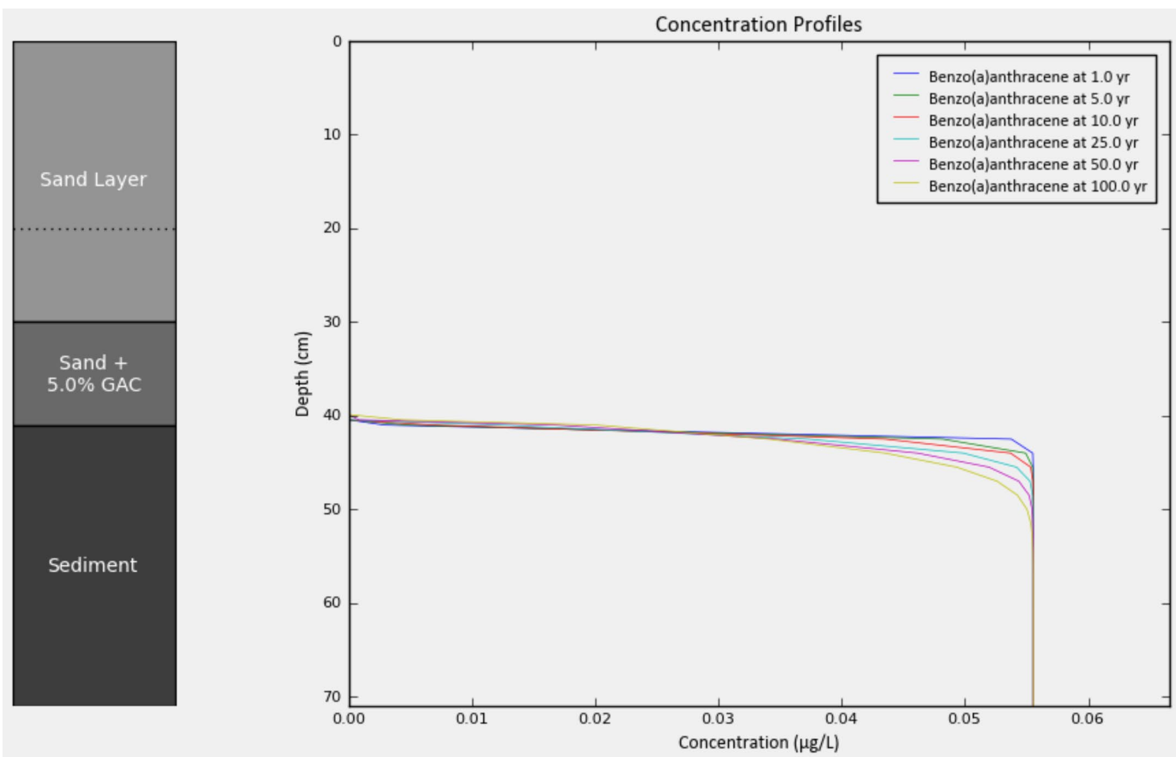


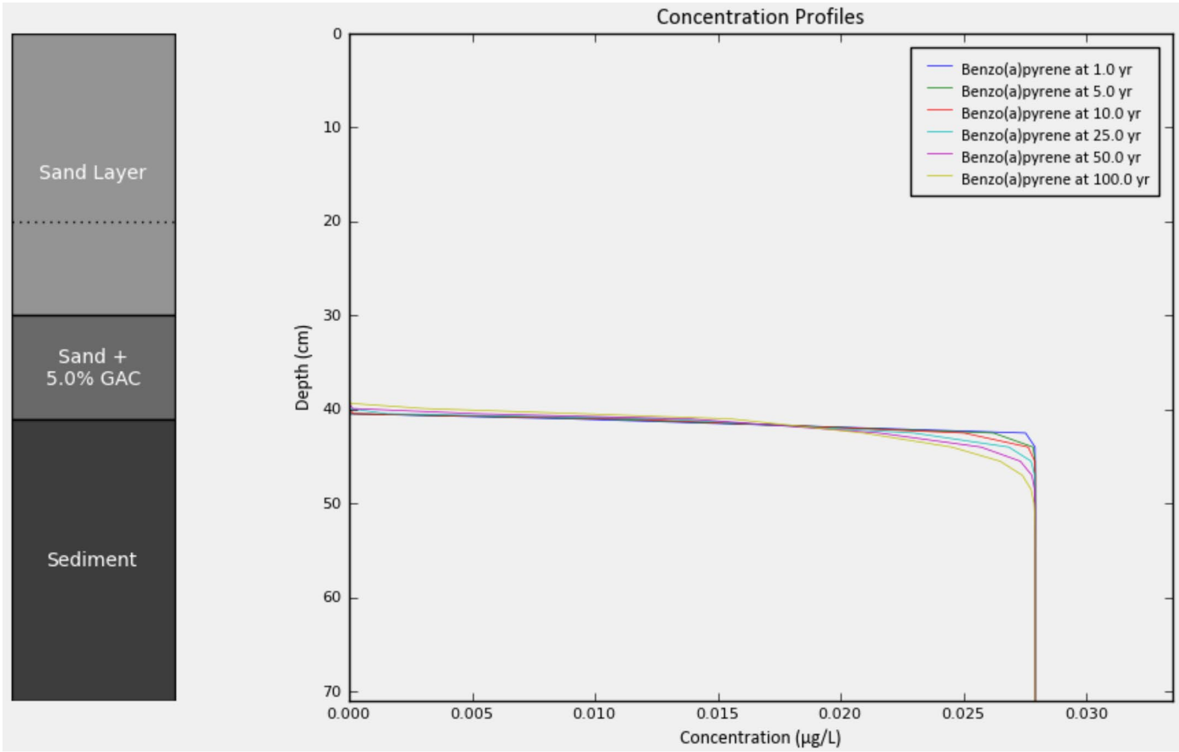


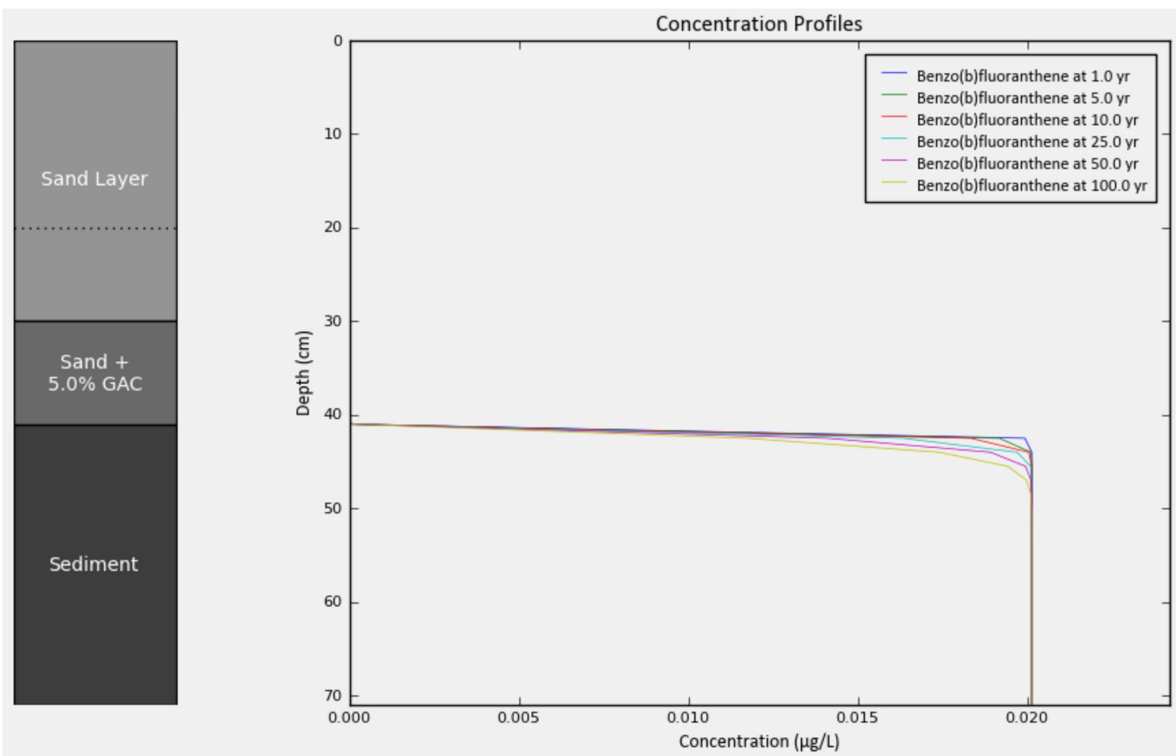

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Acenaphthene at 1.0 yr
Acenaphthene at 5.0 yr
Acenaphthene at 10.0 yr
Acenaphthene at 25.0 yr
Acenaphthene at 50.0 yr
Acenaphthene at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
10
20
30
40
50
60
70
0.0
0.5
1.0
1.5
2.0
2.5

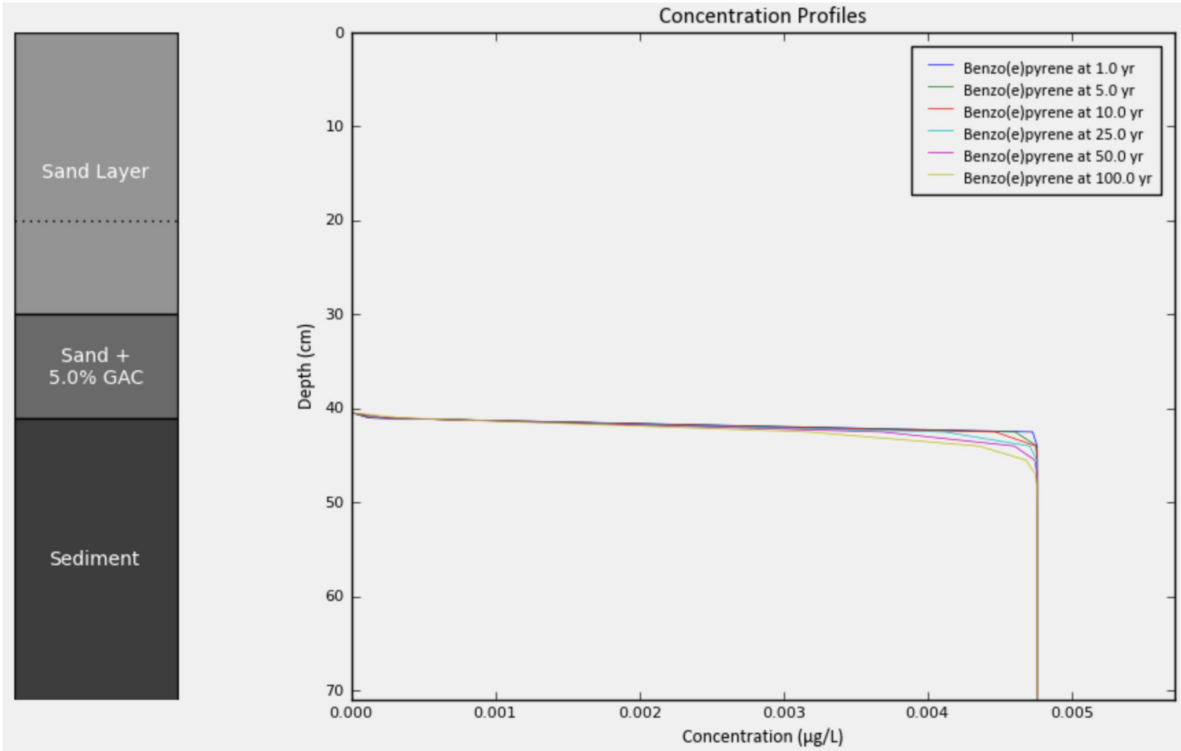

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Acenaphthylene at 1.0 yr
Acenaphthylene at 5.0 yr
Acenaphthylene at 10.0 yr
Acenaphthylene at 25.0 yr
Acenaphthylene at 50.0 yr
Acenaphthylene at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
10
20
30
40
50
60
70
0.0
0.1
0.2
0.3
0.4
0.5

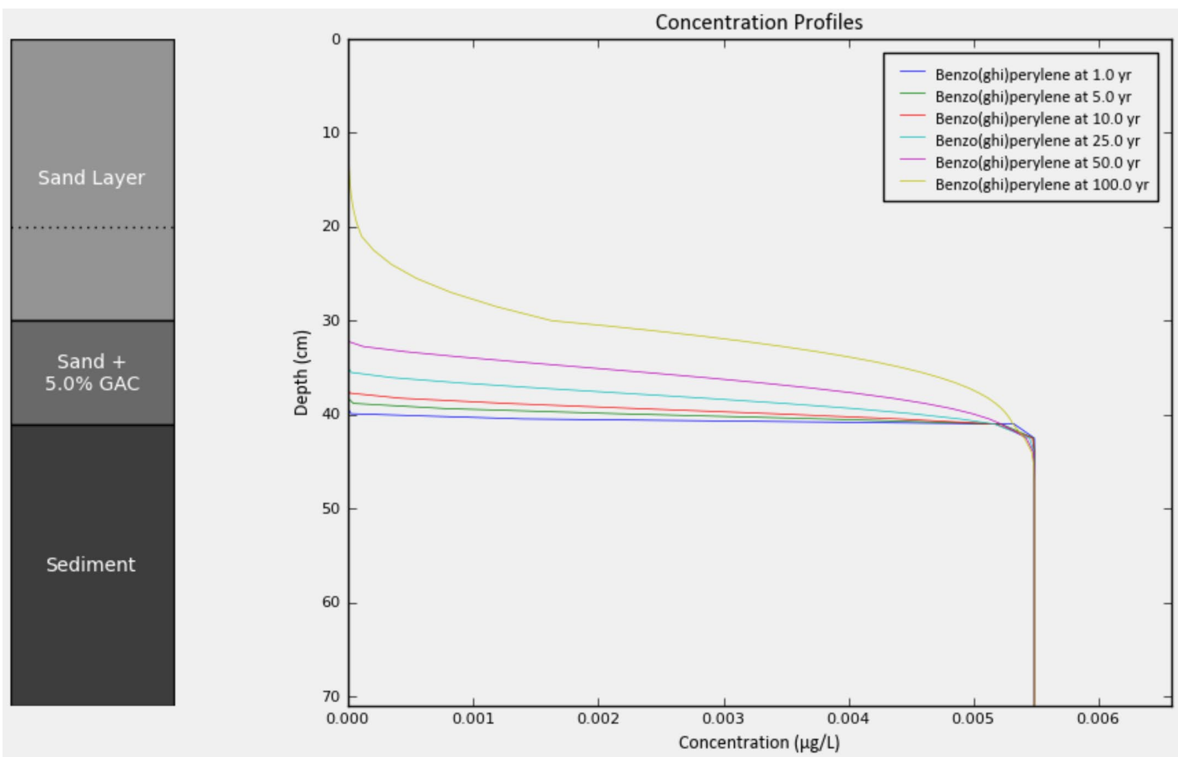

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Anthracene at 1.0 yr
Anthracene at 5.0 yr
Anthracene at 10.0 yr
Anthracene at 25.0 yr
Anthracene at 50.0 yr
Anthracene at 100.0 yr
Depth (cm)
Concentration (µg/L)

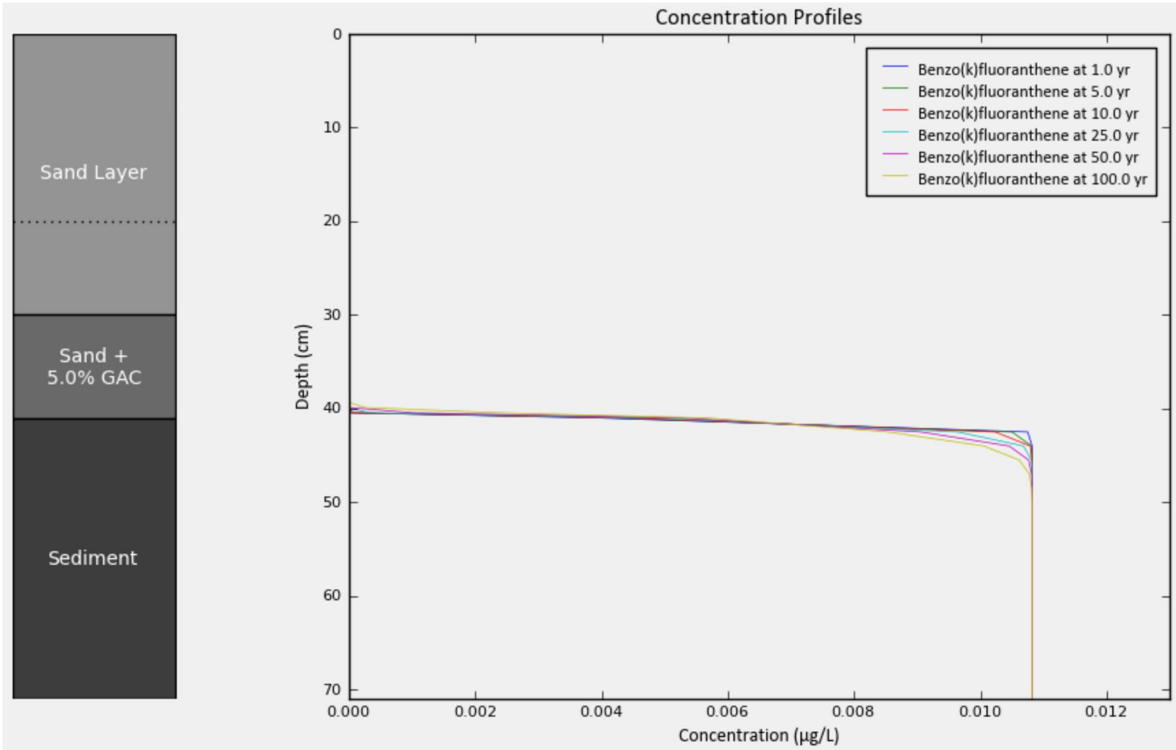

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Benzo(a)anthracene at 1.0 yr
Benzo(a)anthracene at 5.0 yr
Benzo(a)anthracene at 10.0 yr
Benzo(a)anthracene at 25.0 yr
Benzo(a)anthracene at 50.0 yr
Benzo(a)anthracene at 100.0 yr
Depth (cm)
Concentration (µg/L)

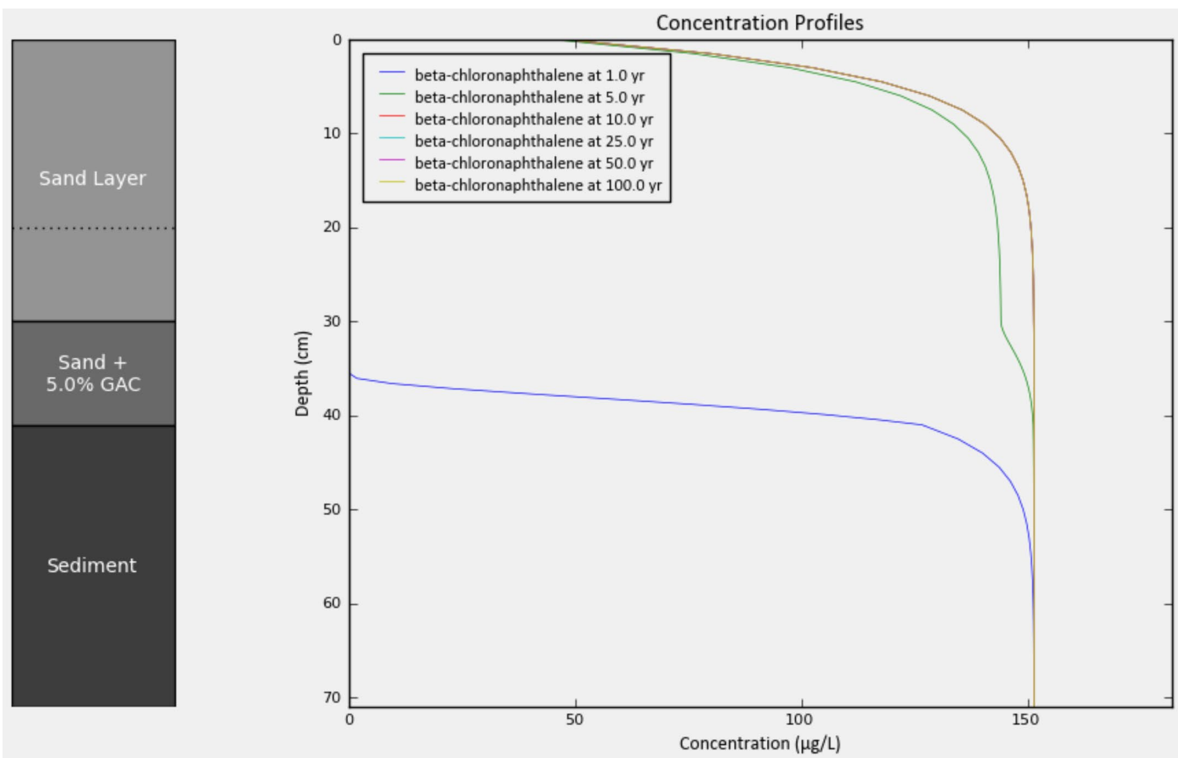

Concentration Profiles
Sand Layer
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(a)pyrene at 1.0 yr
Benzo(a)pyrene at 5.0 yr
Benzo(a)pyrene at 10.0 yr
Benzo(a)pyrene at 25.0 yr
Benzo(a)pyrene at 50.0 yr
Benzo(a)pyrene at 100.0 yr

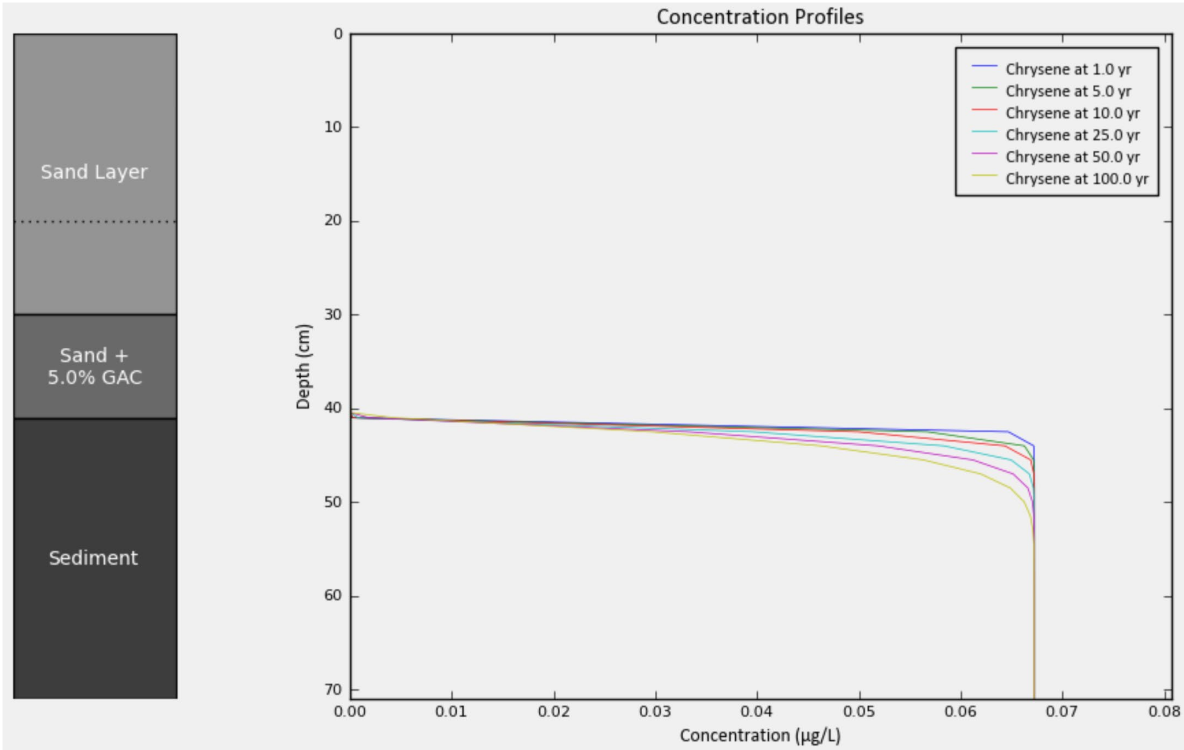

Concentration Profiles
Sand Layer
Sand + 5.0% GAC
Sediment
Depth (cm)
Concentration (µg/L)
Benzo(b)fluoranthene at 1.0 yr
Benzo(b)fluoranthene at 5.0 yr
Benzo(b)fluoranthene at 10.0 yr
Benzo(b)fluoranthene at 25.0 yr
Benzo(b)fluoranthene at 50.0 yr
Benzo(b)fluoranthene at 100.0 yr

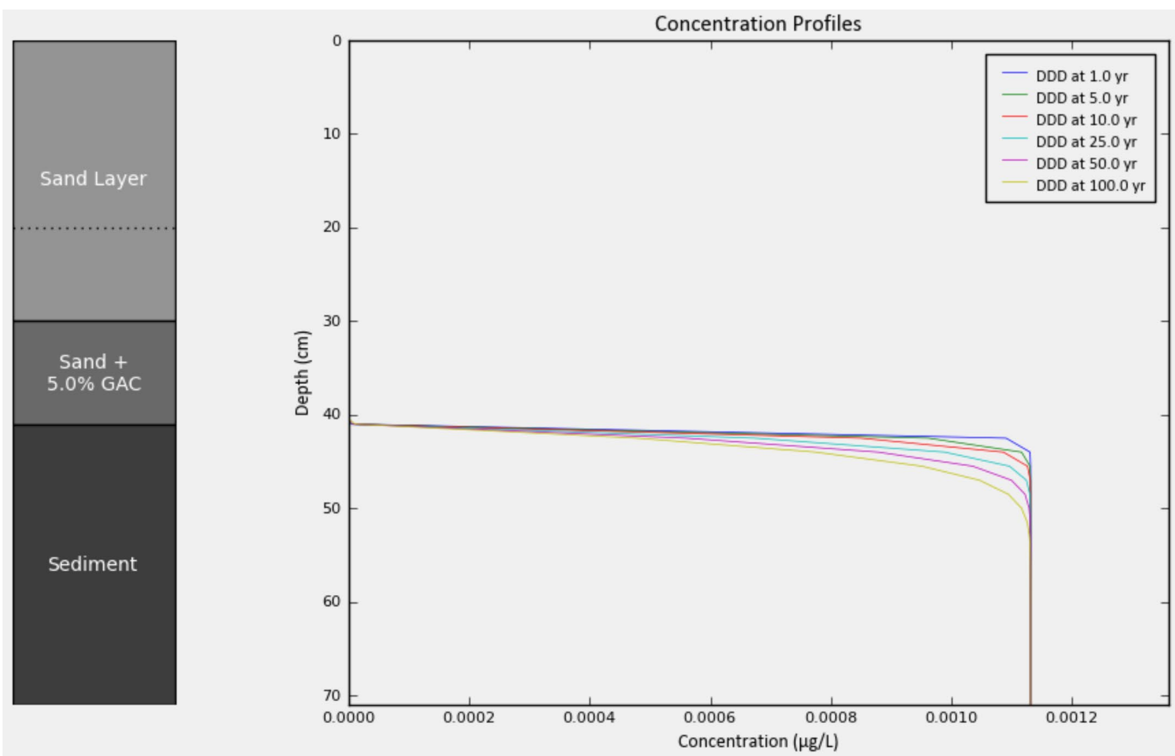

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Benzo(e)pyrene at 1.0 yr
Benzo(e)pyrene at 5.0 yr
Benzo(e)pyrene at 10.0 yr
Benzo(e)pyrene at 25.0 yr
Benzo(e)pyrene at 50.0 yr
Benzo(e)pyrene at 100.0 yr
Depth (cm)
Concentration (µg/L)

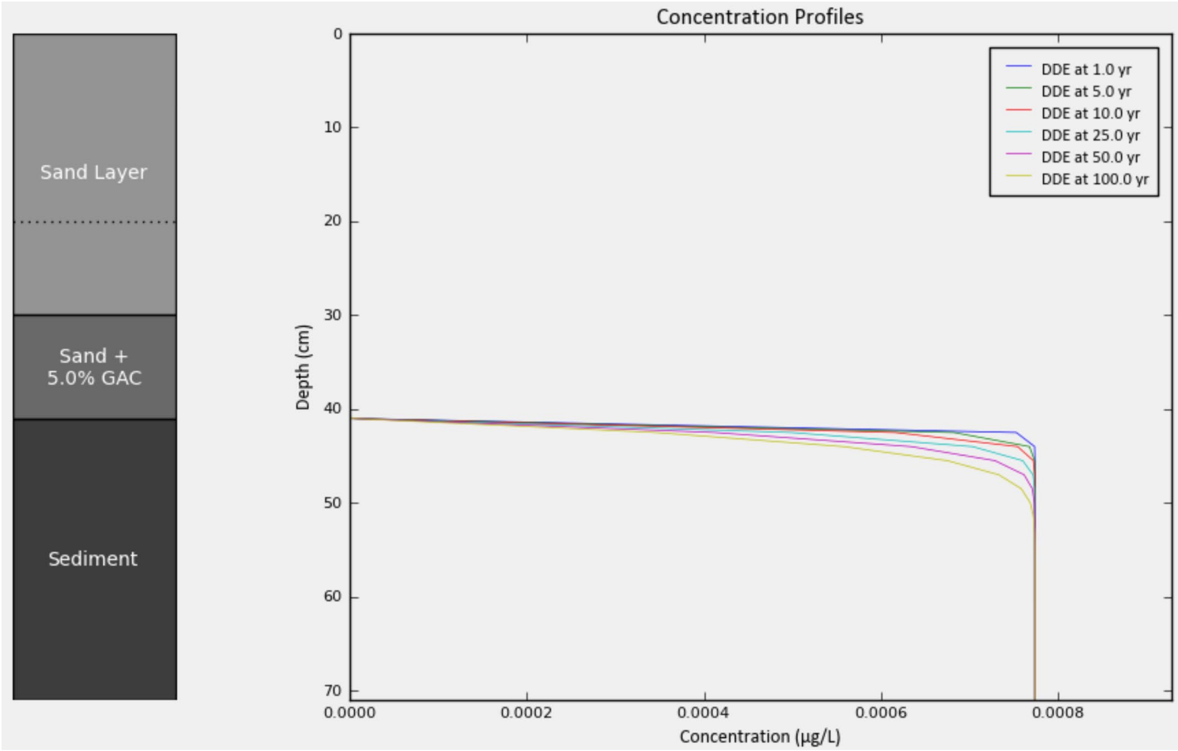

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Benzo(ghi)perylene at 1.0 yr
Benzo(ghi)perylene at 5.0 yr
Benzo(ghi)perylene at 10.0 yr
Benzo(ghi)perylene at 25.0 yr
Benzo(ghi)perylene at 50.0 yr
Benzo(ghi)perylene at 100.0 yr
Depth (cm)
Concentration (µg/L)

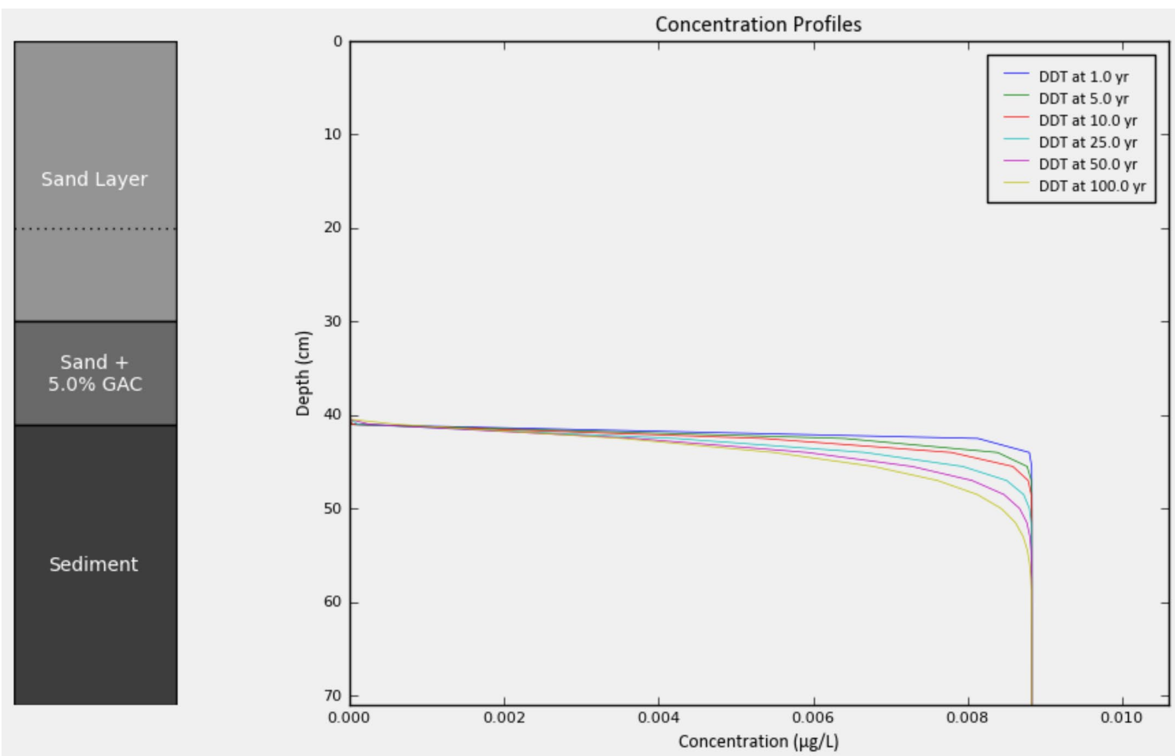

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Benzo(k)fluoranthene at 1.0 yr
Benzo(k)fluoranthene at 5.0 yr
Benzo(k)fluoranthene at 10.0 yr
Benzo(k)fluoranthene at 25.0 yr
Benzo(k)fluoranthene at 50.0 yr
Benzo(k)fluoranthene at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
70
0.000
0.002
0.004
0.006
0.008
0.010
0.012
Concentration (μg/L)

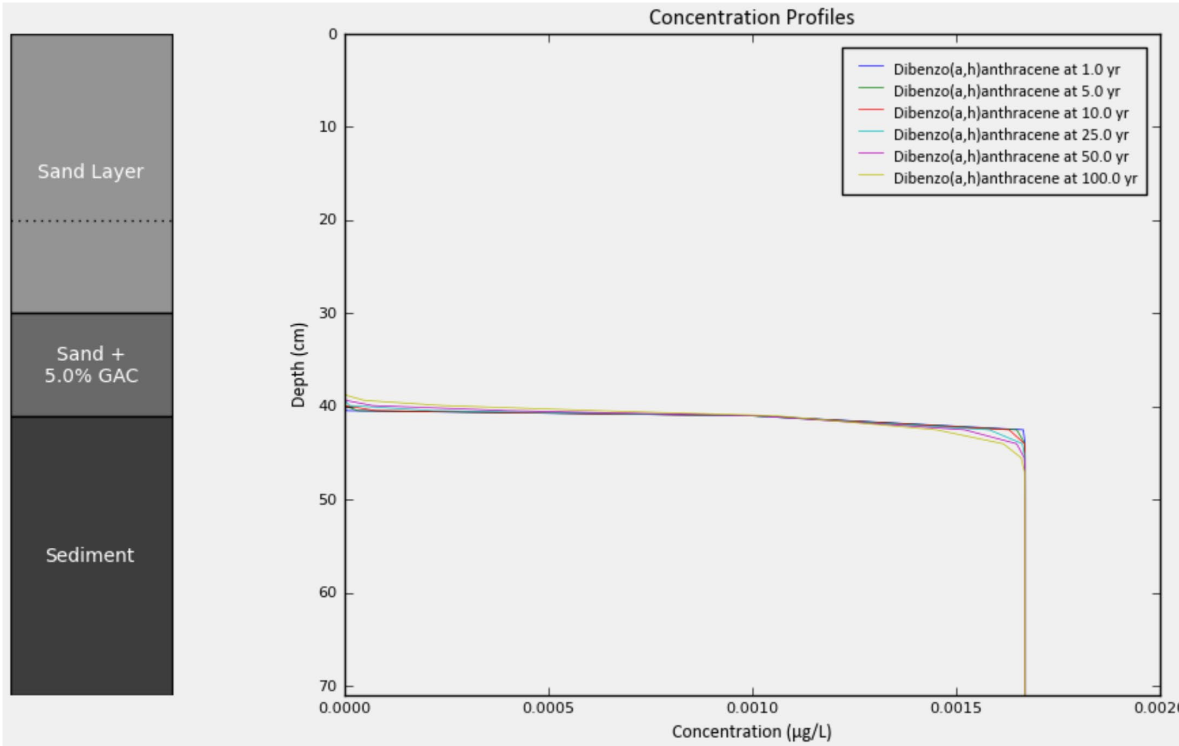

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
beta-chloronaphthalene at 1.0 yr
beta-chloronaphthalene at 5.0 yr
beta-chloronaphthalene at 10.0 yr
beta-chloronaphthalene at 25.0 yr
beta-chloronaphthalene at 50.0 yr
beta-chloronaphthalene at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
70
0
50
100
150
Concentration (μg/L)

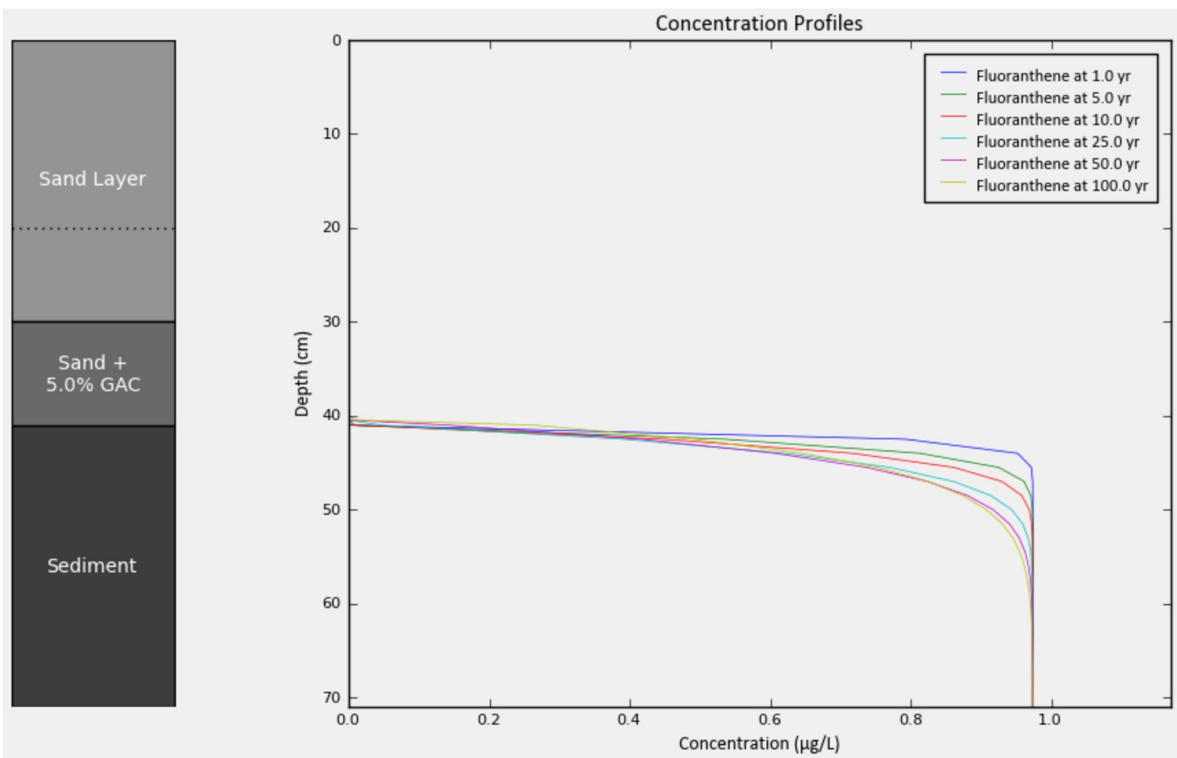

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Chrysene at 1.0 yr
Chrysene at 5.0 yr
Chrysene at 10.0 yr
Chrysene at 25.0 yr
Chrysene at 50.0 yr
Chrysene at 100.0 yr
Depth (cm)
Concentration (μg/L)

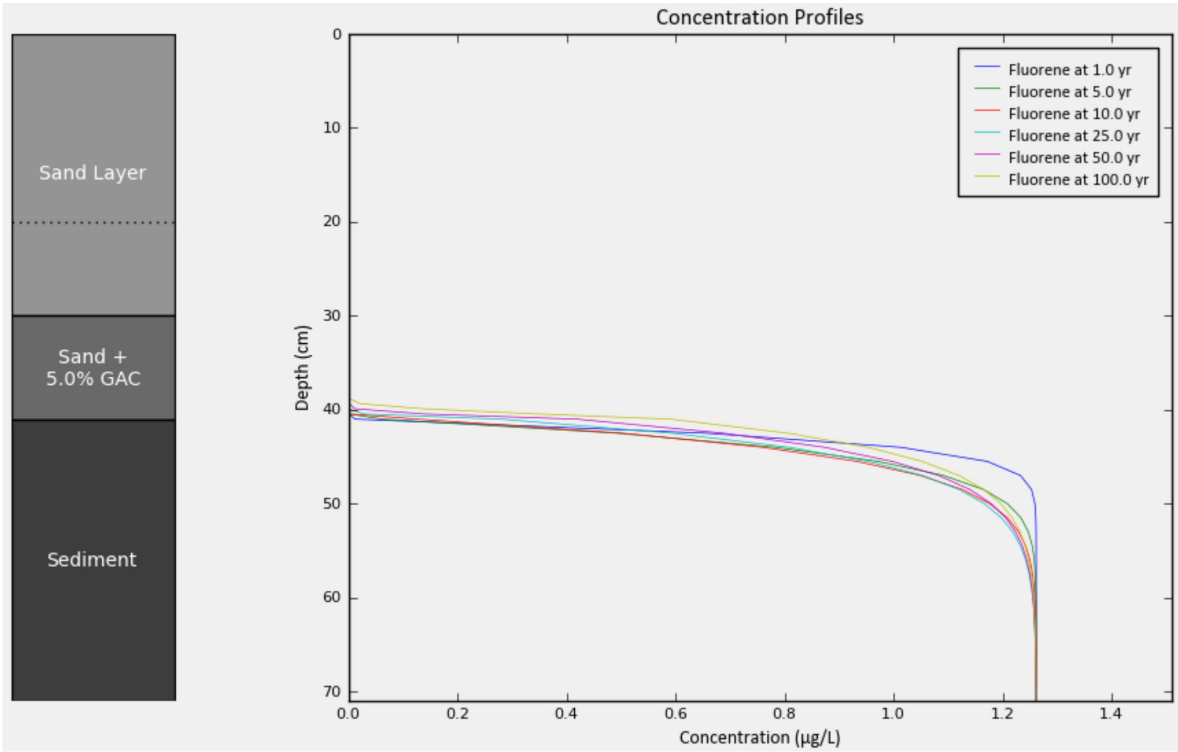

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
DDD at 1.0 yr
DDD at 5.0 yr
DDD at 10.0 yr
DDD at 25.0 yr
DDD at 50.0 yr
DDD at 100.0 yr
Depth (cm)
Concentration (μg/L)

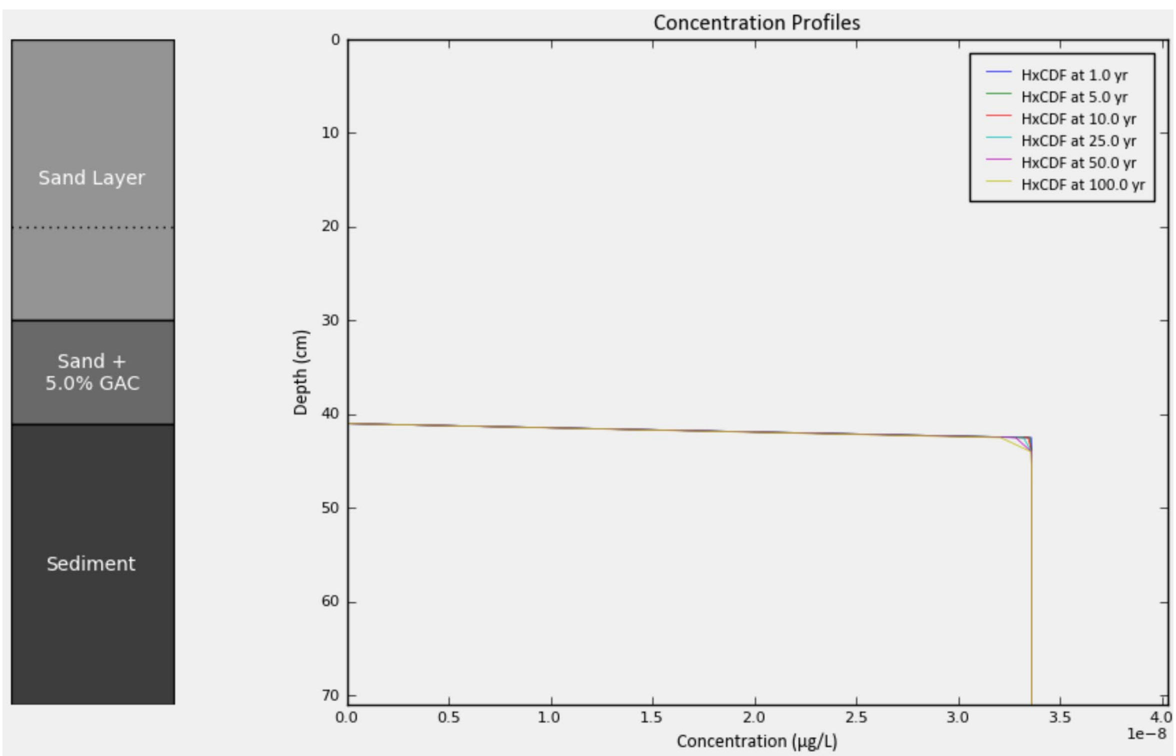

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
DDE at 1.0 yr
DDE at 5.0 yr
DDE at 10.0 yr
DDE at 25.0 yr
DDE at 50.0 yr
DDE at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
70
0.0000
0.0002
0.0004
0.0006
0.0008
Concentration (μg/L)

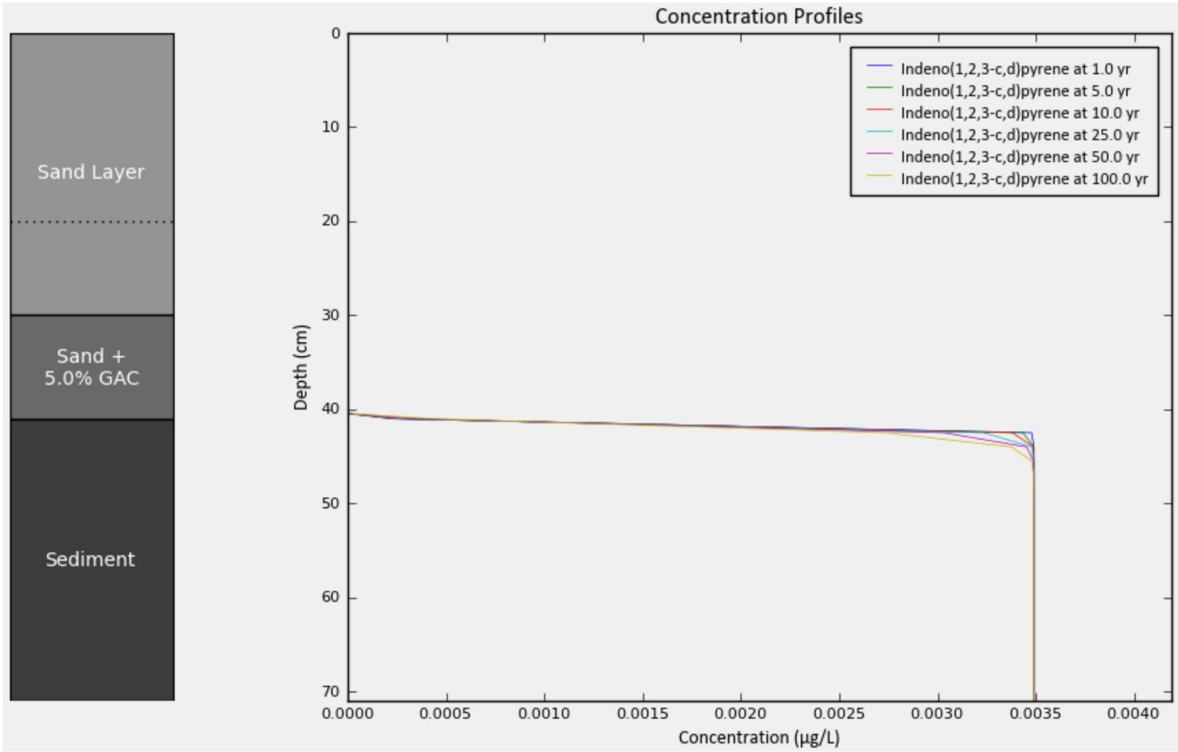

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
DDT at 1.0 yr
DDT at 5.0 yr
DDT at 10.0 yr
DDT at 25.0 yr
DDT at 50.0 yr
DDT at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
70
0.000
0.002
0.004
0.006
0.008
0.010
Concentration (μg/L)

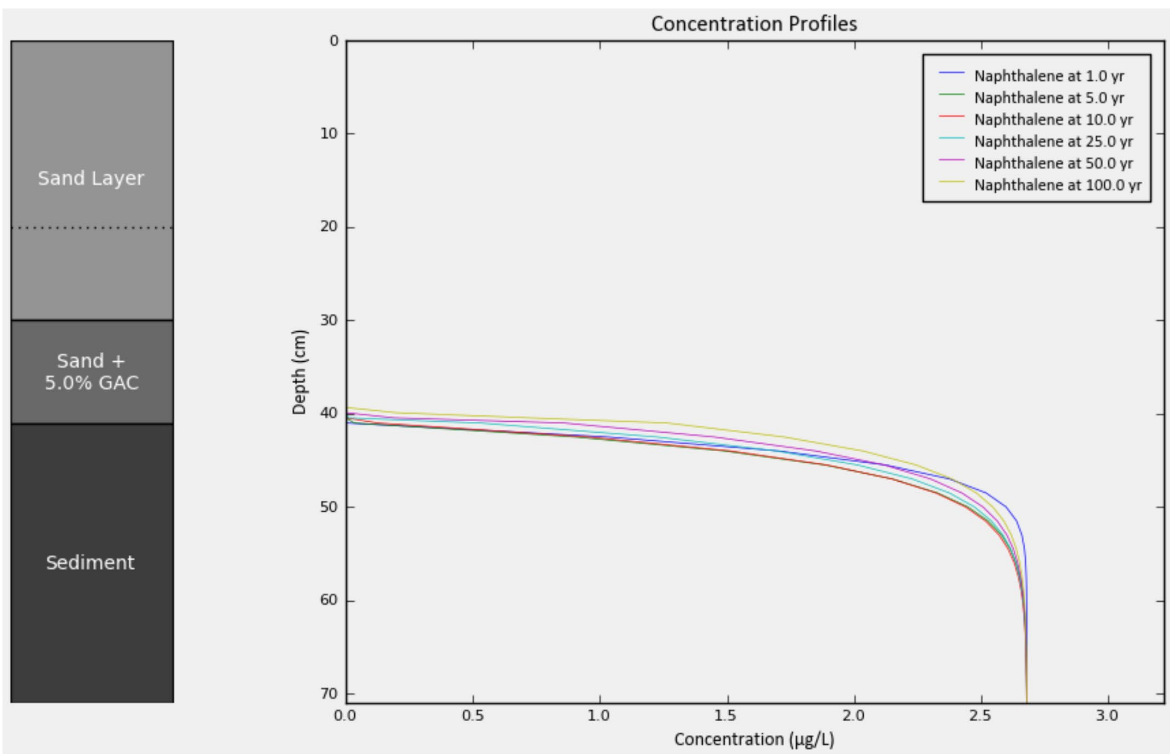

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Dibenzo(a,h)anthracene at 1.0 yr
Dibenzo(a,h)anthracene at 5.0 yr
Dibenzo(a,h)anthracene at 10.0 yr
Dibenzo(a,h)anthracene at 25.0 yr
Dibenzo(a,h)anthracene at 50.0 yr
Dibenzo(a,h)anthracene at 100.0 yr
Depth (cm)
Concentration (μg/L)
0
10
20
30
40
50
60
70
0.0000
0.0005
0.0010
0.0015
0.0020

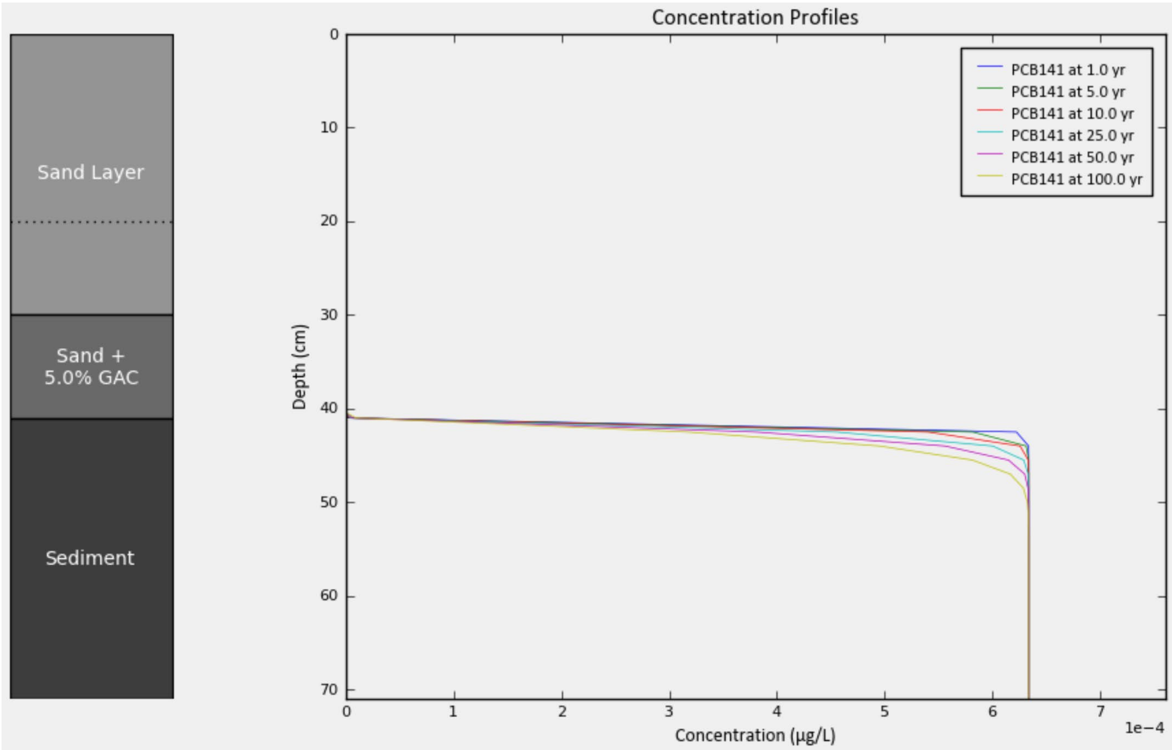

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Fluoranthene at 1.0 yr
Fluoranthene at 5.0 yr
Fluoranthene at 10.0 yr
Fluoranthene at 25.0 yr
Fluoranthene at 50.0 yr
Fluoranthene at 100.0 yr
Depth (cm)
Concentration (μg/L)
0
10
20
30
40
50
60
70
0.0
0.2
0.4
0.6
0.8
1.0

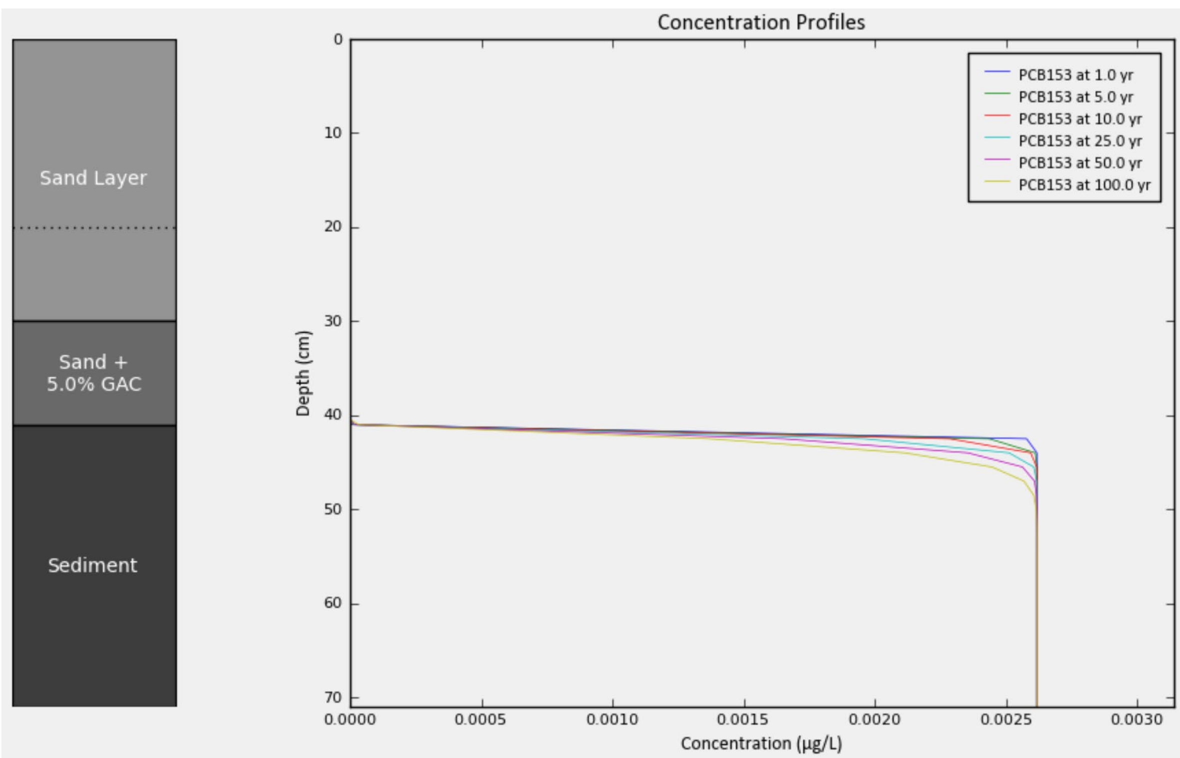

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Fluorene at 1.0 yr
Fluorene at 5.0 yr
Fluorene at 10.0 yr
Fluorene at 25.0 yr
Fluorene at 50.0 yr
Fluorene at 100.0 yr
Depth (cm)
Concentration (μg/L)

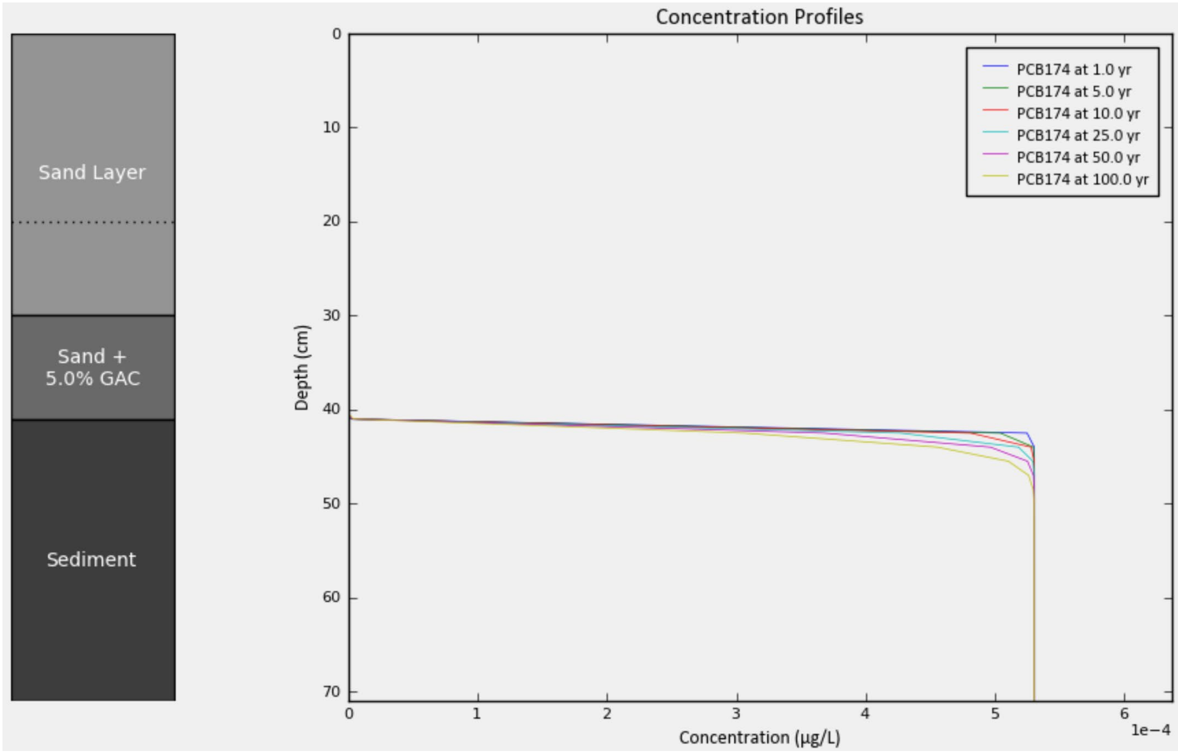

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
HxCDF at 1.0 yr
HxCDF at 5.0 yr
HxCDF at 10.0 yr
HxCDF at 25.0 yr
HxCDF at 50.0 yr
HxCDF at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−8

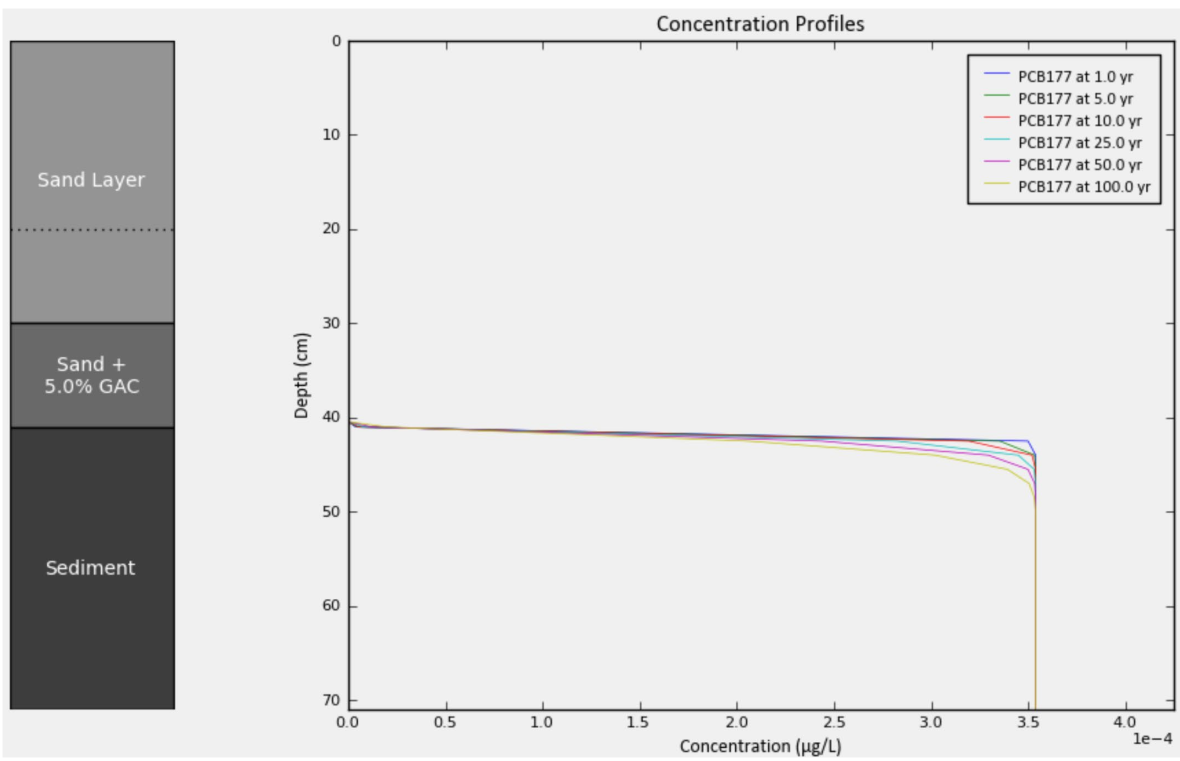

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Indeno(1,2,3-c,d)pyrene at 1.0 yr
Indeno(1,2,3-c,d)pyrene at 5.0 yr
Indeno(1,2,3-c,d)pyrene at 10.0 yr
Indeno(1,2,3-c,d)pyrene at 25.0 yr
Indeno(1,2,3-c,d)pyrene at 50.0 yr
Indeno(1,2,3-c,d)pyrene at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
70
0.0000
0.0005
0.0010
0.0015
0.0020
0.0025
0.0030
0.0035
0.0040
Concentration (µg/L)

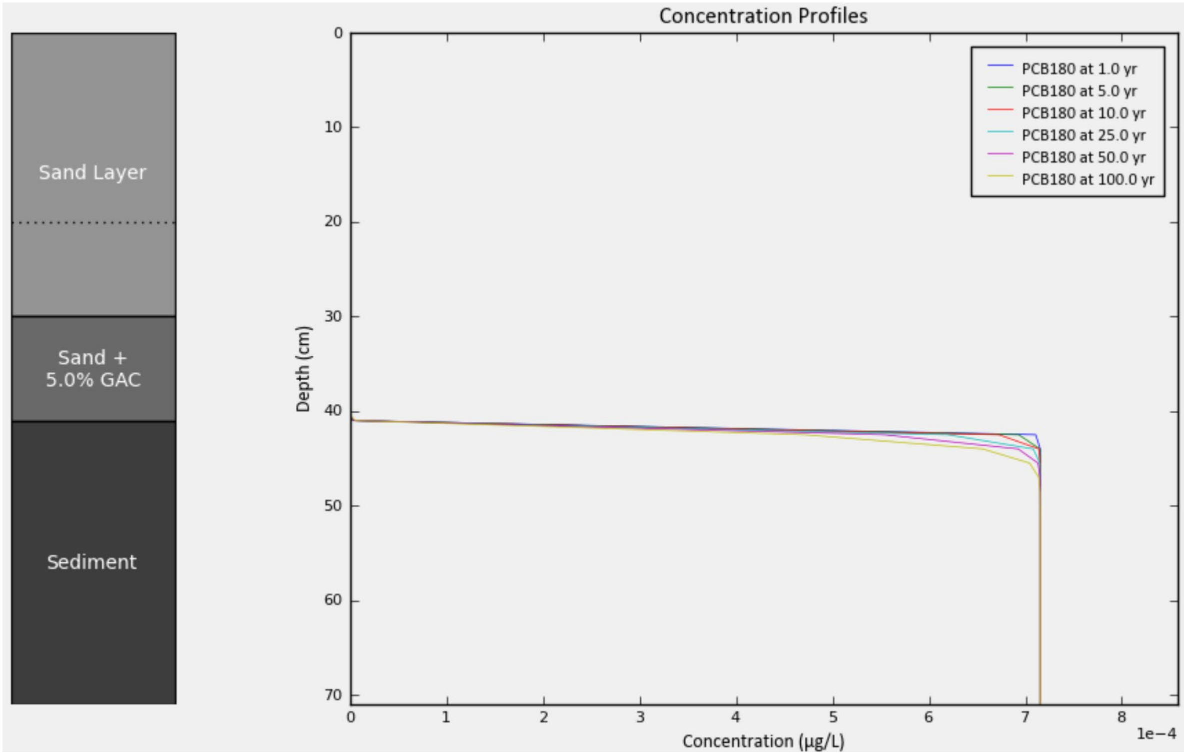

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Naphthalene at 1.0 yr
Naphthalene at 5.0 yr
Naphthalene at 10.0 yr
Naphthalene at 25.0 yr
Naphthalene at 50.0 yr
Naphthalene at 100.0 yr
Depth (cm)
0
10
20
30
40
50
60
70
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Concentration (µg/L)

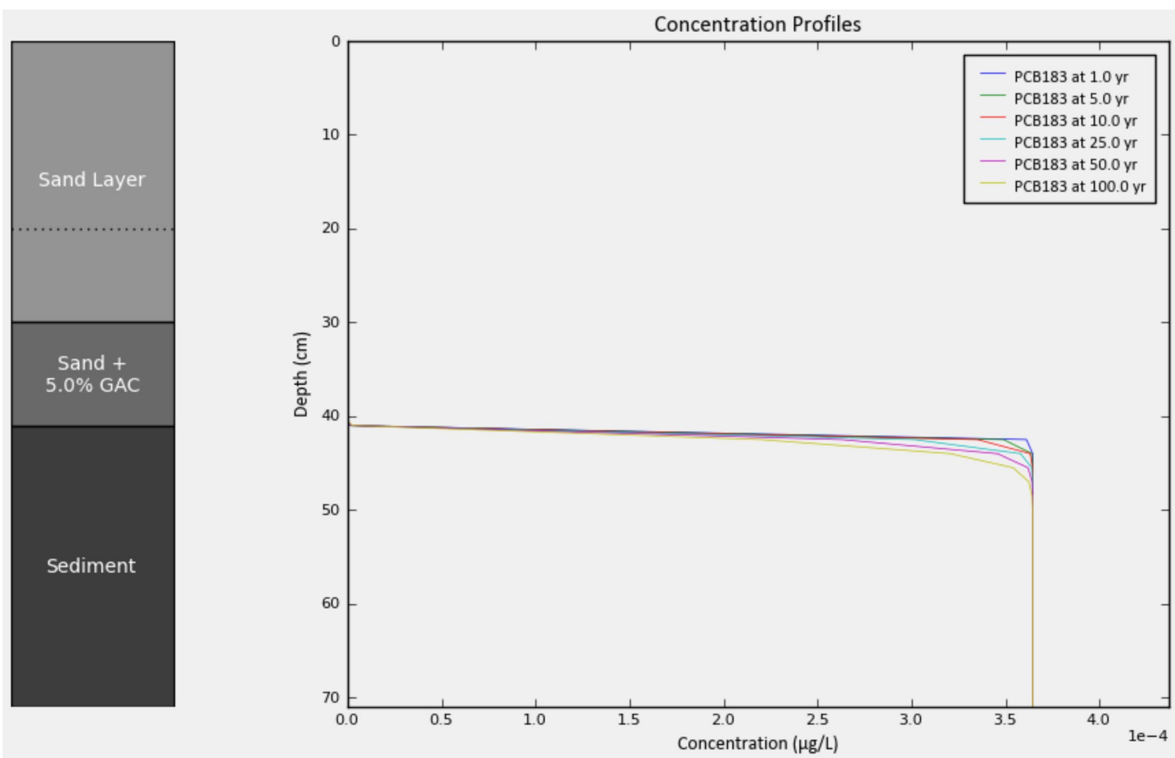

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB141 at 1.0 yr
PCB141 at 5.0 yr
PCB141 at 10.0 yr
PCB141 at 25.0 yr
PCB141 at 50.0 yr
PCB141 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

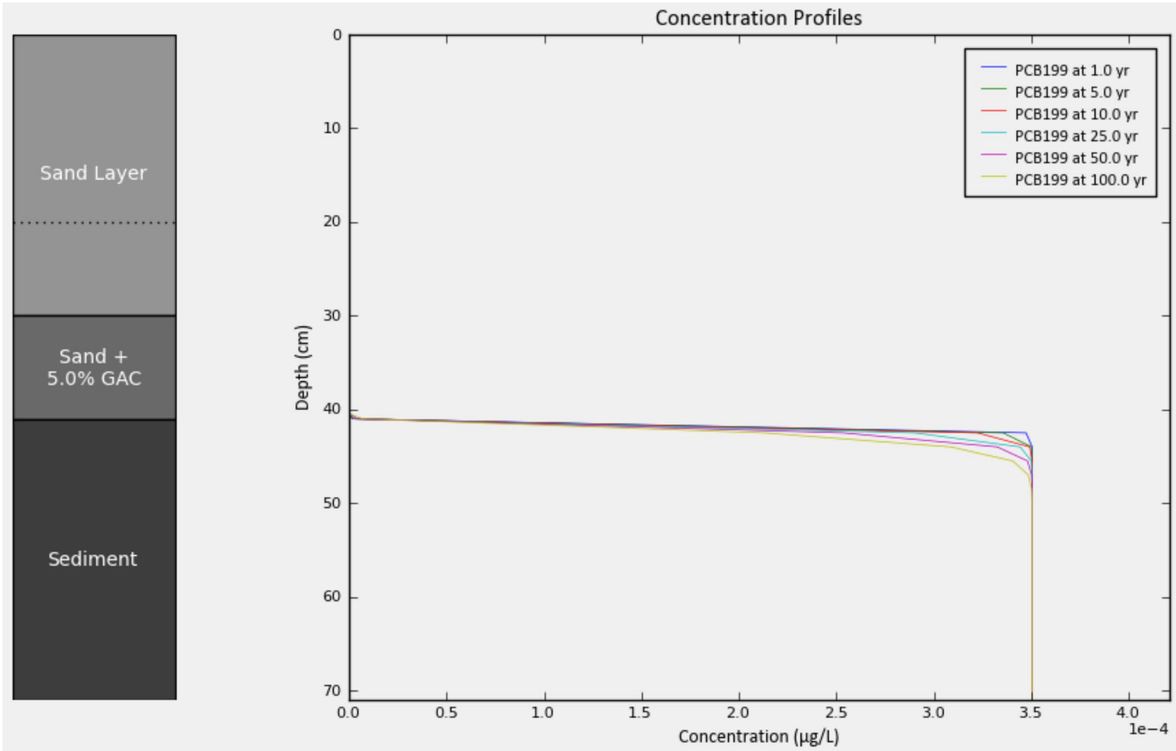

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB153 at 1.0 yr
PCB153 at 5.0 yr
PCB153 at 10.0 yr
PCB153 at 25.0 yr
PCB153 at 50.0 yr
PCB153 at 100.0 yr
Depth (cm)
Concentration (µg/L)

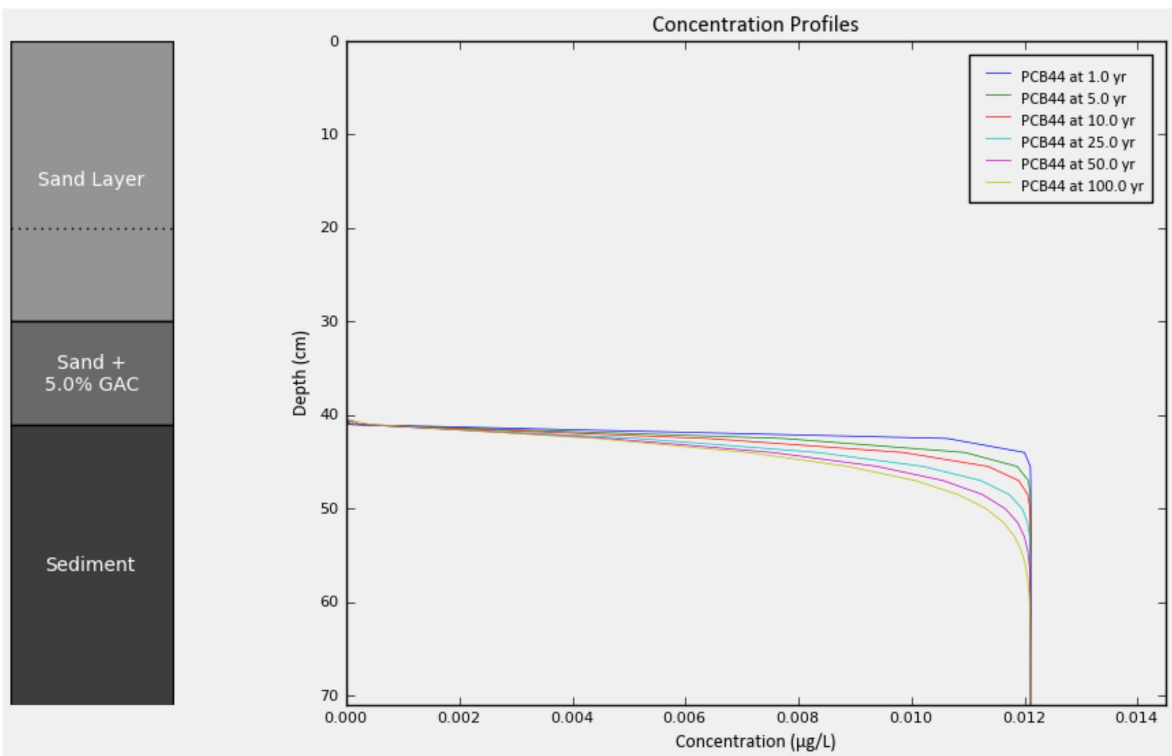

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
PCB174 at 1.0 yr
PCB174 at 5.0 yr
PCB174 at 10.0 yr
PCB174 at 25.0 yr
PCB174 at 50.0 yr
PCB174 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

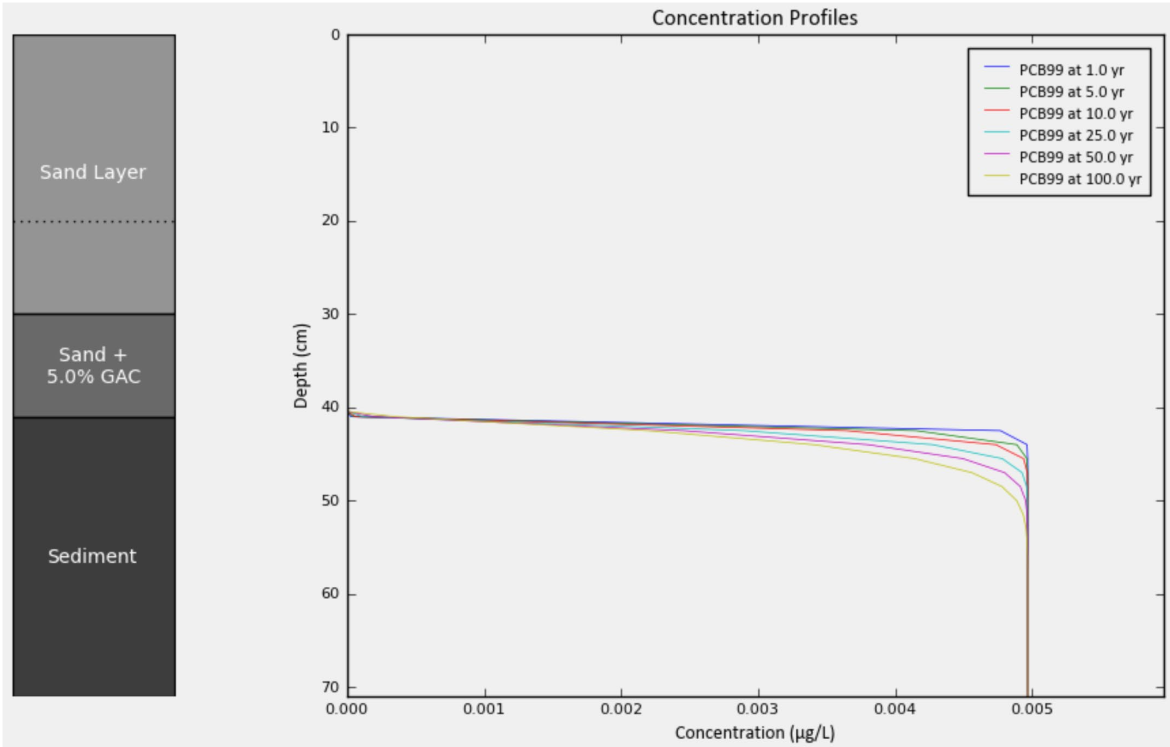

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
PCB177 at 1.0 yr
PCB177 at 5.0 yr
PCB177 at 10.0 yr
PCB177 at 25.0 yr
PCB177 at 50.0 yr
PCB177 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

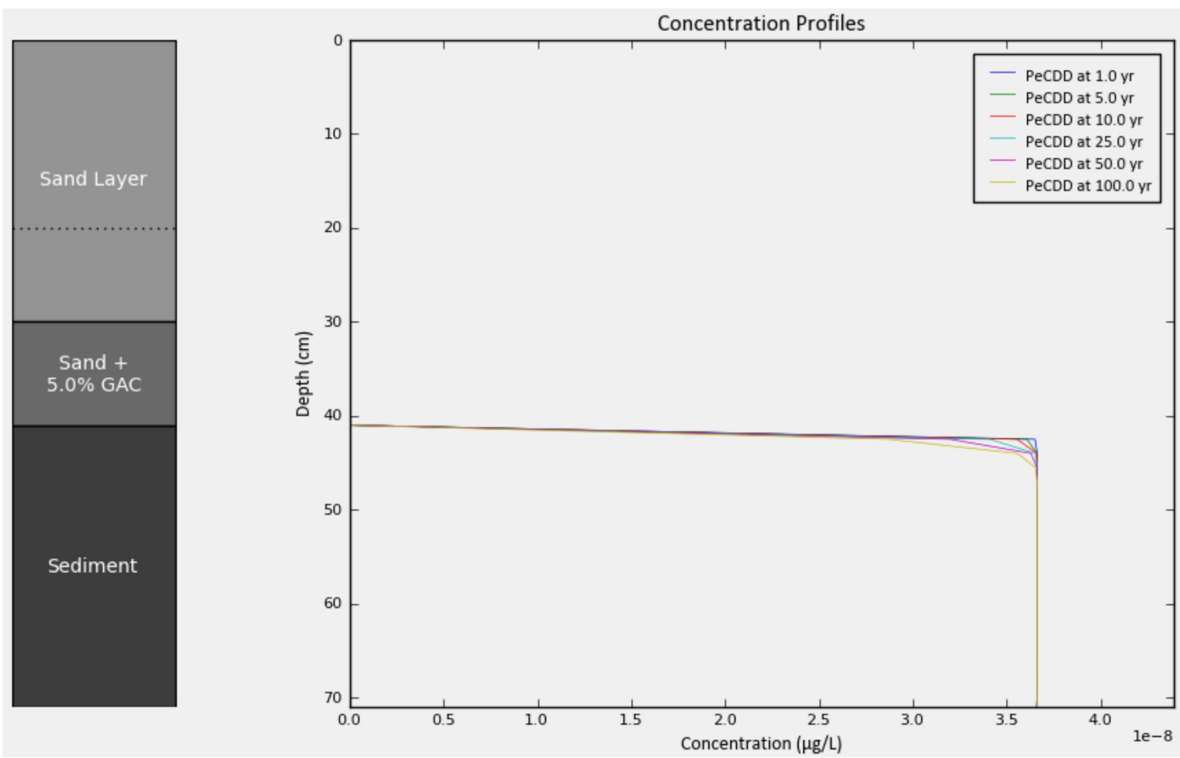

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB180 at 1.0 yr
PCB180 at 5.0 yr
PCB180 at 10.0 yr
PCB180 at 25.0 yr
PCB180 at 50.0 yr
PCB180 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

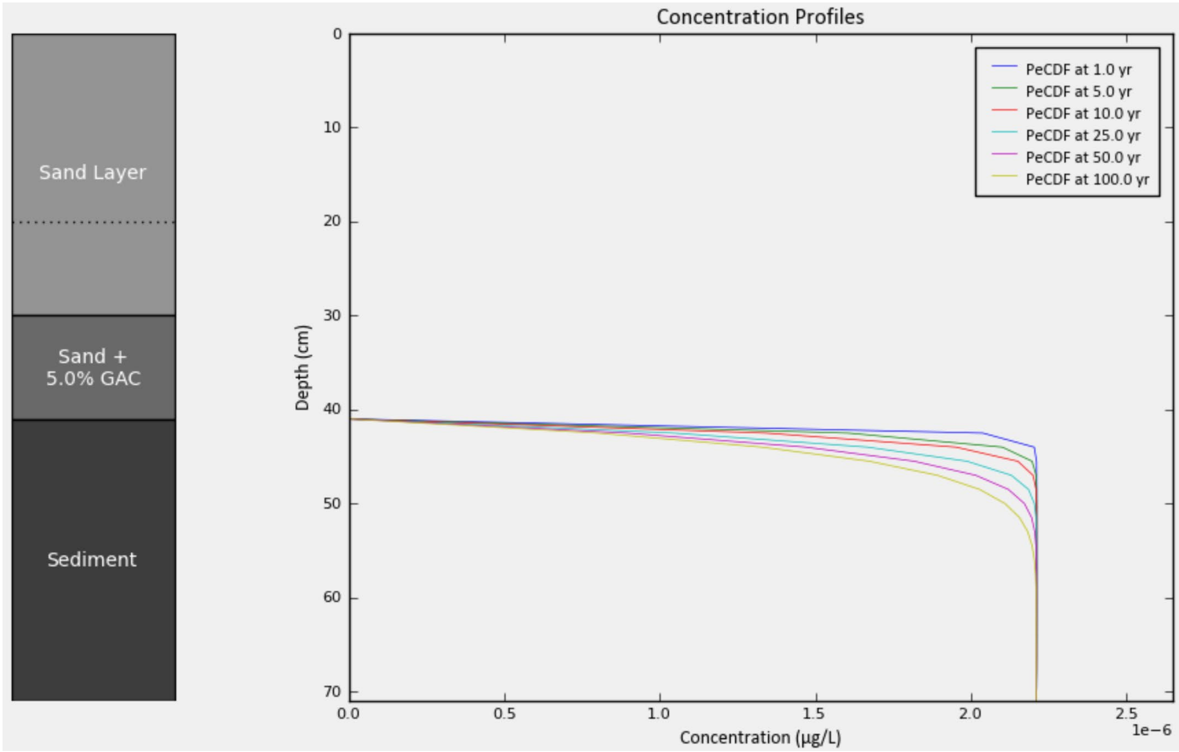

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB183 at 1.0 yr
PCB183 at 5.0 yr
PCB183 at 10.0 yr
PCB183 at 25.0 yr
PCB183 at 50.0 yr
PCB183 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

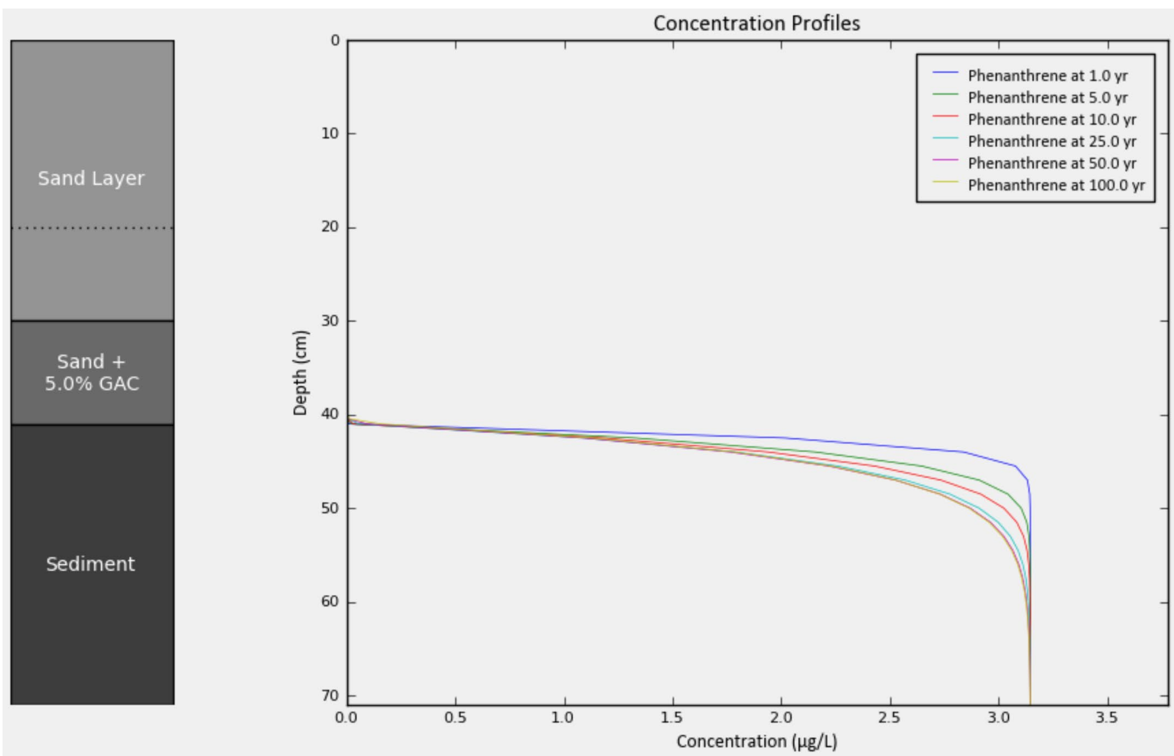

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB199 at 1.0 yr
PCB199 at 5.0 yr
PCB199 at 10.0 yr
PCB199 at 25.0 yr
PCB199 at 50.0 yr
PCB199 at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−4

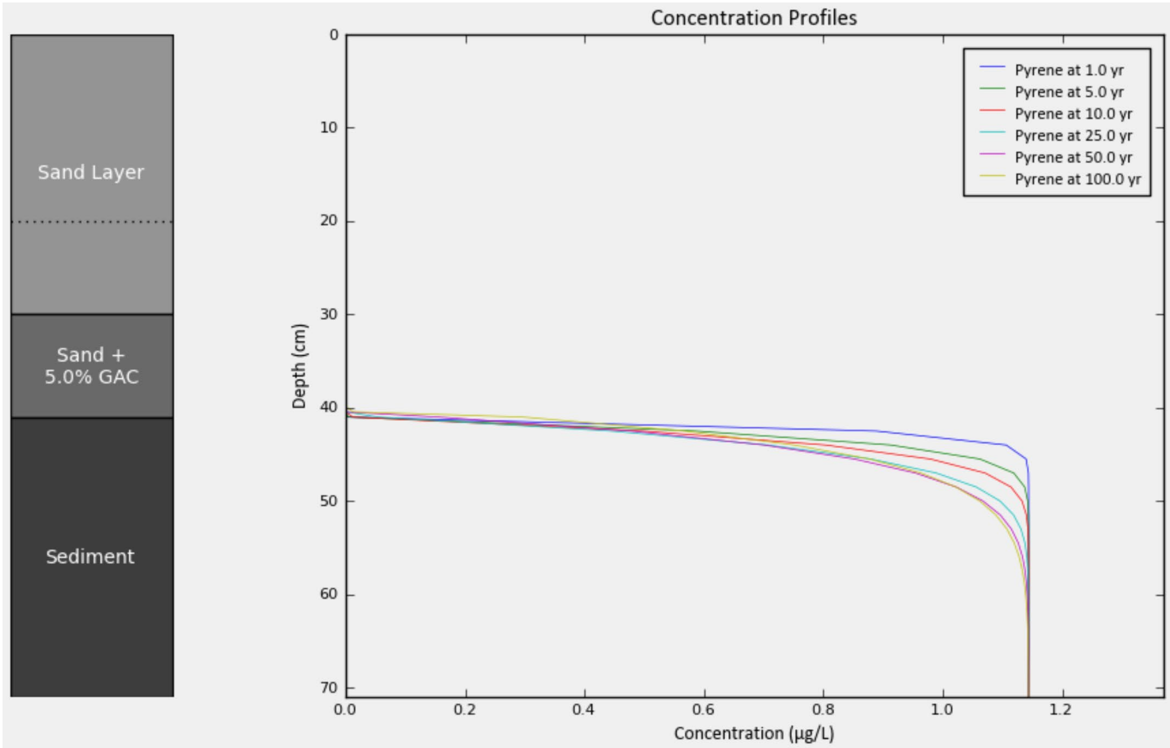

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB44 at 1.0 yr
PCB44 at 5.0 yr
PCB44 at 10.0 yr
PCB44 at 25.0 yr
PCB44 at 50.0 yr
PCB44 at 100.0 yr
Depth (cm)
Concentration (µg/L)

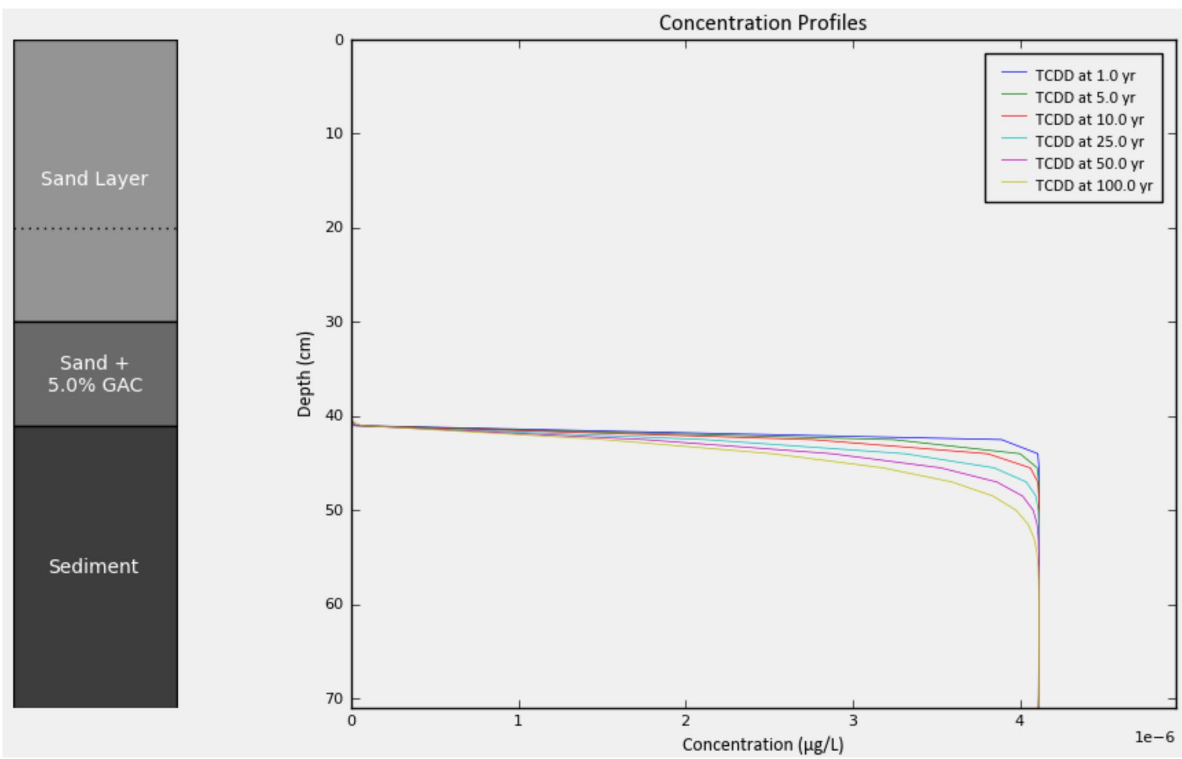

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PCB99 at 1.0 yr
PCB99 at 5.0 yr
PCB99 at 10.0 yr
PCB99 at 25.0 yr
PCB99 at 50.0 yr
PCB99 at 100.0 yr
Depth (cm)
Concentration (µg/L)
0
10
20
30
40
50
60
70
0.000
0.001
0.002
0.003
0.004
0.005

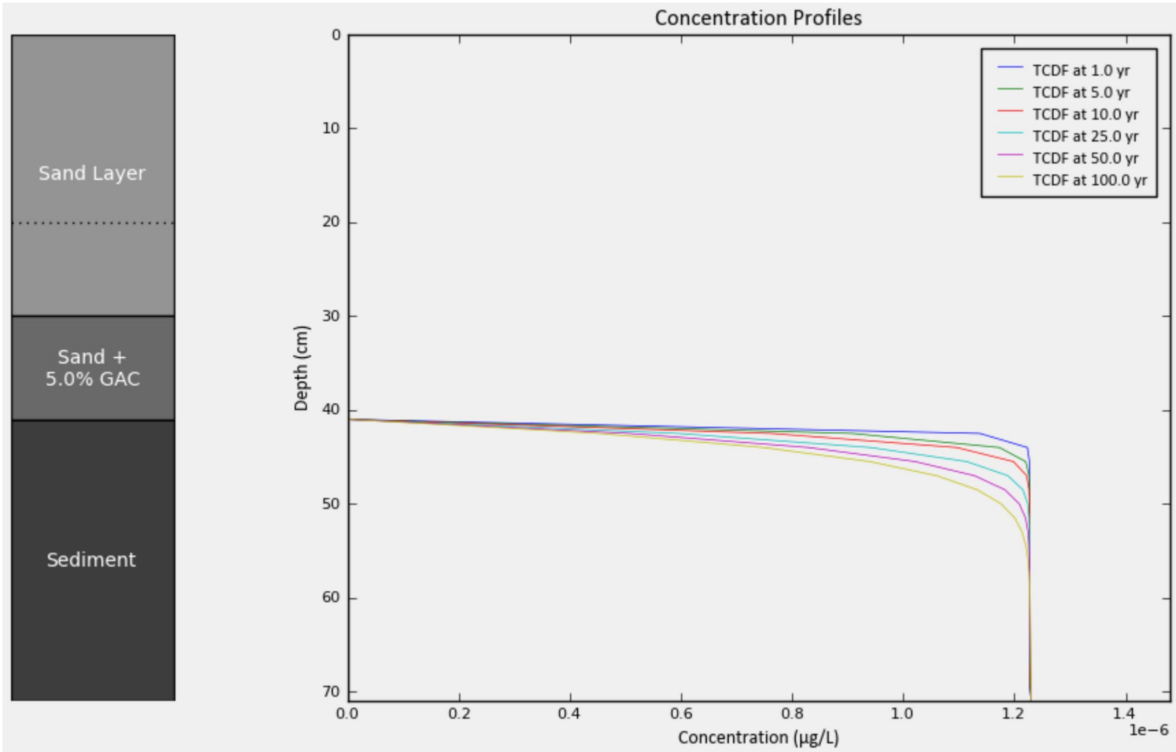

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PeCDD at 1.0 yr
PeCDD at 5.0 yr
PeCDD at 10.0 yr
PeCDD at 25.0 yr
PeCDD at 50.0 yr
PeCDD at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−8
0
10
20
30
40
50
60
70
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

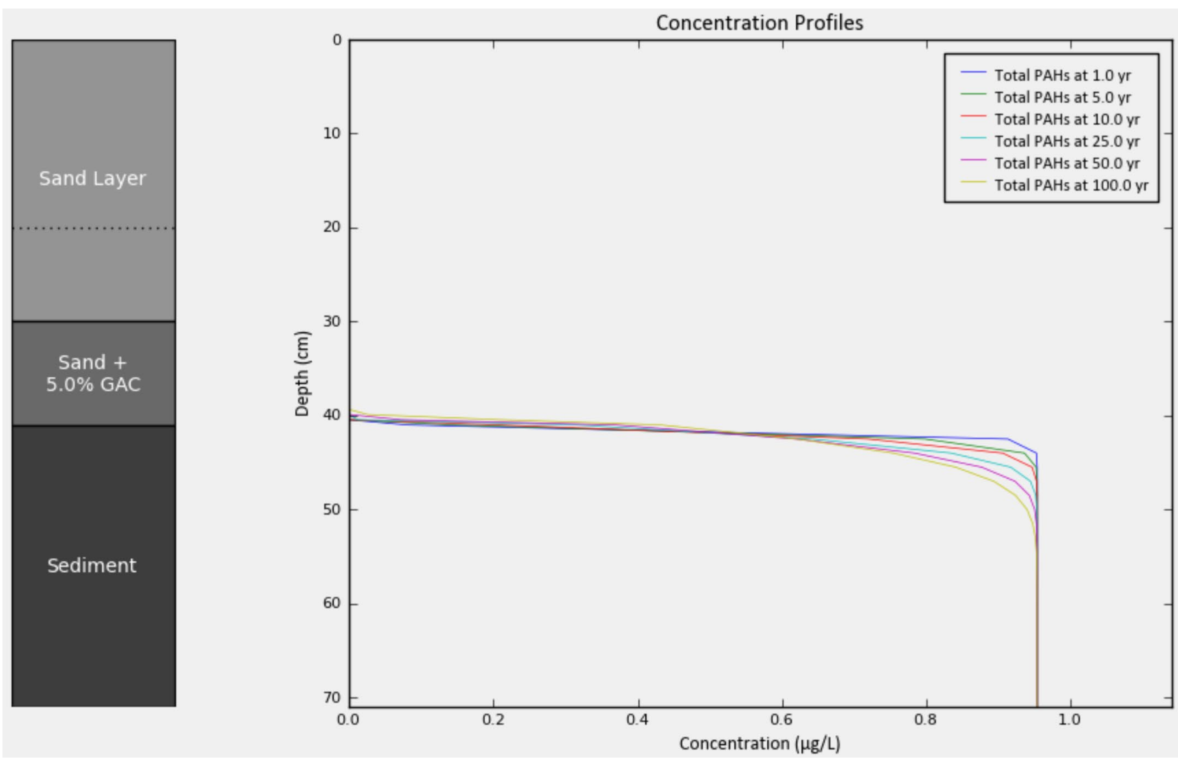

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
PeCDF at 1.0 yr
PeCDF at 5.0 yr
PeCDF at 10.0 yr
PeCDF at 25.0 yr
PeCDF at 50.0 yr
PeCDF at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−6

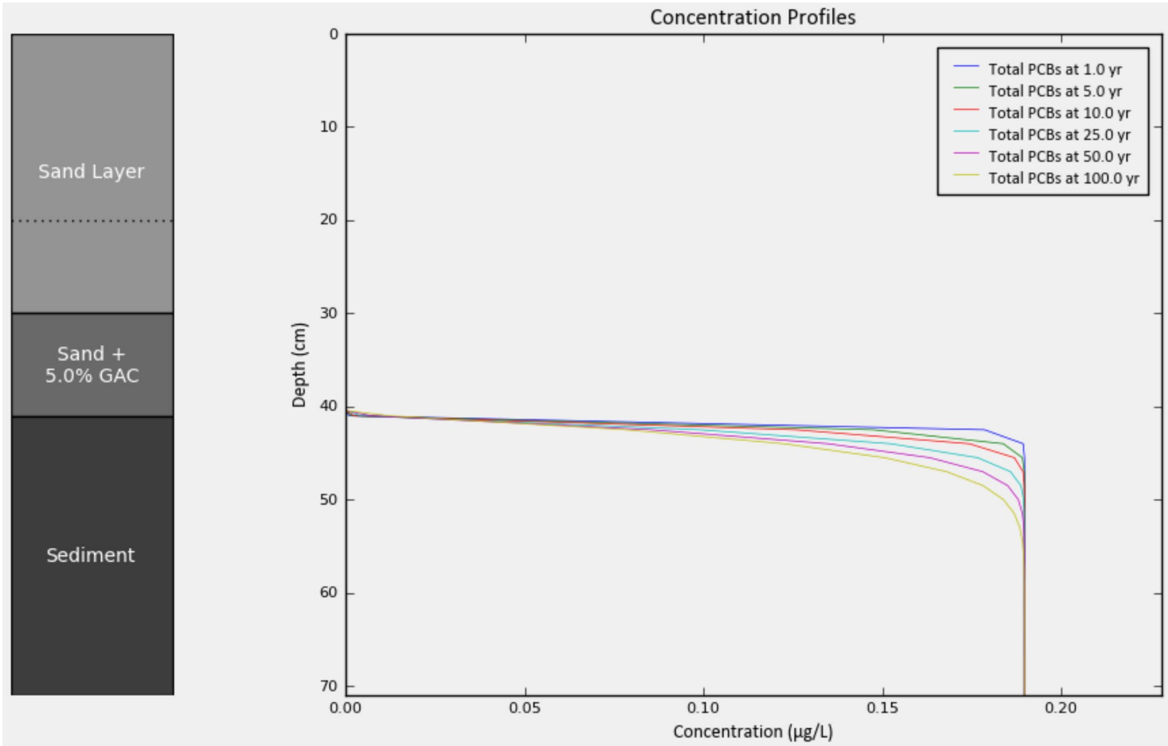

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Phenanthrene at 1.0 yr
Phenanthrene at 5.0 yr
Phenanthrene at 10.0 yr
Phenanthrene at 25.0 yr
Phenanthrene at 50.0 yr
Phenanthrene at 100.0 yr
Depth (cm)
Concentration (μg/L)

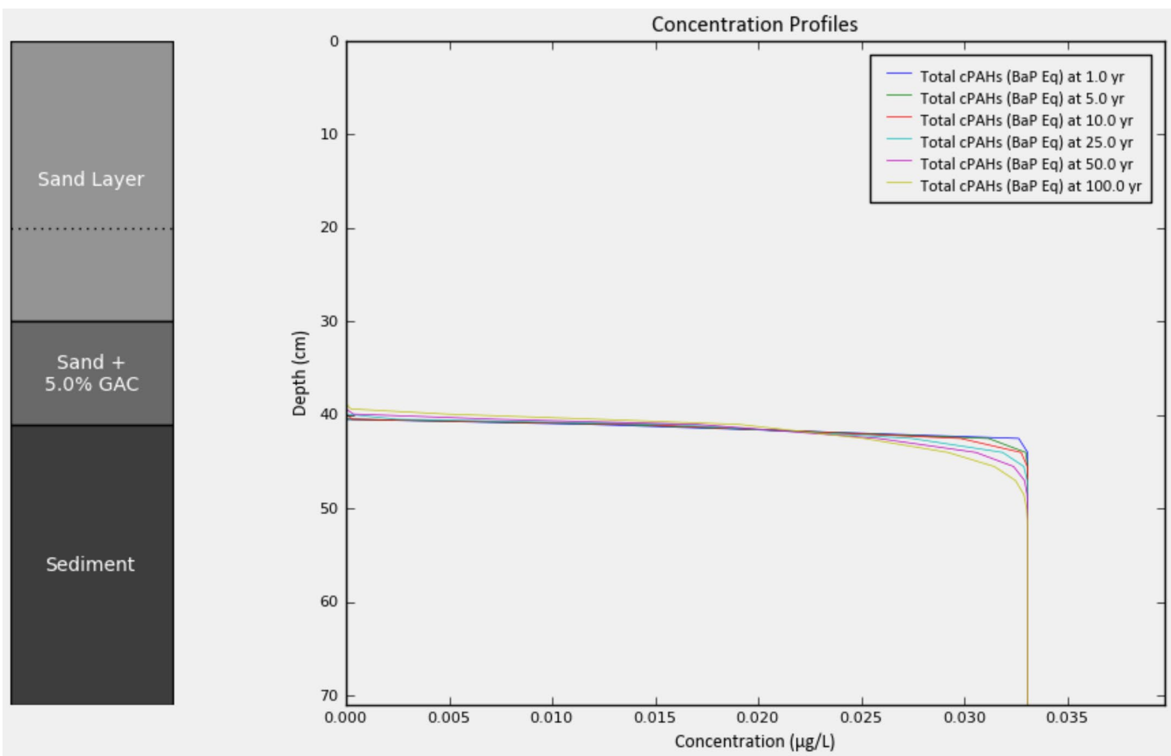

Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Pyrene at 1.0 yr
Pyrene at 5.0 yr
Pyrene at 10.0 yr
Pyrene at 25.0 yr
Pyrene at 50.0 yr
Pyrene at 100.0 yr
Depth (cm)
Concentration (μg/L)
0
10
20
30
40
50
60
70
0.0
0.2
0.4
0.6
0.8
1.0
1.2


Concentration Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
TCDD at 1.0 yr
TCDD at 5.0 yr
TCDD at 10.0 yr
TCDD at 25.0 yr
TCDD at 50.0 yr
TCDD at 100.0 yr
Depth (cm)
Concentration (μg/L)
1e−6
0
10
20
30
40
50
60
70
0
1
2
3
4

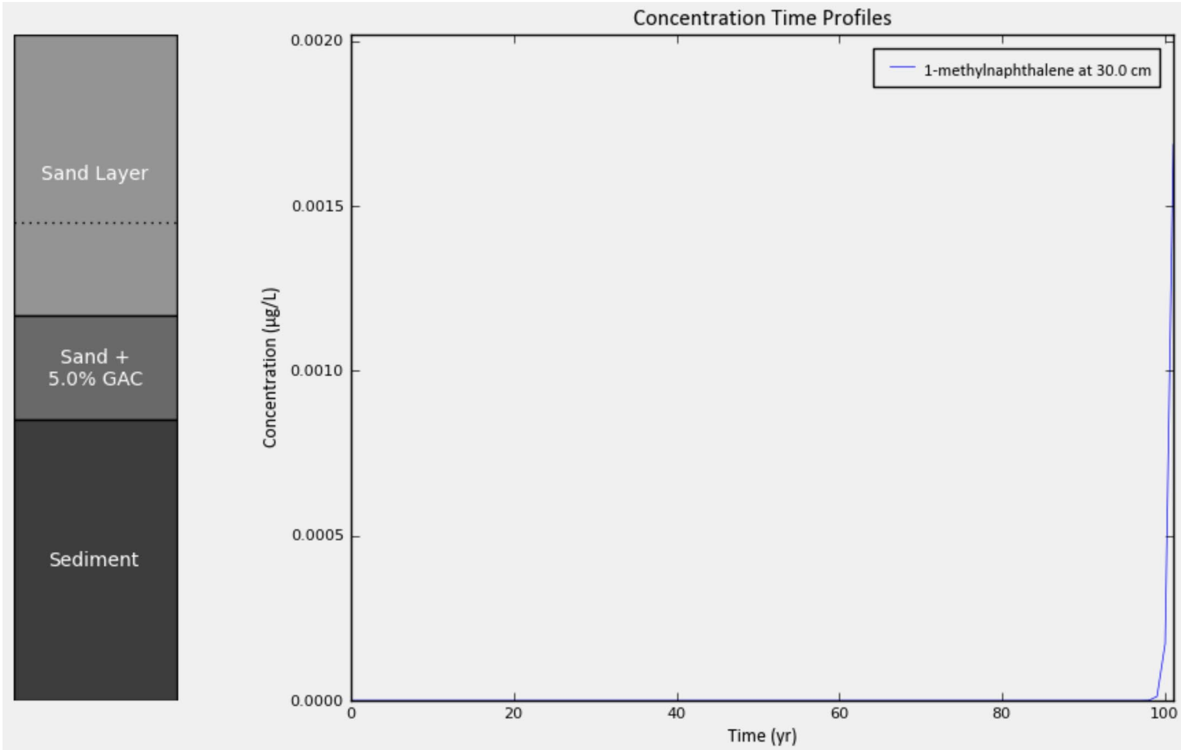

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
TCDF at 1.0 yr
TCDF at 5.0 yr
TCDF at 10.0 yr
TCDF at 25.0 yr
TCDF at 50.0 yr
TCDF at 100.0 yr
Depth (cm)
Concentration (µg/L)
1e−6

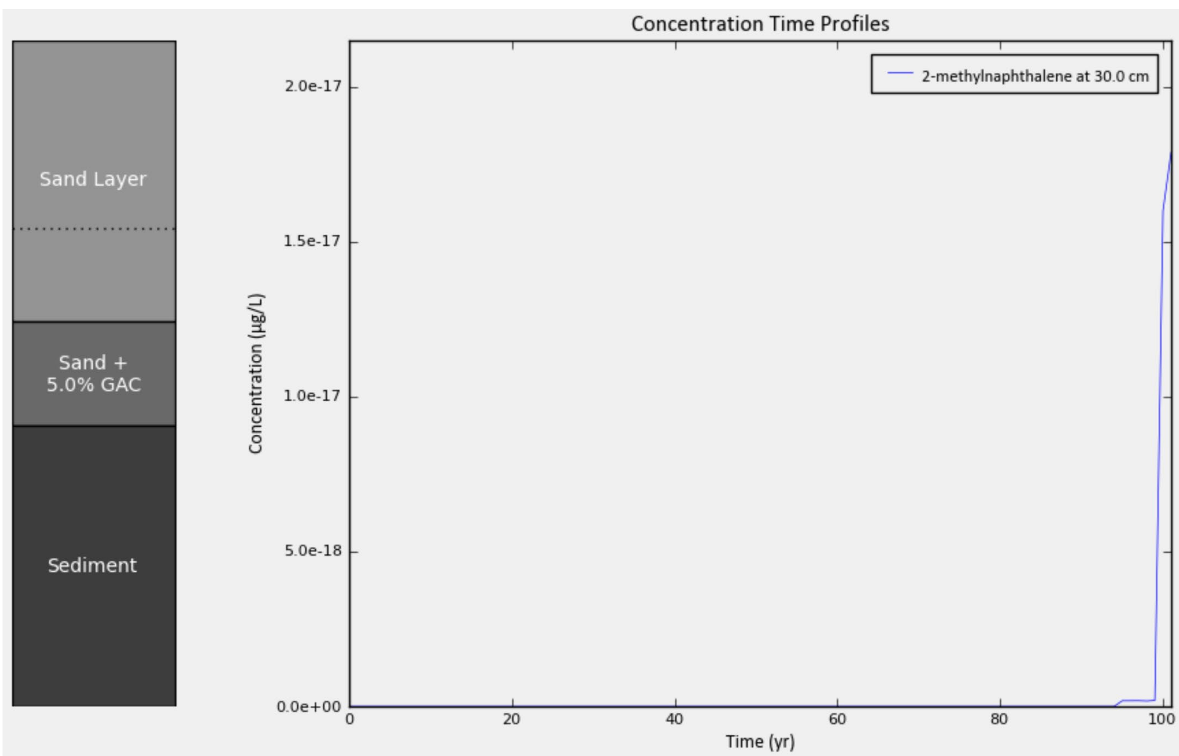

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Total PAHs at 1.0 yr
Total PAHs at 5.0 yr
Total PAHs at 10.0 yr
Total PAHs at 25.0 yr
Total PAHs at 50.0 yr
Total PAHs at 100.0 yr
Depth (cm)
Concentration (µg/L)

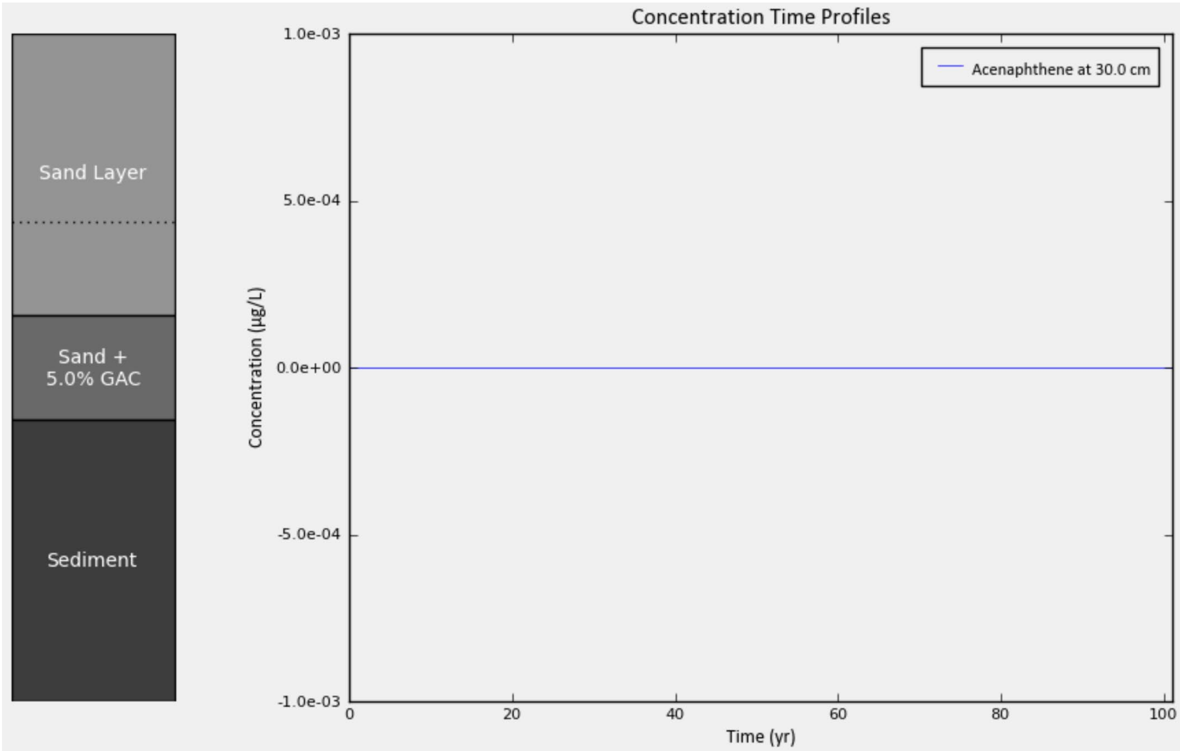

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Total PCBs at 1.0 yr
Total PCBs at 5.0 yr
Total PCBs at 10.0 yr
Total PCBs at 25.0 yr
Total PCBs at 50.0 yr
Total PCBs at 100.0 yr
Depth (cm)
Concentration (µg/L)

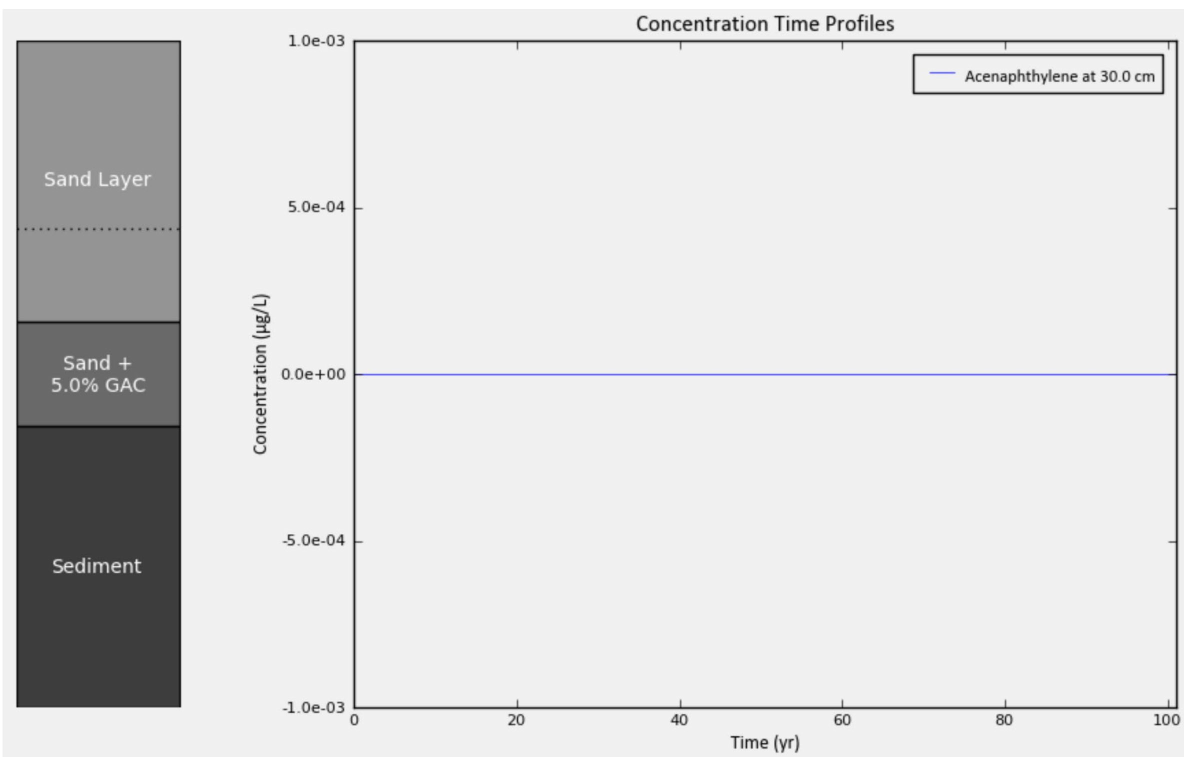

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Profiles
Total cPAHs (BaP Eq) at 1.0 yr
Total cPAHs (BaP Eq) at 5.0 yr
Total cPAHs (BaP Eq) at 10.0 yr
Total cPAHs (BaP Eq) at 25.0 yr
Total cPAHs (BaP Eq) at 50.0 yr
Total cPAHs (BaP Eq) at 100.0 yr
Depth (cm)
Concentration (µg/L)

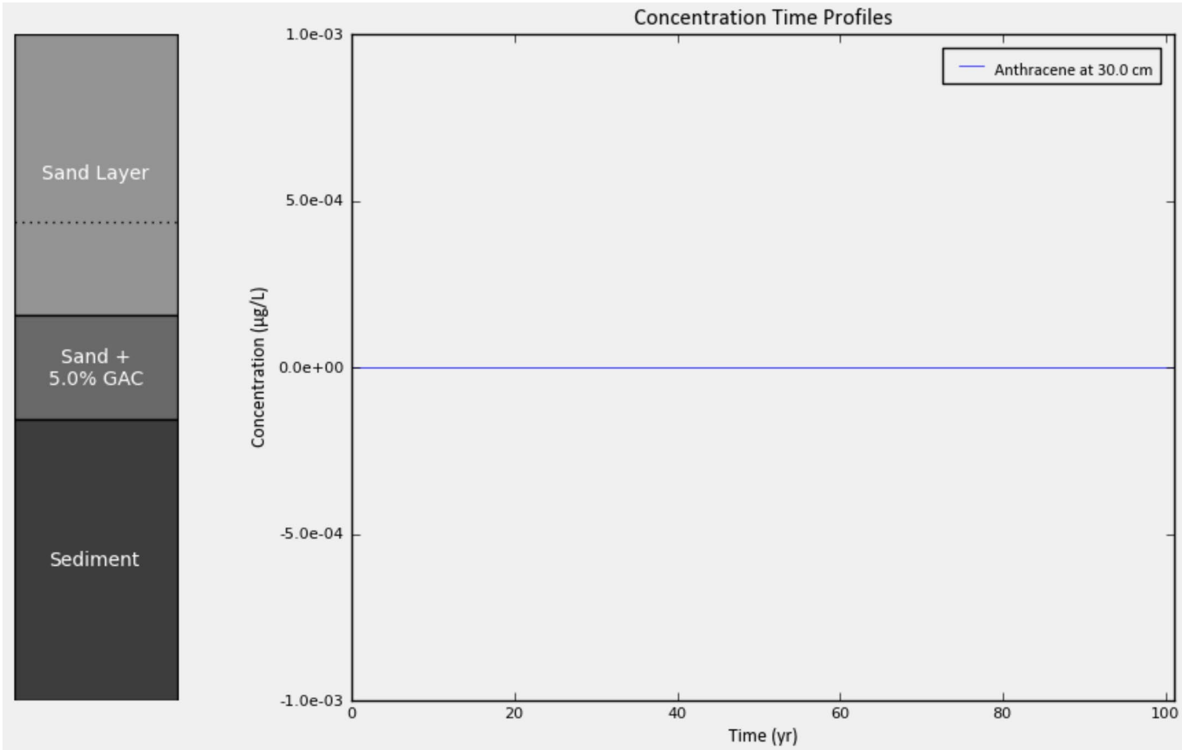
Porewater Concentration – Time

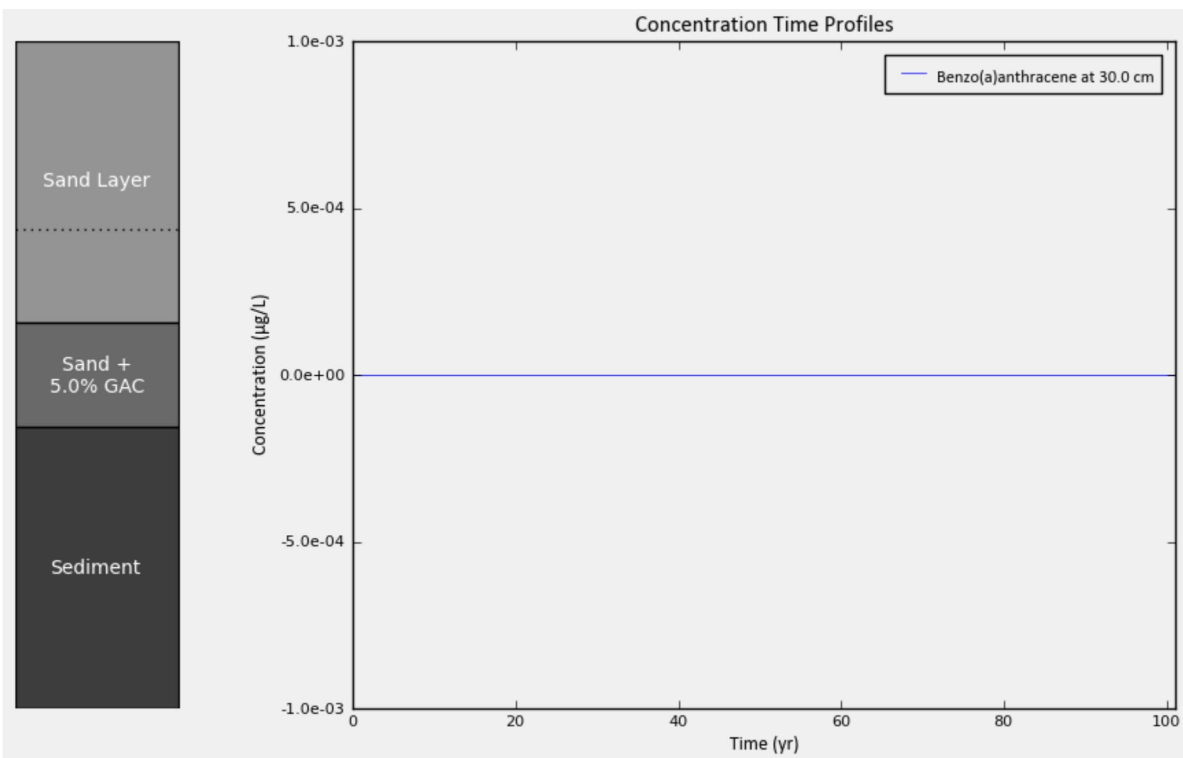


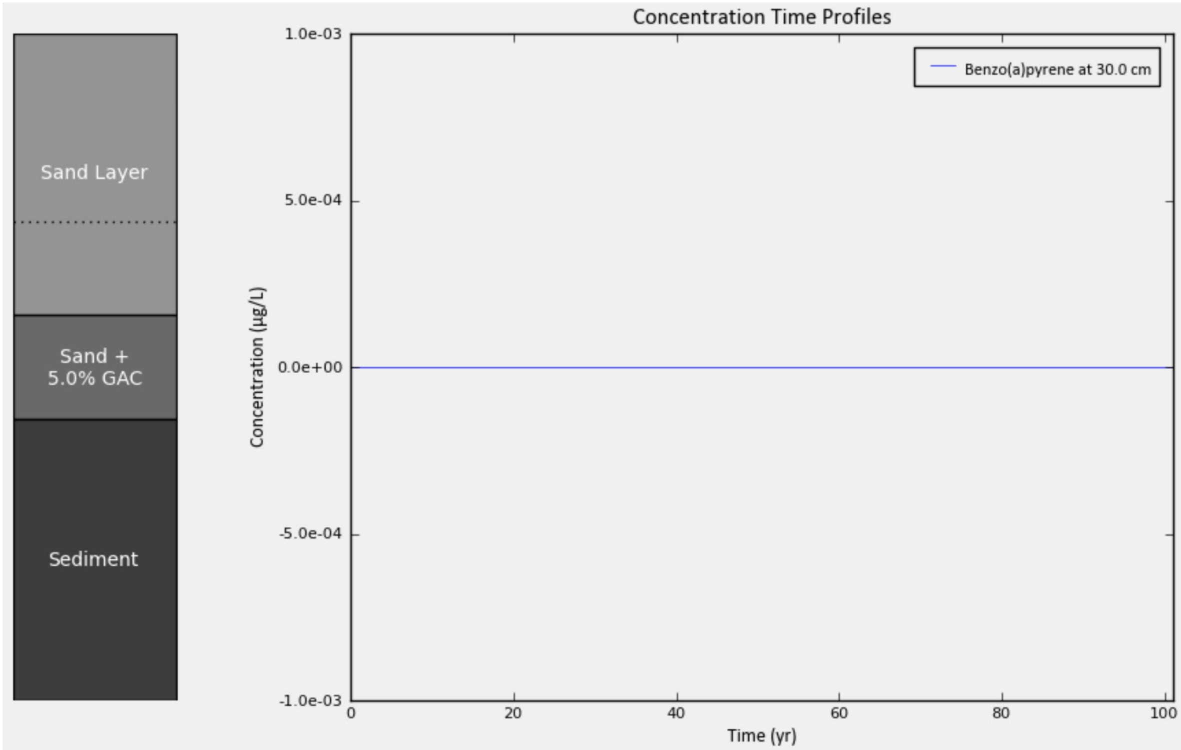


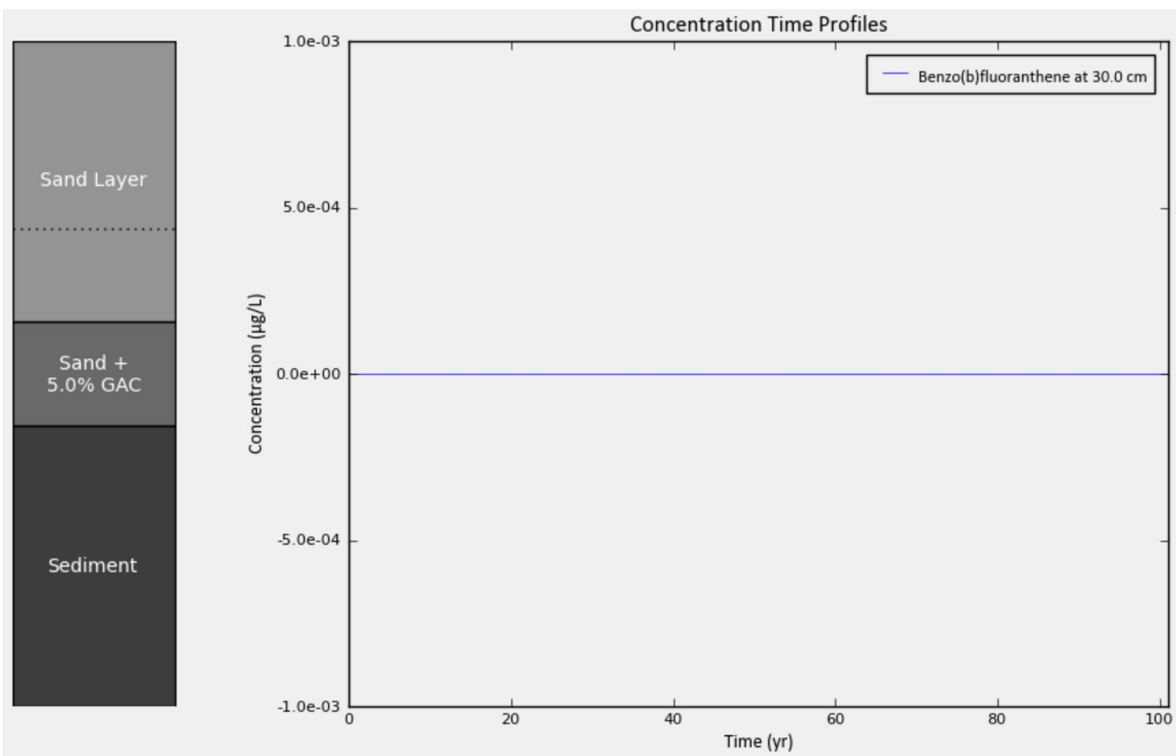

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Acenaphthene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

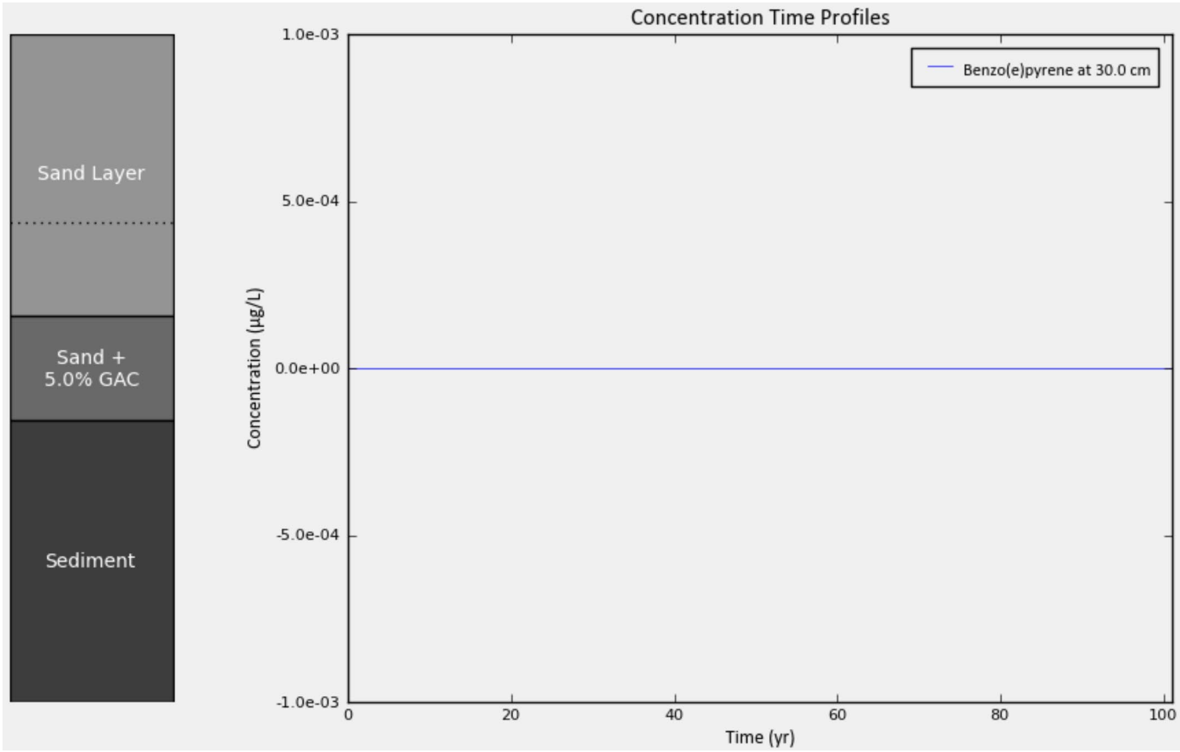

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Acenaphthylene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

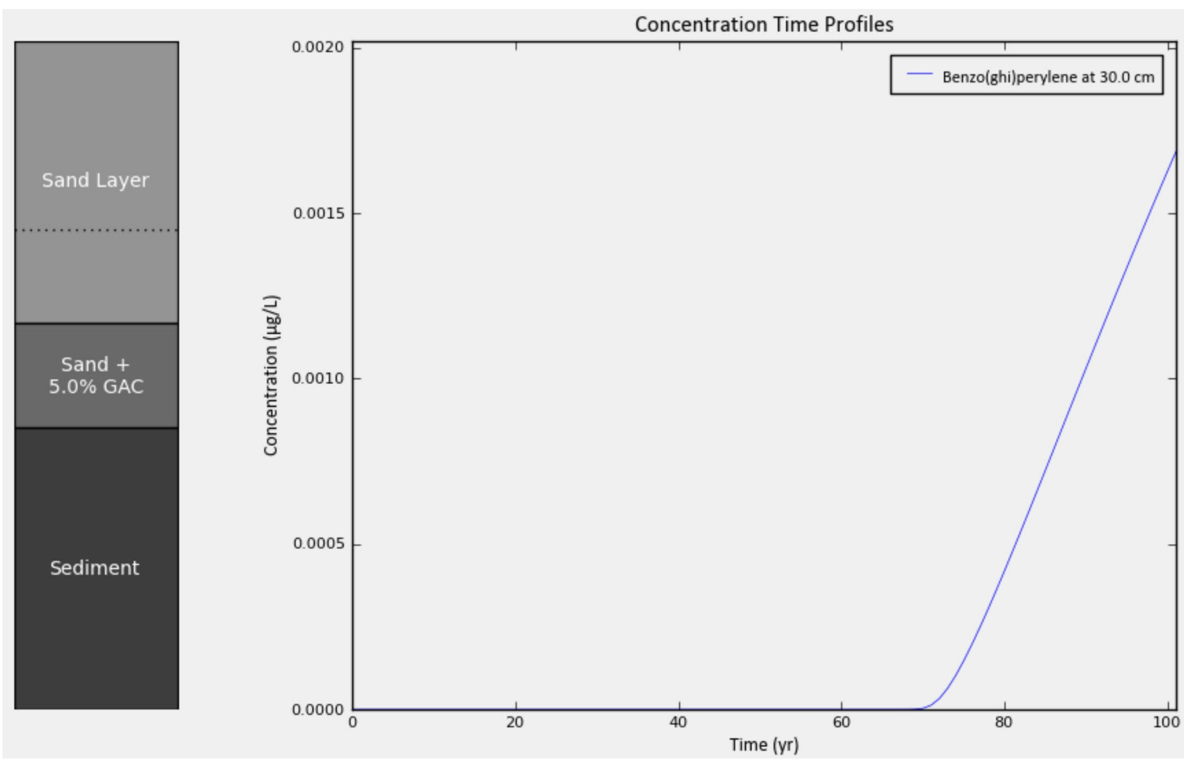

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Anthracene at 30.0 cm
Concentration (μg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

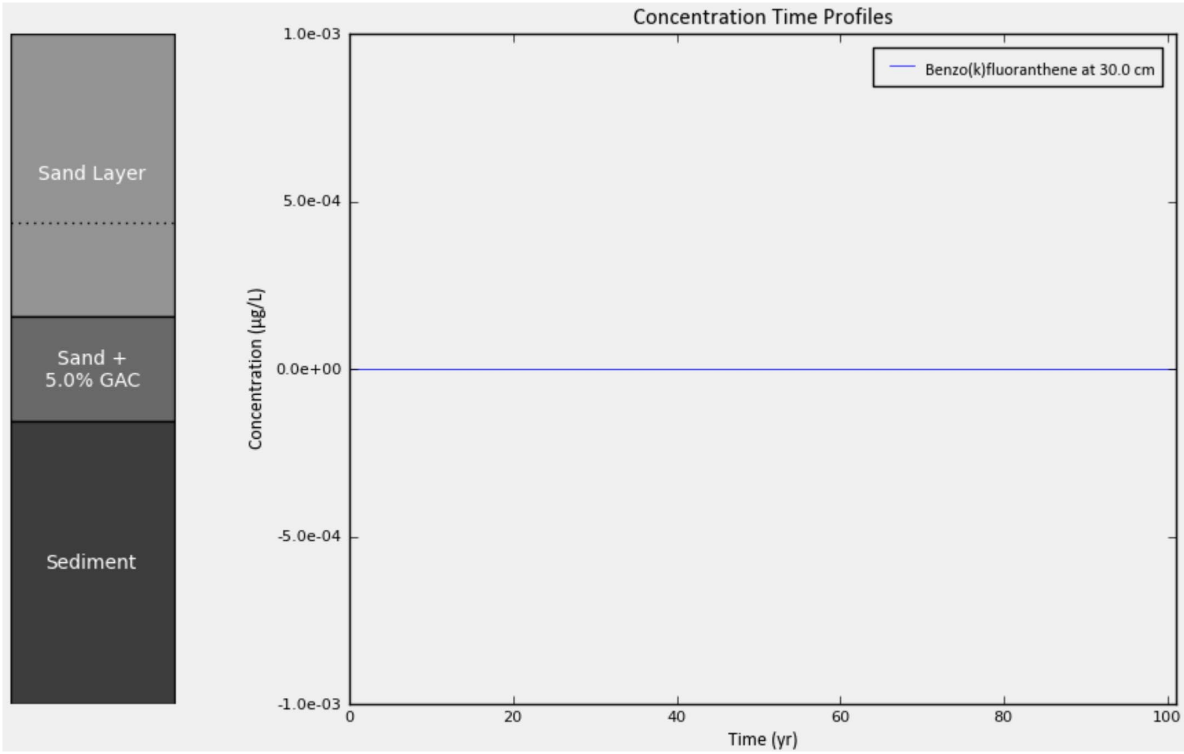

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Benzo(a)anthracene at 30.0 cm
Concentration (μg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

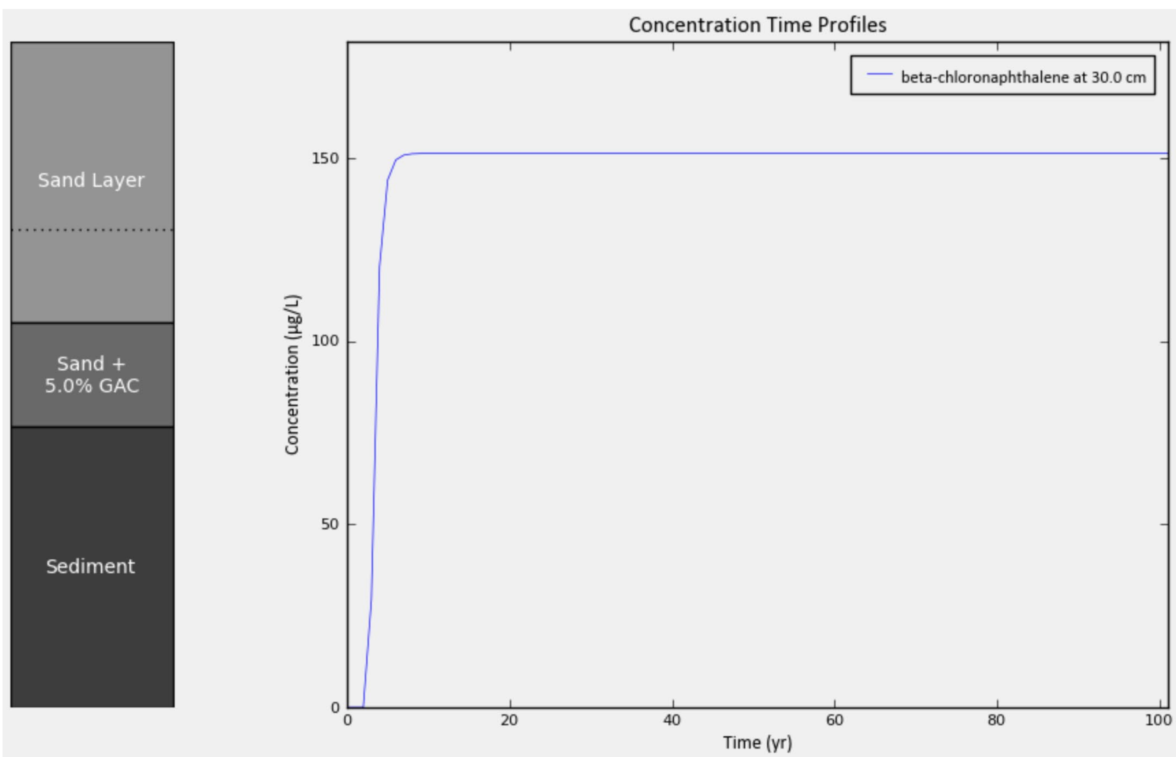

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Benzo(a)pyrene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

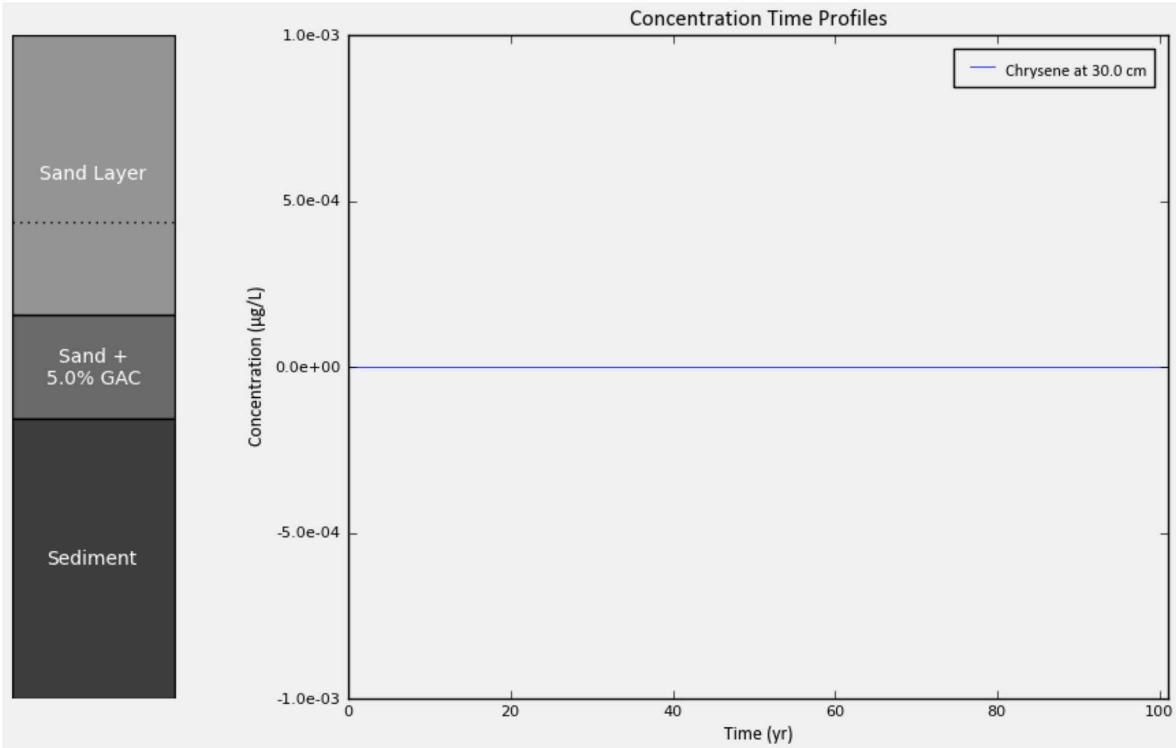

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Benzo(b)fluoranthene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

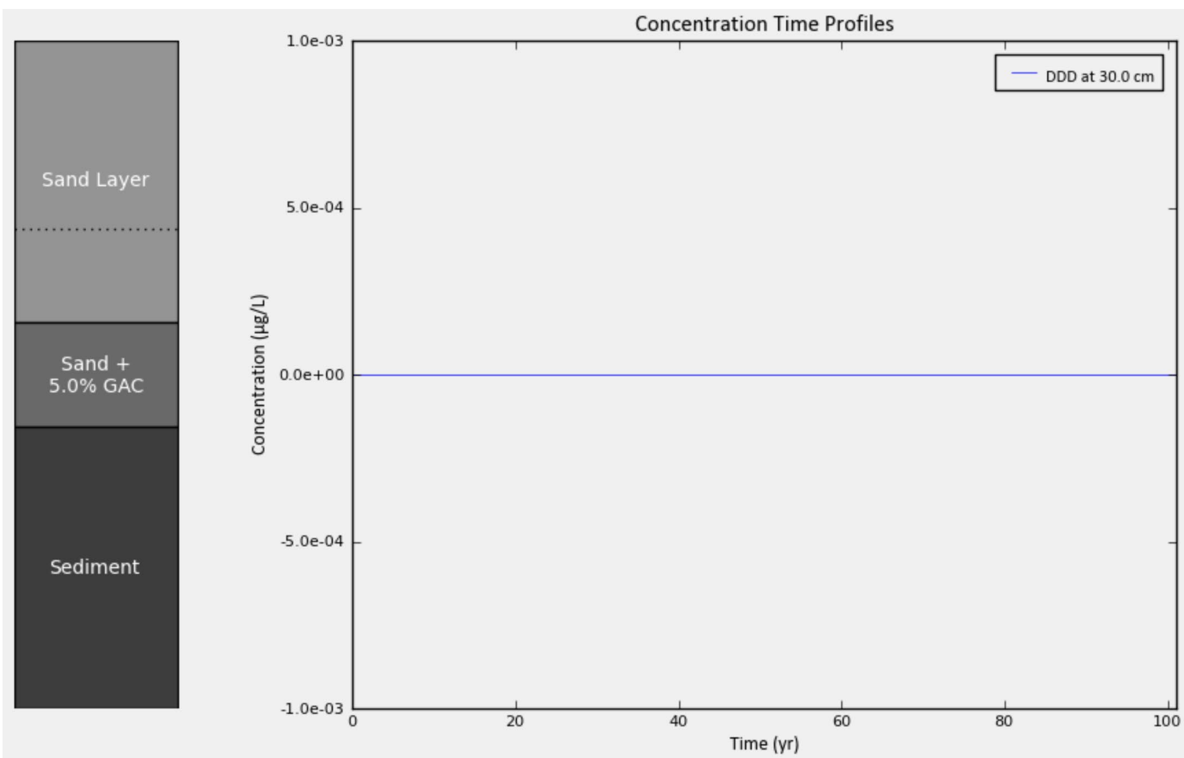

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Benzo(e)pyrene at 30.0 cm
Concentration (μg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

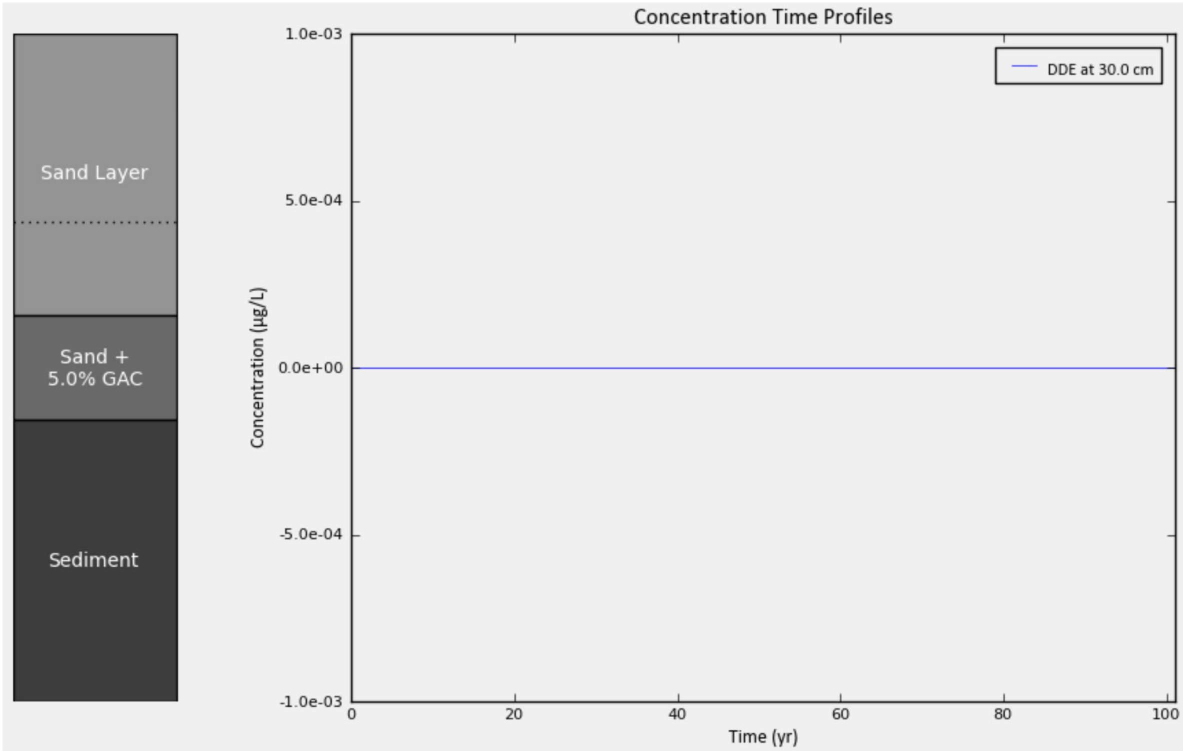

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Benzo(ghi)perylene at 30.0 cm
Concentration (μg/L)
0.0020
0.0015
0.0010
0.0005
0.0000
0
20
40
60
80
100
Time (yr)

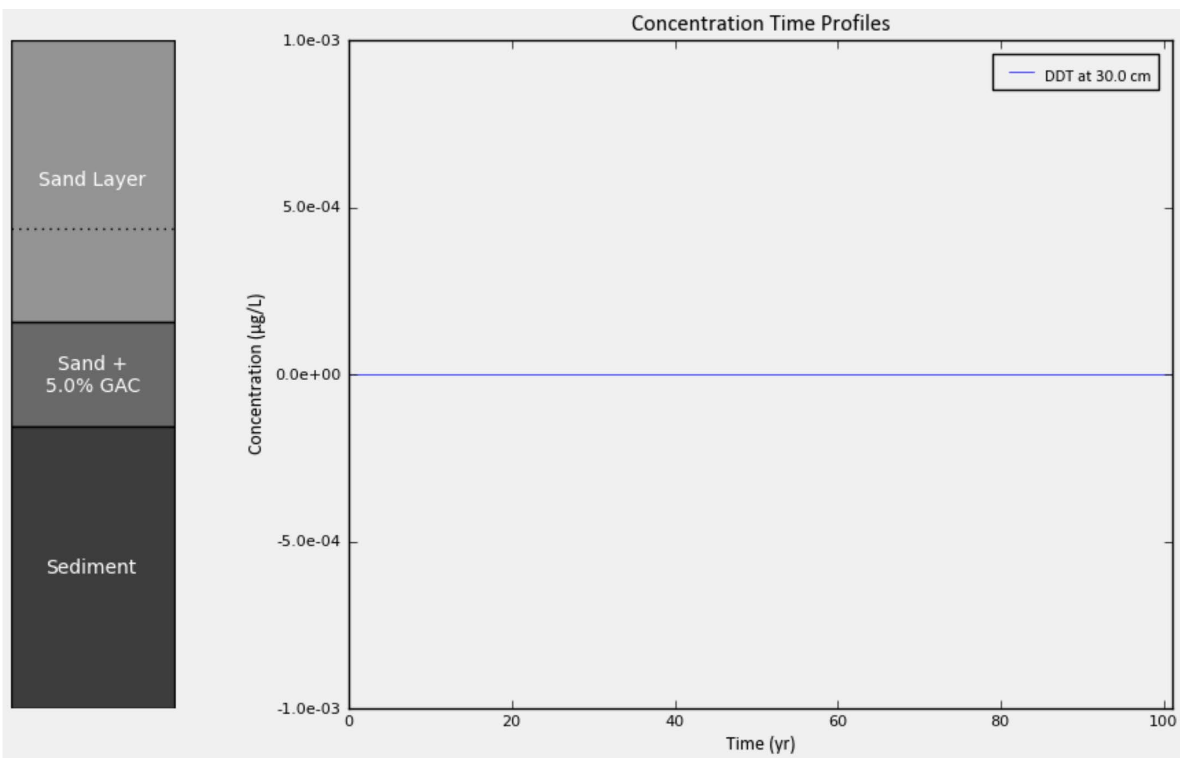

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Benzo(k)fluoranthene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

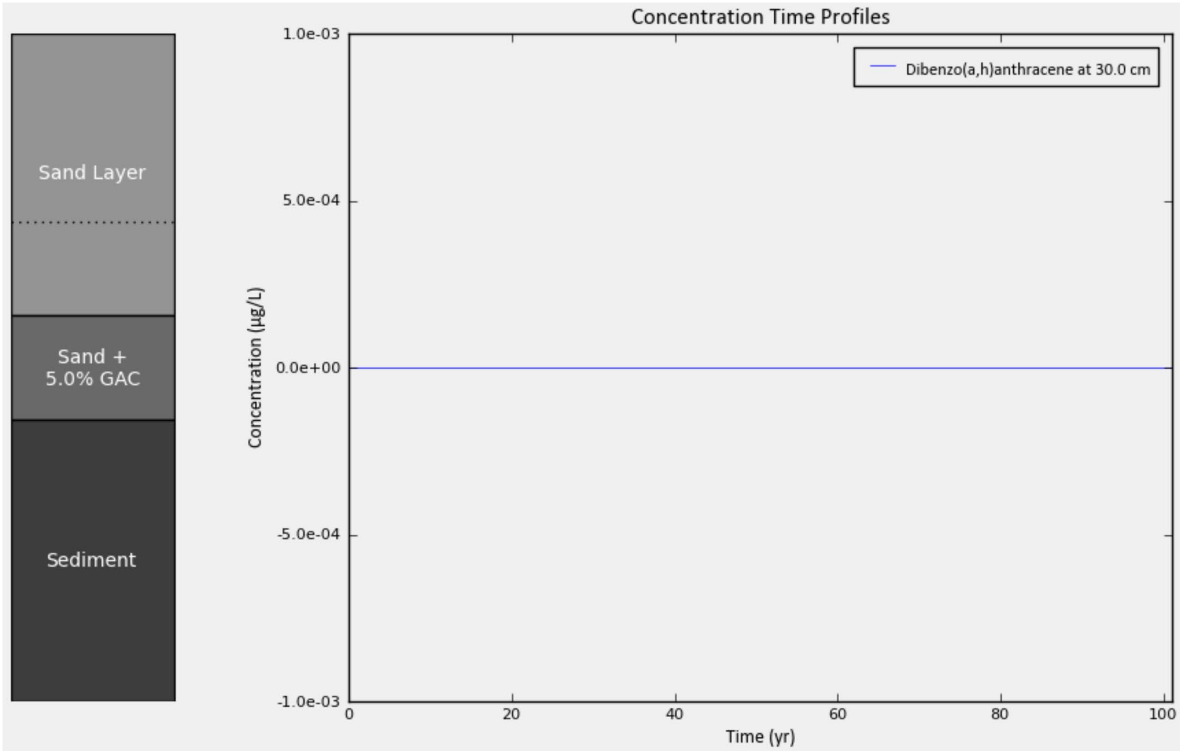

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
beta-chloronaphthalene at 30.0 cm
Concentration (µg/L)
150
100
50
0
0
20
40
60
80
100
Time (yr)

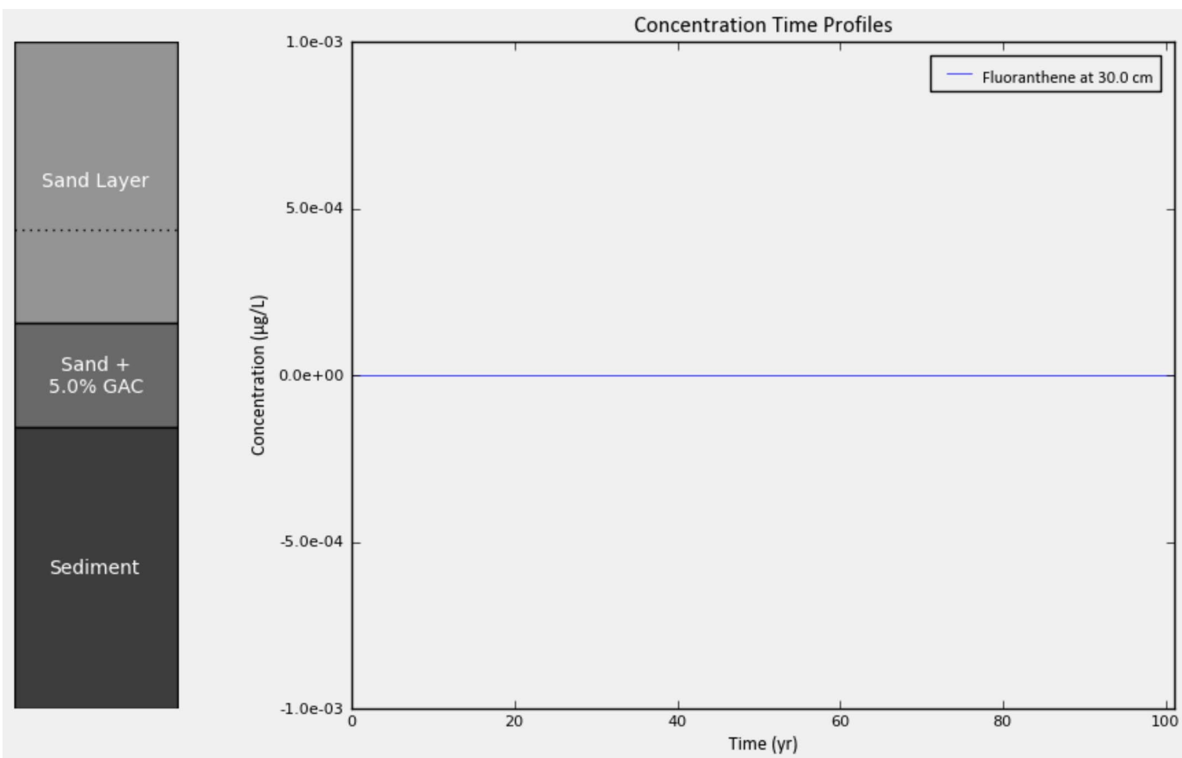

Concentration Time Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Chrysene at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (μg/L)
0
20
40
60
80
100
Time (yr)

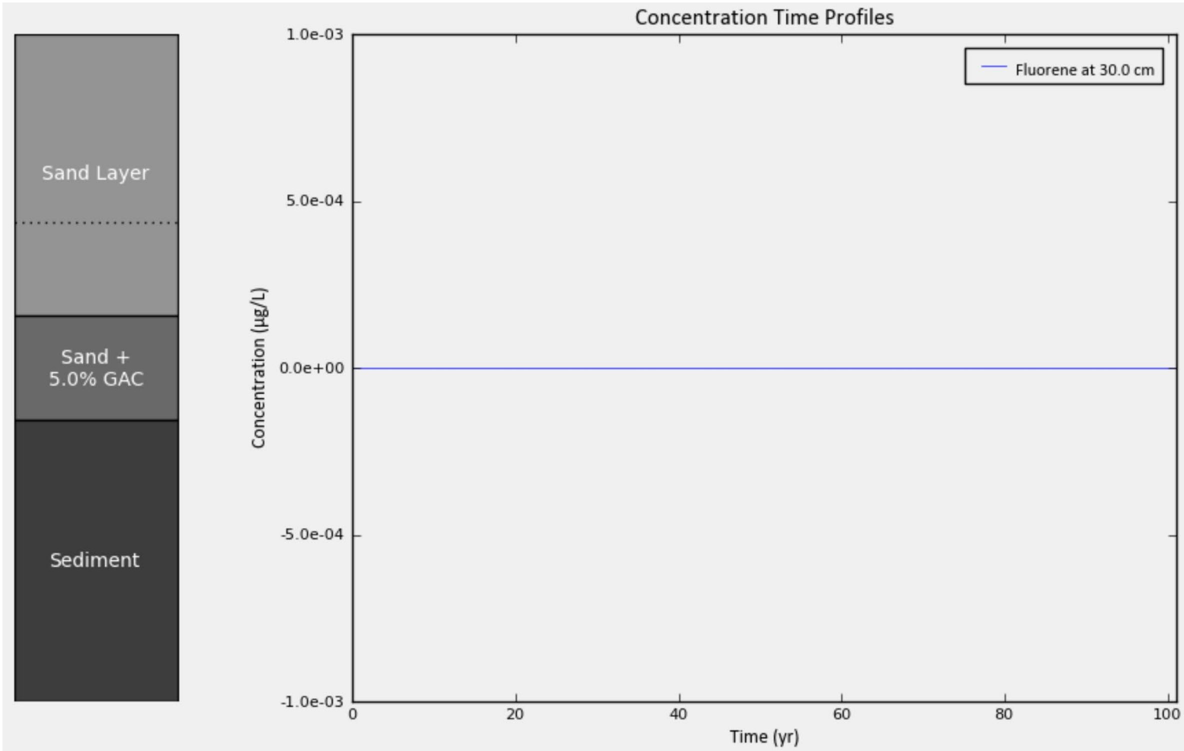

Concentration Time Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
DDD at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (μg/L)
0
20
40
60
80
100
Time (yr)

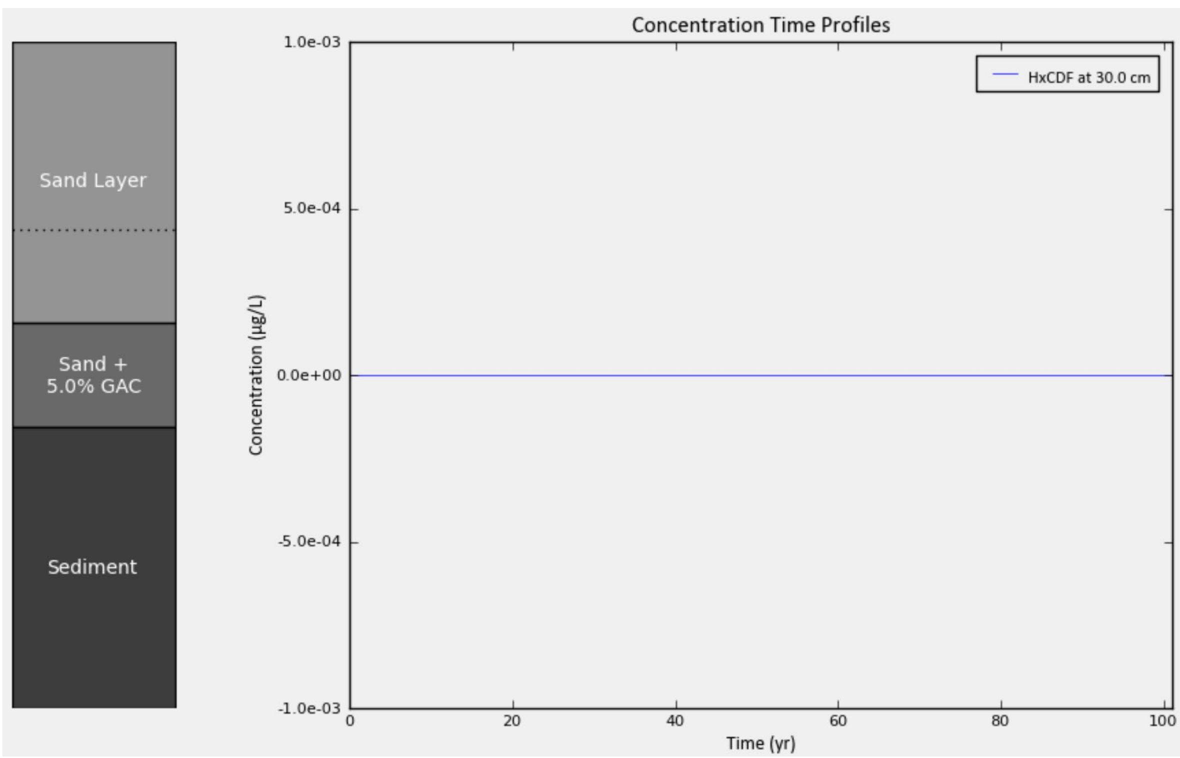

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
DDE at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

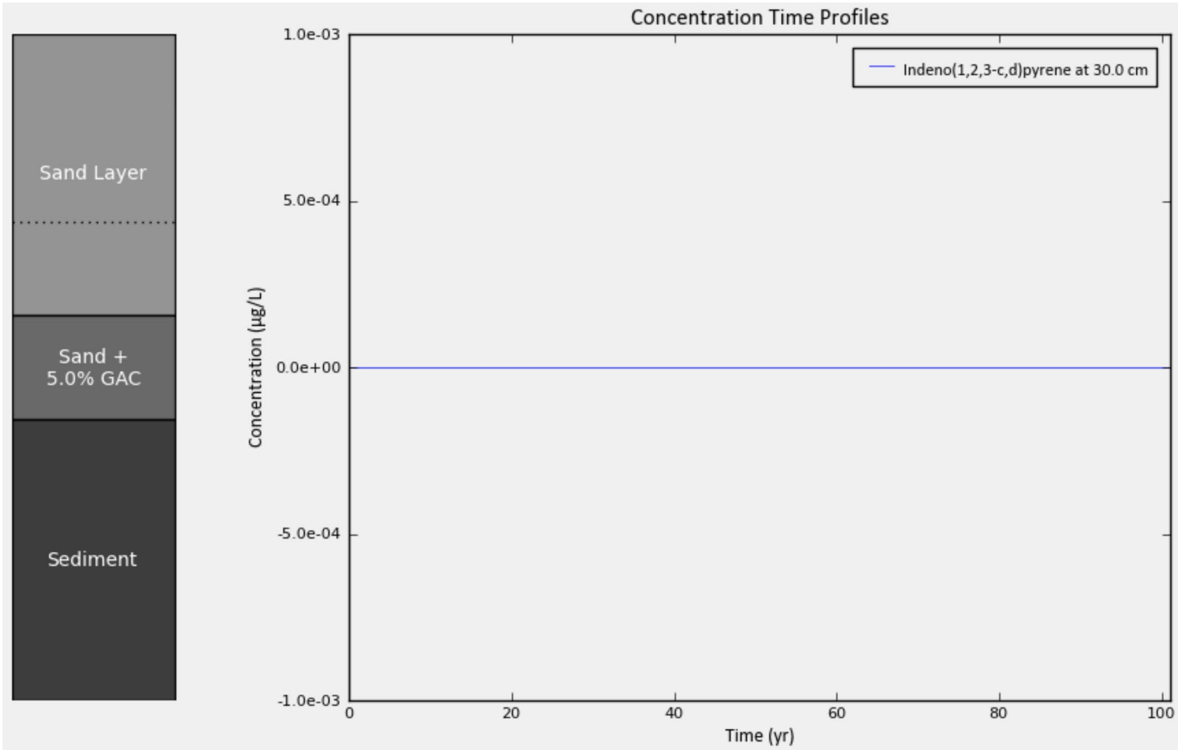

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
DDT at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

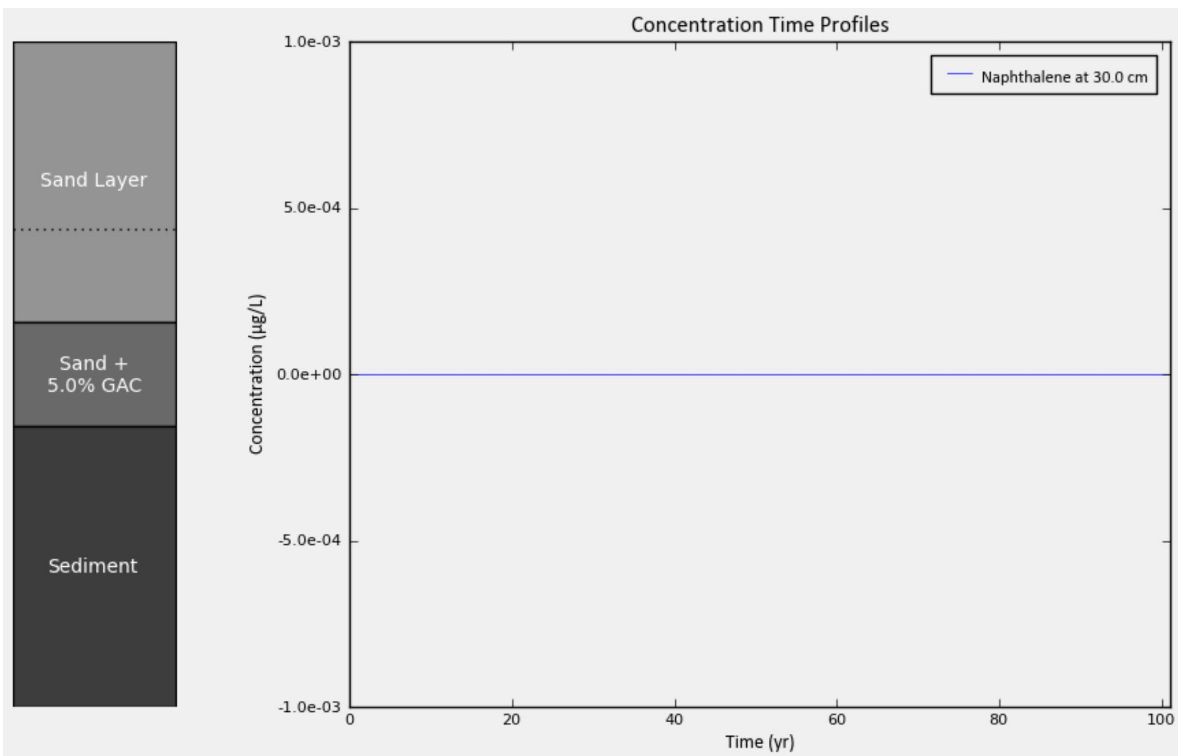

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Dibenzo(a,h)anthracene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

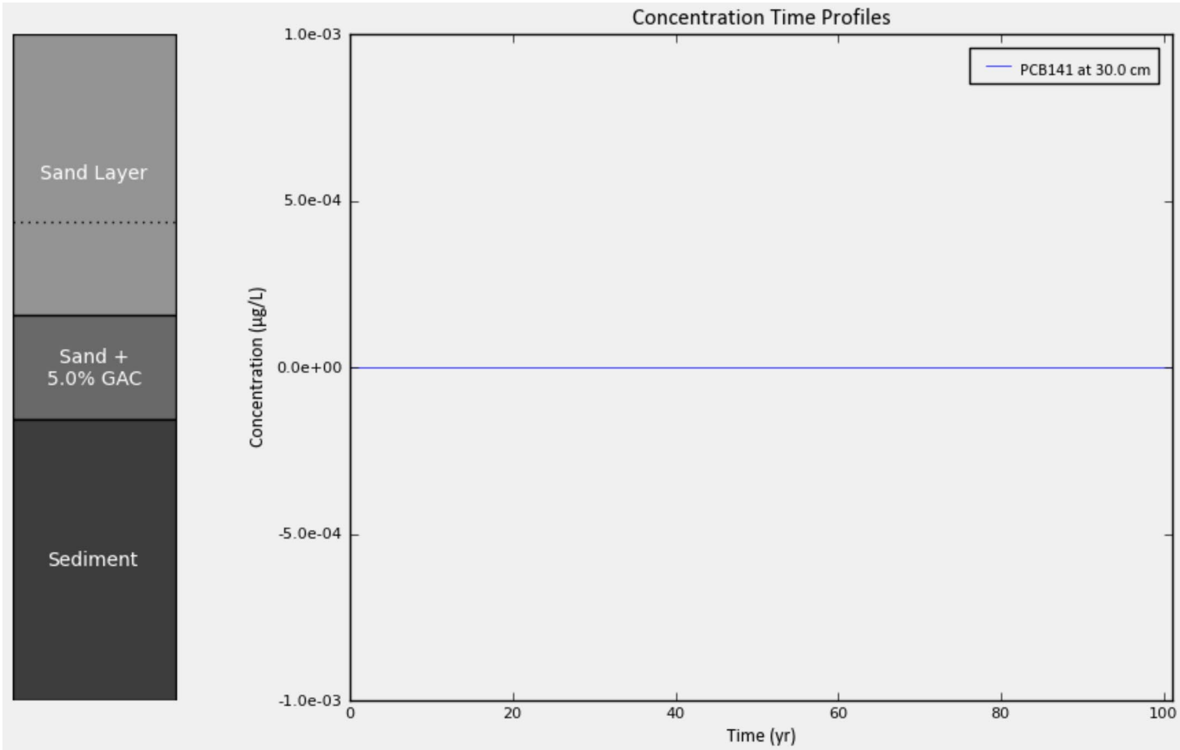

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Fluoranthene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

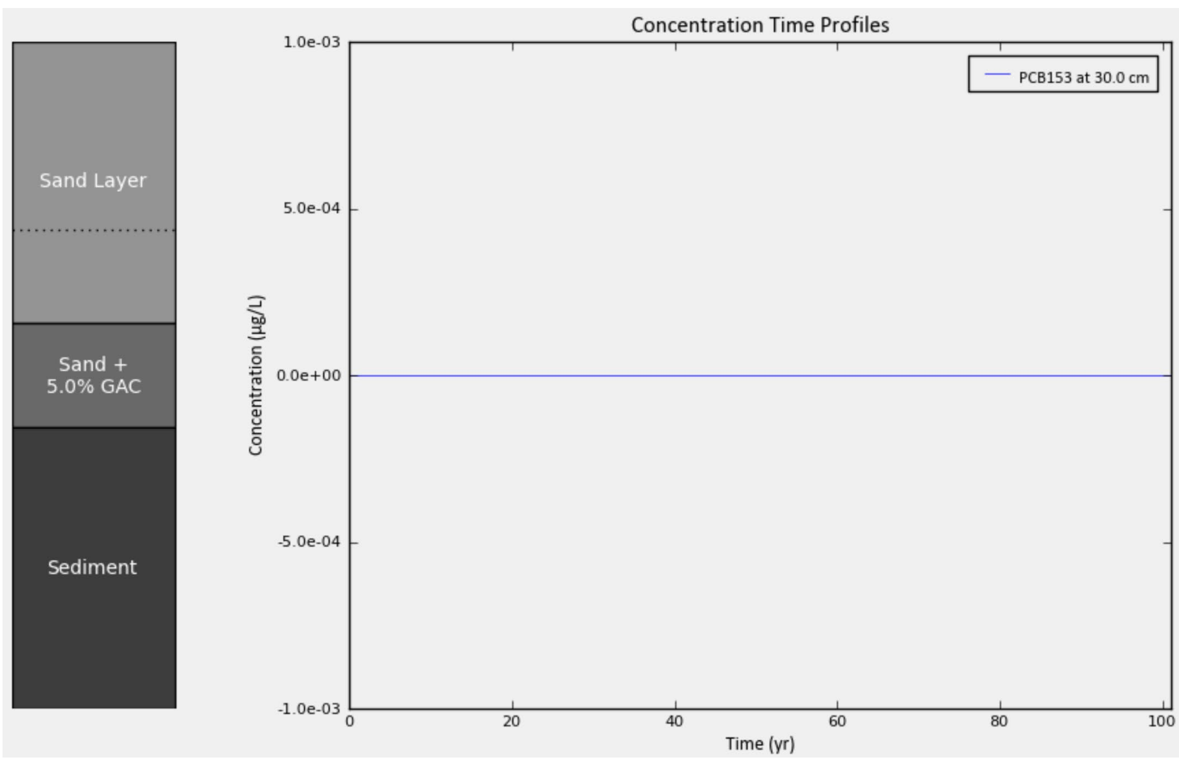

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Fluorene at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

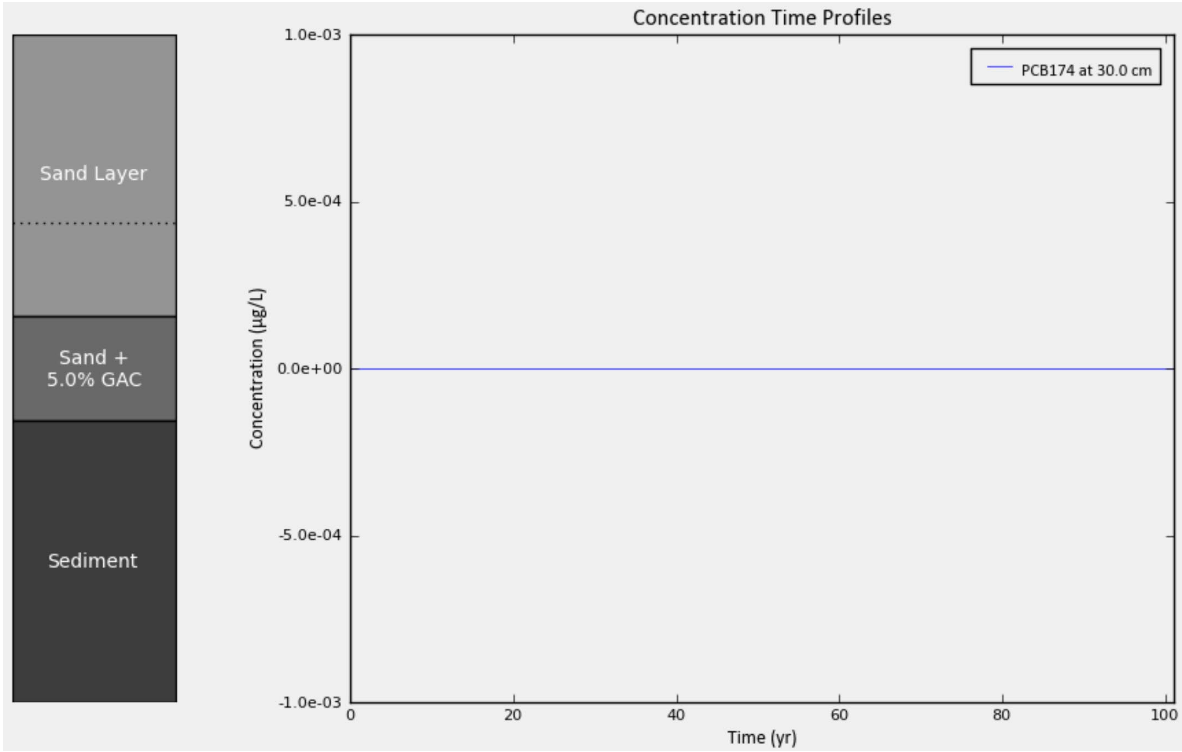

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
HxCDF at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

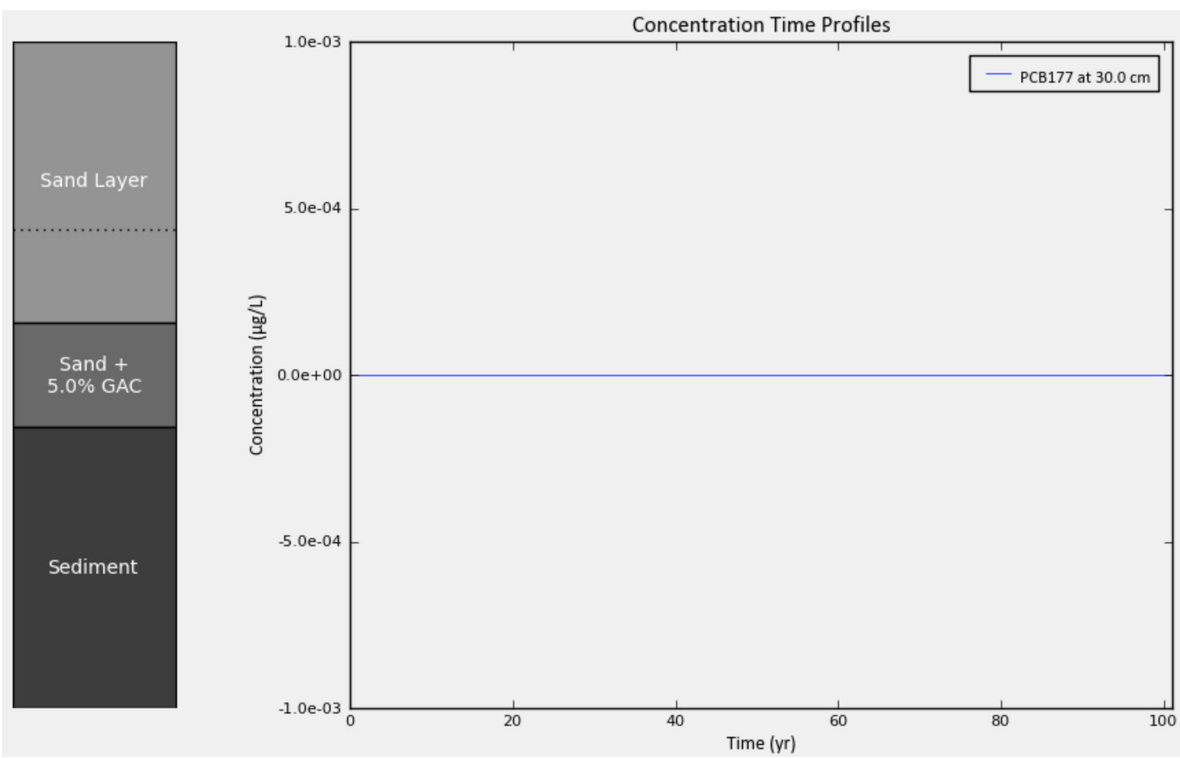

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Indeno(1,2,3-c,d)pyrene at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (μg/L)
0
20
40
60
80
100
Time (yr)

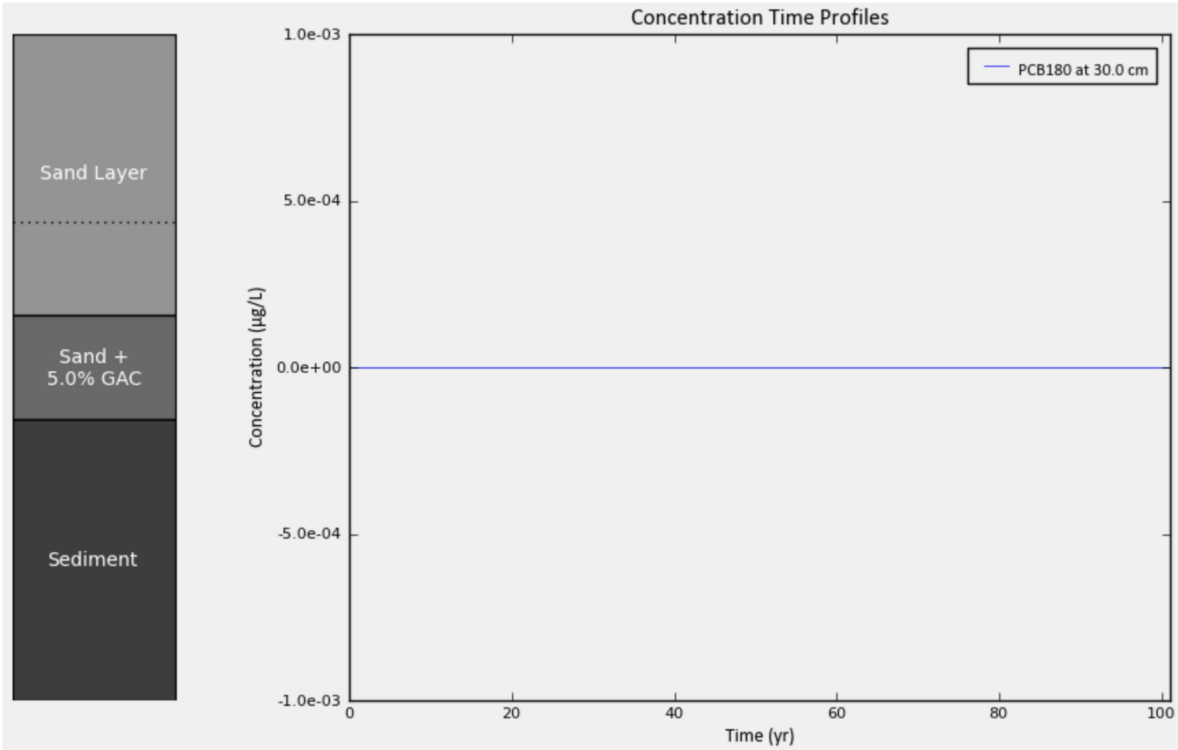

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Naphthalene at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (μg/L)
0
20
40
60
80
100
Time (yr)

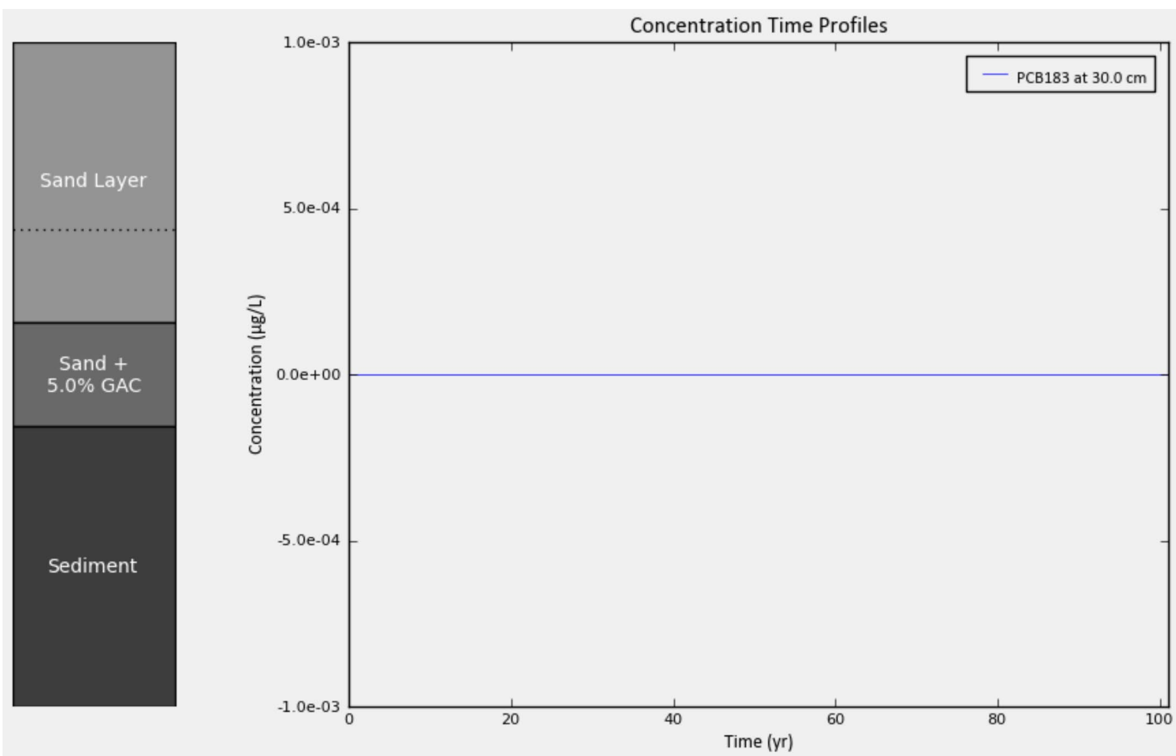

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB141 at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (μg/L)
0
20
40
60
80
100
Time (yr)

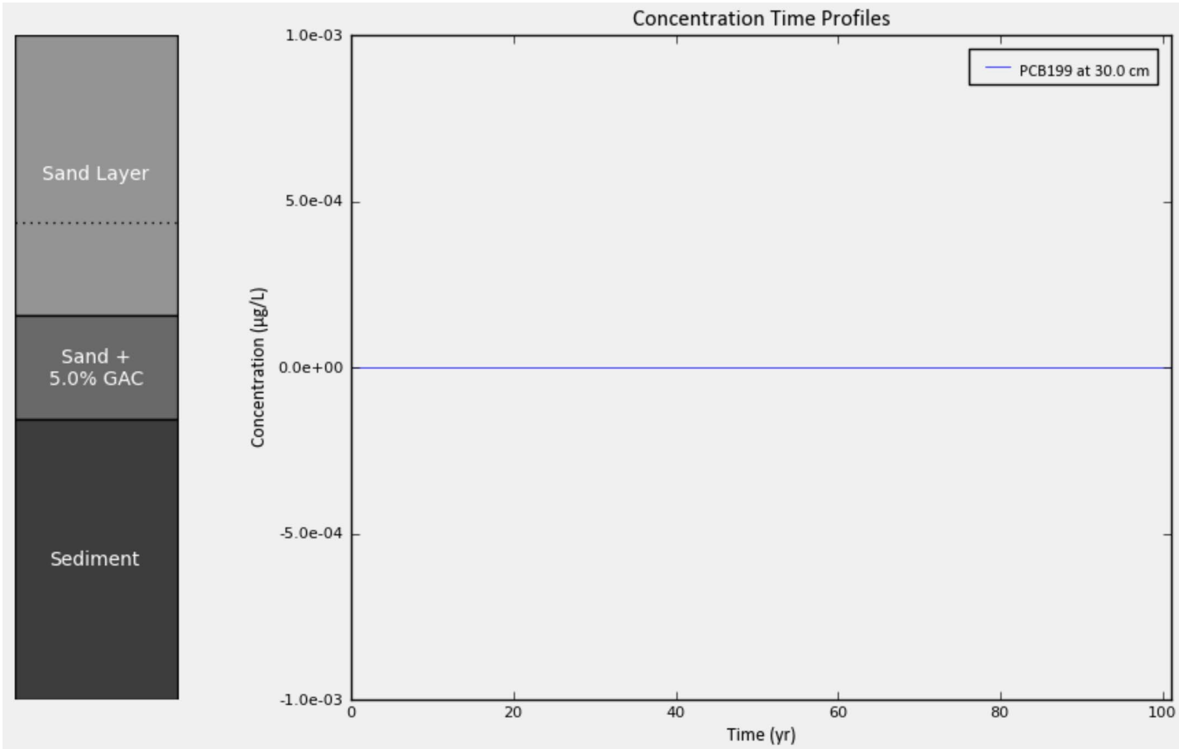

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB153 at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (μg/L)
0
20
40
60
80
100
Time (yr)

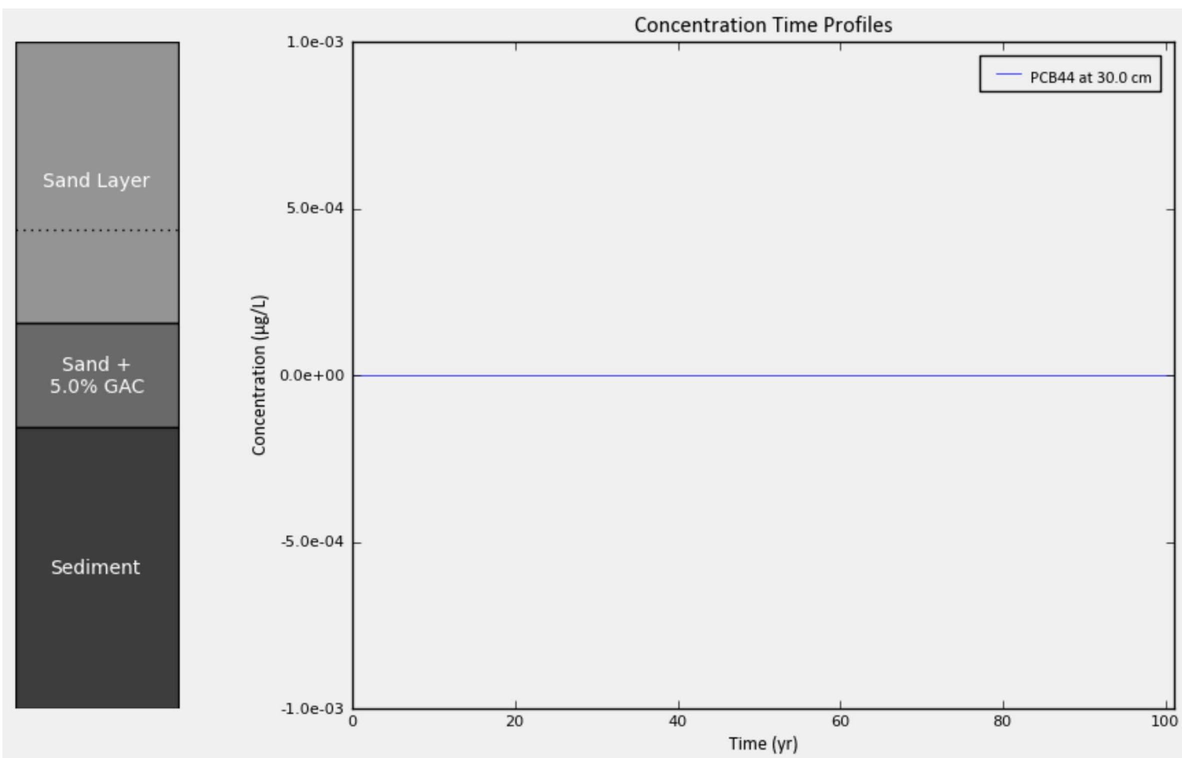

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB174 at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

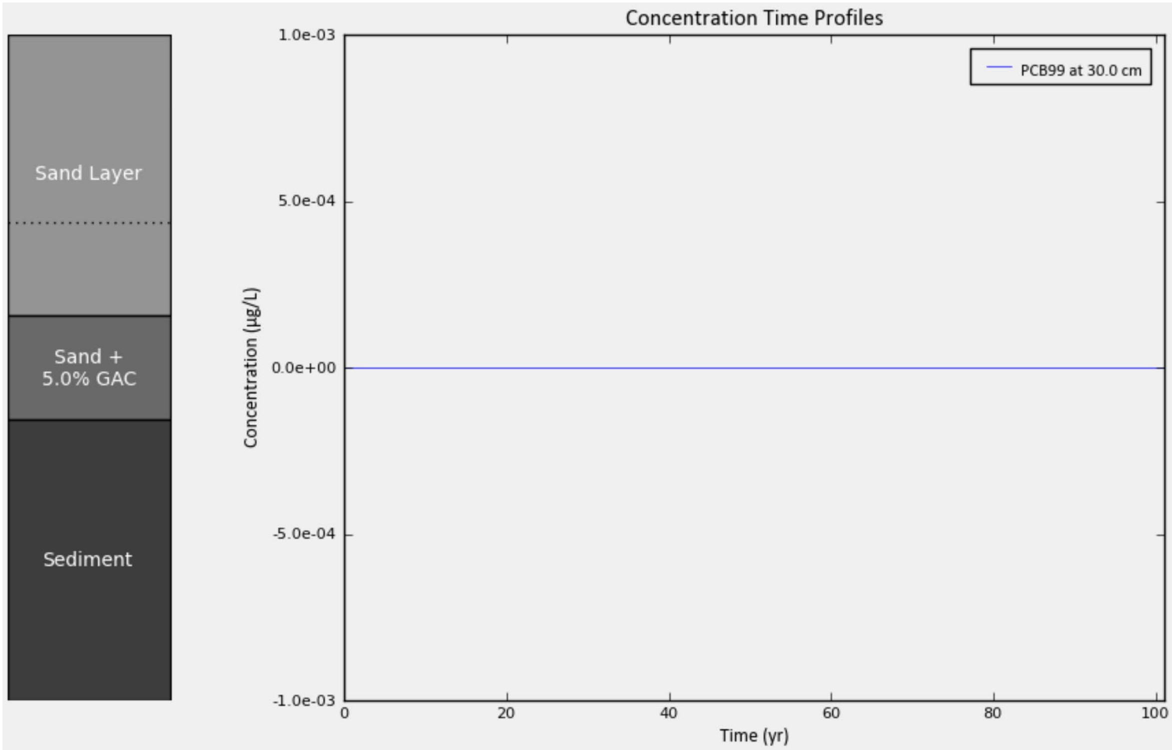

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB177 at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

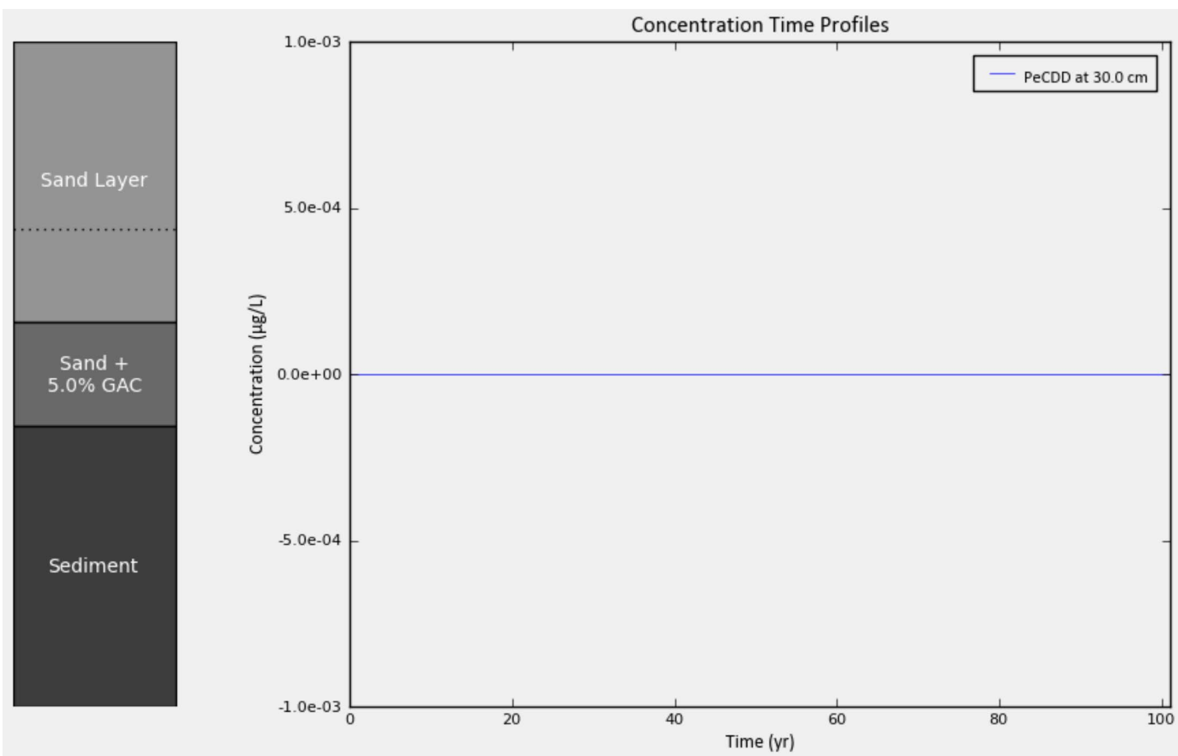

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB180 at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

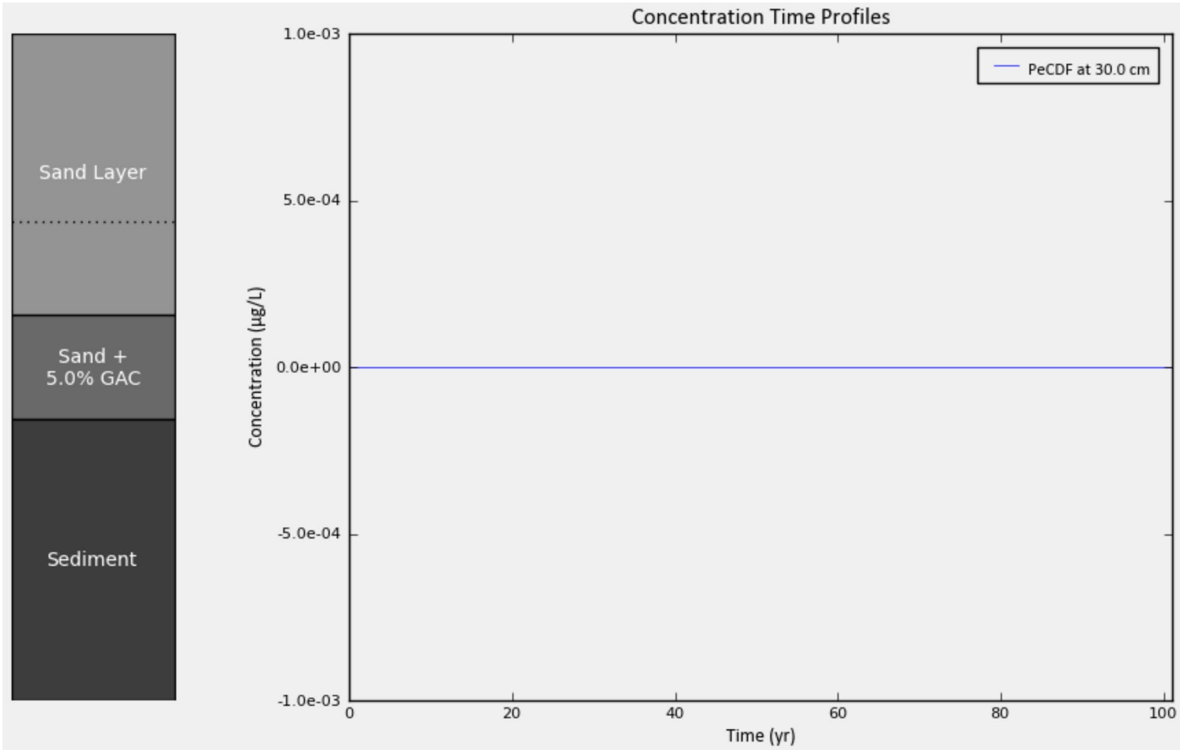

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB183 at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB199 at 30.0 cm
Concentration (μg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB44 at 30.0 cm
Concentration (μg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PCB99 at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
PeCDD at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Concentration Time Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
PeCDF at 30.0 cm
Concentration (µg/L)
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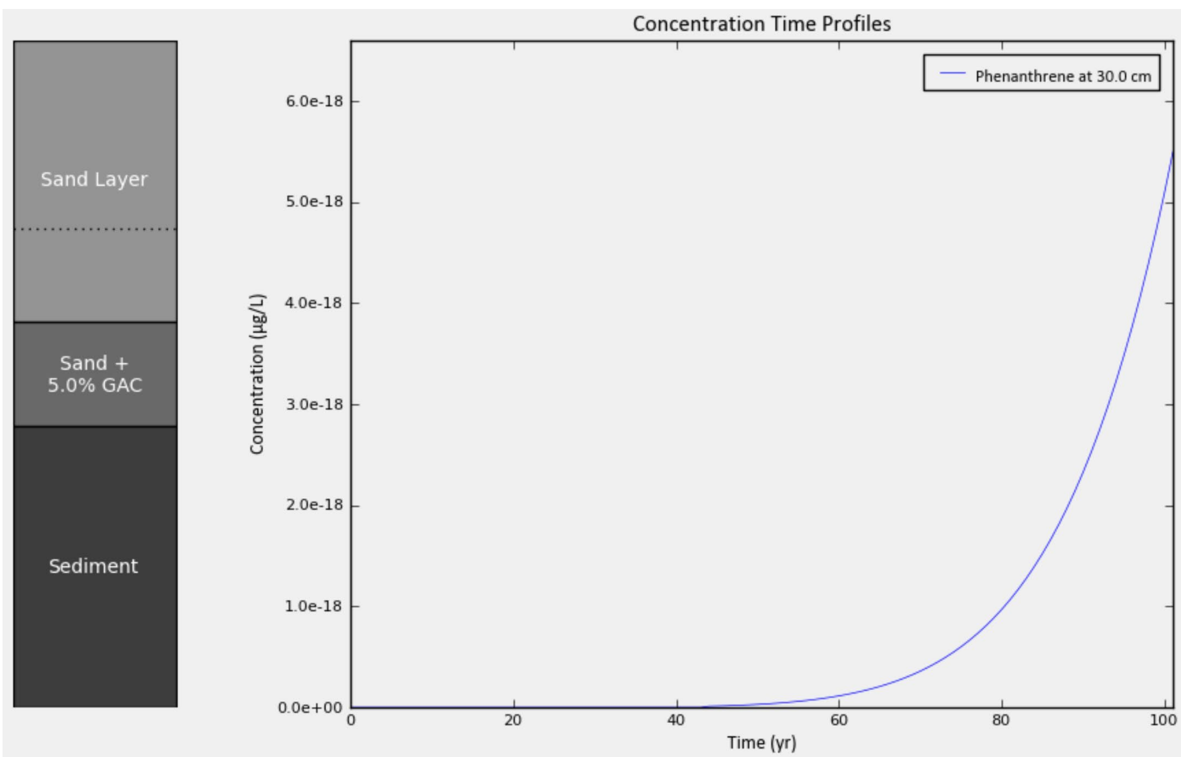
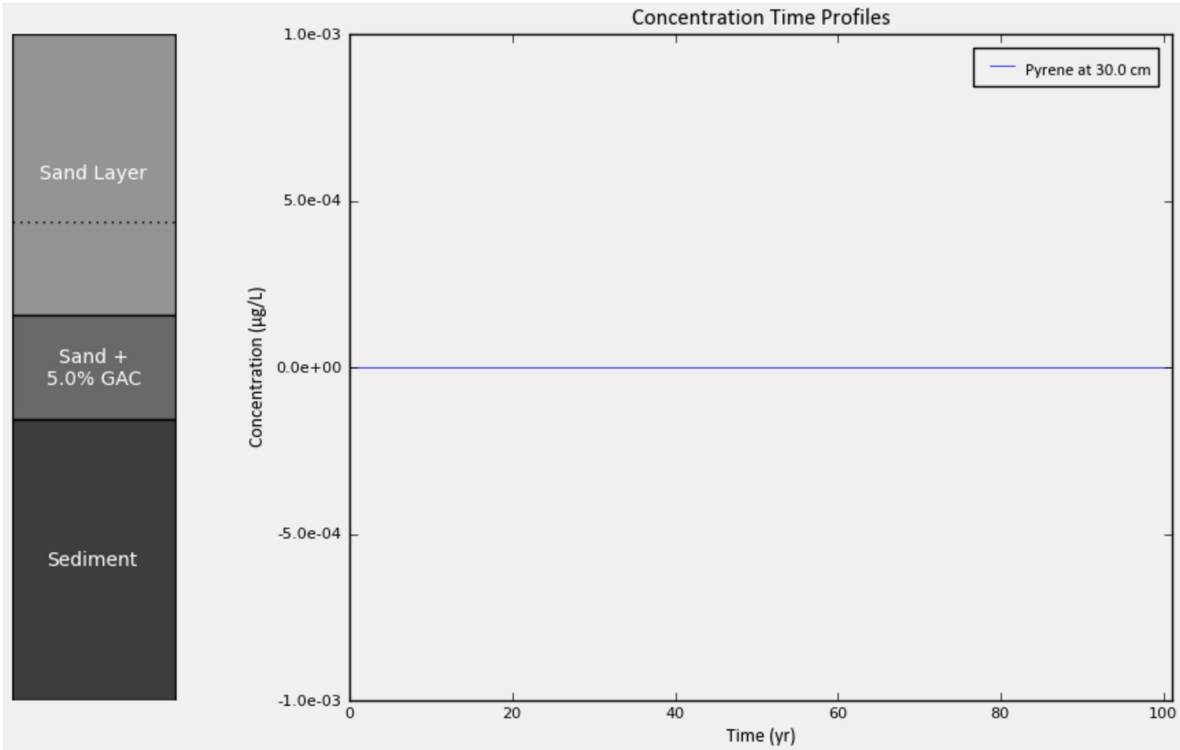
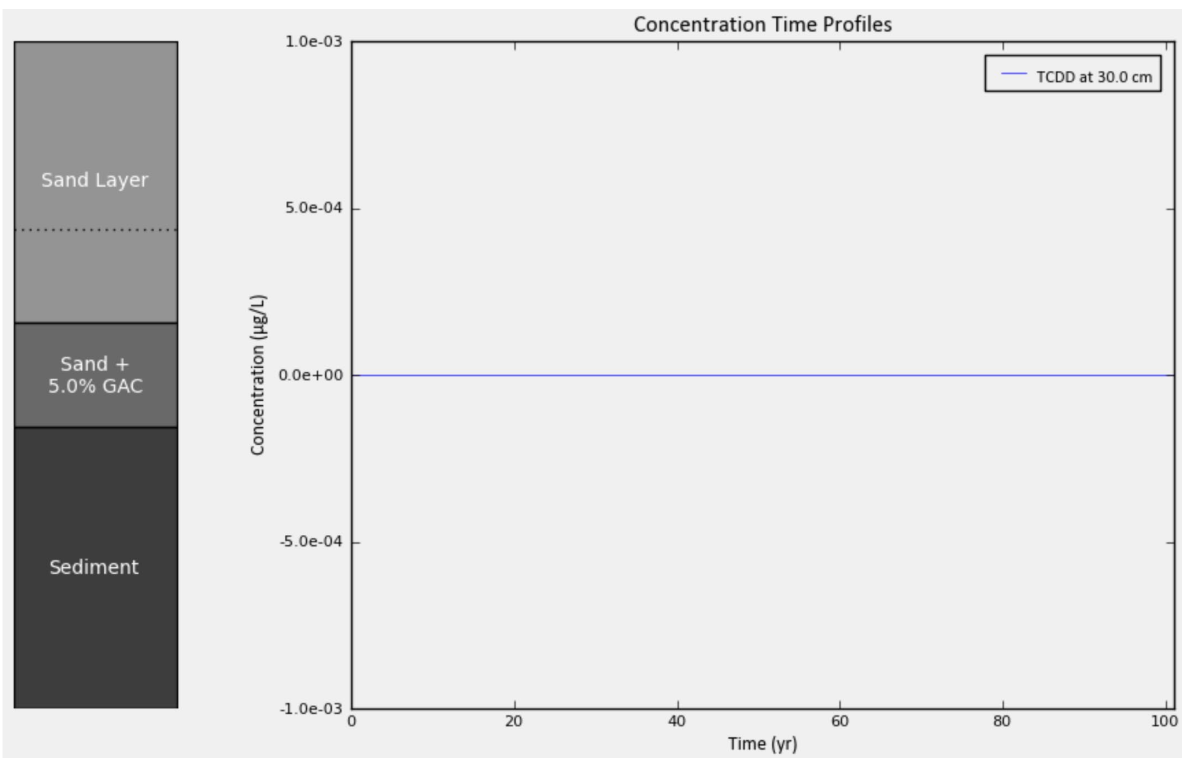
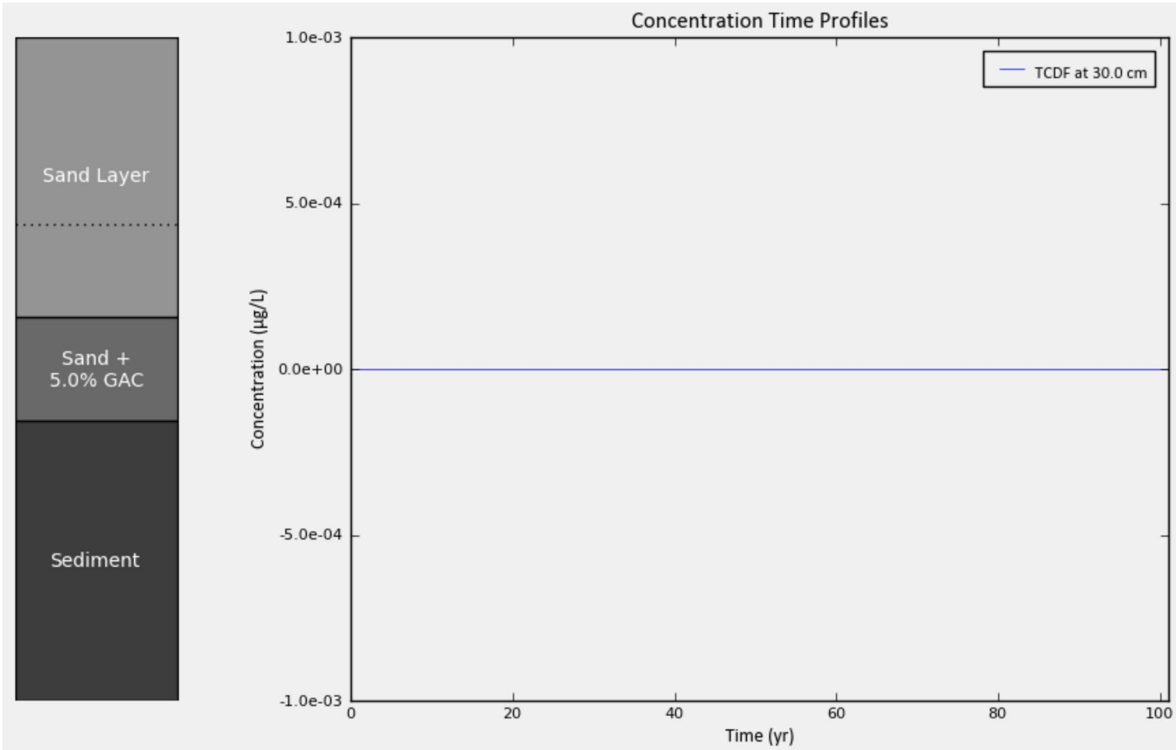
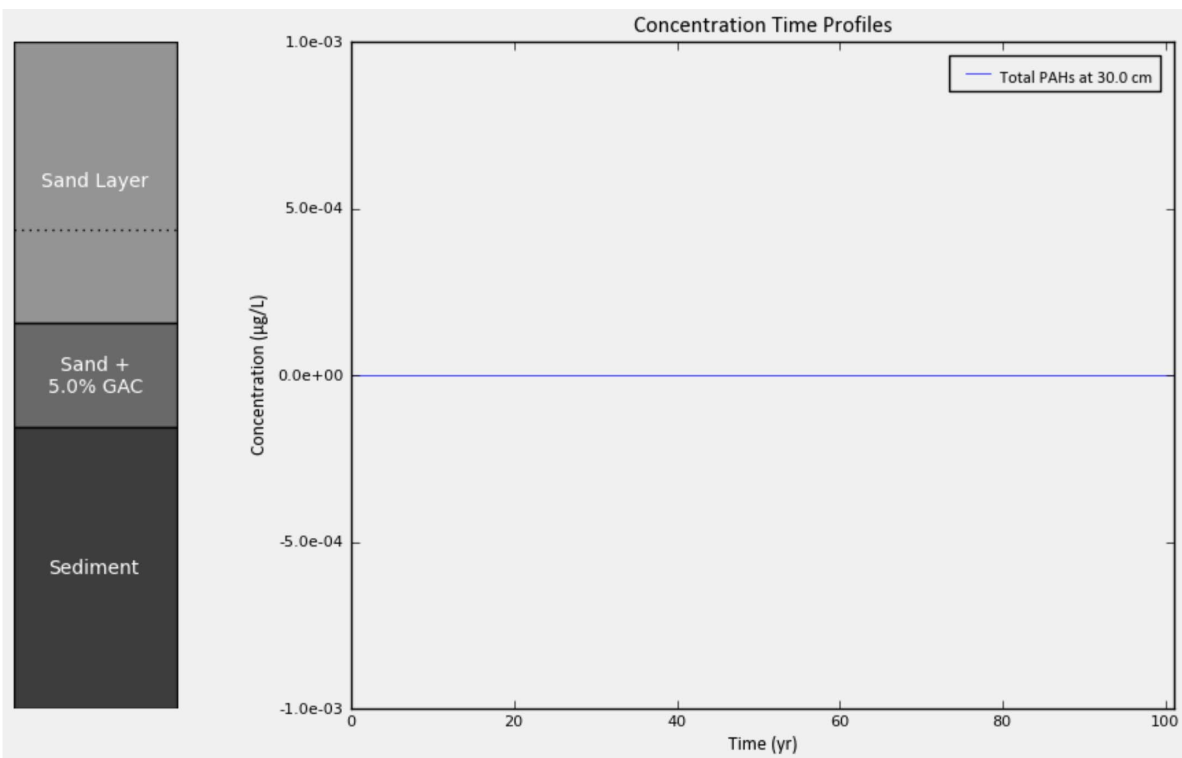
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)

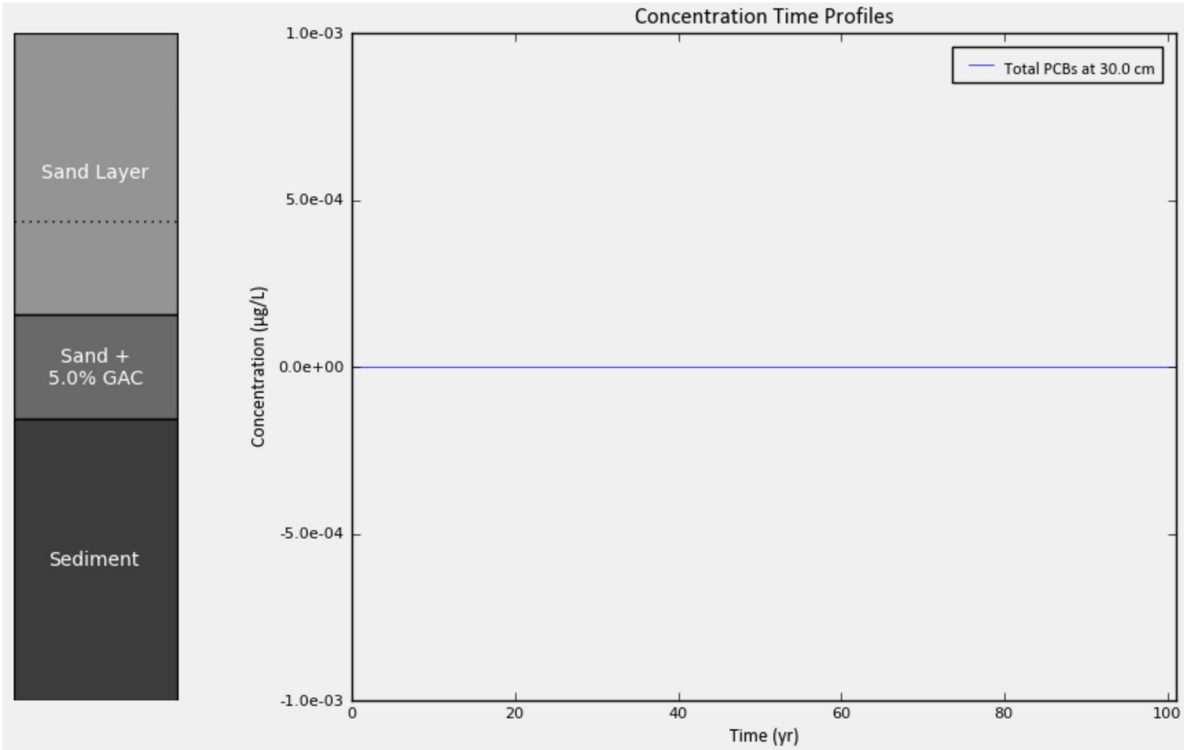

Concentration Time Profiles
Sand Layer
Sand +
5.0% GAC
Sediment
Phenanthrene at 30.0 cm
Concentration (µg/L)
6.0e-18
5.0e-18
4.0e-18
3.0e-18
2.0e-18
1.0e-18
0.0e+00
0
20
40
60
80
100
Time (yr)

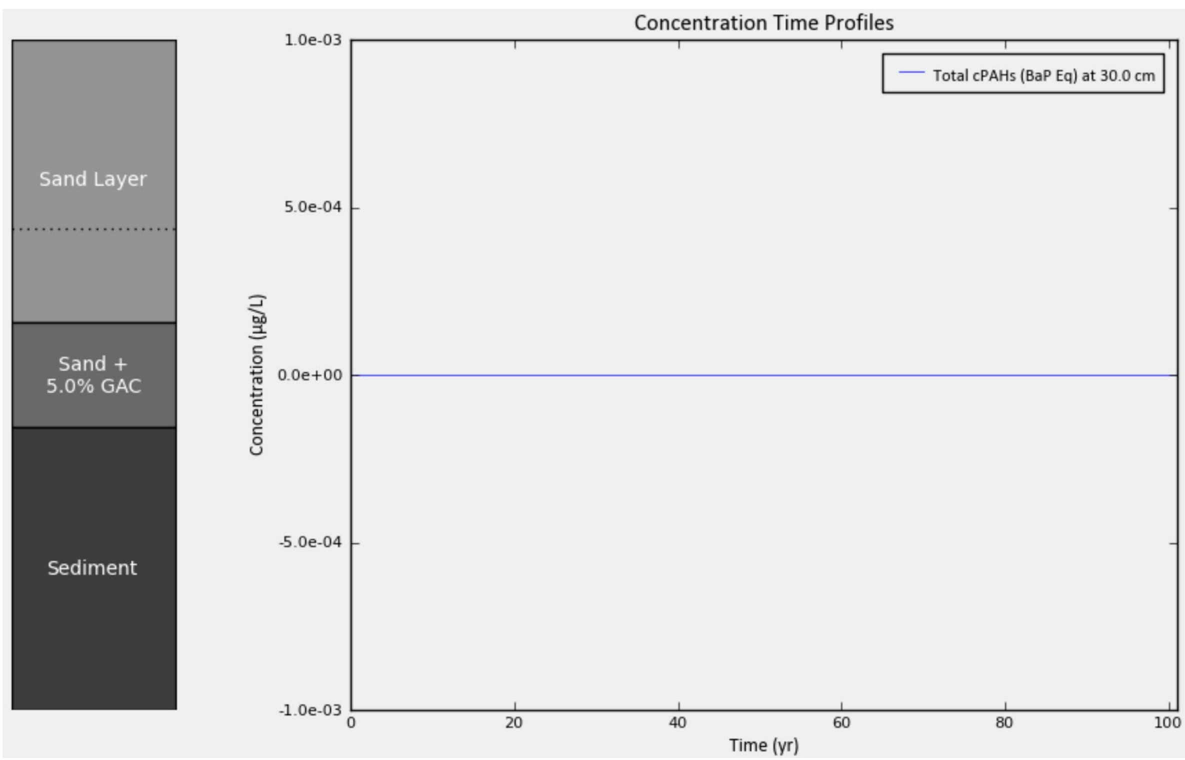

Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Pyrene at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (μg/L)
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
TCDD at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (μg/L)
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
TCDF at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Total PAHs at 30.0 cm
Concentration (µg/L)
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Total PCBs at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)


Sand Layer
Sand +
5.0% GAC
Sediment
Concentration Time Profiles
Total cPAHs (BaP Eq) at 30.0 cm
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Concentration (µg/L)
0
20
40
60
80
100
Time (yr)

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APPENDIX B

DREDGING EVALUATION

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APPENDIX B - DREDGING EVALUATION - REVISION 0
REMEDIAL DESIGN SERVICES, SWAN ISLAND BASIN PROJECT AREA
CERCLA DOCKET NO. 10-2021-001
PORTLAND HARBOR SUPERFUND SITE
PORTLAND, MULTNOMAH COUNTY, OREGON

APPENDIX B - DREDGING EVALUATION

This Appendix B of the Basis of Design Report (BODR) presents a preliminary dredging evaluation used for the Remedial Design (RD) conducted for the Swan Island Basin (SIB) Project Area within the Portland Harbor Superfund Site (PHSS) in Portland, Multnomah County, Oregon. HydroGeoLogic, Inc. (HGL) prepared this evaluation on behalf of the SIB RD Group based on the requirements of the PHSS Record of Decision (ROD) (U.S. Environmental Protection Agency [EPA], 2017); *Remedial Design Guidelines and Considerations* (EPA, 2021a); and the Administrative Settlement Agreement and Order on Consent (ASAOC) (EPA, 2021b). The data used in this dredging evaluation were collected in accordance with the final Pre-Design Investigation (PDI) Work Plan, which the EPA approved in May 2022 (HGL, 2022), and were reported in the PDI Evaluation Report (ER) (HGL, 2024).

The objective of this appendix is to serve as the basis for the development of the dredge design by providing an evaluation of dredging requirements and considerations to implement dredging as a viable remedial approach for SIB based on the updated conceptual site model. This dredging evaluation is not a design document. Information from this dredging evaluation will be used in the future refinement of dredging assessment during the development of the Draft 50% RD. This dredging evaluation addresses the following:

Section 1 Description of sediments potentially subject to dredging;

Section 2 Description of debris and debris removal/handling;

Section 3 Geotechnical slope considerations;

Section 4 Structural considerations;

Section 5 Approach to dredging;

Section 6 Sediment and debris handling and treatment prior to transport;

Section 7 Transport of treated sediments;

Section 8 Other dredging considerations; and

Section 9 Summary of dredging design considerations and limitations.

This appendix generally evaluates where dredging will occur, how it may be accomplished, and how the material may be handled and transported for disposal (as shown in Figure 1-1). The remedial technology assignment is described in the preferred remedial approach (BODR Section 5.4). The area-specific detailed design for dredging, handling, and disposal will be refined

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and presented in the Draft 50% RD. There are a variety of means and methods that may be applied to SIB.

1.0 DESCRIPTION OF SEDIMENTS POTENTIALLY SUBJECT TO DREDGING

Per ROD Section 10.1, sediment management areas were identified as areas where containment or removal technologies were considered to immediately reduce risks upon implementation. As a result, dredging is evaluated as a removal remedial technology in this section. Site configuration considerations include evaluation of site-specific sediment properties, historical dredging, and geotechnical evaluation.

SIB dredging feasibility was evaluated to define areas appropriate for dredging, with considerations using site-specific data including sediment grain sizes, bed slope, dry bulk density, current speed and velocities, and bed shear. Dredging feasibility evaluations focus on the ability of various equipment types to effectively remove the sediments and include consideration of factors such as the presence and extent of debris, the shear strength, density of the sediments, and the presence of underlying hardpan or rock bottoms (Palermo et al, 2008).

1.1 SEDIMENT PROPERTIES

Particle size distribution for the near-surface sediment (up to 1 feet [ft], 30 centimeters [cm)]) was determined using SEDflume core data as noted in Appendix I of the PDI ER (HGL, 2024). Samples showed a mostly uniform grain-size distribution over the near-surface sediment depth analyzed with SEDflume. Based on the particle size distribution, the near-surface sediment in SIB is primarily composed of silt (75 ± 4 percent), followed by clay (12 ± 3 percent), very fine sand (8 ± 3 percent), and sand (5 ± 3 percent) content (Table 1-1). Sand content increases with proximity to the higher-energy environment of the main channel of the Willamette River. The mean of the measured median grain sizes in the basin was determined to be 20 ± 6 micrometers (µm) (Table 1-1, Figure 1-2). The gray lines on Figure 1-3 represent approximate polygons where the median grain sizes shown are assumed to be generally applicable. Based on laboratory test results from geotechnical samples collected between a depth of 1 to 11 ft below the mudline, the sediment primarily consists of fine-grained material, with an average of 82.4 ± 3 percent passing the #200 sieve (75 µm).

Median grain size for the sediment at the interior of the basin (SF1 through SF12) ranged from 13 to 18 µm. Near-surface sediment at the U.S. Coast Guard (USCG) Dock, U.S. Navy Pier, Berth 301, Berth 302, and Dry Docks 3 and 5 had similar median sediment sizes (SF13 through SF18), with values ranging from 16 to 19 µm. Vigorous Dry Dock, Pier D, and Berth 312 showed larger median sediment sizes (SF23, and SF26 through SF28) ranging from 27 to 31 µm (Table 1-1, Figure 1-2). Additional stratigraphic analysis evaluations may be completed during the Draft 50% RD to evaluate depths beyond near surface sediment by using collected sediment cores. Resuspension of material during dredging operations may occur due to the sediment top layer being composed of over 70 percent silt. Best management practices (BMPs) such as silt curtains, debris booms, and/or physical barriers will be implemented to control/manage residuals and contamination release.

The dry bulk density results were used to evaluate the relative ease with which the sediment could be dredged, since density may affect production rates. Sediment dry bulk density was determined by testing the SEDflume samples. The SEDflume core data show that the sediment in the basin has an average dry bulk density of 0.41 ± 0.1 grams per cubic cm (g/cm^3), indicating weakly consolidated mud (Table 1-1, Figure 1-3). The interior of SIB shows dry bulk density (SF 1 through 12) ranging from approximately 0.24 to 0.40 g/cm^3. Portions of Vigorous Dry Dock, Pier D, and Berth 312 showed a dry bulk density ranging from 0.44 to 0.65 g/cm^3 (Table 1-1, Figure 1-3). Samples collected from the main channel tended to be slightly denser than samples from within the SIB interior. In addition, dry bulk density within SIB generally increased with depth due to consolidation, with bottom layer values up to 1 ft (30 cm) below the surface on the order of 0.5 g/cm^3, consistent with partially consolidated mud as noted in Appendix I of the PDI ER (HGL, 2024). The dry bulk density of sediment ranging in depth from 1 to 11 ft below the mudline was evaluated based on laboratory test results from the geotechnical borings performed within the basin. The average dry bulk density of the geotechnical samples from 1 to 11 ft below the mudline is 0.95 ± 0.05 g/cm^3. Overall, dry bulk densities measured in the field are relatively low, indicating soft mud that can be readily dredged (either mechanically or hydraulically) and will likely have high water content.

1.2 HISTORICAL DREDGING

The purpose of the historical dredging evaluation was to build on the information obtained during the owner/operator interviews summarized in the PDI ER. A review of historical dredging information was used to generate a more complete assessment of dredging restrictions imposed by structural limitations. Previous projects evaluated at SIB include a 2015 maintenance dredging project at Shipyard Commerce Center (HME, 2015) and a 2016 dredging project at the USCG Marine Safety Unit (MSU) (MIC, 2016). All of these historical dredging events utilized mechanical dredging. The historical dredging evaluation documented dredge elevations, implemented offsets, design dredge elevations, and information guiding structural stability concerns. Available documentation of historical dredge activities was reviewed with a focus on the following information:

- Hydrographic survey data with supposed structural design dredge elevations adjacent to present-day Berths 301 to 312 (Port of Portland, 1980);
- A stamped "AS BUILT" 1972 drawing set for U.S. Navy Pier (EPI and NMI, 1972) with dredge information;
- A stamped "AS CONSTRUCTED" 1963 drawing for Dry Dock 3 with dredge elevations (Frederick R. Harris. Inc, 1963);
- A stamped "AS CONSTRUCTED" 1978 drawing for the area between Berths 305 and 306 with pre- and post-dredge soundings (Port of Portland, 1978);
- A 1975 study with a focus on the effects of dredging on infrastructure at Berth 301, Pier C, and present-day Dry Dock 1 (then Dry Docks 1 and 2) (CH2M Hill, 1975); and
- A 1981 drawing with an itemized list of design dredge line locations and soundings (Port of Portland, 1981).

The 1981 Port of Portland drawing set provided the most relevant information regarding potential impacts to structures and necessary offsets, including the following:

- No offset at Berth 301;
- Offsets of 20 to 40 ft from Berths 302 to 305 (drawing only shows a 20-ft offset);
- A 40-ft offset from the cell face at the quay wall at Dry Dock 3; and
- Dredging depth information for basins of previously named Dry Docks 1, 2, and 3 stating that required dredge lines for the max submergence could not be achieved in all areas due to structural concerns.

The historical dredging documentation informed geotechnical and structural planning and evaluation by providing valuable insight into the subsurface conditions and performance of slopes and structures during and following prior dredging activities. Knowledge of the historical dredging activity near each structure also helped inform past mudline conditions and elevations at each structure, which were included in the evaluation of each structure's capacity. The documentation was also useful to inform dredge planning and production for the proposed project, including main and ancillary equipment (informs regional market availability and capability), debris, transport and logistics, and in situ material characteristics.

2.0 DESCRIPTION OF DEBRIS AND DEBRIS REMOVAL/HANDLING

This section evaluates the estimated volume/mass requiring removal prior to dredging to lessen the impact on dredging production rates and/or capping operations. Oversized debris may impact dredging operations by slowing production, and damaging equipment, and may have to be removed prior to dredging, which may cause the generation of residuals. The presence of surface debris was determined by examination of bathymetric survey data. Subsurface debris was not accounted for in the bathymetric survey.

As seen in BODR Section 2.6.5, weight bounds were computed based on the assumed density range of unclassified materials. For 1,570 pieces of debris evaluated, the total volume was estimated to be approximately 1,635 cubic yards (CY). The approximate weight bounds for the 1,570 evaluated pieces were from 1,240 to 3,390 tons. Debris that exceeded 2 ft (60 cm) represents approximately 92.9 and 99.8 percent of the total debris count and total volume evaluated, respectively. Evaluation results indicate that most of the surface debris identified in SIB is larger than 2 ft (60 cm) and will have to be removed before or during the dredging operations (as a separate effort from dredging). Surface debris smaller than 1-2 feet might be present but could not be identified due to the resolution of the bathymetry data.

Subsurface debris quantities are unknown, and any estimates of subsurface debris would be subject to high levels of uncertainty. Surface and subsurface debris may be removed prior to dredging or in tandem with dredging. Subsurface debris encountered during dredging may be removed in tandem with dredging; however, this approach would impact dredge production and could cause delays. A mechanical dredge could be used to remove debris in parallel to hydraulic dredging; however, hydraulic dredging operations would have to be paused while debris is removed, also impacting production and schedule.

The eventual methodology for debris removal will be best defined by the selected contractor, their availability of equipment and project scheduling/sequencing approach.

3.0 GEOTECHNICAL SLOPE CONSIDERATIONS

The purpose of the geotechnical evaluation is to assess parameters and outcomes that will aid in establishing preliminary dredging plans for the removal of impacted sediment, further presented in the preferred remedial approach (BODR Section 5). Inputs used in this geotechnical evaluation will also support the evolution of the RD through different stages of the design process.

Dredging activities may change the slope stability of adjacent riverbank slopes, or the erosion potential of the riverbed within the remediation area, as compared to the existing pre-dredge conditions, or both. Understanding these potential changes is a key element of designing post Remedial Action slopes that do not increase the potential for bank erosion, structural instability of shoreline facilities, or other adverse effects that may be unacceptable (Palermo et al., 2008).

To assist in the identification of dredging scenarios that will require detailed engineering analysis and evaluation, representative cross-sections were developed at significant slopes and structures throughout the remediation area (see examples of some of these cross-sections in BODR Figures 6-5 through 6-28). These cross-sections were then annotated with three dredge impact zones (Palermo et. al, 2008). The three dredge impact zones are classified as Critical Zones (defined by up to a 2H:1V[1] slope), Caution Zones (slope ranging from 5H:1V to 2H:1V), and Low-Risk Zones (slopes shallower than 5H:1V). It should be noted that dredging is not prohibited within the Critical Zone and that none of the dredge impact zones represent a required dredge offset distance from a slope or structure. The dredge impact zones are intended to efficiently provide valuable information regarding the potential impact of dredging to slopes and structures where structure- or slope-specific analysis has not yet been performed. In general, dredging in the Critical Zone will nearly always require mitigation measures to protect existing facilities from damage. Dredging in the Caution Zone may cause unstable, unsafe conditions while dredging without mitigation, and dredging in the Low-Risk Zone can typically be performed without employing mitigation measures. Potential mitigation measures include, but are not limited to, load reduction, construction sequencing, ground improvement, structural reinforcement, and both temporary and permanent slope reconfiguration, or a combination of multiple measures.

The potential dredging impacts identified helped inform the development of the preferred remedial approach (BODR Section 5) and provided important baseline geotechnical information for consideration as the project advances to the Draft 50% RD. The preliminary geotechnical analyses conducted for the capping are described in Appendix A Section 3.1. Detailed geotechnical analyses, based on the considerations, constraints, and RD concept described in this BODR Section 5, will be performed as part of the Draft 50% RD.

Characterization of bed slopes is essential for establishing dredging plans, as it impacts slopes of materials adjacent to dredged sediment, and stability of riverbanks and shallow areas. The estimated in situ bed slopes in SIB were derived from the unified bathymetry data presented

[1] Slopes are reported as a ratio of horizontal to vertical length (H:V), the smaller the number in the front of the ratio, the steeper the slope.

in Appendix E of the PDI ER (HGL, 2024). Slopes in SIB vary from 10H:1V to 1H:1V. The steepest bed slopes are found in the vicinity of Dry Dock 3, the northern end of the riverbank from U.S. Navy Pier to The Marine Consortium Dock, and from Berth 302 to the Wind Tunnel (Figure 3-1). The submerged portions of these slopes are likely marginally stable, and include some manner of slope reinforcement, rock protection, or both. Bed slope gradients were considered during the development of the preferred remedial approach and will require continued consideration during the Draft 50% RD, specifically in areas steeper than approximately 3H:1V where mitigation measures will likely be required. Existing bed slopes throughout the site were estimated for the indicated areas shown in Figure 3-1 and summarized in Table 3-1 below.

Table 3-1. Bed Slope Site Characterization

Location	Existing Slope	Comment
Dry Dock 5	10H:1V	Mild slope throughout
Dry Dock Basin (west and northeast)	3H:1V to 1H:1V	None
Dry Dock Basin	7H:1V to 3H:1V	Line running northwest to southeast
Berth 309 (Pier C)	1H:1V to 7H:1V	Not a permanent structure
Dry Dock 3	10H:1V to 1H:1V	Mild slopes bordered by steep slopes
SCC Floating Dock	10H:1V to 1H:1V	Mild slopes bordered by steep slopes
Vigorous Dry Dock	10H:1V to 1H:1V	Primarily mild with steeper slopes
USCG Dock and Pier	2.5H:1V	None
Berth 311	10H:1V to 7H:1V with 1 to 2H:1V	Primarily mild slopes with steep sections
Berth 301 (northern end)	7H:1V to 1H:1V	Mild to steep slopes

4.0 STRUCTURAL CONSIDERATIONS

This evaluation includes an initial consideration of dredging activities near existing structures. A more detailed analysis of structural considerations will be included in the Draft 50% RD. Final setbacks and/or the need for slope or structure stabilization will also be determined during the Draft 50% RD.

Navigational depths (NDs) were assessed based on requested depths from owners/operators and compared to contamination elevations. The desired navigational depths at Dry Docks 3 and 5 and the Vigorous Dry Dock were compared to minimum contaminant elevations derived from sediment cores. Dry Dock 5 has a desired ND that is deeper than the preliminary minimum contamination elevation. However, the contaminant information is currently in progress and the entirety of Dry Dock 5 was not analyzed for dredge volume. Dry Dock 3 and the Vigorous Dry Dock have desired NDs shallower than the preliminary minimum remedial action level (RAL) exceedance elevation. Maintenance dredging has occurred throughout the Dry Dock Basin area.

Further assessment near structures is needed to determine dredging and cap placement depths as they pertain to the considered ND. Structure-specific geotechnical and structural assessment is ongoing.

5.0 APPROACH TO DREDGING

5.1 LATERAL AND VERTICAL EXTENTS OF DREDGING

Lateral and vertical extents used to develop estimated dredge volumes are discussed in the preferred remedial approach (BODR Section 5). The lateral and vertical extents discussion in this section will be updated during Draft 50% RD following structure-specific geotechnical and structural assessments.

5.2 PRELIMINARY OVERDREDGING REQUIREMENTS

Additional dredging can occur if additional water depth is required to fit a cap below navigable depth, and the additional dredging commonly referred to as "over-dredging," which accounts for construction equipment tolerances. Additional dredging for cap placement will depend on the final cap design (where applicable). There are no areas in SIB where PTW is found below the feasible depth of dredging.

Therefore, the term over-dredging here refers to additional assumed dredging depth to account for construction equipment tolerances. According to *Technical Guidelines for Environmental Dredging of Contaminated Sediments* Section 9.2.2: "*Considering the water depths at most contaminated sediment sites, the size of dredges normally employed, and the precision attainable for positioning the dredge head, and overdredge allowance for environmental dredging projects of 6 in. is the current "state of the practice."* (Palermo, 2008)

Moreover, as discussed in the BODR Section 3.3.2, if dredging will be followed up by capping, additional dredging may be necessary to accommodate the elevation of the top of the cap or residual layer to be no higher than the pre-design elevation to avoid loss of submerged aquatic habitat, preserve slope stability, and negate adverse impacts to the floodway. These considerations are included in the preferred remedial approach (BODR Section 5) and will be discussed in further detail in the Draft 50% RD. Additional dredging is incorporated into the design to account for inaccuracies of dredging equipment that may occur ("over-dredging") and to provide additional clearance for the final capped elevations to be met in areas with navigation depth requirements.

5.3 EQUIPMENT SELECTION CONSIDERATIONS

This section evaluates potential mechanical dredging equipment requirements. While a variety of means and methods are applicable to this project, this analysis assumes the use of a mechanical dredge incorporated with both marine and terrestrial transport of material to a transload site and landfill. One transload site used on a previous project was used for evaluating preliminary production rates. While no hydraulic dredging upland dewatering facility or disposal site option has been identified, information may be included and updated if and when it becomes available prior to the completion of the BODR. Additional equipment considerations will be discussed in the Draft 50% RD. Proposed mechanical dredge and transport equipment was developed using historical dredging projects within SIB and previous dredging work experience. The contaminated sediment may be dredged using a mechanical dredge with a large environmental bucket, although hydraulic options may also be feasible.

5.4 PRELIMINARY DREDGING PRODUCTION RATES

Preliminary production rates for dredging and transloading were developed using the equipment discussed in BODR Section 6.1.2.2 Dredging production rates were evaluated from previous recent project construction logs, and assuming Effective Working Time of 60% to account for dredge plant and equipment movement, maintenance, shift changes, etc. A reasonable and conservative daily production rate was assumed to be roughly 2,000 CY/day. The actual production rate(s) to be developed during RD will vary based on the vertical depth of dredging; equipment available; methodology used; and limitations of production including weather, mechanical issues, efficiency, size of equipment used, shifts, slowing or stopping work in response to water quality monitoring triggers, and transload and disposal site locations. For example, a large environmental bucket may be used for the primary dredge volume, while a smaller bucket may be used for precision dredging.

In accordance with the Oregon Department of Fish and Wildlife (ODFW), the SIB Project Area is subject to two preferred in-water work windows; July 1st through October 31st and December 1st through January 31st. The winter in-water work window, December 1st-January 31st permits work below -20 feet National Geodetic Vertical Datum (NGVD) 1947. While this may not impact daily production rates; it is assumed to have an impact on the schedule and duration of the dredging effort.

6.0 SEDIMENT AND DEBRIS HANDLING AND TREATMENT PRIOR TO TRANSPORT

This section includes an evaluation of mechanically dredged sediment transloading and rehandling. While a variety of means and methods of sediment and debris handling and treatment may be applicable to SIB, this assessment evaluates one example. The methodology implemented at SIB will be determined in consultation with the RA contractor. This assessment will evaluate the sediment and debris handling using a mechanical dredge with an environmental bucket and barges at SIB. Using this methodology, the sediment is removed from the water and placed onto an adjoining barge. Any debris collected simultaneously will be placed on the barge for disposal at a later time. Debris may be separated by a bucket on the barge or with the use of a debris screen.

The dredged material will then be placed onto barge(s) and transported to a transload site. Dewatering of the material will occur on the barge with excess dredge water pumped to a storage hold or to a joining water barge and processed when full. The use of drying agents will be applicable to passively dewater sediment and may be used during transport and at the transload site. Additional drying agents may be added at the transload site and/or disposal site, as needed. Cost-effectiveness of using drying agents must be compared to the incremental weight and cost associated with retaining more water in the dredge material. The transload site will have a Derrick barge equipped with an environmental bucket and additional barges and excavators to assist in handling sediment. The material will then be placed onto trucks and transported to a landfill for disposal. There is an option for transport of material by rail. The viability and cost-effectiveness of this option depends on location of disposal and availability of land for sediment processing.

Once the maximum volume of sediment and/or debris has been collected on the barge, the barge will be transported to the transload site via tugs. The dredging operation will occur in parallel to barge transport with barges traveling to and from the transload site in parallel.

7.0 TRANSPORT OF TREATED SEDIMENTS

Dredged sediment and debris may be transported using a combination of marine transport (barges and tugs), rail, and trucks. This assessment discusses the transport of sediment and debris using a combination of barges and trucks. The RA contractor may opt for an alternative methodology.

One of the potential methodologies includes sediment and debris transported on a series of barges with the assistance of tugs to the designated offload site. Transload and disposal site alternatives will be developed in the Draft 50% RD. A previous dredging project at SIB utilized an offload site located at The Dalles; this was evaluated as an option. The time for transportation of dredged material from SIB to The Dalles offload site was estimated by using an average tug speed of 10 knots. Travel speeds are anticipated to vary; 10 knots was used as an initial average speed to estimate overall transit time for a single barge, but travel speed does not control transit production rates, per se, since multiple barges are anticipated to be in transit simultaneously.

The barge route to The Dalles requires vessels to pass through the Bonneville Dam Locks. Per the U.S. Army Corps of Engineers (USACE)-Portland District (USACE, 2024), the locks fill and/or empty in 9 to 13 minutes. The contractor will have to coordinate with the USACE lock operator to schedule passage. Due to the overall length of the transit, time passing through the locks is not anticipated to significantly affect overall transport production rates. Tugs traveling at 10 knots over 96 miles need approximately 8.5 hours one way, which is equivalent to approximately a 17-hour round trip.

In addition to round trip travel time, offload time will likely take a few hours per round trip, depending on material condition (water content), equipment used, and total volume/mass of material. The transload site may be organized in different ways as determined by the contractor. This evaluation considered that the transload site would use a Derrick barge with a crane and environmental bucket with adjoining stationary rehandling barges for ease of sediment management, and the use of excavators for transport of sediment from barge(s) to trucks. At the transload site, sediment and debris may be placed onto the rehandling barges with the use of an environmental bucket. A front-end loader or potentially an excavator may be used to transfer the sediment and debris to haul trucks. While production rates at the transload facility have not been evaluated as a part of this BODR, they will be evaluated as a part of the RD and presented in the Draft 50% RD as they are anticipated to control overall production rates for transportation and disposal of sediment and debris. Transload site production will be evaluated during RD to minimize the impacts of bottlenecks in the overall dredging and disposal process. The haul trucks may then transport the dredge material and debris to the designated landfill. Several landfills have been contacted and preliminary information has been acquired. Communication with landfills is ongoing. The landfill(s) used for SIB will depend on the landfill(s) capacity, the volume of sediment, and the contractor's methodology of sediment processing and transport. This assessment considered the Wasco County Landfill as an example due to its close proximity to the example transload site at The Dalles. Haul trucks leaving the transload site will likely require approximately a 1-hour trip, assuming 30 minutes spent at the landfill and 30 minutes in transit round trip. Further assessments will be conducted as offload and disposal site alternatives are developed in the Draft 50% RD.

In the case of a hydraulic dredging operation (vs mechanical dredging), an upland processing facility (UPF) location would likely be utilized. A UPF has not been identified and will be discussed in the Draft 50% RD, as appropriate. Considerations may include treatment process, land use, real estate acquisition, capital expenditures, operational expenditure periodic costs, and decommissioning. Capital and operational expenditures encompass the cost of designing, developing, constructing, running, and maintaining a UPF site. Disposal site assessments and cost estimates are in progress and will be further refined during the Draft 50% RD.

8.0 OTHER DREDGING CONSIDERATIONS

This section summarizes other dredging considerations, including potential release of contaminants, residual management, utilities, and future monitoring.

The removal of contaminated sediments from waterways by dredging generates concern about the release of contaminants to the water column due to releases of contaminants of concern in the dissolved phase to water during sediment resuspension. Results of release evaluation such as dredging elutriate testing (DRET) can be used to understand the concentrations of contaminants released to the water column during dredging operations. These concentrations can also be compared to water quality standards established for the project (Reible, 2014). The ability to predict the magnitude of these potential releases during the project planning process helps manage potential water quality impacts and controls or mitigation measures for the dredging project. DRET was conducted as a part of the PDI, and the results are reported in the Surface and Subsurface Sediment Sampling Data Report, which is Appendix A of the PDI ER (HGL, 2024). Bulk surface and subsurface sediment and water samples were used to prepare DRET from three sampling locations (grid cells F14, D5, and C22) to represent a range of chemical concentrations (high, medium, and low). Bulk water samples were collected from the middle of the water column at each location.

A comparison of DRET results to surface water quality screening levels indicates that several analytes exceed one or more screening levels, as noted in Appendix A (Table 4-3) of the PDI ER (HGL, 2024). As expected, the elutriate from the conservatively high-solids 10 gram per liter slurries exhibited higher contaminant concentrations than the elutriate from the 1 gram per liter slurries for all analytes and locations. The high solids/high contaminant concentrations results are intended to represent a worst-case scenario and not what is typically expected from a well-executed dredging operation. The results indicate a need for placement of the residual management layer as soon as possible following dredging operations (unless assigned remedial technology includes capping or backfilling). If additional data is needed during subsequent RD, additional DRET will be completed prior to dredging operations.

Future studies in the Draft 50% RD will address emissions impacts and the Spill Prevention, Control, and Countermeasure plan to be developed during the construction phase. Preliminary BMPs and residual management will be developed to ensure dredging, transloading, and offloading activities comply with applicable regulations and requirements.

Existing utilities will be further evaluated before the start of any remedial activities, as discussed in BODR Section 2.6.7, and constructability and construction activity considerations in BODR. Such evaluations will be further discussed in the Draft 50% RD.

Dredging monitoring will be performed in accordance with Section 10.1.1.9 of the ROD to include baseline sampling, short-term monitoring until Remedial Action performance goals are met, and long-term monitoring during statutory Five-Year Reviews until unlimited use/unrestricted exposure for the site is achieved (EPA, 2017). Additional considerations for dredging monitoring and additional potential maintenance needs will be identified in the Draft 50% RD.

9.0 SUMMARY OF DREDGING DESIGN CONSIDERATIONS AND LIMITATIONS

This section summarizes dredging design considerations:

- Overall, dry bulk densities measured in the field are relatively low, indicating soft mud that can be readily dredged (either mechanically or hydraulically);
- Based on a mostly uniform grain-size distribution of near surface sediments, resuspension of material during dredging operations may occur due to the sediment top layer being composed of over 70 percent silt;
- BMPs that comply with regulations and requirements will be implemented to mitigate residuals and contamination release (e.g., silt curtains, closed buckets, others);
- BMPs that comply with regulations and requirements will be implemented to mitigate residuals and contamination release;
- Slopes in SIB vary from 10H:1V to 1H:1V. The primary steep bed slopes are found in the vicinity of Dry Dock 3, the northern end of the riverbank from U.S. Navy Pier to The Marine Consortium Dock, and from Berth 302 to the Wind Tunnel;
- Dredging activities may change the slope stability of adjacent riverbank slopes, or the erosion potential of the riverbed within the remediation area, as compared to the existing pre-dredge conditions, or both. Detailed geotechnical analyses, based on location-specific material properties, the proposed dredge depth, the configuration and material properties of adjacent slopes, the presence of adjacent structures, and any proposed structural or slope stability mitigation measures will be performed as part of the RD and presented in the Draft 50% RD.
- Overdredging allowance due to construction equipment tolerance will generally be 6 inches which is the present state of practice for environmental dredging projects (Palermo 2008). However, in some areas of the project site equipment tolerances may dictate a larger over-dredging allowance (for example 1 ft), due to spatial limitations requiring use of potentially less accurate equipment. BMPs will be developed to include residual management control measures since DRET results indicate the potential need for short-term residual management control;
- Quantification of subsurface debris was not possible using existing data; and
- Most of the previously observed surface debris in SIB may have to be removed before, while some debris may be removed during the dredging operations;

Area-specific dredging design incorporating these considerations will be performed during RD and presented in the Draft 50% RD.

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List of Tables

List of Figures

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TABLES

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Table 1-1
SEDflume Sediment Results
Appendix B - Dredging Evaluation; Swan Island Basin Project Area, Portland, Oregon

Sed Flume Core	Median Particle Size (µm)	Sediment Dry Bulk Density (g/cm^3)	Clay %	Silt %	Very Fine Sand (%)	Sand %
SF1	15	0.28	13	79	5	3
SF2	17	0.36	13	77	6	4
SF3	14	0.29	15	80	4	2
SF4	13	0.39	17	76	5	1
SF5	15	0.40	15	75	6	4
SF6	15	0.35	13	79	7	2
SF7	13	0.36	16	78	4	1
SF8	18	0.37	11	75	8	5
SF9	15	0.29	13	82	4	1
SF10	16	0.31	12	78	6	4
SF11	15	0.34	13	81	4	2
SF12	13	0.39	19	76	4	2
SF13	16	0.38	13	79	6	2
SF14	16	0.35	13	77	6	4
SF15	19	0.36	10	81	7	2
SF16	19	0.36	11	76	8	5
SF17	19	0.45	12	79	7	3
SF18	19	0.37	11	77	7	5
SF19	25	0.42	9	76	10	5
SF20	21	0.49	11	70	8	10
SF21	23	0.42	10	75	10	4
SF22	22	0.74	10	75	10	5
SF23	28	0.44	9	70	13	8
SF24	27	0.41	9	73	13	6
SF25	27	0.40	8	73	12	6
SF26	28	0.60	9	67	12	12
SF27	31	0.65	9	65	13	13
SF28	27	0.45	9	68	12	11
SF29	28	0.44	8	70	13	9
SF30	30	0.41	8	70	14	8
Average	20	0.41	12	75	8	5
S.D.	6	0.10	3	4	3	3

Notes:
% - percent
µm - micrometer
g/cm^3 - grams per cetimeter cubic
S.D. - standard deviation
SF - SEDflume

SEDflume core locations are shown on Figures 3-2 and 3-3.
Particles classified based on particle size as:
Clay - less than 4 µm
Silt - between 4 and 64 µm
Very fine sand - between 64 to 125 µm
Sand - greater than 125µm

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FIGURES

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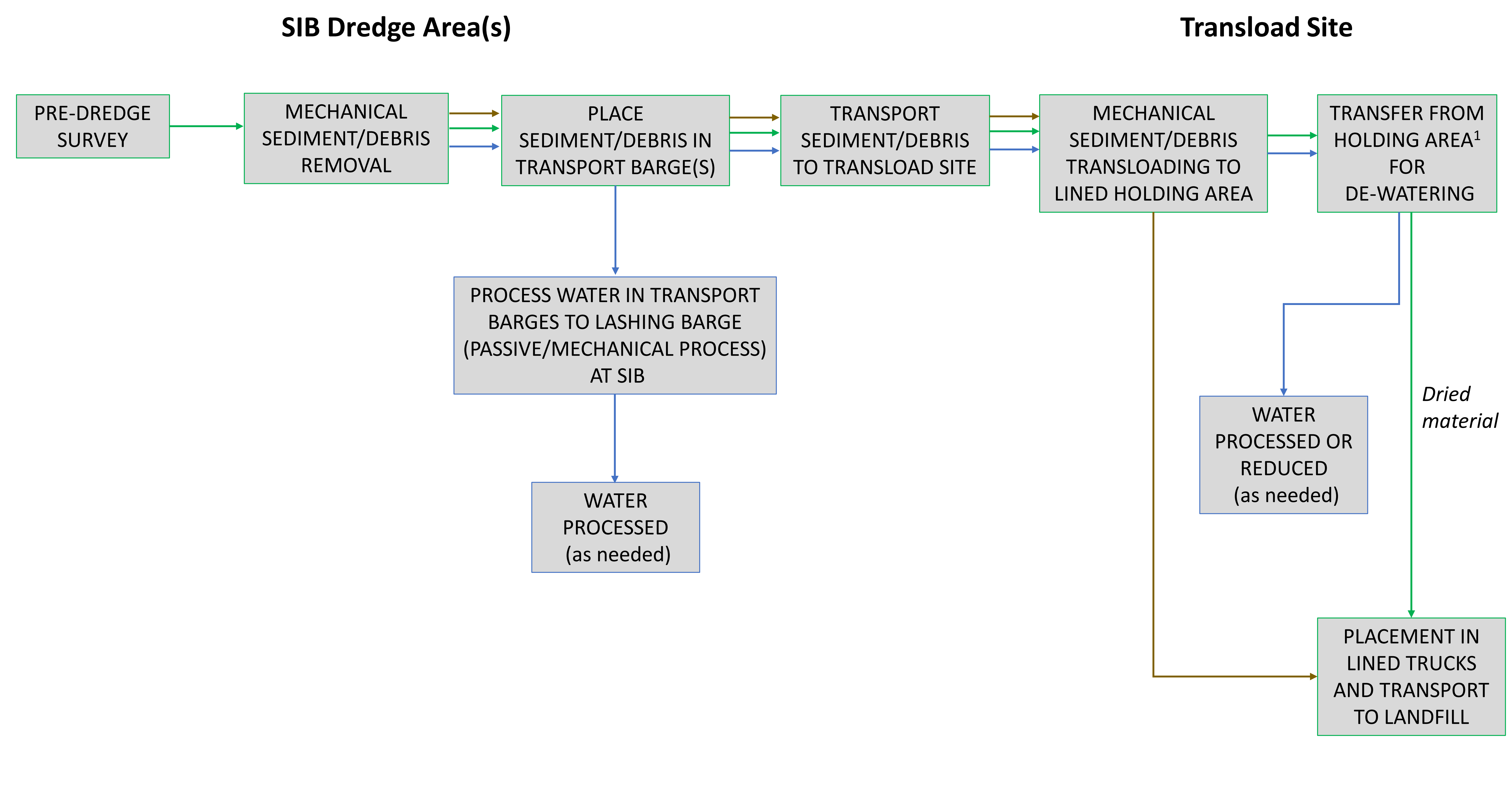

Sediment
Water
Debris

Notes:
[1] Holding Area may include baker tanks for dewatering, equipment to process drying agent admixtures with dredged material, etc. To be determined by disposal retirements.

Figure 1-1
Dredging Process Flow Diagram

Prepared on: 1/23/2024
Appendix B - Dredging Evaluation
Swan Island Basin Remedial Design Group

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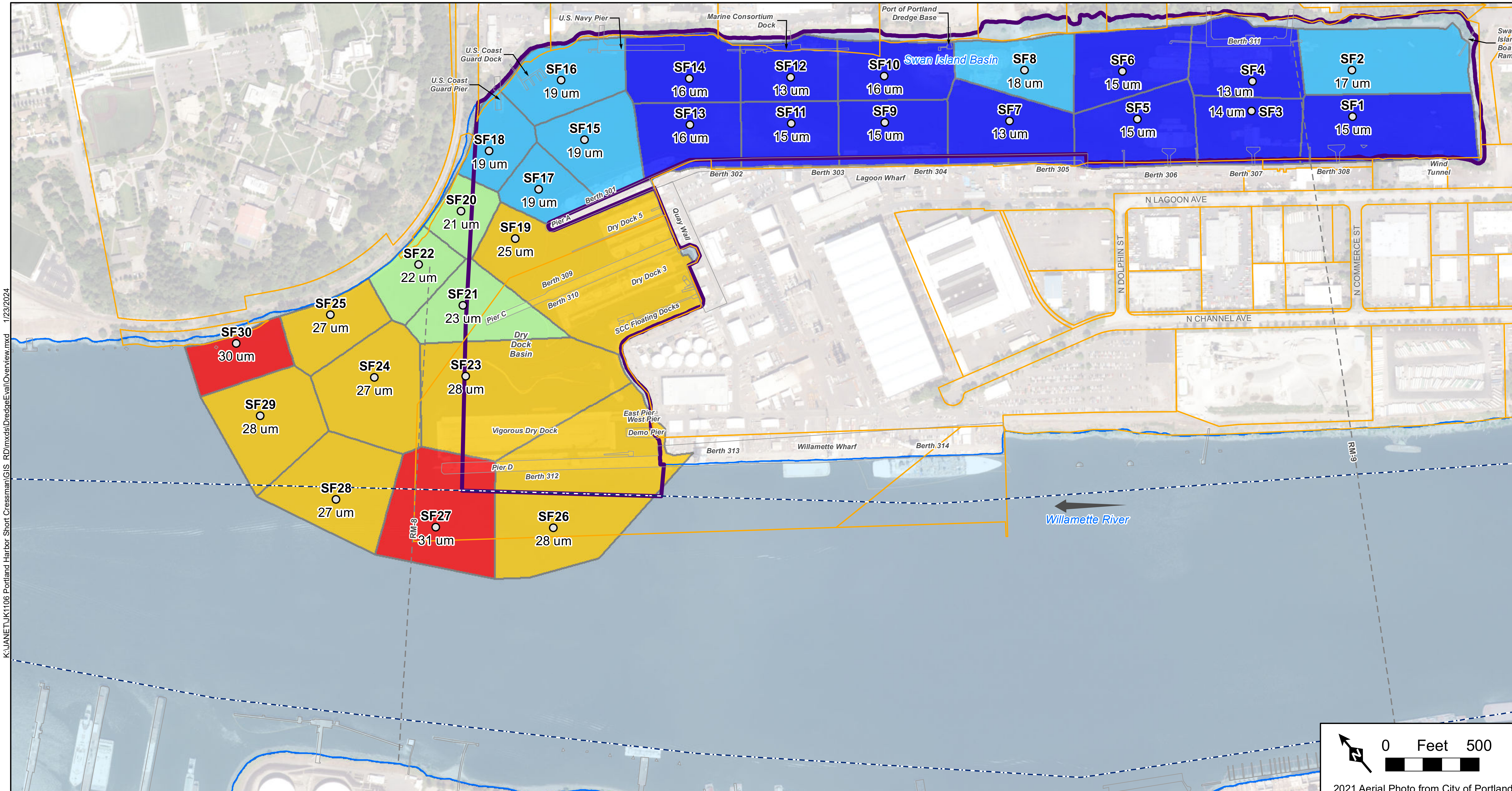

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River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

SedFlume Cores
Median Grain Size (um)
12 - 16
16 - 20
20 - 24
24 - 28
28 - 32

Notes:
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
um – micrometer
USACE – U.S. Army Corps of Engineers

Figure 1-2
Surface Sediment Median Grain Size

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HGL
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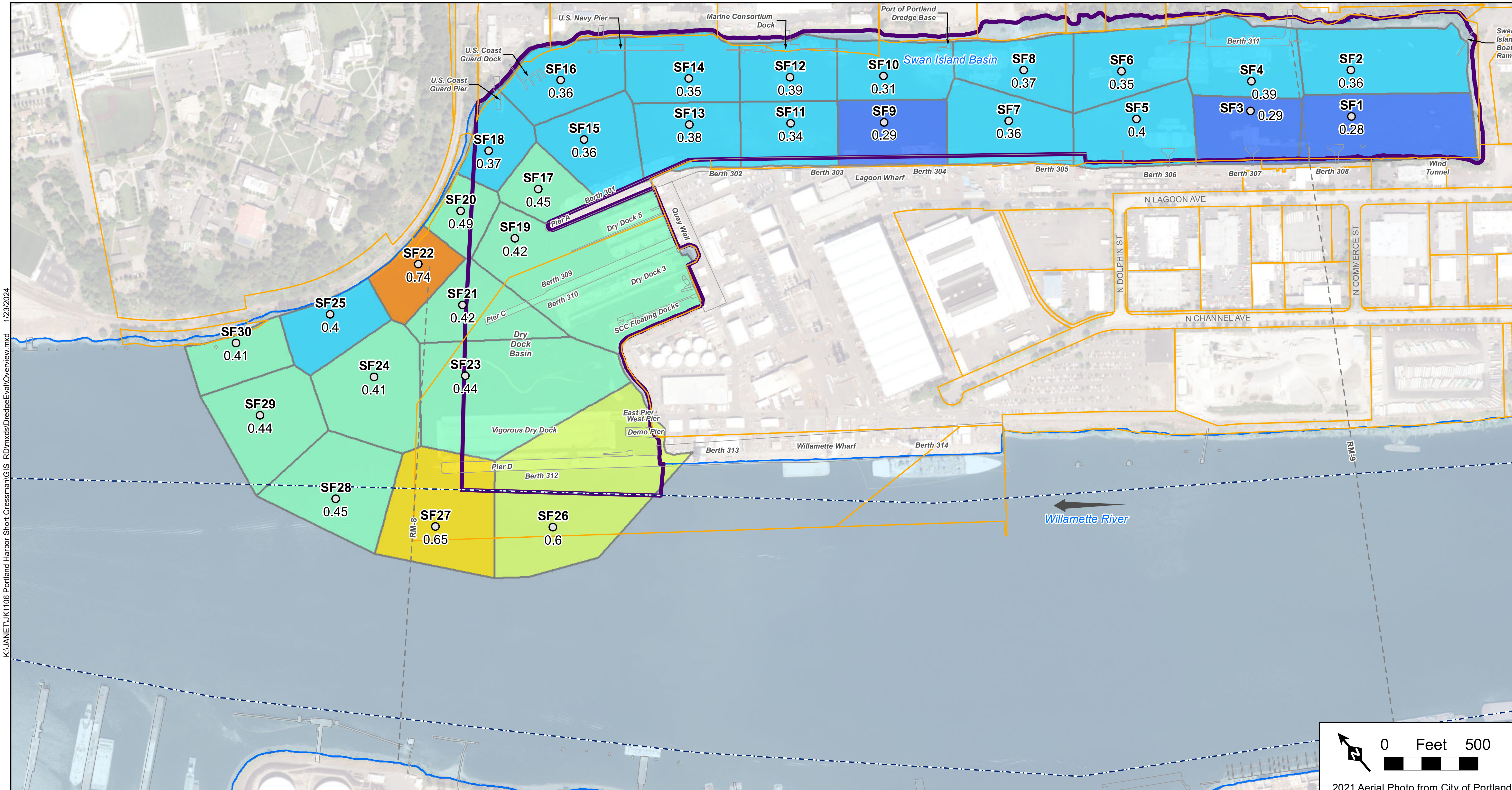

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- River Mile (RM)
- Swan Island Sediment Decision Unit (SDU)
- Federal Navigation Channel (USACE, 2020)
- Docks and Structures
- Tax Lot Boundary
- Ordinary High Water (City of Portland, 2013)
- River Flow Direction

SedFlume Cores

Dry Bulk Density (g/cm^3)

- 0.21 - 0.30
- 0.31 - 0.40
- 0.41 - 0.50
- 0.51 - 0.60
- 0.61 - 0.70
- 0.71 - 0.80

Notes:
g/cm^3 – gram per cubic centimeter
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers

Figure 1-3

Surface Sediment Average Dry Bulk Density

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Appendix B - Dredging Evaluation
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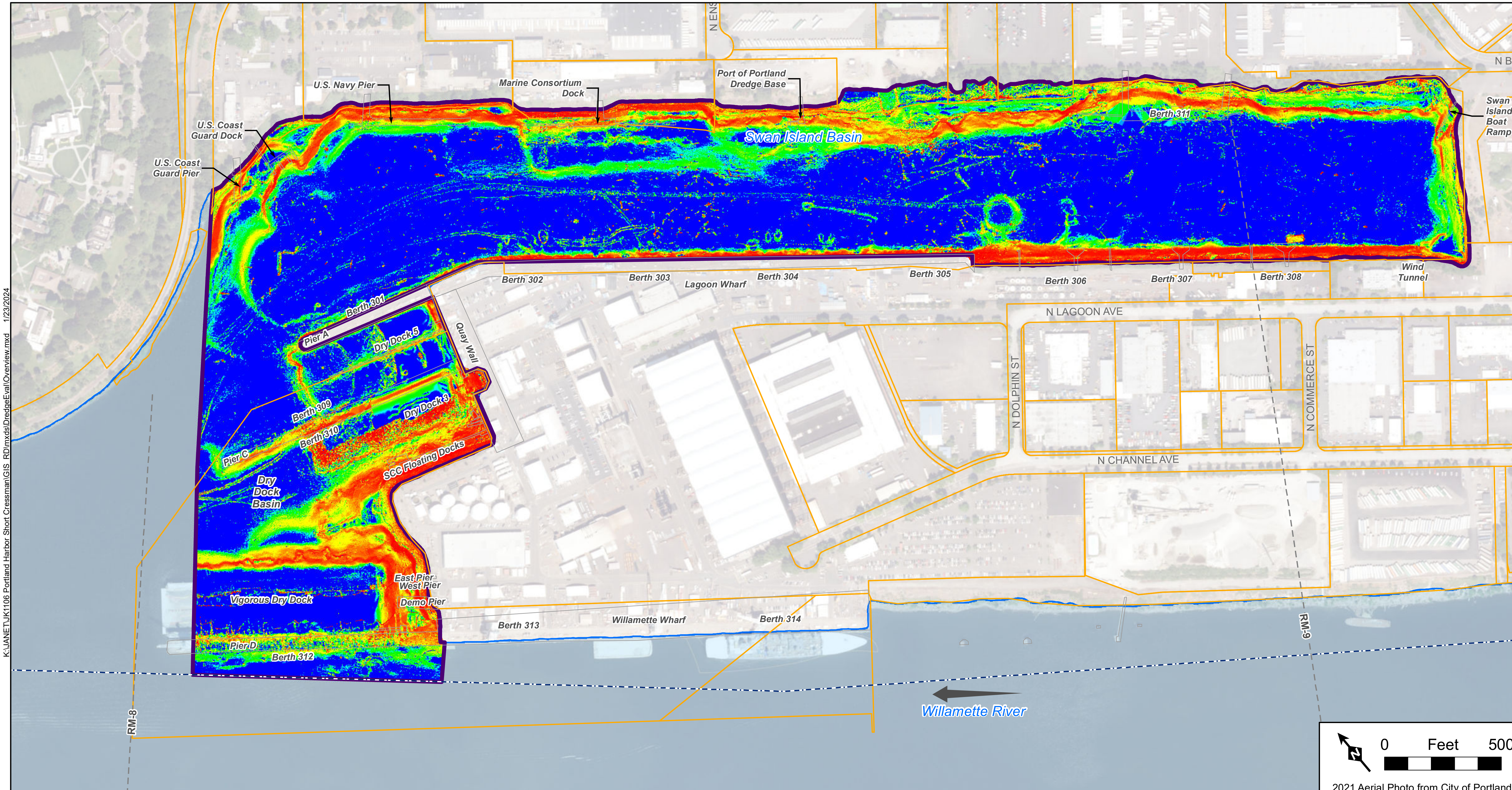

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River Mile (RM)
Swan Island Sediment Decision Unit (SDU)
Federal Navigation Channel (USACE, 2020)
Docks and Structures
Tax Lot Boundary
Ordinary High Water (City of Portland, 2013)
River Flow Direction

Slope [H:V]
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0

Notes:
H – horizontal run
SCC – Shipyard Commerce Center
SIB – Swan Island Basin
SMA – Sediment Management Area
USACE – U.S. Army Corps of Engineers
V – vertical rise

Figure 3-1
Estimated In situ Bed Slopes at Swan Island Basin

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Appendix B - Dredging Evaluation
Swan Island Basin Remedial Design Group

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