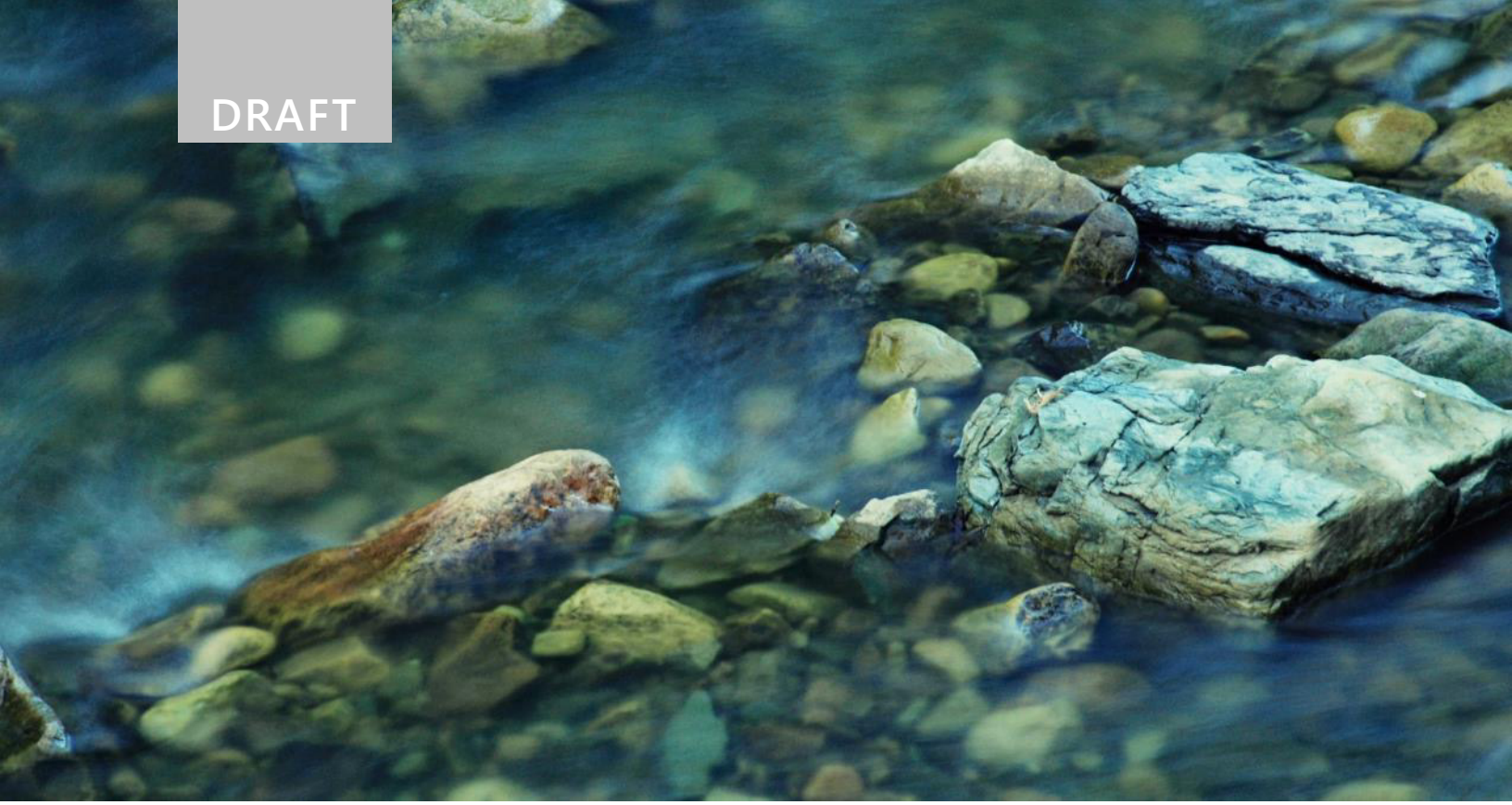
DRAFT



June 2025
Whatcom Waterway Cleanup in Phase 2 Site Areas

ANCHOR QEA

Engineering Design Report

Prepared for Port of Bellingham

DRAFT

June 2025
Whatcom Waterway Cleanup in Phase 2 Site Areas

Engineering Design Report

Prepared for
Port of Bellingham
1801 Roeder Avenue
Bellingham, Washington 98227

Prepared by
Anchor QEA
20 Bellwether Way, Suite 101
Bellingham, Washington 98225

Cleanup Number: 190007-01.01
https://anchorqea.sharepoint.com/sites/WhatcomWaterway-Portal/AQ Internal Documents/EDR/DRAFT_WWP2_EDR_20250509_clean.docx

DRAFT

TABLE OF CONTENTS

1 Introduction 1

1.1 Site Location and Vicinity 1

1.2 Purpose of Report 2

1.3 Report Organization 3

2 Background and Design Basis 4

2.1 Site Background 4

2.2 Required Cleanup Actions 5

2.2.1 Completed and Ongoing Work 7

2.2.2 Cleanup in Phase 2 Site Areas 7

2.3 Sediment Cleanup Levels 10

2.4 Existing Information Used for Phase 2 Design 11

2.4.1 Structural Information 11

2.4.2 Site Surveys 11

2.4.3 Existing Environmental Data Sources 11

2.5 Future Use Expectations 12

2.5.1 Outer Waterway 12

2.5.2 BST Dock Area 13

2.5.3 Inner Waterway 13

2.5.4 GP Dock Area 13

2.5.5 C-Street Outfall Area 14

2.5.6 Rail Span Area 14

2.5.7 ASB and Marine Trades Areas 14

2.5.8 Stormwater Management Planning 14

2.6 Sitewide Design Criteria 15

2.6.1 Cleanup Datums 15

2.6.2 Geotechnical Design Criteria 15

2.6.3 Structural Design Criteria 16

2.6.4 Coastal Engineering Design Criteria 17

2.6.5 In-Water Work Windows and Allowable Construction Work Hours 18

2.6.6 Construction Best Management Practices 18

2.7 Anticipated Permits and Substantive Requirements for Cleanup 18

3 Cleanup Overview 21
3.1 Work Area Preparation, Staging, and Stockpile Activities 23
3.2 Outer Waterway (Units 1A, 1B, and portions of Unit 1C) 23
3.3 BST Dock Area (portions of Unit 1C) 24
3.4 Inner Waterway and Log Pond (Unit 2B and Portions of Units 2C and 4) 25
3.5 GP Dock Area (Portions of Unit 2C) 26
3.6 Head of Waterway (Unit 3A) 27
3.7 ASB Shoulder (Unit 5B) 27
3.8 C-Street Outfall Area (Portions of Unit 5C) 28
3.9 Rail Span Area (Portions of Unit 6) 28
3.10 ASB Remediation and CDF Construction (Unit 8) 29
3.11 Compliance Monitoring and Institutional Controls 31

4 Net Environmental Effects 32
4.1 Fisheries and Invertebrate Resources 32
4.1.1 Surf Smelt and Sand Lance 32
4.1.2 Pacific Herring 32
4.1.3 Salmonids 33
4.1.4 Groundfish 33
4.1.5 Clam, Geoduck, and Oyster 34
4.1.6 Shrimp 34
4.1.7 Crab 34
4.2 Types and Functions of Habitats 35
4.2.1 Riparian (Above Elevation +9.7 feet MLLW) 35
4.2.2 Upper Shorezone (Elevation +9.7 feet to +5.0 feet MLLW) 36
4.2.3 Lower Shorezone (Elevation +5.0 feet to -10.0 feet MLLW) 36
4.2.4 Deeper Shorezone (Below Elevation -10.0 feet MLLW) 37
4.3 Priorities for Improving Habitat 38
4.4 Net Environmental Effects of the Cleanup 39
4.4.1 Increases in Eelgrass 40
4.4.2 Sediment Cleanup 40
4.4.3 Reduction of Overwater Cover 40
4.4.4 Creosote Removal 43
4.4.5 Improving Salmonid Migration Corridors 43
4.4.6 Net Change in Washington State Waters and Waters of the United States 44
4.5 Effects of Advance Mitigation 46

4.5.1 Creosote Removal 46
4.5.2 Eelgrass Enhancement 46
4.5.3 Improving Salmonid Migration Corridors 46
4.5.4 Net Change in Washington State Waters and Waters of the United States 47

5 Site Preparation and Staging 48
5.1 Sediment Transload Facilities 48
5.2 New Stormwater Outfalls 48
5.3 Staging and Stockpile Areas 49
5.4 Stormwater Management 49
5.5 Other Environmental Considerations 50

6 Overall Dredging Design and Material Handling 51
6.1 Overall Dredging Design 51
6.1.1 Dredge Prism Design 51
6.1.2 Dredge Cut Side Slopes 51
6.1.3 Accounting for Material Sloughing 52
6.1.4 Equipment Selection 52
6.1.5 Verifying Dredge Performance 53
6.2 Dredging Requirements for Specific Site Areas 53
6.2.1 Outer Waterway 53
6.2.2 BST Dock Area 54
6.2.3 Inner Waterway and Log Pond 54
6.2.4 GP Dock Area 55
6.2.5 Head of Waterway Area 56
6.2.6 Rail Span Area 56
6.2.7 ASB Shoulder Area 56
6.2.8 ASB Area 57
6.3 Sediment Handling, Transport, and Disposal 57
6.4 Management of Dredging Residuals 58

7 ASB Area Remediation and CDF Construction 59
7.1 Site Preparation Activities 59
7.1.1 Stormwater Management Modifications 59
7.1.2 Removal of ASB Interior Structures 60
7.2 C-Street Outfall Area Remediation 60
7.3 Construction of the CDF Retaining Structure 60

7.3.1 Retaining Structure Design 61
7.3.2 Contaminant Mobility 61
7.4 Design and Operation of the CDF 62
7.5 Remediation of Aquatic Use Area 63
7.6 Construction and Remediation of the ASB Access Channel 63
7.7 Capping of the Completed CDF 63
7.8 ASB Outfall Decommissioning 64
7.9 Capping of ASB Side Slopes 64
7.10 Habitat Restoration Activities 64
7.10.1 Connecting the ASB to the Waterway 64
7.10.2 Fish Passage Structure Installation 65
7.10.3 Enhancement of Habitat Benches 65

8 Cap Design for Unit 2C and Adjacent Side Slope Areas 66
8.1 Structure Removal and Modification 66
8.2 Sediment Cap Design 67
8.2.1 Contaminant Mobility 67
8.2.2 Bioturbation 68
8.2.3 Erosion Protection 68
8.2.4 Future Maintenance 69
8.2.5 Geotechnical Considerations 69

9 Design for the Head of Waterway Area 70
9.1 Removal of Creosote-Treated Pilings 70
9.2 Sediment Cap Design 70
9.2.1 Contaminant Mobility 70
9.2.2 Bioturbation 71
9.2.3 Habitat Enhancement Layer 71
9.2.4 Erosion Protection 71
9.2.5 Future Maintenance 72
9.2.6 Geotechnical Considerations 72

10 BST Dock Area Design 73
10.1 Anticipated Construction Phasing 73
10.2 Site Preparation and Structure Removals 73
10.2.1 Slope Stabilization 73
10.2.2 Structure Removals 74

10.3 Sediment Cap Design 75
10.3.1 Erosion Protection 75
10.3.2 Geotechnical Considerations 75
10.4 Structure Replacements 75

11 Rail Span Area Design 77
11.1 Structure Removal 77
11.2 Sediment Cap Design 77
11.2.1 Contaminant Mobility 78
11.2.2 Bioturbation 78
11.2.3 Erosion Protection 78
11.2.4 Future Maintenance 79
11.2.5 Geotechnical Considerations 79
11.3 Structure Replacement 79

12 ASB Shoulder Design 80

13 Anticipated Implementation Schedule 81

14 References 83

TABLES

Table 2-1 Summary of Current Conditions and Selected Remedy for Each Site Unit [1] 6
Table 2-2 Datum Elevations (Station No. 9449211) 15
Table 3-1 Cleanup Approach by Site Unit 21
Table 3-2 Approximate Dredging and Material Placement Volumes *(Volumes are Subject to Revision)* 22
Table 4-1 Summary of Eelgrass Impacts by Unit Within the Whatcom Waterway 39
Table 4-2 Changes in Overwater Cover 42
Table 4-3 Tonnage of Creosote-Treated Timber to be Removed 43
Table 4-4 Changes in Habitat Acreage 44
Table 4-5 Net Change in Washington State Waters *(Pending)* 45
Table 4-6 Net Change in Waters of the United States *(Pending)* 45

FIGURES

Figure 1-1 Site Vicinity Map
Figure 1-2 Cleanup in Phase 2 Areas

Figure 2-1 Completed Cleanup Phase 1 Areas
Figure 2-2 Construction Cleanup for Phase 2 Areas – Overview
Figure 3-1a Anticipated Construction Season 1
Figure 3-1b Anticipated Construction Season 2
Figure 3-1c Anticipated Construction Season 3
Figure 3-2 Overview of Marine Structure Demolition
Figure 3-3 Overview of Structural Work
Figure 3-4 Potential Site Staging and Stockpile Areas
Figure 3-5 Illustration of GP Dock Shoreline at Completion
Figure 3-6 Illustration of CDF and Aquatic Use Area at Completion
Figure 4-1 Areas of New or Improved Habitat Resulting from the Cleanup and Parallel Actions
Figure 6-1a Outer Waterway Dredging and Material Placement Plan
Figure 6-2a BST Dock Area Dredging and Material Placement Plan
Figure 6-3a Inner Waterway Dredging Plan
Figure 6-3b Inner Waterway Material Placement Plan
Figure 6-4a Head of Waterway Dredging and Material Placement Plan
Figure 6-5a Rail Span Area Dredging and Material Placement Plan
Figure 6-6a ASB and ASB Shoulder Material Dredging Plan
Figure 6-6b ASB and ASB Shoulder Material Placement Plan
Figure 7-1 C-Street Outfall Plan
Figure 7-2 Proposed CDF Retaining Structure

APPENDICES

Appendix A Post-Cleanup Stormwater Plan (Placeholder)
Appendix B Geotechnical Evaluation (Placeholder)
Appendix C Coastal and Propwash Evaluation
Appendix D Best Management Practices
Appendix E Water Quality Monitoring Plan
Appendix F Construction Quality Assurance Plan (Placeholder)
Appendix G Management of Dredging Residuals
Appendix H Compliance Monitoring and Contingency Response Plan
Appendix I Fate and Transport Analysis for CDF
Appendix J Preliminary Sediment Cap Chemical Isolation Layer Design

ABBREVIATIONS

µg/kg	micrograms per kilogram
ASB	Aerated Stabilization Basin
ACES	Automated Coastal Engineering System
ASCE	American Society of Civil Engineers
BMC	Bellingham Municipal Code
BMP	best management practice
BSL	bioaccumulation screening level
BST	Bellingham Shipping Terminal
CAP	Cleanup Action Plan
CDF	Confined Disposal Facility
City	City of Bellingham
Cleanup	Whatcom Waterway Cleanup in Phase 2 Site Areas
cm	centimeter
CMCRP	Compliance Monitoring and Contingency Response Plan
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CQAP	Construction Quality Assurance Plan
CSGP	Construction Stormwater General Permit
cy	cubic yard
D/F	dioxin/furan
DNR	Department of Natural Resources
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
ESA	Endangered Species Act
FSEIS	Final Supplemental Environmental Impact Statement
GP West	Georgia-Pacific West, Inc., mill site
GP	Georgia-Pacific Corporation
H:V	horizontal to vertical (ratio)
hp	horsepower
HPA	Hydraulic Cleanup Approval
HTL	high tide line
IC	institutional controls
mg/kg	milligram per kilogram
MHHW	mean higher high water
MLLW	mean lower low water
MNR	monitored natural recovery
MTCA	Model Toxics Control Act

N/A	not applicable
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
ng/kg	nanogram per kilogram
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Association
NPDES	National Pollutant Discharge Elimination System
OHWM	ordinary high water mark
PLP	potentially liable party
Port	Port of Bellingham
PRDI	Pre-Remedial Design Investigation
propwash	propeller wash
RI/FS	Remedial Investigation and Feasibility Study
RMC	residuals management cover
SCO	sediment cleanup objective
SEPA	State Environmental Policy Act
sf	square foot
Site	Whatcom Waterway Site
SMS	Sediment Management Standards
SWAC	surface-weighted average concentration
SWPPP	Stormwater Pollution Prevention Plan
TEQ	toxic equivalency quotient
UFC	United Facilities Criteria
Unit	Phase 2 Site Unit
USACE	U.S. Army Corps of Engineers
VST	vane shear testing
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife

1 Introduction

This *Engineering Design Report* (EDR) describes the cleanup to be performed within the Phase 2 Site Areas (Cleanup) of the Whatcom Waterway Site (Site) in Bellingham, Washington. The Site location and vicinity are shown in Figure 1-1. Phase 2 Site Areas are shown in Figure 1-2.

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

The Cleanup is to be performed by the Port of Bellingham (Port) and other cooperating potentially liable parties (PLPs) under Ecology oversight, in accordance with Consent Decree No. 07-2-02257-7 (Ecology 2007a), as amended by the First Amendment to the Consent Decree (Ecology 2011) and the Second Amendment to the Consent Decree (Ecology 2024).

1.1 Site Location and Vicinity

Figure 1-1 presents the Site vicinity and location features, including the overall Site boundary and the location of Site Units as originally defined in the Consent Decree (as amended). The extent of required active remediation has been refined since that time and does not necessarily correspond with those initially-defined Site Unit boundaries.

Figure 1-1 also shows the location of several other cleanup sites designated by Ecology and located in adjacent portions of Bellingham Bay. These adjacent sites include the Central Waterfront, I&J Waterway, Cornwall Avenue Landfill, former South State Street Manufactured Gas Plant, and R.G. Haley sites. The cleanup action for the Site is being coordinated with these separate site cleanups by the Port and Ecology.

The Site contains sediments that have been impacted by mercury discharges from the former Georgia-Pacific West, Inc., chlor-alkali plant. The chlor-alkali plant was located on a portion of the adjacent GP West mill site (GP West) and operated between 1965 and 1999, when it was permanently closed. The chlor-alkali plant discharged mercury-containing wastewater into the waterway, primarily during the late 1960s and 1970s. Other site-associated contaminants include wood waste and degradation products from historical log rafting activities and phenolic compounds from pulp mill wastewater discharges.

Dioxin/furan (D/F) compounds are also known to be present as regional contaminants in surface and subsurface sediments throughout most of Bellingham Bay. The distribution and regional background

concentrations of D/F compounds were defined by Ecology during previous investigations (Ecology 2015).

The Site boundary shown in Figure 1-1 was established based on the extent of potentially significant surface and subsurface mercury contamination in sediments as determined during the remedial investigation and feasibility study (RI/FS) process (Anchor Environmental and Hart Crowser 2000; RETEC 2006) and during subsequent pre-remedial design investigations (PRDI) that began in 2008 (Anchor QEA 2010).

1.2 Purpose of Report

This EDR documents the Cleanup to be performed in Phase 2 Site Areas to meet current cleanup requirements as described in the Consent Decree and subsequent amendments. The Phase 2 Site Areas that are subject to active remediation are shown in Figure 1-2 and include the following:

- Portions of the Outer Waterway (Units 1A, 1B, and 1C) including under-dock areas located at the Bellingham Shipping Terminal (BST)
- Portions of the Inner Waterway (Units 2B and 2C) including the Unit 2C side slopes located in the GP Dock Area and along the Log Pond (Unit 4)
- Shallow-water habitat areas at the Head of Waterway (Unit 3A)
- The shallow-water area offshore of the Aerated Stabilized Basin (ASB; Unit 5B)
- Sediments near the mouth of the C-Street Outfall (portion of Unit 5C)
- Portions of the Rail Span Area (portions of Unit 6)
- The ASB (Unit 8)

This document describes the cleanup to be performed in each of these Phase 2 Site Areas. That work includes dredging, material placement (including engineered capping, backfill, armor, and residuals management cover), construction of a nearshore Confined Disposal Facility (CDF) within the ASB, and structural and stormwater work necessary to accomplish the Cleanup.

This EDR describes the compliance monitoring to be performed to verify that cleanup objectives are met and describes the institutional controls (ICs) to be recorded to ensure the long-term integrity of the Cleanup in capping and CDF areas.

For clarity, this EDR also discusses work to be performed by the Port in parallel with the Cleanup as part of the Port's separate advance habitat mitigation activities. That work is separate from the Cleanup but will be conducted as part of the same construction event.

1.3 Report Organization

The information contained in this report has been organized in the following manner:

- **Section 2 – Background and Design Basis:** Section 2 provides background information regarding the cleanup decision and the requirements that must be met by the design. The sources of data used in the design are described, along with design criteria for the Cleanup.
- **Section 3 – Cleanup Overview:** Section 3 provides a high-level overview of the Cleanup to be performed in each area of the Site, including anticipated project sequencing.
- **Section 4 – Net Environmental Effects:** Ecology's cleanup decision included review of the net environmental effects of the Cleanup consistent with the requirements of the SMS and the Final Supplemental Environmental Impact Statement (FSEIS; Ecology 2007b). Section 4 reviews the net environmental effects of the engineering design as proposed in this document.
- **Sections 5 through 12:** Sections 5 through 12 of the report provide a detailed discussion of the design assumptions used for each construction element comprising the Cleanup, including the following:
  - Site preparation and staging (Section 5)
  - Overall dredging design and material handling design (Section 6)
  - ASB remediation and CDF construction, including related work in the ASB Access Channel and C-Street Outfall Area (Section 7)
  - Design for the Inner Waterway and Log Pond areas (Section 8)
  - Design for the Head of Waterway (Section 9)
  - Design for cleanup in the BST Dock Area, including the removal and replacement of marine structures necessary to accomplish the work (Section 10)
  - Design for cleanup in the Rail Span Area (Section 11)
  - Design for the ASB Shoulder (Section 12)
- **Section 13 – Anticipated Implementation Schedule:** The anticipated implementation schedule for the Cleanup is provided in Section 13, including construction, IC, and long-term monitoring requirements.
- **Section 14 – References:** This report builds on many previous documents that have been issued to date. Applicable references cited in this report are listed in Section 14.

2 Background and Design Basis

This section provides additional information regarding the history of the Site and context for the EDR. Also described in this section are the sources for information used in developing the engineering design, and the design criteria applied to the construction elements of the Cleanup.

2.1 Site Background

As described in Section 1.1, the Site includes sediments that have been impacted by mercury discharges from the former GP West chlor-alkali plant. The Site also includes sediments that have been impacted by contaminants historically released from industrial waterfront activities, including wood waste and degradation products from historical log rafting activities, and phenolic compounds from pulp mill wastewater discharges.

There are multiple cleanup sites located adjacent to the waterway as shown in Figure 1-1, and sediment contamination from those other sites is commingled with subsurface contamination in portions of the Site. Cleanup of the Site is being coordinated with these separate actions, which are also overseen by Ecology.

The chlor-alkali plant discharged mercury-containing wastewater into the waterway primarily during the late 1960s and 1970s. Initial environmental investigations of the Site during the 1980s and 1990s identified mercury in sediment at concentrations that exceed applicable standards, as well as other contaminants from industrial releases.

The Port assumed leadership of the cleanup of the Site in 2005 after purchasing GP West's waterfront properties. The cleanup action for the Site was selected by Ecology after completion of an RI/FS, which began in 1996 and has included two supplements. It was finalized in 2006 with a Supplemental RI/FS report (RETEC 2006) describing the nature and extent of contamination, presenting the conceptual Site model, and assessing potential alternatives for cleanup of each portion of the Site. Technologies evaluated in the RI/FS included removal with upland disposal, treatment, reuse, containment (including capping, nearshore confined disposal, and confined aquatic disposal), enhanced natural recovery, monitored natural recovery (MNR), and IC. Potential environmental impacts associated with the cleanup alternatives were evaluated under the State Environmental Policy Act (SEPA) regulations (WAC 197-11). Ecology's SEPA impacts analysis was documented in the FSEIS issued by Ecology (Ecology 2007b).

In 2007, Ecology developed a Cleanup Action Plan (CAP) for the Site. The CAP describes Ecology's selected cleanup action for the Site, consistent with MTCA and SMS requirements. In 2007, after public notice and opportunity to comment, a Consent Decree (Ecology 2007a), including the CAP, was signed by the cooperating PLPs and Ecology and entered into the records of Whatcom County Superior Court.

In 2011, after public notice and opportunity to comment, the First Amendment to the Consent Decree (including amendments to the CAP and schedule) was signed by the cooperating PLPs and Ecology and entered into the records of Whatcom County Superior Court (Ecology 2011). The adjustments made to the original cleanup action incorporated findings from the *Pre-Remedial Design Investigation Work Plan* (Anchor Environmental 2008) including changes to the cleanup action to authorize the use of a CDF for contaminated sediments removed during the cleanup.

Cleanup in the Phase 1 Site Areas (Figure 2-1) was completed during 2015 and 2016. Results of the Phase 1 Site cleanup and of associated Year 0 monitoring are documented in the Phase 1 As-Built Report (Anchor QEA 2018). Monitoring events performed in 2017, 2019, and 2021 have shown that the cleanup is performing within expectations (Anchor QEA 2019, 2020, 2022).

In 2024, after public notice and opportunity to comment, the Second Amendment to the Consent Decree (including amendments to the CAP and schedule) was signed by the cooperating PLPs and Ecology and entered into the records of Whatcom County Superior Court (Ecology 2024). The Second Amendment to the Consent Decree included the following:

- Established the cleanup levels to be applied to D/F compounds within the Site
- Called for reconfiguration of the planned CDF to both improve its capacity while reducing its footprint and better aligning it with Port land use and navigation plans
- Authorized the Port to conduct expedited dredging and upland disposal within portions of Unit 1C to remove areas of sloughed sediments at the BST
- Authorized the Port to conduct dredging and capping in the Head of Waterway (Unit 3A) areas to improve habitat conditions there, conditional on the availability of additional grant funding to support the work

A separate EDR was prepared in 2023 (Anchor QEA 2023) and amended in 2024 (Anchor QEA 2024) detailing the work to be performed to remove sloughed sediments at the BST. That work was initiated during the 2023/2024 dredging season and will be completed during the 2025/2026 dredging season.

2.2 Required Cleanup Actions

Cleanup at the Site is being implemented in multiple cleanup phases, each addressing specific Site Areas and the respective sediment site units (Figures 1 and 2). Table 2-1 summarizes the selected remedy for each project phase and site unit.

Table 2-1
Summary of Current Conditions and Selected Remedy for Each Site Unit [1]

Site Areas				Current Environmental Conditions [2]			Cleanup Remedy		
Site Unit Description	Sediment Site Unit	Site Unit Sub-Area (if applicable)	Site Unit or Sub-Area Acreage	Current Benthic Exceedance Areas (acres)	Mercury BSL Exceedance Areas (acres)	Typical Thickness of Contaminated Sediment (ft) [2]	Selected Cleanup Remedy	Total Volume of Contaminated Sediment (cyd)	Contaminated Sediment Removal Volume (cyd) [3,9]
Phase 1 Site Areas (2015/2016)									
Federal Channel and Berth Areas	1C	Phase 1 Removal Areas [4]	4.5	--	--	8	Removal and Upland Disposal	60,800	60,800
Locally Managed Waterway	2A	--	3.1	--	--	8	Partial Dredge and Capping	39,000	10,100
	2C	Phase 1 Work Areas	2.2	--	--	10	Partial Dredge and Capping	36,000	20,300
	3B	--	3.0	--	--	10	Partial Dredge and Capping	50,000	15,200
Log Pond	4	Excluding Log Pond Corner	6.2	--	--	10	Capping & Habitat Enhancement	100,000	--
Unit 1C Removal Areas (2024/2025)									
Federal Channel and Berth Areas	1C	2024/2025 Work Areas [4]	3.0	--	--	5	Partial Dredge and Upland Disposal [4]	--	24,000
Phase 2 Site Areas									
Federal Channel and Berth Areas	1A	--	5.3	--	--	4	Removal and CDF Disposal	39,800	39,800
	1B	--	9.7	--	--	6		91,700	91,700
	1C	Phase 2 Open Water Areas [4]	6.6	--	--	9		96,300	96,300
		BST Under Dock	1.0	--	--	8		14,000	14,000
ASB Access Channel	2B	--	1.2	--	--	12		31,700	31,700
Locally Managed Waterway	2C [5]	Including GP Dock Area	13.1	--	--	10	Partial Dredge and Capping	212,000	81,900
	3A [6]	--	2.5	--	--	14	Partial Dredging, Capping & Habitat Enhancement [6]	56,000	7,500
Log Pond	4	Log Pond/BST Corner	1.5	--	--	12	Partial Dredge and Capping	30,100	30,100
ASB Shoulder Areas	5B [7]	Inner Portion	2.0	2.0	2.0	4	Removal and CDF Disposal [7]	14,500	14,500
	5C [8]	C-Street Outfall Area [5]	0.7	--	--	10	Capping [8]	12,000	--
Railspan Area	6	Railspan Berthing Area	1.2	--	--	10	Partial Dredge and Capping	20,000	11,300
ASB	8	Aquatic Reuse Area	15.0	--	--	8	Removal and CDF Disposal	195,000	195,000
		CDF Area	15.0	--	--	8	CDF Development	195,000	--
Monitored Natural Recovery (MNR) Areas									
ASB Shoulder Areas	5A	--	42.5	--	--	4	MNR	274,000	--
	5B [6]	Outer Portion	2.3	--	--	4		15,000	--
	5C	--	3.4	--	--	6		33,000	--
Railspan Area	6	Outer Unit 6 Areas	21.4	--	--	10		345,000	--
Starr Rock	7	--	25.6	--	--	6		248,000	--
Outer Site Areas	9	--	554.4	--	--	4		3,577,000	--
Total All Site Areas									
Phase 1 Site Areas (2015/2016)			19.0	--	--			285,800	106,400
Unit 1C Removal Areas (2024/2025) [4]			--	--	--			--	24,000
Phase 2 Site Areas [9]			74.8	2.0	2.0			1,008,100	613,800
MNR Areas			649.6	--	--			4,492,000	-
Total Whatcom Waterway Site			**743.4**	**2.0**	**2.0**			**5,785,900**	**744,200**

Notes:
1. This table provides summary information for the overall project by project phase. Phase 2 site area removal volumes are subject to change during final design and permitting.
2. Current environmental conditions represents the most recent available information for each site unit. Typical thicknesses listed in this table include over-dredge allowance. Actual thicknesses vary significantly within each site unit.
3. For areas not yet dredged, removal volumes are estimates. For areas previously remediated by dredging, actual removal volumes are shown. The Phase 1 removal volumes exclude 6,600 cy of contaminated soils that were removed from adjacent upland areas during the project.
4. A portion of the Unit 1C open water area was dredged during the cleanup in Phase 1 site areas. Additional dredging in shoaled areas was conducted in 2024/2025. The remainder will be dredged during the cleanup in Phase 2 site areas. The 2024/2025 work areas are not listed in acreage or total sediment volume subtotals, because these areas overlap with the Phase 2 site areas and they are not listed to avoid double-counting of areas or volume.
5. Unit 2C removal volumes include both open water areas and Unit 2C side slope areas located beneath the GP Dock.
6. Unit 3A was originally designated as a monitored natural recovery area. Under the 2024 CD Amendment, this area is proposed for conditional remediation by partial dredging, capping, and habitat enhancement.
7. Exceedances of the mercury bioaccumulation screening level (BSL) have been observed in the inner portion of Unit 5B. The affected area will be remediated by dredging. The outer portion of Unit 5B remains an MNR area.
8. Sediments in a portion of the C-street Outfall Area are to be capped to address areas of D/F recontamination identified in areas physically disturbed by outfall discharges. The remaining portions of Unit 5C remain an MNR area.
9. The total removal volumes for the Phase 2 site areas exclude those sediments to be dredged from other cleanup sites and managed by CDF disposal in Unit 8.

2.2.1 Completed and Ongoing Work

Completed and ongoing work includes the cleanup in Phase 1 Site Areas and the expedited removal of contaminated sediment from a portion of Unit 1C:

- Cleanup in Phase 1 Site Areas: The cleanup in Phase 1 Site Areas was constructed between mid-2015 and early 2016. Cleanup work elements included cleanup construction in the Inner Waterway, the Log Pond, and areas near the BST (Figure 2-1). Major activities included dredging, engineered capping, containment wall installation, structure removal, structure replacement, and nearshore habitat improvements.
- Monitoring in MNR Areas: Monitoring of site MNR areas, including portions of Site Units 3A, 5, 6, 7, and 9 (Figures 1-1 and 1-2; Table 2-1), was initiated following completion of the cleanup in Phase 1 Site Areas. To date, no exceedances of benthic sediment quality cleanup levels have been observed in these areas. Monitoring in these areas is ongoing.
- Unit 1C Dredging: An expedited removal of contaminated sediment from a portion of Unit 1C adjacent to the Central and North Terminals (Figure 2-2) was initiated in February 2024. Sloughed sediment and adjacent high spots identified in this area are being removed to restore berthing depths and prevent the potential redistribution of contaminated sediment by vessels. Completion of that work is planned for summer 2025. The cleanup in Phase 2 Site Areas will complete the removal of contaminated sediments from the Unit 1C and BST Dock Area.

2.2.2 Cleanup in Phase 2 Site Areas

The cleanup in Phase 2 Site Areas (Figure 2-2) incorporates multiple remedial technologies including dredging, engineered capping and backfill, and construction of a CDF within the ASB to manage disposal of contaminated sediments.

Dredging is the controlled removal of contaminated sediments from the aquatic environment. Dredging to be performed in the Phase 2 Site Areas is anticipated to be performed with mechanical dredging supported by hydraulic-assisted pipeline transfer of dredge materials to the CDF.

Engineered capping is the controlled, accurate placement of clean material to isolate contaminated sediments from the aquatic environment. Engineered caps protect the aquatic environment by performing three primary functions:

- Physical isolation of the contaminated sediment from the benthic environment
- Prevention of sediment resuspension and transport to other locations
- Reduction of the flux of dissolved contaminants into the engineered cap and overlying water column

Engineered cap composition and thickness can consist of a single layer of clean material, or multiple layers of different material types. Caps are generally constructed of sand overlain by larger size

materials such as gravel or rock to protect against erosion due to hydrodynamic forces. Engineered caps proposed for Phase 2 Site Areas include the following three general capping types (these general cap types will be refined for each Site Area as the design progresses):

- **Type 1:** Three-layered engineered cap (sand, gravel filter, and rock armor) used to isolate contamination and provide erosion protection from wind waves and propeller wash (propwash forces). This engineered cap design is primarily employed along shorelines and in nearshore areas.
- **Type 2:** Two-layer cap (sand and gravel armor) used to isolate contamination and provide erosion protection primarily from propwash forces. This engineered cap design is primarily used in open-water areas where water depths result in lower propwash velocities and wind-wave forces than areas where Type I caps are used.
- **Type 3:** Two-layer cap (gravel filter and rock armor) used to provide long-term resilience (protection from erosion) in shoreline areas that if destabilized could result in exposure of buried contaminated soils or sediments in adjacent areas.

A nearshore CDF will be built within the inner portion of the existing ASB. Consistent with the Second Amendment to the Consent Decree, the CDF has been reconfigured to provide sufficient capacity for disposal of the contaminated sediments to be generated during the Cleanup, as well as additional contaminated sediments removed during the final cleanups at the Harris Avenue Shipyard site and the I&J Waterway site, and planned maintenance dredging within the Squalicum Marina in Bellingham.

The Cleanup will include work in the following areas:

- **Outer Waterway (Units 1A, 1B, and portions of Unit 1C):** Remedial actions will include both open-water dredging and dredging within under-pier areas of the BST Dock Area. Open-water dredging will occur in Units 1A, 1B, and 1C. Contingency re-dredging will be used to address missed inventory and a thin layer of residuals management cover (RMC) will be placed to control generated residuals in the open-water dredging area. Dredging will also be performed in the footprint of the North and Central terminal berth and under-pier areas of the BST (side slopes of Unit 1C). This dredging will be conducted in coordination with structural demolition and subsequent replacement of the pier to provide construction access to the slope. A Type 3 cap will also be placed beneath the BST to contain any deeply buried contaminated sediments that are impracticable to remove and ensure the stability of the shoreline following completion of the cleanup.
- **Inner Waterway Area and Log Pond (Units 2B, 2C, and portions of Unit 4):** Both dredging and capping will be used to remediate areas of the Inner Waterway and side slopes along the Log Pond and GP Dock Area. In the outer areas of Unit 2C and in the ASB Access Channel (Unit 2B), dredging is expected to completely remove contaminated sediments from the

waterway and channel bottoms. However, capping will be required in adjacent side slope areas. In the remaining areas of the Inner Waterway, a cap will be placed over the waterway bottom as well as on the side slopes. Cleanup in the Inner Waterway will also include structure demolition and removal, including removal of the GP Dock to facilitate remediation of contaminated sediments in the Unit 2C side slope areas below the existing dock structure. Side slopes along the boundary between Unit 2C and the Log Pond (Unit 4) will be stabilized by capping, with dredging conducted as necessary to establish appropriate side slope elevations.

- **Head of Waterway (Unit 3A):** The Second Amendment to the Consent Decree authorized the Port to change the remedy at the Head of Waterway (Unit 3A) to improve habitat quality within the Whatcom Creek estuary for use by juvenile salmonoids and forage fish. Following the removal of abandoned creosote pilings to be conducted by the Port, proposed remedial actions in this area include partial dredging of contaminated sediments followed by placement of sediment caps with a layer of habitat substrate (i.e., "fish mix") placed over the cap to optimize habitat quality. Implementation of the additional cleanup in Unit 3A is contingent on the availability of grant funding to support the work.
- **ASB Shoulder (Unit 5B):** Dredging and placement of backfill material will be performed in the area offshore of the ASB. To avoid destabilizing slopes and structures, no dredging will be performed immediately adjacent to the ASB berm or the existing buried outfall structure. After completion of dredging activities, Unit 5B will be backfilled with clean materials to maintain existing elevations and habitat functions.
- **C-Street Outfall Area (Portions of Unit 5C):** A localized area of sediment recontamination near the C-Street Outfall will be remediated by capping. The shoreline and outfall will also be reconfigured in this area to minimize the potential for future recontamination, optimize climate resiliency, and facilitate remediation of the adjacent ASB Area.
- **Rail Span Area (Portions of Unit 6):** Remedial actions in this area will include both dredging and capping. Prior to dredging, the former "chemical dock" and portions of the Rail Span structure will be removed facilitate removal of contaminated sediments. Following dredging, a Type 1 cap will be placed to contain the remaining contaminated sediments.
- **Aerated Stabilization Basin (Unit 8):** A CDF will be constructed within a portion of the ASB to manage contaminated sediments dredged during the Cleanup. Prior to construction, existing stormwater discharges to the ASB will be re-routed to new stormwater outfalls. A CDF retaining structure will then be constructed to separate the ASB into a nearshore CDF portion and an offshore aquatic reuse area. Contaminated sediments will then be dredged from the aquatic reuse area and disposed of in the nearshore CDF portion along with contaminated sediments from other areas of the Site and from related Port cleanups. Additionally, a set of dolphins will be installed adjacent to the ASB to support construction of the CDF. Following

placement of materials within the CDF, a cover will be placed over the top and the aquatic reuse area will be reconnected to Bellingham Bay.

Monitoring and ICs are an integral part of the cleanup. ICs will be recorded to ensure the long-term stability of the sediments in the CDF, capping, and MNR areas of the Site. Long-term monitoring will be implemented throughout the Site, including ongoing monitoring in the MNR and Phase 1 Site Areas, and supplemental monitoring in Phase 2 Site Areas.

2.3 Sediment Cleanup Levels

Sediment cleanup levels and points of compliance are defined in the CAP and Consent Decree (Ecology 2007a) for the Site. These cleanup levels were amended in the Second Amendment to the Consent Decree (Ecology 2024). Site cleanup levels and points of compliance include the following:

- **Cleanup Levels for Protection of the Benthic Community:** Sediment cleanup levels for protection of the benthic community (i.e., sediment-dwelling organisms) were established at the Sediment Quality Standards criteria applicable at the time of the Consent Decree. These criteria remain unchanged, but under the updated SMS regulations (Ecology 2013) these values are now referred to as the sediment cleanup objective (SCO) benthic criteria. Compliance with cleanup levels protective of the benthic community is determined using a combination of chemical testing and contingent bioassay testing. Samples that exceed the chemical SCO value but pass bioassay testing are considered to comply with the SCO, consistent with Washington's SMS regulations and associated guidance (Ecology 2021).
- **Cleanup Levels for Protection of Human and Ecological Health:** Site-specific cleanup levels protective of human and ecological health have also been established for bioaccumulative compounds, including mercury and D/F compounds:
  - Mercury: The site-specific cleanup level (the bioaccumulation screening level [BSL]) for mercury was established in the Consent Decree (Ecology 2007a) at a value of 1.2 milligrams per kilogram (mg/kg). Compliance with the BSL is measured on a point-by-point basis.
  - D/F Compounds: For D/F compounds, the cleanup level was established at 9.8 nanograms per kilogram (ng/kg) toxic equivalency quotient (TEQ) in the Second Amendment to the Consent Decree (Ecology 2024), based on an analysis of what is technically possible to achieve given the presence of ongoing recontamination sources for D/F compounds. Compliance with this cleanup level is measured on a SWAC basis throughout the Site.
  - cPAH Compounds: An evaluation was also conducted for carcinogenic polycyclic aromatic hydrocarbon (cPAH) compounds. As described in the Second Amendment to the Consent Decree (Ecology 2024), the current surface-weighted average concentration (SWAC) of cPAH (67.8 µg/kg TEQ) is less than the risk-based threshold (229 µg/kg) established by Ecology.

- **Sediment Points of Compliance:** Compliance with the sediment cleanup levels is measured based on the thickness of the sediment biologically active zone. In Bellingham Bay, this thickness is the upper 12 centimeters (cm) of the sediment bed (RETEC 2006; Ecology 2007a). Compliance with cleanup levels protective of the benthic community are measured on a point-by-point basis, as is compliance with the mercury BSL. Compliance with cleanup levels protective of human and ecological health for cPAH and D/F compounds are measured on a SWAC basis throughout the Site.

2.4 Existing Information Used for Phase 2 Design

The engineering design for Phase 2 areas relies on evaluation of Phase 1 cleanup completion efforts and additional studies that have been completed to date. Available information used in development of this EDR is described in this section.

2.4.1 Structural Information

Current marine structural conditions are defined by Port-provided designs, record drawings, and structural assessments for existing waterfront infrastructure, including infrastructure that has been installed, repaired, or maintained subsequent to the 2007 Consent Decree. Supplemental structural assessments were performed by WSP USA in September 2020 to evaluate Phase 2 existing structural conditions including the ASB, GP Dock, BST Dock, and GP West "chemical dock" and Rail Span berth (WSP USA 2021).

2.4.2 Site Surveys

Hydrographic and topographic surveys have been performed throughout the Site over the years, and several sources of data have been used to develop the Cleanup basemap and to support initial remediation design efforts. Physical site conditions are represented by bathymetric surveys and topographic surveys completed in 2019, 2020, 2021, and 2023 by Northwest Hydro, Wilson Engineering, and Landau Associates.

2.4.3 Existing Environmental Data Sources

Environmental and geotechnical data were collected previously during the RI/FS process as supplemented by PRDI investigations and site monitoring activities. These previous studies include the following:

- *Remedial Investigation and Feasibility Study for the Whatcom Waterway Site* (Anchor Environmental and Hart Crowser 2000)
- *Bellingham Bay Comprehensive Strategy, Final Environmental Impact Statement* (Ecology 2000)
- *Draft Supplemental Feasibility Study for the Whatcom Waterway Site* (Anchor Environmental 2002)

- *Whatcom Waterway Pre-Remedial Design Evaluation Data Report* (Anchor Environmental and Landau Associates 2003)
- *Bellingham Bay Comprehensive Strategy, Draft Supplemental Environmental Impact Statement* (Ecology 2002)
- *Supplemental Remedial Investigation and Feasibility Study. Volume 1: RI Report and Volume 2: FS Report* (RETEC 2006)
- *Final Supplemental Environmental Impact Statement for the Cleanup of the Whatcom Waterway Site, Bellingham Bay Comprehensive Strategy* (Ecology 2007b)
- *Cleanup Action Plan for the Whatcom Waterway Site* (Ecology 2007a)
- *First Amendment to the Consent Decree – Whatcom Waterway Site* (Ecology 2011)
- *Final As-Built Report for the Whatcom Waterway Cleanup in Phase 1 Site Areas* (Anchor QEA 2018)
- *Year 1 Monitoring Report, Whatcom Waterway Cleanup in Phase 1 Site Areas* (Anchor QEA 2019)
- *Year 3 Monitoring Report, Whatcom Waterway Cleanup in Phase 1 Site Areas* (Anchor QEA 2020)
- *Pre-Remedial Design Investigation Data Report Phase 2 Site Areas* (Anchor QEA 2021)
- *Year 5 Monitoring Report, Whatcom Waterway Cleanup in Phase 1 Site Areas* (Anchor QEA 2022a)
- *Pre-Remedial Design Investigation Work Plan Amendment No. 4 Data Report* (Anchor QEA 2022b)
- *C-Street Stormwater Outfall Assessment* (Integral 2024)
- *Second Amendment to the Consent Decree – Whatcom Waterway Site* (Ecology 2024)
- *Pre-Remedial Design Investigation Work Plan Amendment No. 5 Data Report* (Anchor QEA, under development)

2.5 Future Use Expectations

Remedial design for dredging, capping, and shoreline stabilization within the Site addresses current and anticipated future waterway uses consistent with the Consent Decree (Ecology 2007a), Port Resolution 1397 (Port of Bellingham 2021), and the Second Amendment to the Consent Decree (Ecology 2024). Specific uses are discussed as part of the design, as discussed in the following sections.

2.5.1 Outer Waterway

The Outer Waterway provides navigation access for deep-draft vessels to the BST. It is also the gateway to the Inner Waterway. The Outer Waterway remains part of the federal navigation channel. The current authorized Cleanup depth for the federal navigation channel is 30 feet below mean

lower low water (MLLW), although most mudline elevations are deeper. Berth areas are to be maintained at deeper depths with target working elevations of 34 feet below MLLW.

All contaminated sediments are to be removed from the Outer Waterway. This will reduce risks of future recontamination in this actively maintained, deep-draft navigation area.

2.5.2 BST Dock Area

The BST Dock Area includes the active Port terminal. This area is subject to extensive propwash and requires active facility maintenance. As part of the Cleanup, the contaminated sediments beneath the steep-sloped Central and North terminal areas will be removed by dredging to the extent practicable, and the shoreline will be protected with a Type 3 cap. A number of structures will need to be removed and replaced to facilitate this remediation.

2.5.3 Inner Waterway

The Inner Waterway is no longer part of the federal navigation channel. It is a locally managed waterway serving commercial and recreational navigation, as well as providing important public access and habitat functions:

- **Head of Waterway:** The Head of Waterway (the first 500 feet offshore of the Roeder Avenue Bridge, including the area in front of Waypoint Park) consists of shallow-water areas targeted for estuary improvements. No motorized navigation or maintenance dredging is anticipated for this area.
- **Unit 2C Cap Areas:** The Unit 2C Cap Areas of the Inner Waterway are a multi-purpose waterway supporting a mix of commercial, industrial and recreational navigation uses. The working water depth for the inner capped portion is 18 feet below MLLW datum. The working water depth for the outer capped portion of Unit 2C (offshore of the future ASB Access Channel) is 25 feet below MLLW, consistent with the future working water depth inside the ASB.
- **Unit 2B and 2C Full Removal Areas:** The future ASB Access Channel (Unit 2B) and the outer portion of Unit 2C will be remediated by dredging, with full removal of contaminated materials from the waterway bottom. This removal will support ongoing navigation uses in these areas. Caps will be placed in side slope areas to contain residual contaminated sediments in these areas, increase resiliency, and protect shorelines from future erosion.

2.5.4 GP Dock Area

The GP Dock Area is part of the Unit 2C side slope areas. The dock itself is an aging marine structure that was previously part of GP's pulp and tissue mill operations. The dock no longer meets the changing navigation and land use needs of the Waterfront District. It is to be removed to allow completion of the Cleanup. In the future, this shoreline area is expected to be used for visitor

moorage facilities and public access improvements associated with Waypoint Park. The GP Dock Area shoreline will be capped following removal of the dock structure.

2.5.5 C-Street Outfall Area

The C-Street Outfall Area is a large City of Bellingham stormwater outfall discharging into intertidal sediments of the Whatcom Waterway alongside the ASB. This area is to be capped as part of the Cleanup. The capping design considers ongoing navigation uses at the adjacent C-Street Terminal, which are to be preserved. It also includes extension and reconfiguration of the existing C-Street Outfall to preserve its function while minimizing risks of sediment recontamination.

2.5.6 Rail Span Area

The Rail Span Area includes active stub pier and Rail Span structures used for barge loading and unloading. Continued use of the structures is required to support ongoing Port operations. Working water depths are to be maintained at an elevation 15 feet below MLLW at the Rail Span. Water depths are shallower at the stub pier.

The former chemical dock is located south of the Rail Span structure and is no longer useful for Port operations. The chemical dock will be removed to facilitate sediment remediation in the Rail Span Area. The main Rail Span structure will be preserved for ongoing use, but unused portions of the Rail Span structure will also be removed to facilitate the cleanup.

2.5.7 ASB and Marine Trades Areas

Consistent with Port Resolution 1397, the ASB has been designated in the Port's Comprehensive Scheme of Harbor Improvements (Port of Bellingham 2024) for construction of a CDF and development of 12 to 14 acres of usable upland property fronting a similar acreage of navigable marine waters with a working depth of approximately -25 feet MLLW. These areas will be used to support marine trades uses. Integral to that land use is the Port's plan to reconnect the ASB Aquatic Use Area to Bellingham Bay following its cleanup. The Port also plans to incorporate public access along portions of the ASB berm and to incorporate habitat enhancement in portions of the ASB interior.

2.5.8 Stormwater Management Planning

The ASB was constructed by GP West in 1978 for treatment of industrial stormwater and wastewater. The ASB continues to provide treatment in compliance with an individual National Pollutant Discharge Elimination System (NPDES) permit for stormwater generated from portions of the former GP West mill property and portions of the Central Waterfront area. The Port has been developing plans for updated stormwater infrastructure to serve these two areas.

As part of the Cleanup in Phase 2 Site Areas, two new outfalls will be installed to provide discharge points for the collected and treated stormwater (Figure 2-2). One will be located along the shoreline of the Log Pond, and the other will be located on the side of the ASB. The overall plan for stormwater collection, treatment, and discharge is described in the Post-Cleanup Stormwater Plan (Appendix A).

2.6 Sitewide Design Criteria

Design criteria applicable to the Cleanup are described in the following sections.

2.6.1 Cleanup Datums

The horizontal datum that will be used is Washington State Plane North Zone, North American Datum of 1983 (NAD83), measured in units of feet.

The vertical datum will be National Ocean Survey MLLW based on National Oceanic and Atmospheric Administration (NOAA) Station No. 9449211, located in Bellingham, Washington. Table 2-2 outlines the different water levels based on the NOAA Station No. 9449211 benchmarks.

Table 2-2
Datum Elevations (Station No. 9449211)

Tide Level	Meters (MLLW)	Feet (MLLW)
Highest Observed (1/5/1975)[1]	3.177	10.4
Ordinary High Water	3.116	10.2
High Tide Line	2.957	9.7
Mean Higher High Water	2.594	8.5
Mean High Water	2.375	7.8
Mean Tide Level	1.546	5.1
Mean Sea Level	1.510	5.0
Mean Low Water	0.718	2.4
Mean Lower Low Water	0.000	0.0
Lowest Observed (12/30/1974)[1]	-1.057	-3.5
NAVD88	0.147	0.5

Note:

1. NOAA Station No. 9449211 was active from March 30, 1973, to July 21, 1975. Tidal predictions for the area have been higher and lower than those observed.

2.6.2 Geotechnical Design Criteria

Environmental and geotechnical data were collected previously during the *Supplemental Remedial Investigation and Feasibility Study* (RETEC 2006); during implementation of the 2008 PRDI Work Plan (Anchor Environmental 2008) and its amendments; and during the Year 1, Year 3, and Year 5

Compliance Monitoring (Anchor QEA 2017, 2020, 2022) and more recently as part of PRDI Work Plan Addendum No. 5 (Anchor QEA 2024).

The geotechnical design criteria are based on guidance from various technical references (WSDOT 2011; Duncan and Wright 2005; NCHRP 2008; Kramer 1996) and the American Society of Civil Engineers (ASCE) 7-10 code (ASCE 2010). The Geotechnical Evaluation (Appendix B) contains a detailed discussion of the soil and sediment data utilized for characterization and development of soil properties and parameters for analyses, the methodologies employed, and the results and conclusions of the geotechnical engineering evaluations that have been completed to date.

The other geotechnical design criteria that will be applied to the Site are as follows:

- Site characterization and soil properties such as unit weights, strength parameters, compressibility, and modulus parameters are derived from the soil borings, sediment cores, in situ geotechnical tests such as Standard Penetration Testing and vane shear testing (VST), and relevant laboratory data collected during the PRDI and Non-Remedial Design Investigation, as well as other geotechnical investigation data that are available from other investigation efforts completed near the Site.
- Slope angles are currently being evaluated for dredged and capped areas and bulkheads based on target static factors of safety of 1.3 for short-term conditions and 1.5 for long-term conditions, which are consistent with Washington State Department of Transportation guidance (WSDOT 2011). A target factor of safety of 1.1 is selected for global seismic slope stability at the BST and other Site Areas.
- The seismic performance for non-structural remedial elements (e.g., earthen slopes and caps) is being assessed by evaluating potential permanent seismic slope displacements for a seismic design-level event developed using the ASCE 7-10 code, which is similar to a 475-year earthquake. Seismic slope displacements of less than 3 feet are generally considered acceptable (Duncan and Wright 2005).
- Cap stability is being evaluated based on a target factor of safety of 2.0 against bearing-capacity failure. This design criterion is used to assess the maximum lift thickness of the cap that can be placed at a given time.

2.6.3 Structural Design Criteria

The following structural design criteria apply to structural design, demolition, and improvement efforts for the Cleanup:

- 2021 *International Building Code* with state (Chapter 51-50 WAC) and local (Bellingham Municipal Code [BMC] 17.10.020 Section 117) amendments
- United Facilities Criteria (UFC) 4-152-01, *Design: Piers & Wharves*, 2005
- UFC 4-151-10, *General Criteria for Waterfront Construction*, 2001

- ASCE, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, ASCE 7-16 with Supplement 1, 2016. American Concrete Institute, *Building Code Requirements for Structural Concrete*, ACI 318-19, 2019
- American Institute of Steel Construction, *Specification for Structural Steel Buildings*, AISC 360-16, 2016

Design life for proposed structures is 50 years, assuming completion of regular visual inspections and appropriate structure maintenance.

2.6.4 Coastal Engineering Design Criteria

Sitewide basis of design criteria for coastal engineering considerations include the following, with additional details provided in Appendix C:

- A potential rise in sea level of 4.2 feet (50 inches) by 2120 is considered as part of remedial design. This magnitude of sea level rise is consistent with the requirements for development within the Waterfront District as documented in *Section 3: Jurisdiction Profiles and Mitigation Strategies* of the Whatcom County Natural Hazards Mitigation Plan (WCSD-DEM 2021) completed by the Whatcom County Sheriff Department – Department of Emergency Management in September 2021. A rise of 4.2 feet would result in a future predicted mean higher high water (MHHW) elevation of +12.7 feet MLLW.
- Wave conditions at the Site are estimated based on results of a wind-wave hindcast evaluation for 100-year recurrence interval events. Wave height configurations are estimated using 100-year wind speeds from the west-northwest, west, west-southwest, and southwest directional bins, which represent the longest fetches for wave attack for the waterway.
- Near-bed velocities due to vessel propeller jets (propwash) were developed using Maynord (1998) and Blaauw and van de Kaa (1978) methods based on evaluation of existing operations within the Cleanup area. Estimated velocities were used to determine stable sediment and rock sizes. Specific vessel and operations criteria, as well as additional detail regarding the propwash evaluation, can be found in Appendix C.
- Wind-generated wave heights were adjusted to account for potential wave reflection within the waterway.
- Stable sediment and armor size for nearshore areas impacted by 100-year wind-generated wave orbital velocities were calculated using the U.S. Army Corps of Engineers (USACE) Automated Coastal Engineering System (ACES) Linear Wave Theory module and Maynord's Equation (1998).
- Stable sediment and armor size for shoreline areas impacted by 100-year wind-generated wave breaking were calculated using the USACE ACES Revetment and Rubble Mound module.

2.6.5 *In-Water Work Windows and Allowable Construction Work Hours*

In-water construction activities will be performed consistent with allowable work windows established in coordination with state and federal resource agencies. Final work windows will be specified in Cleanup permits based on the prevalence of different fish species of concern, but this section summarizes the anticipated windows based on the Phase 1 Cleanup.

Most in-water construction activities will be limited to the period between August 1 and March 14. Work may also be completed below the ordinary high water mark (OHWM) in the dry (i.e., during periods of low tide) between July 16 and July 31. Work between February 15 and March 14 will be limited to placement of engineered caps (consisting of clean sand, gravel filter, and rock armor) and RMC; no dredging will occur during this time period.

Initial construction activities performed in the ASB prior to the connection to the waterway are not subject to typical fishing windows and may be conducted outside of the established in-water work window.

Based on the current land use classifications for the Site Area (industrial and commercial mixed use or marine industrial), there are currently no hours of work restriction, and construction activities are assumed to be allowed 24 hours per day, 7 days per week.

2.6.6 *Construction Best Management Practices*

Appropriate best management practices (BMPs) are to be used during Cleanup construction activities. These BMPs will be used to minimize potential environmental impacts during Cleanup construction. The BMPs will be updated as appropriate following completion of Cleanup permitting reviews. BMPs are provided in Appendix D.

2.7 Anticipated Permits and Substantive Requirements for Cleanup

Permitting will address Phase 2 remediation activities associated with dredging, capping, removal and modification of marine structures, construction of a CDF within the ASB, and enhancing habitat conditions.

Cleanup actions at the Site are anticipated to require the following permits:

- **Section 10/404 Individual Permit:** A Section 10/404 individual permit will be issued by the USACE for Cleanup in Phase 2 Site Areas. The federal permitting process includes review of issues relating to wetlands, tribal treaty rights, threatened and endangered species, habitat impacts, historic/archaeological resources, dredged material management, environmental impacts, and other factors. The time required to complete federal permitting and associated regulatory reviews can vary from one to several years, and it will include review under the Endangered Species Act, Section 106 of the National Historic Preservation Act, Coastal Zone

Management Act, National Environmental Policy Act, and use or alteration of a civil works Cleanup under 33 United States Code 408.

- **Section 408 Permit:** The USACE is also the lead agency for Section 408 review. It is anticipated that the actions occurring within the federal navigation channel (in Units 1A, 1B, and 1C) will trigger this review. Recent and updated federal guidance detailed in Engineering Circular 1165-2-220, from September 2018 (USACE 2018), indicates USACE's intention to consolidate regulatory and Section 408 reviews; however, specific details of the consolidation process are still being defined.
- **Section 401 Water Quality Certification:** If a Section 10/404 individual permit is issued by USACE, Ecology may require a Section 401 water quality certification. This certification ensures that the Section 404 permitted actions will comply with state water quality standards and other aquatic resource protection requirements under Ecology's authority. Ecology may not require a formal Section 401 water quality certification if a Nationwide 38 permit is issued, in which case water quality issues will be addressed by Ecology as part of the EDR review and approval.
- **NPDES Permitting:** Stormwater and construction process water will be appropriately managed for all upland materials transloading, stockpiling, and rehandling. Management of stormwater and water from dredge material management is allowed under the existing NPDES permit maintained by the Port for the ASB and the associated GP West-owned outfall. To support the remediation activities, a modification of the NPDES permit will be obtained from Ecology. The construction work may also require a Construction Stormwater General Permit (CSGP) for certain activities not otherwise covered under the existing NPDES permit or the Section 401 water quality review. At the conclusion of the Site cleanup work, the existing ASB NPDES permit is anticipated to be terminated because the ASB will no longer be used for stormwater treatment.

Because the work will be conducted under an MTCA Consent Decree, the Cleanup is exempt from the procedural requirements of most state and local permits (Revised Code of Washington 70.105D.090). However, MTCA requires compliance with the substantive provisions of these regulatory programs. In the past, Ecology has assisted the Port in working with state and local agencies to demonstrate substantive compliance. The substantive requirements of the following approvals, known at this time to be applicable to the cleanup, will be addressed during design and permitting.

- **Hydraulic Cleanup Approval:** The lead review agency for the Hydraulic Cleanup Approval (HPA), issued under the Washington State Hydraulic Code, is the Washington Department of Fish and Wildlife (WDFW). The Cleanup will not require a formal HPA due to substantive compliance. The HPA defines state requirements for construction activities in order to avoid

unnecessary disturbance to fish, shellfish, and wildlife. The Port and Ecology will work with WDFW to ensure protection of fish, shellfish, and wildlife during Cleanup construction.

- **Shoreline Permit:** The City of Bellingham (City) is the lead review agency for Shoreline Management Act consistency. Shoreline Management Act regulations defer to Ecology for site-specific review of cleanup actions conducted under MTCA. Ecology will consider the substantive provisions of the City's Shoreline Master Program (City of Bellingham 2013) as part of the Cleanup, but a shoreline permit will not be required.
- **Critical Areas Ordinance Consistency Determination:** The City is the lead review agency for Critical Areas Ordinance consistency per BMC Chapter 16.55. The substantive provisions of the City's Critical Areas Ordinance will be considered by Ecology as part of the Cleanup, but a critical areas consistency determination will not be required.
- **Development Permits:** Cleanups within the City that include fill and grade activities and construction of new infrastructure require grading, building, or other related development permits. These permits are issued by the City and include requirements to protect the environment and human health and safety. Portions of the CDF construction are expected to be subject to these substantive requirements (in addition to formal issuance of building permits that are anticipated to be required for the CDF).

The placement of caps on state-owned aquatic lands currently managed by the Department of Natural Resources (DNR) will involve development of appropriate agreements (e.g., easement agreements) consistent with the planned remedial action. The Port and DNR have an existing interagency agreement supporting completion of the Cleanup. The Port will work with DNR to coordinate development of final agreements required for Cleanup construction and implementation of IC required under the Cleanup.

The Cleanup includes a number of mitigation measures to protect and improve existing habitat quality. No additional on-site or off-site mitigation activities are expected to be required to implement the Cleanup.

In parallel the Cleanup, the Port will be conducting a number of additional habitat mitigation measures to improve habitat quality and quantity in Bellingham Bay. The Port intends to reserve these surplus mitigation credits for use by the Port in the future. Written advance mitigation agreements will be developed by the Port with applicable federal, state, and local permitting agencies prior to construction. Agreements currently under development include Advance Mitigation Agreements with WDFW, Ecology, the National Marine Fisheries Service (NMFS)/U.S. Fish and Wildlife Service, and the USACE.

3 Cleanup Overview

This section provides an overview of the Cleanup, as shown in Figure 2-2 and in Figures 3-1 through 3-4. Table 3-1 summarizes the cleanup approach for each Site Unit, and Table 3-2 summarizes the estimated quantities of dredging and capping in each Site Unit.

Refer to Sections 5 through 12 of this EDR for more detailed information regarding the Cleanup in each Site Area.

Table 3-1
Cleanup Approach by Site Unit

Cleanup Area	Site Unit	Cleanup Description	Cap Type	Working Water Depths in Cap Areas [1]
Outer Waterway Area	1A	Full Dredge; RMC	--	--
	1B	Full Dredge; RMC	--	--
	1C	Full Dredge; RMC	--	--
BST Dock Area	1C (BST Dock area)	Dredge and Cap	Type 3 (Slope Only)	-40 feet MLLW (Base of Slope)
Inner Waterway Area	2B Inner	Full Dredge; RMC, Side slope Capping	Type 3 (Slope Only)	-25 feet MLLW (Base of Slope)
	2B Outer	Full Dredge; RMC, Side slope Capping	Type 1 (Slope Only)	-25 feet MLLW (Base of Slope)
	2C (Inner Cap Area)	Dredge and Cap	Types 1 and 2	-18 feet MLLW
	2C (Outer Cap Area)	Dredge and Cap	Type 1	-25 feet MLLW
	2C (Full Removal Area)	Full Dredge; RMC, Side slope Capping	Type 1 (Slope Only)	-25 feet MLLW and -40 feet MLLW [2] (Base of Slope)
GP Dock Area	2C (GP Dock Area)	Dredge and Cap	Type 1	-18 feet MLLW (Base of Slope)
Head of Waterway Area	3A	Dredge and Cap	Type 1 and 2	-4 feet MLLW (Top of Habitat Layer) [3]
Log Pond Slope	4	Dredge and Cap	Type 1	-40 feet MLLW, -25 feet MLLW and -18 feet MLLW (Base of Slope) [2]
ASB Shoulder	5B	Dredge and Backfill	--	--
C-Street Outfall Area	5C	Cap	Types 1 and 3	-6 feet MLLW (Base of Slope) [4]
Rail Span Area	6	Dredge and Cap	Type 1	-15 feet MLLW (Berth Area)

Cleanup Area	Site Unit	Cleanup Description	Cap Type	Working Water Depths in Cap Areas [1]
ASB	8	Full Dredge; RMC	Type 3 [5]	-25 feet MLLW (Base of Slope) [5]

Notes:
--: not applicable

1. To provide for future maintenance dredging, the target working water depths include 2 feet of clearance to the top of the cap unless otherwise specified (i.e., a working water depth of -25 feet MLLW means that the top of the cap is -27 feet MLLW).
2. The working water depth varies by location. Refer to the EDR figures for the transition points between different areas.
3. The working water depth for the Unit 3A cap represents the proposed maximum elevation of the habitat (i.e., fish mix) layer. No future maintenance dredging is assumed for this cap.
4. The base of the C-Street Outfall Area cap is based on the surrounding mudline elevations. No additional dredging allowance is assumed for this cap.
5. The ASB Type 3 cap is located only along the ASB berm. No cap is required for the base of the ASB Aquatic Use Area, which is designed with a working water depth of -25 feet MLLW. Along the ASB exterior, the caps will maintain the current mudline elevations.

Table 3-2
Approximate Dredging and Material Placement Volumes *(Volumes are Subject to Revision)*

Unit	Contaminated Sediment Dredging Volume (cy) [1]	Clean Sand Dredging Volume (cy) [2]	Clean Material Placement Volume (cy)
1A	39,800	--	9,800
1B	91,700	--	18,000
1C	96,300	--	12,700
1C (BST Dock Area)	14,000	--	8,000
2B	31,700	61,000	3,800
2C (All Open Water Areas)	66,400	--	163,000
2C (GP Dock Area)	15,500	--	23,200
3A	7,500	--	5,500
4	30,100	--	15,600
5B	14,500	--	15,500
5C (C-Street Outfall Area)	TBD	--	TBD
6	11,300	--	10,100
8	195,000	132,300	14,500
Total	613,800	193,300	299,700

Notes:
--: not applicable

1. Table 3-2 includes only the volumes of dredging associated with the cleanup of the Whatcom Waterway Site. All contaminated sediments dredged from the Site will be placed within the Unit 8 CDF. An additional 39,700 cubic yards of contaminated sediments will also be disposed of in the CDF. These other sediments will be dredged from the Harris Avenue Shipyard site, the I&J Waterway site, and the Squalicum Marina.
2. Clean sand/stone materials dredged from these areas will be reused within the Cleanup.

3.1 Work Area Preparation, Staging, and Stockpile Activities

A number of preparation activities are required to support the Cleanup, including the following:

- **Staging Areas**: Portions of the upland areas adjacent to where shoreline and in-water sediment remediation will be performed will be made available to the contractor for use in construction as staging and stockpiling areas. This may include storage of construction equipment and materials, potential offloading or stockpiling of debris removed during remediation, and potential temporary stockpiling of clean sand materials from the ASB prior to their reuse. These areas will be made available to the contractor should they elect to design, construct, and manage the facilities on the Port's property. Areas that may be available for the Cleanup are shown in Figure 3-4. Final staging and material stockpiling areas will be determined during final design.
- **Construction Stormwater Management:** Stormwater associated with Cleanup staging areas will be appropriately managed to prevent the discharge of pollutants. Stormwater from upland construction areas not otherwise managed under the Port's ASB NPDES permit will be managed under a Washington State NPDES CSGP. The contractor will be responsible for preparing a Stormwater Pollution Prevention Plan (SWPPP) that meets applicable regulatory and permit requirements. As the CSGP is associated with cleanup work, the development of an Administrative Order with Ecology is anticipated.
- **New Stormwater Outfall Construction:** Two new stormwater outfalls will be constructed at the locations shown in Figures 2-2, 3-1, and 3-3 to allow disconnection of stormwater lines currently discharging to the ASB. One outfall will be located along the ASB shoreline to manage stormwater generated from portions of the Central Waterfront site. That outfall will also be used to manage stormwater generated from the surface of the completed CDF area following completion of the cleanup. The second outfall will be located along the Log Pond shoreline to manage stormwater generated from portions of the GP West site.
- **Installation of Sediment Offloading Dolphins:** A series of 12 sediment offloading dolphins will be constructed alongside the ASB at the locations shown in Figures 2-2 and 3-3 for use in transloading contaminated sediments from barges into the ASB. The dolphins will be constructed of steel and will be connected to the shoreline via a catwalk to provide personnel access during the Cleanup.

3.2 Outer Waterway (Units 1A, 1B, and portions of Unit 1C)

The Cleanup within the open-water portions of the Outer Waterway includes mechanical dredging of open-water portions of Units 1A, 1B, and 1C. Testing will be performed to verify that contaminated sediments have been fully removed from these areas. Following completion of dredging, dredging residuals will be managed by the placement of RMC.

The remediation in Outer Waterway areas is expected to occur in Construction Seasons 2 and 3 (see Figures 3-1b and 3-1c). Table 3-2 provides the estimated dredging and material placement volumes for Units 1A, 1B, and 1C.

Required dredging elevations vary in different portions of the Outer Waterway. These required dredge elevations provide for complete removal of the contamination and unencumbered use and future maintenance of the federal navigation channel. Based on the estimated bottom elevation of the contaminated sediments, approximately 22,700 cubic yards (cy) of contaminated sediment will be removed from open-water areas of Unit 1. Dredged materials from all open-water areas of Units 1A, 1B, and 1C are to be transported by barge and placed in the CDF located within the ASB (see Section 3.10).

Progress and post-construction bathymetric surveys will be used to verify the contaminated sediments are removed to the required dredging elevation, and sediment testing will confirm that the dredging has removed all of the contaminated sediments. After dredging, RMC material will be placed over the dredged areas. This material will consist of a minimum placement of 6 inches of clean sand with an allowable over-placement of 6 inches, resulting in placement volume of approximately 40,500 cy of clean RMC material.

3.3 BST Dock Area (portions of Unit 1C)

The existing BST dock (Figure 2-2) is an overwater structure approximately 1,230 feet long. The BST dock includes three sections, each constructed at different times with different materials:

- **South Terminal:** Constructed of creosote-treated wood timbers, this offshore dock section is located in deeper water without steep side slopes characteristic of the Central and North Terminals.
- **Central Terminal:** The Central Terminal is located in the middle of the BST Dock Area and is the youngest dock section. Most of it was constructed of concrete panels and metal pilings in the late 1970s. A portion of the Central Terminal is currently being reconstructed by the Port with a removable deck section and metal pilings to facilitate the Cleanup. The upper shoreline beneath the Central Terminal includes a pile-supported concrete wall structure.
- **North Terminal:** The North Terminal was constructed primarily of creosote wooden timbers and closely spaced, creosote-treated timber pilings. One offshore portion of the dock was reconstructed more recently with metal pilings. The upper shoreline beneath the North Terminal includes a metal bulkhead.

Contaminated sediment will be removed from the steep slopes beneath the North Terminal and Central Terminal structures. Most of the North Terminal and Central Terminal dock structures will need to be removed and replaced to support the sediment remediation. The Port will remove all creosote-treated wood pilings from these areas as part of parallel advance mitigation activities. The

existing timber pier section that extends from the North Terminal into the Log Pond will be permanently removed.

Shoreline stabilization measures will also be required to prevent slope failures during and following the Cleanup. These will include construction of updated bulkheads and ground improvement along the top of slope at the Central and North terminals.

Contaminated sediments located on the steep slopes of the North Terminal and Central Terminal will be removed by mechanical dredging equipment. Contaminated sediments generated by the dredging will be disposed of in the CDF. Following contaminated sediment removal, a Type 3 cap will be placed in the removal areas to protect the slope against future erosion and ensure climate resiliency.

Remediation at the BST Dock Area will be completed and the structures removed and replaced in phases to accommodate permit-required fish windows and to maintain Port terminal operations throughout the cleanup. The anticipated construction sequencing of associated work at the BST Dock Area is shown in Figures 3-1a through 3-1c.

The estimated dredge volume is approximately 14,000 cy. Dredged materials removed from the BST Dock Area will be transported by barge and placed in the CDF within the ASB (see Section 3.10). Following completion of dredging, approximately 8,000 cy of Type 3 cap will be placed to stabilize the shoreline against erosion.

The North and Central terminal dock structures and associated breasting and mooring dolphins will be replaced following Type 3 cap construction. This replacement will be phased with the dredging and capping activities.

3.4 Inner Waterway and Log Pond (Unit 2B and Portions of Units 2C and 4)

Open-water areas of the Inner Waterway and side slopes along the Log Pond will be remediated using both dredging and capping. The Cleanup in Site Units 2 and 4 includes the following four subareas:

- **ASB Access Channel (Unit 2B):** The ASB Access Channel will reconnect the Inner Waterway and the ASB following completion of the Cleanup in Unit 8. The access channel will be opened up by the Port as part of parallel advance mitigation activities. The final access channel will have a final working elevation of -25 feet MLLW. All contaminated sediments will be removed from the base of the access channel as part of the Cleanup. Capping will be used only on the access channel side slopes. Type 1 (Outer Unit 2B) and Type 3 (Inner Unit 2B) caps will be placed over the exposed sides of the access channel to contain contaminated sediments, prevent future erosion of the ASB berms, and ensure climate resiliency.

- **Unit 2C Inner Capped Area:** The portion of Unit 2C located between Laurel Street and the ASB Access Channel is to be remediated by dredging and capping. In this area the dredging and capping will support a future working water depth of -18 feet MLLW. Dredging will be followed by placement of Type 1 and Type 2 sediment caps.
- **Unit 2C Outer Capped Area:** A portion of Unit 2C located offshore of the ASB Access Channel and adjacent to the Log Pond will be remediated by dredging and capping. Dredging will be followed by placement of a Type 1 sediment cap on the waterway floor. The dredging and capping in most of this area will support a future working water depth of -25 feet MLLW.
- **Unit 2C Full Removal Areas:** The portion of Unit 2C located adjacent to the Outer Waterway will be remediated by dredging. Planned removal depths vary throughout this area. Placement of caps will be required along the Unit 2C side slopes near the ASB and along the Log Pond.
- **Log Pond Slope (Portion of Unit 4):** Capping will be used to remediate and stabilize the side slopes located along the Log Pond (including portions of Unit 2C and Unit 4). Some dredging will be performed as necessary to seat the cap into the slope at appropriate target elevations. Dredging will be followed by placement of Type 1 sediment caps.

All contaminated dredge materials generated from the Inner Waterway areas will be disposed of in the CDF. Clean sediments dredged from Unit 2B will be reused within the Cleanup for capping and backfill materials. The final surface elevations in all capping areas will be at least 2 feet below the target working water depths for each area.

Capping materials to be used for Unit 2C include clean sand materials to be dredged from the outer portion of Unit 8. Other capping materials will consist of imported sand, gravel, and stone materials from quarry sources or beneficial reuse materials that comply with Site cleanup standards.

Figures 3-1b and 3-1c illustrate the anticipated construction sequence for the Inner Waterway and Log Pond areas. Dredging work in Unit 2C and Unit 4 is expected to occur in Construction Season 2 along with placement of an interim layer of RMC material. Final capping of Unit 2C is expected to be conducted in Season 3. Dredging, RMC placement, and capping work in Unit 2B is also expected to be conducted during Season 3.

3.5 GP Dock Area (Portions of Unit 2C)

The GP Dock Area is located along the side slopes of Unit 2C. The dock structure will be removed to facilitate the cleanup. The Port will remove all creosote-treated pilings as part of parallel advanced mitigation activities. Then the area will be remediated using a combination of dredging and capping.

Dredging will be used as necessary to prepare the shoreline for cap placement. The cap slopes and elevations for this area have been designed with consideration of slope stability and expected future navigation uses. The caps will be constructed with side slopes at a ratio of 3 horizontal to 1 vertical

(3H:1V). The caps will extend to the top of the slope to provide climate resilience. The base of the caps will be contiguous with the caps placed over the open-water portions of Unit 2C, with a working water depth of -18 feet MLLW at the toe of the capped slope.

Total dredge and capping volumes are estimated at 15,500 and 32,200 cubic yards, respectively. Dredged materials removed from the GP Dock Area will be transported by barge and placed in the CDF within the ASB (see Section 3.10).

An illustration of the post-remediation GP Dock slope after removal of the structure and completion of the cleanup is shown in Figure 3-5. Cleanup in the GP Dock Area is expected to occur during Season 3 (Figure 3-1c).

3.6 Head of Waterway (Unit 3A)

The Head of Waterway extends approximately 500 feet outward from the Roeder Avenue Bridge. It includes the existing shallow-water areas located in front of Waypoint Park and the mouth of Whatcom Creek.

Unit 3A was designated in the Consent Decree as an MNR area. However, the Second Amendment to the Consent Decree authorizes the Port to upgrade the remedy to enhance habitat quality in the area. This change is contingent on availability of grant funding to support the work.

The modified cleanup in Unit 3A includes dredging, capping, and placement of habitat enhancement materials. Prior to the Cleanup, the Port will remove the remnant creosote-treated pilings from the former Citizens' Dock as part of parallel advance mitigation activities.

Sediments will be dredged from the central portions of Unit 3A to prepare the area for placement of a sediment cap and habitat materials. Estimated dredging volumes are 7,500 cy. Dredged materials will be transported by barge and placed in the CDF (see Section 3.10).

Following completion of dredging, a Type 1 cap will be placed within Unit 3A. Habitat materials (fish mix) will be placed on top of the cap to provide suitable substrate for eelgrass and macroalgae development. The final working water depth in this area will be approximately -4 feet MLLW to support development of eelgrass and macroalgae.

The Port plans to plant eelgrass in the completed area as part of advance mitigation activities.

Cleanup work in Unit 3A is expected to occur in Construction Season 2 (Figure 3-1b).

3.7 ASB Shoulder (Unit 5B)

Unit 5B is located immediately offshore of the ASB, in the transition area between the ASB and the Outer Waterway. It consists of a relatively shallow-water area subject to higher wave energies that

has been resistant to natural recovery. Surface sediments within this area contain mercury concentrations that remain above cleanup standards and are not expected to recover naturally within a reasonable restoration time frame.

Unit 5B will be remediated by dredging. Removal depths will be to the base of the contamination 3 feet below the existing mudline, plus a 1-foot overdredge allowance. To avoid destabilizing the adjacent ASB berm slopes, no dredging will be performed immediately adjacent to the ASB berm or the buried outfall structure.

Sediment testing will be used to confirm that all contaminated sediments have been removed. The removed sediments will be transported by barge for placement within the CDF that will be constructed in the ASB (see Section 3.10). The total dredging volume is estimated to be 14,500 cy.

In order to maintain existing shallow-water habitat conditions in Unit 5B, the depression created by contaminated sediment removal will be restored by backfilling with clean sediment.

Dredging and backfill material placement in Unit 5B is expected to occur in Construction Season 3 (Figure 3-1c).

3.8 C-Street Outfall Area (Portions of Unit 5C)

Localized areas of sediment recontamination have been observed in the area adjacent to the C-Street Outfall. This recontamination has been caused primarily by downcutting of the intertidal sediment surface by waters discharged from the C-Street Outfall.

The contaminated sediments in the C-Street Outfall Area will be remediated by placement of Type 1 and Type 3 sediment caps. The capping work will also include several other measures to improve resiliency, protect against future recontamination, and support remediation of the adjacent ASB. These measures include removing existing pilings and debris, reconfiguring the outfall and shoreline to prevent the discharge of stormwater from scouring intertidal sediments, and developing an access ramp between the existing C-Street Terminal and the ASB berm. The access ramp will be used during remediation of the ASB for transportation of steel sheets and building materials needed for construction of the CDF retaining structure (Section 3.10).

Completion of work in the C-Street Outfall Area is expected to occur during Season 1.

3.9 Rail Span Area (Portions of Unit 6)

The cleanup in the Rail Span Area includes dredging and capping in the existing berth areas. The remaining portions of Unit 6 are being successfully addressed through MNR.

To facilitate the cleanup, the former chemical dock and unneeded portions of the Rail Span structure will be removed. The Port will remove existing creosote-treated pilings as part of parallel advance mitigation activities.

Approximately 11,300 cy of contaminated sediments will then be dredged from the berth area to prepare it for cap placement. Sediments dredged from the Rail Span Area will be disposed of in the CDF.

Following dredging, a Type 1 cap will be placed in the berthing and side slope areas (Figure 2-2). The cap design accommodates a working water depth of -15 feet MLLW consistent with the existing design and use of the Rail Span.

Structure removal and cleanup in the Rail Span Area are expected to occur during Seasons 1 and 2 (Figures 3-1a and 3-1b).

3.10 ASB Remediation and CDF Construction (Unit 8)

Remediation within Unit 8 will include dredging, capping, and CDF construction. Dredging will occur in the outer portion of the ASB (the Aquatic Use Area), and construction of the CDF will occur within the inner portion (the future marine trades reuse area). The two areas will first be separated by a newly constructed CDF retaining structure. Capping will occur only in ASB side slope areas.

The CDF retaining structure will include two outer metal walls enclosing a core of clean sandy fill material. The final form of the structure will depend on final detailed remedial design evaluations but will consist either of a cofferdam structure (with two straight walls connected by bracing and tie-backs) or a cell-wall structure (with a series of interlocking, circular wall sections constructed in series).

The cleanup work in Unit 8 is expected to occur over at least three construction seasons, as shown in Figures 3-3a, 3-3b, and 3-3c. This work is expected to include the following sequence of activities:

- The existing stormwater discharges to the ASB will be disconnected to isolate the ASB. That stormwater will be managed using new stormwater outfalls installed as described in Section 3.1. The water level in the ASB will then be lowered to facilitate construction of the CDF retaining structure.
- Interior structures (interior weirs, piping, and aerators) located within the ASB will be removed. The ASB outfall structure will be retained and protected. It will be used for discharge of treated remediation waters generated during the Cleanup.
- The CDF retaining structure will then be constructed across the ASB using a combination of staged and floating equipment located within the ASB. Contaminated sediments located between the outer walls of the structure will be removed, and this interior space will be backfilled with clean sandy materials.

- Contaminated soft sediments located in the outer portion of the ASB will then be removed by dredging and will be placed into the CDF. This dredging is expected to occur using mechanical dredge equipment with hydraulic placement of the dredge materials into the ASB. Waters used to help place the dredge materials into the CDF will be treated and reused to minimize water generation rates.
- The contaminated transition sands located immediately beneath the soft sediments will also be removed by dredging from the outer portion of the ASB. These sediments will also be disposed of in the CDF.
- The CDF will then be filled with contaminated sediments removed from other Cleanup Areas and from other Port cleanup and maintenance dredging projects. These sediments will be transloaded into the ASB from barges. The barges will be moored alongside the ASB using the transloading dolphins newly installed for that purpose, as described in Section 3.1. Sediments will then be pumped in an enclosed pipeline into the CDF. This transloading method minimizes the potential for sediment spills. It also allows the location of sediment placement to be accurately controlled by adjusting the pipeline discharge location. Waters used as part of the sediment transloading operation will be treated and reused to minimize water generation rates.
- Excess stormwater and remediation waters generated during the cleanup will be treated and discharged to Bellingham Bay via the existing ASB Outfall in compliance with the Port's NPDES permit for the ASB. A modification of the ASB NPDES permit will be obtained during design and permitting to support the Cleanup.
- Clean sands located within the ASB Aquatic Use Area (i.e., below the transition sands) will be removed for beneficial reuse within the Cleanup as clean backfill material, sediment cap material, and CDF capping material.
- After filling of the CDF and remediation of the outer portion of the ASB, the Port will construct the access channel between the ASB and the Whatcom Waterway. This will be completed as part of parallel advance mitigation activities. The Port will also install a fish passage structure in the ASB berm alongside the existing eelgrass flat adjacent to the I&J Waterway. A Type 1 cap will be placed on the side slopes in the outer portion of Unit 2B, and a Type 3 cap will be placed on the side slopes in the inner portion of Unit 2B and along exterior and interior ASB side slopes.
- After all contaminated sediments have been placed within the CDF, the CDF will be capped with a 2-foot minimum thickness of clean sand and gravel material. Interim stormwater management facilities will be provided to manage stormwater generated from the CDF cap surface. This environmental cap is intended to be covered in the future by a working surface (to include paving, structures, or gravel working surfaces) to be constructed as part of marine trades area redevelopment. Placement of that future working surface is not part of the Cleanup but has been considered in the design of the Cleanup.

- Following cleanup of the ASB and its reconnection to the Whatcom Waterway, the ASB outfall building and standpipe will be removed, the outfall pipe will be permanently decommissioned, and the Port's associated NPDES permit for the ASB will be terminated.

3.11 Compliance Monitoring and Institutional Controls

The Cleanup will include compliance monitoring both during and after construction to ensure that cleanup standards are met.

- **Protection Monitoring:** Protection monitoring includes water quality monitoring and health and safety monitoring to ensure protection of human health and the environment during Cleanup construction activities. The Draft Water Quality Monitoring Plan is attached as Appendix E. Additional water quality monitoring will be performed as part of NPDES and CSGP permit compliance.
- **Performance Monitoring:** Performance monitoring includes the measurement of bathymetry and sediment quality to document that the Cleanup is meeting its performance targets for sediment removal and capping. Performance monitoring methods and locations are described in Appendix F.
- **Long-Term Compliance Monitoring:** Long-term compliance monitoring will include supplemental sediment and groundwater quality testing to document that the completed Cleanup is meeting the Site cleanup standards. This work is in addition to the ongoing monitoring implemented since 2017 in Phase 1 Site Areas and MNR areas and is described in Appendix H.

4 Net Environmental Effects

This section discusses the environmental resources and habitats located in each of the Phase 2 Site Areas. Section 4.4 summarizes the expected net environmental effects associated with the Cleanup. These effects are positive, resulting in substantial improvements to habitat quality within the Site. The expected net environmental effects associated with the Port's parallel advance mitigation activities are described in Section 4.5.

Ecology's cleanup decision for the Site (Ecology 2007a, 2011) included consideration of its net environmental effects consistent with SMS requirements. As described in the FSEIS (Ecology 2007b), Ecology expected that the cleanup action would have a beneficial impact on aquatic habitats within the Site.

The Cleanup design achieves a net improvement of habitat quality by removing existing creosote-treated structures, reducing overwater cover, removing shoreline debris, and reconstructing shoreline slopes in a manner that provides expanded areas of valuable nearshore intertidal and shallow subtidal habitat along migration corridors for juvenile salmonids.

4.1 Fisheries and Invertebrate Resources

The Site has been used by a variety of fish and invertebrate species for various purposes (e.g., foraging, migration, and spawning); however, the current degraded habitat conditions within portions of the Site limit the functions and value of that habitat for many species. This section provides information on the known species' use of the Site and those factors that limit use of the waterway by those species.

4.1.1 Surf Smelt and Sand Lance

Surveys by WDFW and Fairbanks Environmental Services have documented spawning beaches in Bellingham Bay (WDFW 2024a; Fairbanks 2016). However, no surf smelt or sand lance spawning has been documented in the Inner Waterway, presumably because suitable substrates are not available (Ecology 2007b). One area documented with potential surf smelt and sand lance spawning habitat is the shoreline within the Log Pond area (WDFW 2024a).

Existing contaminated sediments, creosote-treated structures, over-steepened slopes, lack of suitable spawning substrates (i.e., fine-grained materials within intertidal areas), and shoreline obstructions such as vertical bulkheads may limit the productivity of surf smelt and sand lance in the Site.

4.1.2 Pacific Herring

Herring are known to congregate in the deeper waters of Bellingham Bay (WDFW 2024a). This species deposits its eggs on marine vegetation such as eelgrass and other submerged aquatic

vegetation in the shallow subtidal and intertidal zones between 1 foot above and 5 feet below MLLW. However, only relatively low-density spawning deposition occurs in the bay, and none of that has been documented in the vicinity of the Site (WDFW 2024a).

Existing contaminated sediments, creosote-treated structures, over-steepened slopes, lack of suitable spawning substrates (i.e., limited suitable marine vegetation), and shoreline obstructions such as vertical bulkheads may limit the productivity of herring in the Site.

4.1.3 Salmonids

The Nooksack River has the largest salmon runs in Bellingham Bay, followed by Whatcom Creek (Beamer et al. 2016). Concentrations of chum, coho, and Chinook salmon along the shoreline and in offshore waters in Bellingham Bay peak annually around mid-May. Juvenile coho and Chinook salmon appear to have different migration habits. Coho salmon remain in Bellingham Bay for approximately 30 to 35 days, while Chinook salmon remain for about 20 days (Ecology 2007b).

Existing contaminated sediments, creosote-treated structures, over-steepened slopes resulting in limited suitable intertidal habitat and increased available predator habitat, and shoreline obstructions such as vertical bulkheads may limit the productivity of salmonids in the Site. Pocket estuary habitat in Bellingham Bay, including Whatcom Waterway, is important habitat for juvenile out-migrating Chinook salmon. Restoring habitat and improving connectivity between nearshore habitat in Bellingham Bay would benefit the endangered species of salmonids that utilize the nearshore area in the bay (Beamer et al. 2016).

Chinook salmon in Puget Sound are listed as threatened under the Endangered Species Act (ESA), with Nooksack River Chinook salmon designated as one of the five genetic diversity units within the Puget Sound evolutionarily significant unit that is critical to recovery of the evolutionarily significant unit (NMFS 2007). Bellingham Bay is considered critical habitat for Chinook salmon, and Whatcom Creek is considered critical habitat for threatened Puget Sound steelhead (NMFS 2005). Restoring nearshore connectivity between the Whatcom Waterway and Bellingham Bay is essential for the ESA-listed species that use this habitat.

4.1.4 Groundfish

Several species of groundfish occur in both shallow and deep waters in Bellingham Bay for part or all of their lives. Detailed information on groundfish species and their timing and use of Bellingham Bay is not available. Key characteristics of groundfish occurring in northern Puget Sound are generally applicable to Bellingham Bay (Ecology 2007b).

Groundfish may be present in the nearshore and deep-water areas of the Site. However, their use of the waterway may be limited by the over-steepened slopes and shoreline obstructions such as vertical bulkheads, resulting in limited suitable intertidal habitat for juveniles.

4.1.5 Clam, Geoduck, and Oyster

Bellingham Bay supports a variety of marine invertebrates, ranging from infauna (worms, clams, and small ghost shrimp that penetrate benthic sediments) to epibenthic plankters (organisms such as very small crustaceans that move off the substrate surface) to larger invertebrates such as oysters, crabs, and shrimp. The predominant bivalves in Bellingham Bay are intertidal and subtidal hardshell clams (Ecology 2007b).

Shellfish densities are relatively low along the eastern shore of Bellingham Bay in the vicinity of the waterway, although bivalves are the dominant benthic organism within the waterway (Anchor Environmental 1999, as referenced in Ecology 2007b). Scattered oysters also occur along the shoreline of the Whatcom Creek estuary (Palm 1995, as referenced in Ecology 2007b). Geoduck, which is only present in a handful of locations in the bay, does not occur within the waterway (Ecology 2007b). Low shellfish densities may be linked to existing habitat conditions in the Site.

4.1.6 Shrimp

Seven species of pandalid shrimp, including, pink, coonstripe, dock, and spot shrimp, occur in nearshore and deeper waters of Bellingham Bay. For example, coonstripe shrimp have been observed in intertidal areas immediately offshore of the Cornwall Avenue Landfill (which is just south of the waterway), and this species is common around piers and floats. Shrimp densities in the areas surrounding the Whatcom Waterway are moderate when the bay is viewed as a whole (Ecology 2007b).

4.1.7 Crab

Crab trawls conducted for the Puget Sound Dredge Disposal Analysis investigations indicate that the predominant crab resources in Bellingham Bay are the non-edible purple or graceful crab, the edible red rock crab, and the edible Dungeness crab (Ecology 2007b). Dungeness crab is generally abundant in most areas of Bellingham Bay and has been documented in the Whatcom Waterway.

The northern and eastern shorelines of Bellingham Bay serve as nursery and rearing areas for juvenile Dungeness crab. A shell substrate is a preferred habitat for the first 8 to 10 weeks after larvae settle. Other substrates, such as small cobbles and gravel, eelgrass, and algae, are also recognized as important rearing habitat for juvenile crab. Because the Site has relatively limited quantities of these habitats, its current usefulness as a nursery and rearing area is likely limited, with the exception of the Log Pond (Ecology 2007b).

Since 2019, invasive European green crabs have been found in several areas of Bellingham Bay (Washington Sea Grant 2019). Capture rates in Bellingham Bay have been low compared to nearby areas such as Drayton Harbor and the Lummi sea pond, where tens of thousands of European green crabs have been removed since they were first documented in Whatcom County (WDFW 2024b). These invasive crabs have the potential to significantly harm species such as native eelgrass (*Zostera marina*) and Dungeness crab via competition and predation (Colnar and Wayne 2007).

4.2 Types and Functions of Habitats

The 2007 FSEIS described three types of habitats that can be found within the Site. The habitats include intertidal, shallow subtidal, and subtidal (Bailey et al. 1993; Berry and Ritter 1997; Dethier 1990; Ecology 2007b). These habitat types are similar to the habitat types described in the Puget Sound Habitat Conservation Calculator, published by NMFS, the regional tool used to determine habitat impacts as debits and habitat improvements as credits. For the purposes of this document, the NMFS habitat types are discussed further in the following subsections.

The three main types of aquatic habitat found within the Site include the following (Ehinger et al. 2023a):

- Upper shorezone
- Lower shorezone
- Deeper shorezone

In addition, riparian habitat provides essential ecological functions to nearshore aquatic habitats, including shade/microclimate, large woody material recruitment, litter/organic matter inputs, and water quality (filtration). In general, these habitats are highly degraded due to long-term industrial use of the waterway and associated sediment contamination, in-water and overwater structures, vertical bulkheads, the presence of extensive manmade shoreline debris, and other habitat-limiting factors. The features and functions of habitat types within the Site are discussed in the following subsections.

4.2.1 Riparian (Above Elevation +9.7 feet MLLW)

Aquatic species access to the riparian area is limited to occasional extreme high tides, and the area is otherwise not directly tidally influenced. However, this habitat does benefit aquatic organisms by providing allochthonous material inputs to the nearshore habitat (Duffy et al. 2010) and by controlling runoff and erosion through soil stabilization from roots and vegetation.

Material inputs may consist of dead organic matter, large woody material, and insects, which serve as food for nearshore organisms. The riparian zone may also provide shading to the upper shorezone, which can reduce desiccation of forage fish eggs (Lee and Levings 2007; Penttila 2001; Quinn et al. 2012).

This zone may also include emergent marsh vegetation, most of which is in the Nooksack Delta in the northern areas of Bellingham Bay (Beamer et al. 2016). Marsh vegetation provides valuable water filtration and sediment stabilization at the dynamic and constantly changing intersection of terrestrial and pelagic habitat types.

4.2.2 Upper Shorezone (Elevation +9.7 feet to +5.0 feet MLLW)

Sand, mud, and cobble habitat is found in the upper shorezone. This area supports rooted plants to varying degrees, with increased numbers and variety occurring at higher elevations.

Premium intertidal habitat of this kind, with the appropriate substrate, energy levels, and other conditions providing maximum benefit to juvenile salmonids, is limited in the waterway to areas at the Head of Waterway, areas along portions of the sides of the waterway, and in portions of the Log Pond area (Ecology 2007b).

The higher elevation area of this zone supports emergent marsh vegetation, which locally is generally limited to the Nooksack Delta in the northern area of Bellingham Bay (Beamer et al. 2016).

Pocket marsh habitat, including emergent marsh vegetation within the higher elevation area of this zone, serves as fringe, but important, habitat for aquatic organisms by providing allochthonous productivity, prey input, and refuge at higher tides.

Mudflats and gravel beaches within this substratum support epibenthic prey that is consumed by juvenile salmon migrating through the area during high tide.

Large woody material recruitment from the riparian zone may serve as natural riprap in this zone, partially protecting soil from erosion and increasing habitat complexity.

4.2.3 Lower Shorezone (Elevation +5.0 feet to -10.0 feet MLLW)

The physical and biological features of the lower shorezone are important for juvenile salmonids that rear and out-migrate through the nearshore area.

The lower shorezone generally has the highest abundance of submerged aquatic vegetation. Mudflats and eelgrass within this substratum support epibenthic prey that is consumed by juvenile salmon (Munsch et al. 2021; Shaffer et al. 2020). Complex vertical structure such as eelgrass serves as predator refuge for nearshore fishes and crabs, and provides sediment stabilization, nutrient cycling, and carbon sequestration (Hansen and Reidenbach 2012; McRoy 1974; Waycott et al. 2009). Mudflats are also important for many intertidal species. For example, organisms such as small flatfish commonly forage in unvegetated mudflats despite the comparatively low amount of complex vertical structure (Able et al. 2005).

The substrate within the lower shorezone can also provide suitable habitat for Dungeness crab mating and egg brooding (Rasmuson 2013). These mudflats also are habitat for many valuable species of bivalve such as clams, geoducks, and oysters. Shallow subtidal areas (i.e., lower shorezone) are currently located at the heads and along portions of the sides of the waterway and in the Log Pond area.

Native eelgrass is found at the lower tidal range of this habitat deeper than 0 feet MLLW. Native eelgrass is present in the vicinity of the waterway, mostly along the northern edge of the ASB Area (Christiaen et al. 2022). Non-native Japanese eelgrass (*Nanozostera japonica*) is a Class C noxious weed that usually occurs in areas of Puget Sound shallower than 0 feet MLLW in areas with less intense wave action (Christiaen et al. 2022; Washington State Noxious Weed Control Board 2012).

Brown, green, and red algae are also found throughout this area. Invertebrates common to this substratum include crabs, shrimp, sponges, sea anemones, worms, sea stars, oysters, and a variety of fish such as surf perch, sculpin, prickleback, flatfish, and some juvenile salmon.

Rocky shallow subtidal habitats are located along portions of the waterway and in portions of the Log Pond area (Ecology 2007b).

4.2.4 Deeper Shorezone (Below Elevation -10.0 feet MLLW)

Sand, mud, and cobble habitat is also found in the deeper shorezone. Most portions of the Cleanup area consist of deeper shorezone habitat with sand or mud bottom (Ecology 2007b).

Native eelgrass may be present in scattered areas below -10 feet MLLW (Christiaen et al. 2022); however, light is limited and both eelgrass and macroalgae are much less prevalent than in shallower areas. NMFS defines the deeper shorezone as either -10 feet MLLW, or the deepest extent where submerged aquatic vegetation occurs, whichever is deeper (Ehinger et al. 2023a). Thus, the exact cutoff between the lower shorezone and the deeper shorezone will vary by location.

Some varieties of hardshell clams are also less abundant with increased depth, while the geoduck clam tends to be more abundant in deeper water.

The substrate within the deeper shorezone can provide suitable habitat for Dungeness crab mating and egg brooding (Rasmuson 2013). The substrate and water column are also used for feeding and migrating by a variety of fish, including subadult and adult juvenile salmon.

Primary productivity in this area is mostly planktonic in origin (Ehinger et al. 2023a), with low structural complexity and limited benthic complexity.

As juvenile salmonids move into this area, they become increasingly pelagic, with escape and avoidance their primary means of survival, rather than relying on refuge in complex vertical habitat such as eelgrass (Simenstad et al. 1982). While still important for several functions, the deeper

shorezone is considered less important habitat for salmonids than the upper and lower shorezones (Ehinger et al. 2023a).

Larger-sized fish and shellfish often occur in deeper waters. In addition, the occurrence of some species, such as oyster, is rare.

4.3 Priorities for Improving Habitat

The Bellingham Bay Pilot Comprehensive Strategy (Ecology 2000) provides an integrated strategy to expedite source control, sediment cleanup, and associated habitat restoration in Bellingham Bay. As part of this approach, the Comprehensive Strategy considers contaminated sediments, sources of pollution, habitat restoration, and in-water and shoreline land use from a bay-wide perspective.

The Comprehensive Strategy also contained a Preliminary Draft Habitat Mitigation Framework that identifies objectives for sustaining habitat and aquatic resources and increasing habitat area and function in Bellingham Bay. Selected specific objectives related to the Cleanup include the following:

- Provide clean sediments to support functions and species.
- Restore and enhance degraded estuaries of Whatcom, Squalicum, Padden, and Little Squalicum creeks.
- Restore, enhance, and protect viable habitat that provides connective corridors between estuary and open-water habitats and between other habitats in the open-water environment.
- Endeavor to achieve net gains in aquatic area and habitat functions.
- Maximize habitat restoration and protection opportunities (including marine buffer) with remediation and shoreline Cleanups.
- Restore lost habitat attributes by removing shoreline fills, shoreline landfills, removing remnant structures, and removing or replacing treated timber structures where practicable.

The implementation of the current Cleanup accomplishes several of the aforementioned objectives.

In parallel with the Cleanup, the Port is proposing to conduct additional habitat mitigation activities to improve habitat quantity and quality within the Site and adjacent areas. These advance mitigation activities include the following:

- Opening of the ASB Aquatic Use Area and reconnecting it to Bellingham Bay
- Constructing a fish passage structure to provide continuity between the ASB Aquatic Use Area and the existing eelgrass flat located in between the ASB and the I&J Waterway
- Developing habitat benches along the portions of the ASB berm interior between the new ASB Access Channel and the fish passage structure
- Removing hundreds of creosote-treated piles within multiple portions of the Site

The advance mitigation actions will be funded and implemented by the Port in parallel with the Cleanup to optimize the timing of habitat mitigation work and to minimize construction disturbances to fisheries resources.

4.4 Net Environmental Effects of the Cleanup

Figure 4-1 summarizes the net environmental effects of the Cleanup and distinguishes between the Cleanup and the Port's advance mitigation actions. Detailed discussion of these effects is provided in Sections 4.4.1 through 4.4.4.

The Cleanup is expected to result in significant net improvements to habitat quantity and quality within the Site through the following actions:

- Cleanup of contaminated sediments
- Removal of existing creosote-treated derelict structures
- Reduction in overwater cover
- Removal of shoreline debris
- Flattening of over-steepened slopes to improve availability of important nearshore habitats
- Preserving and enhancing existing shallow-water habitats at the ASB Shoulder and Head of Waterway

Table 4-1
Summary of Eelgrass Impacts by Unit Within the Whatcom Waterway

Unit Name	Action	Impact	Area of Eelgrass Impact (sf)
Planned Cleanup Work			
5B[1]	Dredging and backfill to same elevation	Temporary eelgrass impact	-19,620
6	Dredging and cap placement	Permanent Impact	-926
2B	Dredging	Permanent Impact	-12,720
BST/Log Pond corner	Dredging and cap placement	Permanent Impact	-1,720
GP Dock/Log Pond	New eelgrass planting	Increase in eelgrass cover	30,800
Total estimated net change[1]			15,434
Additional Work as Part of Advance Mitigation			
3A	New eelgrass planting	Increase in eelgrass cover	51,089

Note:
1. Temporary eelgrass impacts are not included in the total estimated net change because those areas are expected to reestablish with no net change to eelgrass coverage.

4.4.1 Increases in Eelgrass

Some eelgrass impacts are integral to completion of the Cleanup. Eelgrass will be either temporarily or permanently impacted in several areas as shown in Figure 4-1. Eelgrass impacts by Site Area are summarized in Table 4-1.

Unit 5B is expected to experience temporary negative eelgrass impacts resulting from dredging activities. Backfill material placement within Unit 5B will bring the elevations of that unit back to its original elevation, meaning that these impacts will be temporary.

Planned dredging and capping in Units 2B, the BST/Log Pond corner, and the Rail Span Area will result in elevation changes that will preclude successful eelgrass recolonization after Cleanup completion. These permanent eelgrass impacts are more than compensated by eelgrass improvements conducted as part of the Cleanup.

To account for eelgrass loss in Unit 2B, Unit 6, and the BST/Log Pond corner, eelgrass will be out-planted in the GP Dock Area of the Log Pond. Additional eelgrass out-planting is also proposed in Unit 3A at the Head of Waterway as part of advance mitigation activities to be performed by the Port in parallel with the Cleanup.

4.4.2 Sediment Cleanup

The Cleanup will benefit habitat quality throughout the Phase 2 Site Areas through the cleanup of contaminated sediments. The Phase 2 Site Areas to be actively remediated during the Cleanup total approximately 60 acres.

4.4.3 Reduction of Overwater Cover

To accommodate the dredging and removal of contaminated sediments, certain existing overwater superstructures within the waterway will be removed and disposed of at an approved and permitted upland landfill facility. Removal of these overwater structures will result in an overall net reduction in overwater cover in the waterway, increasing the overall level of habitat connectivity within the waterway by removing existing nearshore habitat obstructions. This removal will be conducted in parallel with the Port's removal of creosote-treated piling performed as part of advance mitigation activities (see Section 4.4.4).

Some of the structures to be removed will be replaced as part of the cleanup with structures composed of more environmentally friendly materials. For example, some existing creosote-treated timber multiple-pile dolphins will be replaced by dolphins or single piles constructed of concrete or steel.

Removal of existing overwater cover and debris within intertidal and shoreline areas, and associated slope treatments resulting in slopes of 2H:1V grade or flatter, will result in habitat conditions that are

significantly more favorable to juvenile salmonid movement and migration than under current conditions. The improved habitat conditions will reduce the number of current deep-water areas and shaded areas where piscivorous predators can reside and provide connected intertidal migration and foraging corridors along large portions of the shoreline of the waterway, allowing for increased juvenile salmonid growth opportunities. Table 4-2 lists the change in overwater cover for each site area.

Table 4-2
Changes in Overwater Cover

Construction Element	Cleanup Component	BST Dock Area[1] (sf)	Inner Waterway[1] (sf)	GP Dock Area[1] (sf)	Head of Waterway[1] (sf)	Rail Span Area[1] (sf)	Total All Areas[1] (sf)
Cleanup	Chemical Dock Removal	0	0	0	0	-25,405	-25,405
	BST Extension Removal (Log Pond Area)	-3,891	0	0	0	0	3,891
	GP Dock Removal	0	0	-104,419	0	0	-104,419
	Partial Removal of Rail Span Elements	0	0	0	0	-1,319	-1,319
	Piling and Pile Stub Removal/Replacement[2,3]	0	0	0	0	-98	-98
	New Dolphins	20	59	0	0	19	98
Cleanup Total		-3,871	59	-104,419	0	-26,803	-135,034
Advance Mitigation	Piling and Pile Stub Removal/Replacement[2,3]	-72	0	-870	-46	-33	-1,021
Advance Mitigation Total		-72	0	-870	-46	-33	-1,021

Notes:

1. Positive numbers reflect an increase in overwater coverage area, and negative numbers reflect a reduction in overwater coverage area.
2. Piling removal/replacement encapsulates the net piling overwater cover.
3. All replacement piles will replace existing piles that are being removed.

4.4.4 Creosote Removal

During the Cleanup, a number of creosote-treated timber structures will be removed. Table 4-3 details the tonnage of creosote-treated timber structures to be removed by area.

Table 4-3
Tonnage of Creosote-Treated Timber to be Removed

Construction Element	Cleanup Component[1]	BST Dock Area	GP Dock Area	Head of Waterway	Rail Span Area	Total
Cleanup	Tons of creosote-treated wooden superstructures to be removed[2-7]	35 tons	950 tons	0 tons	403 tons	1,388 tons
Advance Mitigation	Tons of creosote-treated wooden pilings to be removed[2-7]	126 tons	1,050 tons	28 tons	266 tons	1,470 tons

Notes:

1. Creosote-treated timber includes creosote-treated piling, dolphins, and bulkheads.
2. Overwater cover included in Table 4-2 assumed to be creosote, and decking assumed to be 6 inches thick on average.
3. Piles were counted from available site plans and from aerial imagery; not all pilings were clearly visible or accessible.
4. Overall piling length above mudline was estimated using tidal predictions and available bathymetry.
5. Total estimated piling length is assumed to be twice the piling length above mudline.
6. Creosote unit weight is assumed to be 54.98 pounds per cubic foot.
7. Creosote unit weight is based on the Puget Sound Nearshore Habitat Conservation Calculator (NOAA 2024).

Additional creosote removal will be conducted as part of the Port's advance mitigation activities described in Section 4.5.

4.4.5 Improving Salmonid Migration Corridors

Nearshore and intertidal habitat conditions will be greatly improved over existing conditions as a result of the Cleanup. These changes will benefit juvenile salmon by improving the quality and quantity of nearshore salmonid migration, refugia, and foraging areas. Restoring and connecting pocket estuary habitat across Bellingham Bay is a key restoration objective for the ESA-threatened Nooksack River Chinook salmon genetic diversity unit (Beamer et al. 2016).

The changes to upper, lower, and deeper shorezone habitat elevations as a result of the Cleanup are shown in Table 4-4. Additional changes associated with the Port's advance mitigation activities are described in Section 4.5.

Table 4-4
Changes in Habitat Acreage

Habitat Elevations (feet MLLW)	HTL to +5	+5 to 0	0 to -10	Total Upper Shorezone and Lower Shorezone Habitat (HTL to -10)	Total Deeper Shorezone Habitat (Below -10)
Cleanup Elements					
Outer Waterway	N/A	N/A	N/A	N/A	N/A
BST Dock Area	0.07	0.16	0.36	0.59	0.93
Inner Waterway	N/A	N/A	N/A	N/A	N/A
GP Dock Area	0.15	0.33	0.98	1.46	0.93
Head of Waterway	N/A	0.07	1.63	1.70	-XX
Rail Span Area	N/A	0.01	0.21	0.22	0.42
ASB Shoulder	N/A	N/A	N/A	N/A	N/A
C-Street Outfall Area	XX	XX	XX	N/A	N/A
Total Cleanup	*0.22*	*0.57*	*3.18*	*3.97*	*XX*
Advance Mitigation Elements					
ASB Aquatic Use Area	0.57	0.48	0.84	1.89	11.86
Total Advance Mitigation	*0.57*	*0.48*	*0.84*	*1.89*	*11.86*

Notes:
Table 4-4 summarizes creation and conversions of aquatic habitats. These values do not include the acreages of aquatic lands remediated during the Cleanup. That remediation will improve the quality of existing aquatic habitats.

1. All areas are in acres.
2. Habitat area values are rounded to the nearest one-hundredth of an acre.
3. The estimated changes in acreage assume that the Cleanup is completed consistent with the current design, using approximately 50% of cap over-placement allowance in capped areas.
4. Positive numbers reflect a net gain in aquatic habitat area; negative numbers reflect a net reduction in aquatic habitat area.

4.4.6 Net Change in Washington State Waters and Waters of the United States

The Cleanup includes several areas where dredging and slope cutbacks will result in a significant net increase in the amount of Washington State waters as shown in Table 4-5. The Cleanup will result also in a net increase in Waters of the United States as shown in Table 4-6.

Table 4-5
Net Change in Washington State Waters *(Pending)*

Construction Element	Outer Waterway	BST Dock Area	Inner Waterway	GP Dock Area	Head of Waterway	Rail Span Area	ASB Shoulder	ASB Aquatic Use Area	Total
Cleanup	XX	XX	XX	XX	XX	XX	XX	0	XX
Advance Mitigation	XX	XX	XX	XX	XX	XX	XX	XX	XX

Notes:

1. Conversion of Washington State waters to uplands is defined as those areas that are currently below the HTL of the waterway that are being converted into uplands (areas above HTL).
2. HTL is defined as elevation +9.7 feet MLLW.
3. All areas are in acres rounded to the nearest hundredth of an acre.
4. Positive numbers reflect a net gain in area of Washington State waters, and negative numbers reflect a net reduction in area of Washington State waters.
5. The estimated changes in acreage assume that the Cleanup is completed consistent with the current design, using approximately 50% of cap over-placement allowance in capped areas.

Table 4-6
Net Change in Waters of the United States *(Pending)*

Construction Element	Outer Waterway	BST Dock Area	Inner Waterway	GP Dock Area	Head of Waterway	Rail Span Area	ASB Shoulder	ASB Aquatic Use Area	Total
Cleanup	XX	XX	XX	XX	XX	XX	XX	0	XX
Advance Mitigation	XX	XX	XX	XX	XX	XX	XX	XX	XX

Notes:

1. Conversion of the Waters of the United States to uplands is defined as those areas that are currently below the MHHW of the waterway that are being converted into uplands (areas above MHHW).
2. MHHW is defined as elevation +8.5 feet MLLW.
3. All areas are in acres.
4. Positive numbers reflect a net gain in area of Waters of the United States, and negative numbers reflect a net reduction in area of Waters of the United States.
5. The estimated changes in acreage assume that the Cleanup is completed consistent with the current design, using approximately 50% of cap over-placement allowance in capped areas.

4.5 Effects of Advance Mitigation

In parallel with the Cleanup, a number of advance mitigation activities are to be conducted by the Port. These activities provide substantial improvements to the quantity and quality of existing aquatic habitats in addition to those provided by the Cleanup.

4.5.1 Creosote Removal

Although not required for cleanup, the Port is electing to remove creosote-treated timber piling, dolphins, and bulkheads from a number of shoreline areas, including the BST Dock Area, GP Dock Area, Head of Waterway, and Rail Span Area. These creosote-treated structures will be removed and disposed of at an approved upland landfill.

Approximately 1,050 creosote-treated timber piles will be removed as advance mitigation. Table 4-3 details the tonnage of creosote-treated timber piling to be removed by area and includes the removal of both creosote-treated timber piles and bulkheads to be removed by the Port as part of advance mitigation activities.

4.5.2 Eelgrass Enhancement

The Port is planning to out-plant eelgrass in the new shallow-water habitat area to be constructed at the Head of Waterway. This could result in over 51,000 square feet of new eelgrass in addition to that provided as part of the Cleanup.

4.5.3 Improving Salmonid Migration Corridors

In addition to the creation of new and improved nearshore and intertidal habitats during the Cleanup, the Port will create areas of new aquatic habitat within the ASB and the associated access channel. The changes to upper, lower, and deeper shorezone habitat elevations are shown in Table 4-4.

These changes will benefit juvenile salmon by improving the quality and quantity of nearshore salmonid migration, refugia, and foraging areas. Restoring and connecting pocket estuary habitat across Bellingham Bay is a key restoration objective for the ESA-threatened Nooksack River Chinook salmon genetic diversity unit (Beamer et al. 2016).

Opening the ASB will create nearly 14 acres of new aquatic habitat within the ASB Aquatic Use Area, with a variety of elevations. This includes over a quarter mile of new salmon migration corridor between the Whatcom Waterway and the eelgrass flat located between the ASB and the I&J Waterway. A habitat bench will be created along the interior of the ASB berm along this new corridor to maximize its value to juvenile salmon and other aquatic resources.

4.5.4 Net Change in Washington State Waters and Waters of the United States

The opening of the ASB to Bellingham Bay as part of the Port's advance mitigation activities will add substantially to the acreage of Washington State waters (Table 4-5) and Waters of the United States (Table 4-6). These expanded acreages are in addition to the net improvements in aquatic area provided by the Cleanup.

5 Site Preparation and Staging

As part of cleanup construction activities, the selected contractor will be required to bring the necessary barges, dredges, and other water-based specialized equipment to the Site. The equipment will be moored and repositioned within the work areas as necessary to complete the required work. Completion of the work may also require mobilization of land-based equipment including backhoes, shore-based cranes, pile-driving equipment, loaders, and other equipment. This section discusses potential site areas that may be used by the contractor to stage equipment, or for staging, stockpiling, or loading contaminated sediments and other materials.

5.1 Sediment Transload Facilities

Sediment transloading facilities are required to support the placement of contaminated dredge materials into the CDF. The dredged sediments will be loaded onto barges and transported directly to the CDF for placement and disposal. To facilitate the transfer of material, 12 mooring dolphins will be installed on Port-owned aquatic lands located in between the ASB and the Whatcom Waterway (location shown in Figure 3-3).

Water depths in the proposed dolphin installation area are greater than 10 feet below MLLW, meaning that the dolphin locations will not interfere with areas of existing shallow-water habitat. The locations are also appropriately cited to prevent conflicts with existing navigation patterns within the Whatcom Waterway.

A grated metal catwalk will provide personnel access between the ASB and the transloading dolphins. During sediment offloading, it is expected that the contaminated sediment be transferred using hydraulically assisted pumping and an enclosed pipeline. This minimizes the potential for spillage of the sediment during offloading and allows the sediments to be accurately placed at the desired location by relocating the pipeline discharge point within the ASB.

Required BMPs for sediment transportation, placement, and disposal within the CDF are described in Appendix D.

5.2 New Stormwater Outfalls

Stormwater that currently discharges to the ASB will be rerouted prior to starting construction activities in the ASB. This will include the construction of two new stormwater outfalls that will be constructed at the locations shown in Figure 3-3 to allow disconnection of stormwater lines currently discharging to the ASB.

- One outfall will be located along the ASB shoreline to manage stormwater generated from portions of the Central Waterfront site. That outfall will also be used to manage stormwater generated from the surface of the completed CDF area following completion of the cleanup.

The outfall will be 36 inches in diameter and will discharge along an existing armored slope, protecting against disturbance of nearby shallow-water habitat areas.

- The second outfall will be located along the Log Pond shoreline to manage stormwater generated from portions of the GP West site. This outfall will be 42 inches in diameter and will discharge along an existing armored slope.

In parallel with the outfall design, the Port is developing upgrades to the stormwater infrastructure that will connect with the two new outfalls under separate projects. Additional details regarding the upland drainage areas and stormwater infrastructure planning is provided in the Post-Cleanup Stormwater Plan (Appendix A).

The construction of the outfalls will be completed early in the first construction season.

5.3 Staging and Stockpile Areas

Portions of the upland area will be made available to the contractor for use in construction and for material and equipment staging activities. This may include storage of construction equipment and materials and potential offloading or stockpiling of debris removed during remediation. These potential staging areas are shown in Figure 3-4. Other locations may alternatively be proposed for use by the contractor for sediment and debris offloading and staging, pending approval from the Port, Ecology, and other permitting agencies or project stakeholders.

Required BMPs for upland staging and transload facilities are described in Appendix D. The contractor will be required to submit a Construction Work Plan that will detail operations, including setup, breakdown, stormwater management, and cleaning of the offload facility.

5.4 Stormwater Management

A CSGP and associated administrative order will be obtained for those upland construction activities located in areas where the stormwater is not otherwise managed under the Port's existing NPDES permit (Permit No. WA-000109-1). Stormwater will be managed according to CSGP permit conditions at the upland materials stockpile and staging areas.

The contractor will prepare an SWPPP that meets conditions of the permit, and details BMPs that will be implemented to minimize generated waters and ensure compliance with applicable water quality criteria and discharge requirements. The purpose of the SWPPP will be as follows:

- Identify potential sources of pollution that may be reasonably expected to affect the quality of stormwater discharge from the work area.
- Describe and ensure implementation of practices that will be used to reduce the pollutants in stormwater discharge from the work area.

- Ensure compliance with terms of the CSGP and associated administrative order.
- Identify applicable BMPs for stormwater management.

5.5 Other Environmental Considerations

The following environmental considerations associated with upland staging and stockpiling activities will be addressed:

- **Control of Fugitive Dust:** The contractor will control fugitive dust from the stockpile and staging areas using appropriate BMPs. The tracking of soil or dust off site to City streets will be controlled.
- **Mitigation of Traffic Impacts:** Traffic impacts associated with Cleanup construction activities will be mitigated to the extent practicable. This will include using barges where appropriate to transport construction materials to and from the Site and using designated truck haul routes. Flaggers will be used if necessary to ensure traffic safety.

Additional environmental considerations based on required permit conditions are described in detail in Appendix D.

6 Overall Dredging Design and Material Handling

This section describes the overall dredging design; dredging requirements for specific Site Areas; management of dredge residuals; and handling, transport, and disposal of the dredged material. Figure 2-2 provides an overview of planned dredging areas. Detailed dredging plans are provided in Figures 6-1, 6-2, 6-3a, 6-4a, 6-5, and 6-6a.

6.1 Overall Dredging Design

This section describes the remedial design for dredging that is applicable to all Site Areas. Special requirements applicable to specific areas are detailed in Section 6.2.

6.1.1 Dredge Prism Design

Dredge prisms have been designed for each Site Area based on the nature and extent of contamination in each area and on the target sediment removal elevations or depths. In areas proposed for full removal, the extent and accessibility of the contamination drives the dredging design. In areas to be capped following partial dredging, the target removal elevations consider the proposed final capping design and required future working water depths.

Secondary considerations in dredge prism designs include geotechnical properties of the sediment, locations and characteristics of adjacent structures, and the typical precision and accuracy of dredging equipment that will likely be utilized to implement the work.

The primary criterion of the dredge prism is to provide a constructable surface that removes the contaminated sediment above the predicted contaminated neatline surface. The dredge prism also needs to balance being overly conservative and unnecessarily dredging too much uncontaminated sediment as part of remedial dredging, which has the potential to significantly increase Cleanup costs and may trigger other unnecessary impacts.

The dredge prism design is based on both a quantitative evaluation (use of the interpolated neatline surface and required operational depths, as applicable) and a subjective evaluation based on past dredging experience. Because the dredge prism design relies on multiple sets of data, the precision of each dataset (e.g., bathymetry, sediment sampling results, and interpolated contaminant extents) affects the level of certainty that the dredge prism removes all of the contaminated sediments.

6.1.2 Dredge Cut Side Slopes

Based on identified sediment geotechnical properties and best professional judgment, external side slope grades of 3H:1V have been incorporated into the design around the perimeter of most of the required dredging areas where the daylight cuts can be performed without adversely affecting

existing structures or creating loss of upland area. These daylight side slope grades have been verified based on the geotechnical analysis as described in Appendix B.

Steeper side slope grades are presumed for under-dock areas at the BST Dock Area. Dredging in that area will be preceded by slope stabilization measures (updated bulkheads and ground improvement) to allow dredging in that area to be conducted safely.

6.1.3 Accounting for Material Sloughing

Internal transitions between dredging areas with different required final elevations may require work by the contractor to remove sloughed material. The occurrence of such slough between one dredging area and another will vary depending how the work is implemented. Slough material will be removed prior to acceptance of the work in these transition areas.

Sloughing of material can also occur in areas where dredging equipment access is limited due to the presence of nearby marine structures. The engineering design includes removal of marine structures in the BST Dock Area, the GP Dock Area, and the Rail Span Area to minimize this occurrence. Where sloughing is anticipated, that material is expected to slough into the dredge area once the toe support has been dredged and the contractor will be required to remove the sloughed material. The contractor will be required to make a cleanup pass in areas where sloughing may occur prior to final approval of dredged material removal and after allowing adequate time for sloughing to occur.

6.1.4 Equipment Selection

Dredging work will be conducted using mechanical dredge equipment. Hydraulic dredging has been determined to be inappropriate for remediation in the Phase 2 Site Areas. However, it is likely that hydraulically assisted pumping will be used to transload mechanically dredged sediments from transport barges into the CDF for material placement and disposal. Dredging method selection for the Phase 2 Site Areas has considered the following factors:

- Ability of mechanical dredging equipment to meet Cleanup requirements, including compliance with applicable water quality criteria
- Presence of debris within the dredging areas (hydraulic dredging equipment is subject to fouling with such debris, and extensive debris is expected in the BST Dock Area and the GP Dock Area)
- Ability of mechanical dredging to achieve higher solids loadings in the dredged materials, without necessitating costly and area-intensive dewatering methods
- Smaller quantities of generated waters produced by mechanical dredging, minimizing both risks to receiving waters and the water treatment needs necessary to address those risks
- Improved availability of equipment and expertise within the Pacific Northwest for mechanical dredging as opposed to hydraulic dredging

- Ability to use mechanical dredging equipment for other Cleanup activities within the Site (e.g., material placement)

The selected contractor will determine the specific pieces of mechanical dredging equipment required to perform the Cleanup work. It is assumed that the contractor will use dredge derricks, barges, and tugs. Excavators may also be used in shallower water environments and difficult access areas. The contractor will be required to specify equipment and procedures in advance, and the description of means and methods to complete the dredging activities will be included in the contractor's pre-construction Construction Work Plan submittal.

Equipment selection will comply with environmental controls and permit requirements associated with water quality criteria. The Water Quality Monitoring Plan (Appendix E) will be implemented during completion of dredging activities to ensure protection of water quality.

6.1.5 Verifying Dredge Performance

In addition to completion of water quality monitoring, the completeness of dredging will be verified as described in the Construction Quality Assurance Plan (CQAP; Appendix F) and in the Compliance Monitoring and Contingency Response Plan (CMCRP; Appendix H).

- Progress surveys, both those performed by the contractor and those performed on behalf of the Port, will verify that design dredge elevations or thickness cuts have been achieved. In locations where required elevations or depths have not been achieved, the contractor will be required to remove additional material to reach target elevations and slopes included in the design.
- Chemical testing of sediments has been included to verify that dredging in proposed full removal areas has reached the uncontaminated sediment layer and that the residuals thicknesses and composition are within design parameters. In locations where the chemical testing demonstrates the presence of missed inventory, the contractor will be required to remove additional material. This type of chemical testing is not required in areas designed for subsequent capping.

6.2 Dredging Requirements for Specific Site Areas

This section describes specific design requirements for completion of cleanup dredging activities in specific Site Areas.

6.2.1 Outer Waterway

Dredge cut elevations vary in the open-water portions of the Outer Waterway. As shown in Figure 6-1, required dredge elevations vary between -36 feet MLLW and -39 feet MLLW in Units 1A and 1B, and between -36 feet MLLW and -41 feet MLLW for Unit 1C.

Each of these Units also allows for a 1-foot payable overdredge allowance to ensure that required dredge elevations are achieved throughout the Unit. These required dredge elevations have been established to provide complete removal of the contaminated sediment and unencumbered use and future maintenance of the federal navigation channel area.

The completeness of dredging will be verified using bathymetric surveys, and chemical testing will be used to verify that contaminated materials have been satisfactorily removed and that dredging residuals are within design parameters. Re-dredging may be triggered if missed inventory is present or if dredging residuals are excessive.

Following completion of Cleanup dredging activities and performance monitoring, dredging residuals will be managed by placing an RMC layer in the Outer Waterway areas (see Section 6.4).

6.2.2 BST Dock Area

The proposed under-pier remediation work in the BST Dock Area includes removal of contaminated sediments detected at depths of at least 6 feet below mudline. Under-pier slopes are relatively steep, requiring special consideration for slope stability during and following the completion of dredging.

The dredging plan for the BST Dock Area assumes that existing dock structures will be removed to facilitate access for construction equipment to the dredge prism in this area. The newer portion of the Central Terminal has been constructed with a removable deck to facilitate cleanup access for the Cleanup. The other portions of the Central Terminal and North Terminal dock will be fully removed to accomplish the Cleanup and then replaced to restore terminal operations.

Other prerequisites to dredging in this area include the construction of updated bulkheads in the bank cut-back areas at the top of slope within the Central and North terminals, and completion of related ground improvement activities.

The Central Terminal and North Terminal docks will be replaced following completion of dredging and placement of the Type 3 cap. The wooden extension of the North Terminal that extends into the Log Pond will be fully removed and will not be replaced.

The dredge prism in the BST Dock Area is based on the extent of contaminated material requiring removal, as well as the elevation requirements for placement of a Type 3 cap to stabilize the dredged slope and prevent future erosion. A plan view of this area is shown in Figure 6-2.

6.2.3 Inner Waterway and Log Pond

The required dredge elevations vary by location through Site Units 2B and 2C and along the Unit 2C side slopes bordering the Log Pond. The dredging plan for these areas is shown in Figure 6-3a.

All design dredge elevations include a 1-foot payable overdredge allowance. Where future cap placement is planned, the dredging and capping plan also includes a 2-foot allowance for future maintenance dredging over the cap surface. Allowances for cap placement vary by area.

- **Unit 2B:** The base of the future access channel into the ASB (Unit 2B) will be fully remediated by dredging. Dredging of the Inner Portion of Unit 2B will extend to -26 feet MLLW. Based on the depth of contamination, dredging in the Outer Portion of Unit 2B will be deeper, to -34 feet MLLW. RMC will be placed over the bottom of the access channel following dredging. Type 3 and Type 1 caps will be placed along the side slopes of Inner Unit 2B, and the Outer Unit 2B, respectively.
- **Unit 2C Inner Cap Area:** The inner cap area of Unit 2C will be capped at an elevation designed to support a working water depth of -18 feet MLLW. Dredging elevations are established at -25 feet MLLW to accommodate placement of a Type 2 cap in this area following dredging.
- **Unit 2C Outer Cap Area:** The outer cap area of Unit 2C will be capped at an elevation designed to support a working water depth of -25 feet MLLW, consistent with that planned for the ASB and Unit 2B. Dredging elevations in this area are established at -34 feet MLLW to accommodate placement of a Type 1 cap following dredging.
- **Unit 2C Full Removal Areas:** The outer portions of Unit 2C will be remediated by full dredging to the base of contamination. Dredging depths in this area will vary between -34 feet MLLW (along the ASB side of the waterway) and -41 feet MLLW (along the BST and Log Pond). These depths are based on the extent of contamination, which corresponds to the deepest historical dredge elevations in these areas. Capping in these areas will be limited to Unit 2C side slopes.
- **Unit 2C / Log Pond Corner:** The Unit 2C / Log Pond Corner is designed to support a working water depth consistent with those in the BST berth areas. The planned dredging will support the placement of a Type 1 Cap extending to the base of the waterway and a side slope of 3H:1V. This dredging will extend into the Log Pond as shown in Figure 6-3a.

6.2.4 GP Dock Area

The Phase 2 Site Cleanup includes removal of the existing GP Dock structure to facilitate limited dredging and placement of engineered sediment caps. Dredge cut thicknesses within the GP Dock Area assumes placement of a cap with a future 3H:1V side slope extending from the base of the waterway to the top of slope.

Dredging elevations incorporate a 1-foot payable overdredge allowance.

Where the GP Dock Area dredging activity borders the existing sediment cap placed during the cleanup in Phase 1 Site Areas, the existing cap will be protected from dredging-related recontamination using appropriate BMPs, including a silt curtain placed during dredging.

6.2.5 Head of Waterway Area

Following the removal of creosote-treated timber piling, contaminated sediments located within Unit 3A at the Head of Waterway will be removed to a required elevation of -10 feet MLLW. This required dredge elevation accounts for placement of a Type 1 sediment cap over the dredged area followed by placement of additional substrate to enhance habitat conditions. The planned dredging area is shown in Figure 6-4.

In Unit 3A areas with deeper elevations suitable for cap placement (the areas alongside Waypoint Park), no dredging will be conducted. No dredging will be performed along the north side of the waterway in the area where Whatcom Creek flows beneath the Roeder Avenue Bridge.

6.2.6 Rail Span Area

The existing chemical dock structure adjacent to the Rail Span barge moorage structure will be removed to facilitate implementation of sediment dredging in the Rail Span Area. Additionally, minor portions of the Rail Span structure will be removed or reconfigured.

Following structure removals, the contaminated sediment below the structures will be dredged. As shown in Figure 6-5a, the planned required dredge elevation within the Rail Span Area is -24 feet MLLW, which allows future placement of a Type 1 cap and a future working water depth of -15 feet MLLW. That working water depth includes a 2-foot allowance for future maintenance dredging over the cap surface.

6.2.7 ASB Shoulder Area

During Cleanup, sediments from within the portion of the ASB Shoulder Area (Unit 5B) that currently exceed surface cleanup standards will be dredged (Figure 6-6a). Removal depths will be to the base of the contamination or at least 3 feet below the existing mudline surface including a 1-foot overdredge allowance. To avoid destabilizing slopes and structures, no dredging will be performed immediately adjacent to the ASB berm or the buried outfall structure.

To preserve existing shallow-water habitat conditions in the ASB Shoulder Area, the dredge prism will be backfilled with clean materials to restore initial sediment elevations as shown in Figure 6-6b.

6.2.8 ASB Area

The dredging plan for the ASB Aquatic Use Area is shown in Figure 6-6a. Contaminated sediments removed from these areas will be disposed of in the CDF. The dredging of contaminated sediments includes a number of different elements:

- **CDF Retaining Structure Interior:** Contaminated soft sediments and transition sands located between the outer walls of the CDF retaining structure will be removed by dredging. Following dredging the interior space will be backfilled with clean sandy materials.
- **Soft Sediments from ASB Aquatic Use Area:** The soft sediments from the floor and sides of the ASB Aquatic Use Area will be removed by dredging. This is expected to be conducted separately from the removal of the transition sands to maximize control of dredging residuals.
- **Transition Sands from ASB Aquatic Use Area:** Following removal of the soft sediments, the ASB transition sands will be removed from the bottom and sides of the ASB.

Once all contaminated sediments have been removed from the ASB Aquatic Use Area, clean sands will be dredged for beneficial reuse during the Cleanup. These clean sandy sediments will be removed to a depth of -27 feet MLLW. That removal depth supports a future operational elevation of -25 feet MLLW plus a 2-foot allowance for future maintenance dredging.

Additional details regarding remediation of the ASB Area and construction of the CDF are described in Section 7.

6.3 Sediment Handling, Transport, and Disposal

As described in Section 3.10, contaminated sediments from all Site Areas will be managed for disposal in the CDF. Transport of dredged sediment to the CDF will be performed using a watertight barge with sidewalls of sufficient height to fully contain the material. Water collected on the barge will be managed at the receiving facility (i.e., at the CDF).

Contaminated sediments from areas located outside of the ASB will be offloaded at the CDF using the 12 mooring dolphins that will be installed along the exterior of the ASB. It is expected that the offloading will occur directly from the material barge and the dredged material is expected to be transported directly to the CDF using a transload pump and enclosed pipeline. The pump/pipeline approach offers a reduced potential for spills and allows for precision placement of the dredge materials by relocating the end of the pipeline. Proposed BMPs for dredged sediment offloading and placement within the CDF are included in Appendix D.

Contaminated sediments from areas located inside the ASB will be transloaded and placed in the CDF using a similar methodology. The sediments will be transported by barge to the edge of the CDF retaining structure. Then the sediments will be transloaded and placed directly in the CDF using a transload pump and pipeline.

Waters generated during the sediment transloading operations will be treated and reused to minimize overall water generation rates. Excess waters will be treated and discharged to Bellingham Bay via the ASB Outfall. The water treatment, discharge, and monitoring will be conducted in compliance with the Port's NPDES permit for the ASB. As part of design and permitting, that permit will be modified to specifically support the Cleanup.

Debris removed during dredging will be transloaded to an upland staging and stockpile area and then transported to an upland Subtitle D landfill facility for disposal. Final transportation to the landfill may occur by rail or truck, depending on the selected landfill facility and the transportation logistics selected by the contractor. Examples of permitted Subtitle D landfills that have historically managed dredged sediments and debris include the Waste Management landfills in Wenatchee, Washington, and Arlington, Oregon, and the Republic Services facility located in Roosevelt, Washington. Other landfills may be utilized for disposal management, provided that they meet Subtitle D permitting requirements.

6.4 Management of Dredging Residuals

At contaminated sites, dredge residuals—the thin veneer of contaminated surface sediments—occur with all types of dredging technologies. The quantity and quality of dredge residuals vary depending on the dredge material properties, the presence of debris, and other factors.

Placement of RMC material will be designed to mix with the dredge residuals to produce a sediment surface that meets sediment cleanup levels. A minimum of 6 inches of clean sand (i.e., RMC material) will be placed to manage anticipated dredge residuals generated by dredging activities in the following areas:

- Outer Waterway Area (Units 1A, 1B, and 1C)
- Full removal areas of Unit 2B and Unit 2C in the Inner Waterway
- The bottom of the future ASB Aquatic Use Area (Unit 8)

An over-placement allowance of up to 6 inches (total placement thickness of 12 inches) is included as part of the design, and this potential over-placement would provide further reductions in final surface concentrations. Appendix G provides a detailed discussion and calculations of multiple residual management scenarios and includes recommendations for dredge production and cleanup pass requirements for different areas.

The total volume of RMC material to be placed is approximately 58,800 cy. The sand will be clean, unused material sourced from a commercial quarry or clean sands dredged from lower elevations of the ASB Aquatic Use Basin that are suitable for beneficial reuse. The sand material will be tested prior to use to verify that it complies with Site cleanup levels and design requirements.

The final surface elevation will be surveyed and sediment chemical quality tested following placement of the RMC materials as described in the CMCRP (Appendix H).

7 ASB Area Remediation and CDF Construction

This section describes the work to be completed for the remediation of the ASB and adjacent areas, including both the Cleanup and parallel advance mitigation activities to be performed by the Port. Types and locations of work described in this section include each of the following:

- Site preparation work prerequisite to the construction of the CDF, including construction of new stormwater outfalls and remediation of the adjacent C-Street Outfall Area
- Construction of a CDF within the shoreward portion of the ASB for management of contaminated sediments
- Remediation of the ASB Aquatic Use Area, located in the offshore portion of the ASB
- Operation of the CDF for disposal of contaminated sediments
- Construction and remediation of the ASB Access Channel (Unit 2B)
- Capping the completed CDF and the ASB side slopes
- Restoration of habitat within the ASB
- Decommissioning of the ASB outfall structure

7.1 Site Preparation Activities

The ASB currently operates as a stormwater and wastewater treatment facility under an individual NPDES permit. Prior to construction of the CDF, existing stormwater functions will need to be modified and interior ASB structures will need to be removed.

7.1.1 Stormwater Management Modifications

The existing ASB permit will be modified as part of design and permitting to support the Cleanup. That modification will address each of the following:

- Construction of new stormwater outfalls for management of stormwater formerly treated by the ASB
- Termination of ongoing non-remediation water treatment activities, including revisions to facility piping connections
- Definitions of the types and quantities of remediation wastewater and stormwater to be generated during the Cleanup
- Methods for collection, treatment, and testing of remediation-related stormwater and wastewater generated during the Cleanup
- Other pertinent permit requirements related to the Cleanup

As described in Section 5, Figure 2-2, and Appendix A, two new stormwater outfalls will be installed along the Whatcom Waterway to provide discharge points for the stormwater that formerly was treated in the ASB. Ongoing non-remediation stormwater discharges to the ASB will then be terminated to permit initiation of ASB remediation.

7.1.2 Removal of ASB Interior Structures

The ASB interior includes a number of structures associated with its use as a wastewater treatment facility. Structures to be removed during the Cleanup include the following:

- Interior weir and wing wall structures
- Timber pilings
- Submerged aeration piping and aerator/mixers
- Liquid transfer piping located along the ASB berms
- Asphalt lining of the upper berm slopes

The ASB outfall structure includes a standpipe and building, and also the submerged outfall and diffuser. These structures will be protected and will remain operational throughout the Cleanup. They will be decommissioned following the Cleanup as outlined in Section 7.10.

7.2 C-Street Outfall Area Remediation

The C-Street Outfall Area is located in between the ASB and the C-Street Terminal. Remediation activities must be completed in this area prior to construction of the CDF retaining structure. This is necessary to support the transfer of materials and equipment from the C-Street Terminal to the ASB berm in order to support that construction. Remediation in the C-Street Outfall Area will include the following:

- Removing timber pilings and debris in the cap areas
- Placing Type 1 and Type 3 caps within the capping areas
- Extending the C-Street Outfall structure through the capped area and installing a tide gate on the outfall
- Constructing an access roadway over the capped area to allow for transfer of materials and equipment from the C-Street Terminal to the ASB berm

The cap footprint and the plan for reconfiguration of the shoreline and outfall are shown in Figure 6-3B and Figure 7-1.

7.3 Construction of the CDF Retaining Structure

Following completion of ASB infrastructure and debris removal activities in the ASB Area, a retaining structure will be constructed across the ASB as shown in Figure 6-6a, 6-6b, and 7-2.

The current design approach for the CDF containment wall is described in Section 7.3.1. The CDF retaining structure will then be constructed across the ASB using a combination of staged and floating equipment located within the ASB. Contaminated sediments located between the outer walls of the structure will be removed, and this interior space will be backfilled with clean sandy materials.

The CDF containment wall, existing ASB berms, and current shoreline areas will serve as the outer boundaries for the CDF and will contain all contaminated sediments that are placed within the CDF area.

Figure 7-2 illustrates the current containment structure design approach, and final selection of the containment structure design approach will be made during completion of future engineering design phases of the Cleanup. The containment wall design approach is based on parameters that include evaluation of constructability, stability, and predicted post-construction contaminant mobility. The following sections discuss the basis of design criteria for the current containment wall design approach.

7.3.1 Retaining Structure Design

The CDF retaining structure will be constructed of outer and inner walls constructed of steel sheet piles, with an interior filled with a thick layer of clean sandy soils at least 40 feet across. The final wall design may use either a cofferdam style wall (with two linear walls linked by bracing and tie-backs) or a cellular wall structure like that shown in Figure 7-2. The cellular wall design offers several design advantages over the cofferdam approach: 1) the cell wall allows for a greater unsupported wall height; 2) the cell wall design results in fewer obstructions (e.g., tie-backs) located within the wall interior; and 3) the cell wall can be constructed using steel sheet sections driven from the ASB berm and staging pads.

As shown in Figure 7-2, either CDF retaining structure design will include a concrete cap. Concrete facing will be installed along the exterior wall surface to maximize its design life.

Contaminated sediments from in between the outer and inner walls of the CDF retaining structure will be removed by dredging. Clean sandy soils will be used to fill the wall interior. These clean sediments will provide an attenuation zone for groundwater contaminants and will provide locations for the installation of future groundwater monitoring wells.

7.3.2 Contaminant Mobility

The contaminated sediments to be disposed of within the CDF are primarily mercury and D/F compounds. D/F compounds are highly immobile in groundwater. The fate and transport processes of mercury can be more complex and were evaluated in detail as described in Appendix I.

As described in Appendix I, the mercury present in the Site sediments is present as mercury sulfides. These complexes have extremely low solubilities, and they are stable under anaerobic conditions. The design approach for the CDF will retain those anaerobic conditions because 1) the groundwater in the vicinity of the CDF exhibits highly reducing conditions, 2) the sediments themselves contain elevated hydrogen sulfide concentrations, 3) the sediments contain elevated organic carbon concentrations that will sustain anaerobic conditions over the long-term, and 4) the sediments

containing the highest mercury levels will be placed in the lower portions of the CDF where they will be submerged in groundwater. Under these conditions, the mercury sulfide complexes will be sustained, resulting in very low dissolved mercury concentrations.

The CDF retaining structure is not designed to be completely impermeable. Groundwater from within the completed CDF will slowly migrate through the wall into the clean sandy fill within the retaining structure. Groundwater monitoring will be used to verify that contaminant concentrations comply with levels protective of surface water as described in Appendix E. This will be performed using standard groundwater monitoring wells installed within the CDF retaining structure and screened across the water table.

7.4 Design and Operation of the CDF

The CDF is essentially a four-sided box in which contaminated sediments will be placed, consolidated, and capped.

The four sides of the CDF are constructed of low-permeability materials. The existing ASB berms include a thick sequence of sandy soils with an interior lining of bentonite. The CDF retaining structure will be constructed as described in Section 7.3.

Filling of the CDF may be constructed using either mechanical or hydraulic placement of dredge materials. Hydraulic material placement will likely be used for most materials, excluding potentially the uppermost fill layers and the final CDF cap placement.

As described in Section 6, most contaminated sediments will be transported to the CDF on barges. Sediments from inside the ASB will be moved adjacent to the CDF retaining structure. Sediments from outside the ASB will be barged to the sediment transloading dolphins constructed adjacent to the ASB.

Once located adjacent to the ASB, contaminated sediments will be pumped in a pipeline into the ASB. Water used in the pumping process will be treated and reused to minimize required water generation rates. The sediment placement process will be controlled by moving the pipeline discharge point within the ASB to the desired locations, and then adjusting those locations over time.

As the contaminated material is placed within the CDF, consolidation and settlement will occur, induced by the weight of the sediment itself and from the weight of the import fill and cover layers placed above. This consolidation will take place over a period of years and has been considered in the design and phasing of the project. Also considered in the design of the project is the type and geotechnical properties of the different sediments to be placed in the CDF. The geotechnical evaluation conducted for the CDF is described in Appendix B.

7.5 Remediation of Aquatic Use Area

As described in Section 6, the Aquatic Use Area inside the ASB will be remediated by dredging. This will include removal of three different sequences of materials:

- The contaminated soft sediments will be removed from the base and sides of the ASB and will be disposed of in the CDF.
- The contaminated transition sands will be removed from the base and sides of the ASB and will be disposed of in the CDF.
- Following contaminated sediment removal, the deep clean sands from the ASB Aquatic Use Area will be removed for reuse within the Cleanup.

7.6 Construction and Remediation of the ASB Access Channel

Following remediation of the ASB Aquatic Use Area, the Port will open the ASB Access Channel (Unit 2B) and reconnect the ASB to Bellingham Bay. This reconnection will occur as part of the Port's parallel advance mitigation activities as described in Section 7.9. Clean materials generated during this channel opening will be retained for reuse during the Cleanup.

Once the ASB has been reconnected to Bellingham Bay, final remediation of Unit 2B sediments will be conducted as part of the Cleanup. This will include the removal of all contaminated sediments to the base of the contaminated layer, and generation of clean sandy materials for reuse within the Cleanup.

Following completion of dredging, Type 1 caps will be placed over the contaminated sediments at the edge of the dredged area in the Outer Unit 2B (see Figures 6-3b and 6-6b). Side slopes in the Inner Unit 2B area will be protected with a Type 3 cap as shown in the same figures.

7.7 Capping of the Completed CDF

After all contaminated sediments have been placed in the CDF, the CDF will be capped. The cap will consist of a minimum thickness of 2 feet of clean material. This cap will consist of clean sand and gravel materials. It will be graded for drainage and stormwater management prior to future redevelopment of the CDF for Marine Trades. Stormwater generated from the capped areas will be treated and then discharged through the new stormwater outfall installed adjacent to the ASB as described in Section 5.

The CDF design allows for future placement of a final working surface over the cap. The future working surface may include gravel, asphalt surfacing, or placement of structures as part of future marine trades land uses. The current maximum cap elevation is 22 feet above MLLW with the final working surface estimated at a maximum of 24 feet above MLLW.

7.8 ASB Outfall Decommissioning

Following completion of remediation activities within the ASB Area and breaching of the ASB berm, the existing outfall control structure and outfall pipeline to Bellingham Bay will be decommissioned.

The discharge point to the outfall will be plugged at the location where it passes through the ASB berm. The pipe will then be grouted through the existing embankment with controlled density fill. The discharge control structure and associated structural elements will be demolished and removed from within the ASB Aquatic Use Area. Prior to removing the control building and concrete control structure, the existing piping and valves, mechanical and electrical equipment, and other associated appurtenances will be dismantled and removed.

Decommissioning of the outfall and diffuser sections located outside of the ASB will be performed by GP, the outfall's owner, in compliance with applicable permit requirements.

7.9 Capping of ASB Side Slopes

The design for the ASB remediation and for the CDF incorporates Type 3 caps along exposed side slopes to provide climate resiliency and protect against future shoreline erosion. The locations of these Type 3 caps are shown in Figures 6-3b and 6-6b. The Type 3 caps along the interior of the outer ASB berm will be covered with habitat restoration materials as part of the Port's advance mitigation activities as described in Section 7.10.

7.10 Habitat Restoration Activities

The Port's plans for the remediation and reuse of the ASB include several coordinated actions to restore and enhance aquatic habitat for juvenile salmonids and other aquatic species. These additional habitat restoration actions will be performed as part of the Port's advance mitigation work to be conducted in parallel with the Cleanup.

7.10.1 Connecting the ASB to the Waterway

The new ASB Access Channel to be installed by the Port will reconnect the ASB interior to Bellingham Bay. This work will be performed once the interior of the ASB has been appropriately remediated to enable this step.

Reconnection of the ASB will result in conversion of the ASB Aquatic Use Area to riparian, shallow-water, and deep-water aquatic habitats.

7.10.2 Fish Passage Structure Installation

The Port will install a new fish passage structure in the southwestern corner of the existing ASB berm. This structure will allow free passage of juvenile salmonids and other fish between the ASB nearshore areas and the eelgrass flat located just outside of the ASB, adjacent to the I&J Waterway.

This fish passage structure will improve the fish migration corridors through the new ASB habitat benches to be installed along the interior of the ASB.

7.10.3 Enhancement of Habitat Benches

The interior side of the ASB berm located between the ASB Access Channel and the fish passage structure will be enhanced as a habitat bench for use by juvenile salmon. This will include flattening of the side slopes to optimize the area of riparian and shallow-water habitat in this area. The habitat bench construction will be coordinated with Type 3 capping to be installed in deeper portions of this area.

8 Cap Design for Unit 2C and Adjacent Side Slope Areas

This section summarizes the capping design for Unit 2C and the adjacent side slope areas along the ASB, GP Dock, and Log Pond shorelines. The Unit 2C capping areas described in this section are shown in Figure 6-3b and include the following:

- **Unit 2C Inner Capping Area and Side Slopes:** This is the inner portion of Unit 2C, including the areas adjacent to the GP Dock Area. This cap is designed for a working water depth of -18 feet MLLW. A Type 2 cap over the waterway bottom and a Type 1 cap will be placed along the side slopes including the areas located beneath and adjacent to the GP Dock.
- **Unit 2C Outer Capping Area and Side Slopes:** This is the outer capped portion of Unit 2C. It is located offshore of the future ASB Access Channel and will include a Type 1 cap on the waterway bottom and associated side slopes. The caps will support a working water depth of -25 feet MLLW
- **Unit 2C Full Removal Area Side Slopes:** The Unit 2C Full Removal Area will be remediated by dredging, but Type 1 caps will be placed along each of the side slopes. This will include both the BST/Log Pond Corner and the Unit 2C side slopes adjacent to the ASB.

This section describes the structure removals and capping design for each of these areas. Dredging activities for these areas is summarized separately in Sections 6.2.3 and 6.2.4 of this EDR.

8.1 Structure Removal and Modification

Structure removals in each of the Unit 2C side slope areas will occur prior to dredging. Structures to be removed include the following:

- **Removal of BST North Terminal Pier Extension:** The BST North Terminal pier extension will be removed and will not be replaced. Following sediment remediation in this area, its function will be restored by the installation of breasting and mooring dolphins as described in Section 10.
- **Removal of GP Dock and Associated Pilings and Dolphins:** The entire GP Dock superstructure will be removed during the Cleanup to facilitate dredging and capping in this area. The Port will remove all associated creosote-treated pilings and dolphins as part of parallel advance mitigation activities. The overall GP Dock structure is approximately 1,250 feet long by 85 feet wide and is located on the southeast side of the Whatcom Waterway channel adjacent to Unit 2C, parallel to Granary Avenue (Figure 2-2). The pier is composed of timber and steel piles, timber pile caps, and timber stringers and is topped with a concrete deck slab and asphalt overlay. The top of deck elevation is assumed to be approximately +17 feet MLLW and the mudline elevation along the fender piles at the face of the dock ranges between -17 feet MLLW and -22 feet MLLW (Moffat & Nichol 2015). The structure is showing signs of significant deterioration, and the northeastern portion of the dock is largely cut off from ready vehicular access due to mixed use redevelopment shoreward of the structure (WSP USA 2021). The structure is not well suited to continue providing current and foreseeable land and navigation

uses for the Inner Waterway and is to be removed to facilitate sediment remediation. The GP Dock also supports a pump station used to transfer stormwater from the GP West mill site area to the ASB. Prior to dock demolition, these facilities will be disconnected, with their function replaced by new stormwater outfalls installed as described in Section 5.

In addition to planned structure removals, modifications will be required for one existing stormwater outfall prior to capping:

- **Extension of the Laurel Street Outfall:** An existing municipal stormwater outfall is located along the face of the GP Dock Area at the end of Laurel Street. This outfall provides stormwater management for portions of downtown Bellingham as well as portions of the Waterfront District. The outfall will remain in place. An extension of the outfall will be constructed as necessary to accommodate the revised shoreline geometries associated with the sediment remediation.

8.2 Sediment Cap Design

The thicknesses of engineered caps are based on parameters that include evaluation of contaminant mobility, bioturbation, erosion protection, future maintenance, construction tolerances, and geotechnical considerations.

8.2.1 Contaminant Mobility

The engineered cap design addresses contaminant mobility by developing a chemical isolation layer that is typically placed directly above the contaminated sediment surface. The cap chemical isolation layer is designed by simulating the transport of dissolved-phase contaminants within an engineered cap to identify a chemical isolation layer configuration (i.e., thickness and composition) that would provide long-term effectiveness in limiting concentrations at the cap surface to which benthic organisms can be exposed.

The widely used 1D model of chemical transport within sediment caps, CapSim (version 4.2; Reible 2023), was used to evaluate the cap dissolved-phase chemical isolation layer design. This analysis was performed to design a cap thickness that would be capable of meeting performance standards in the top of the cap for mercury and D/F TEQ (0.41 mg/kg and 9.8 ng/kg, respectively).

Results of the chemical isolation layer evaluation are described in Appendix J for new capping areas within the Whatcom Waterway. That analysis demonstrated that a minimum chemical isolation layer thickness of 1.5 feet of sand would meet the design targets for more than 100 years in all of the evaluated Unit 2C and side slope capping areas.

8.2.2 Bioturbation

An important consideration in the long-term evaluation of engineered capping systems is the potential for bioturbation or exposure of surficial and deep-burrowing aquatic life within the cap to subsurface contaminants.

Detailed core analyses performed in Bellingham Bay suggest that the sediment bioactive zone is approximately 12 cm (5 inches) in thickness, and that bioturbation is minimal below a depth of approximately 0.5 foot (15 cm; Officer and Lynch 1989; Anchor Environmental and Hart Crowser 2000).

Designed cap thicknesses provide robust protection of the bioactive zone and also provide protection against periodic deep-burrowing organisms such as ghost shrimp. Additionally, the presence of the surface gravel armor layer will tend to limit deep bioturbators such as ghost shrimp from burrowing into the underlying sand chemical isolation layer. These conclusions are based on the following estimated cap thicknesses:

- The Type 2 engineered caps to be placed in the Unit 2C Inner Capping Area will have a sand chemical isolation layer with a minimum thickness of 1.5 feet, with a gravel armor layer (1 foot) to protect against potential propwash disturbances. With the over-placement allowances, the final cap thickness will vary between 3 and 4 feet.
- The Type 1 engineered caps to be placed in the remaining Unit 2C capping and side slope areas will be at least 4 feet in thickness. This includes the minimum 1.5 feet of sand serving as the chemical isolation layer, the 6-inch gravel underlayer, and the cap armor layer.

8.2.3 Erosion Protection

Design criteria for erosion protection of engineered caps located in the open-water portions of the Outer and Inner waterways is based on impacts due to wind-generated waves and vessel operations generating propwash. Tidal- and wave-induced near-bed currents are significantly lower in magnitude in these areas compared to those produced by propwash (see Appendix C). The propwash modeling assessed stable armor sizes associated with propwash impacts from four typical commercial vessels that use the Outer and Inner waterways. The selected design vessels include two tug tows and two fishing vessels evaluated at the five capping areas and one dredge area within the Outer and Inner waterways. Criteria assumed for evaluation of propwash for these vessels are as follows (additional detail provided in Appendix C, including a discussion of potential uncertainties associated with the evaluation):

- **Vessels Modeled for Unit 2C Inner Capping Areas:**
  - *Brian S.* (tug tow)
    - Propeller diameter of 6.7 feet
    - Propeller draft of 13.1 feet
    - Horsepower (hp) applied at 20% and 100% of available power (3,000 hp)
  - *The Duchess* (fishing vessel)

    - Propeller diameter of 1.3 feet
    - Propeller draft of 9.0 feet
    - hp at 20% of available power (14 hp)
- **Vessels Modeled for Unit 2C Outer Capping Areas:**
  - *Kinani H*. (tug tow)
    - Propeller diameter of 8.3 feet
    - Propeller draft of 15.4 feet
    - hp at 20% and 100% of available power (4,800 hp)
  - *Northern Eagle* (fishing vessel)
    - Propeller diameter of 6.2 feet
    - Propeller draft of 23.0 feet
    - hp at 20% of available power (1,069 hp)

Based on results of propwash modeling (Appendix C), the Type 1 cap armoring will use a D50 armor of 12 to 16 inches (24-inch to 32-inch thickness) with a 6-inch-thick gravel underlayer with a D50 of 2 inches.

Armoring for the Type 2 cap to be placed in the Unit 2C Inner Capping Area will consist of a 1-foot-thick layer of gravel with a D50 of 2 inches.

Sources of uncertainty with everyday operations propwash evaluation include power level assumptions, maneuvering area assumptions, and assumptions of future operational criteria. The propwash analysis also excluded emergency operations because emergency maneuver frequency and intensity are difficult to predict.

8.2.4 Future Maintenance

Water depths in the Unit 2C capping areas are expected to be maintained in the future by periodic maintenance dredging. The cap design elevations incorporate 2-foot allowances to support maintenance of working water depths without damaging the cap.

8.2.5 Geotechnical Considerations

Engineered cap design to satisfy minimum cap thickness requirements or final required elevations will depend on the compressibility of the existing surface sediments and those exposed after dredging. A geotechnical analysis will be conducted to evaluate several key engineered cap design parameters. Components of the geotechnical evaluation are provided in Appendix B and include review of the following issues:

- Stability of the engineered capped slopes
- Potential displacements during seismic events
- Bearing capacity of the capped subgrade sediments
- Settlement of the engineered cap from consolidation of the capped subgrade sediments

9 Design for the Head of Waterway Area

Dredging activities for the Head of Waterway Area are described in Section 6. Dredge performance will be verified by bathymetric testing. This section describes the site preparation and capping activities to be performed in the Head of Waterway Area.

9.1 Removal of Creosote-Treated Pilings

The existing piles located at the Head of Waterway will be removed by the Port prior to dredging and capping in that area. This removal will be conducted as part of the Port's advance mitigation activities separate from the Cleanup.

9.2 Sediment Cap Design

Following dredging of the Head of Waterway Area as described in Section 6, the area will be capped. That cap has been designed to both contain contaminated sediments and to incorporate or accommodate improved substrate and elevations to enhance habitat for the growth of eelgrass and macroalgae. In existing shallow-water areas, a Type 1 cap will be used. In deeper areas, a Type 2 cap will be used (see Figure 6-4).

The properties of the engineered caps are based on parameters that include evaluation of contaminant mobility, bioturbation, erosion protection, future maintenance, construction tolerances, and geotechnical considerations. The following sections discuss the basis of design criteria associated with cap thickness design within the Head of Waterway Area (Unit 3A).

9.2.1 Contaminant Mobility

The engineered cap design addresses contaminant mobility by developing a chemical isolation layer that is typically placed directly above the contaminated sediment surface. The cap chemical isolation layer is designed by simulating the transport of dissolved-phase contaminants within an engineered cap to identify a chemical isolation layer configuration (i.e., thickness and composition) that would provide long-term effectiveness in limiting concentrations at the cap surface to which benthic organisms can be exposed.

The widely used 1D model of chemical transport within sediment caps, CapSim (version 4.2; Reible 2023), was used to evaluate the cap dissolved-phase chemical isolation layer design. This analysis was performed to design a cap thickness that would be capable of meeting performance standards in the top of the cap for mercury and D/F TEQ (0.41 mg/kg and 9.8 ng/kg, respectively).

Results of the chemical isolation layer evaluation are described in Appendix J for new capping areas within the Whatcom Waterway. That analysis demonstrated that a minimum chemical isolation layer thickness of 1 foot of sand would meet the design targets for more than 100 years in Unit 3A.

9.2.2 Bioturbation

An important consideration in the long-term evaluation of engineered capping systems is the potential for bioturbation or exposure of surficial and deep-burrowing aquatic life within the cap to subsurface contaminants.

Detailed core analyses performed in Bellingham Bay suggest that the sediment bioactive zone is approximately 12 cm (5 inches) in thickness, and that bioturbation is minimal below a depth of approximately 0.5 foot (15 cm; Officer and Lynch 1989; Anchor Environmental and Hart Crowser 2000).

The engineered cap placed in the Head of Waterway Area (except for the marginal boundary area) will have a sand chemical isolation layer with a minimum thickness of 1.5 feet. Final cap thicknesses will vary by area:

- The Type 1 cap placed in shallow-water areas will include both a gravel filter layer and a surficial armor layer to protect against potential propwash disturbances. With the over-placement allowance, the final cap thicknesses will vary between 3 and 4 feet.
- The Type 2 cap placed in deeper water areas will include an isolation layer of 1.5 feet and a gravel armor layer of 1 foot. With over-placement allowances, the final Type 2 cap thicknesses will be between 3 and 4 feet. Additional habitat enhancement material will be placed over the engineered sediment cap.

The cap thicknesses provide robust protection of the bioactive zone and also provide protection against periodic deep-burrowing organisms such as ghost shrimp.

9.2.3 Habitat Enhancement Layer

A layer of fish mix will be placed over the engineered caps to raise final elevations to between -4 and -5 feet MLLW. These elevations are intended to enable colonization of the area with eelgrass and macroalgae.

The habitat enhancement layer is not part of the engineered cap, so some redistribution of the material is anticipated to occur in the future due to wave action. This redistribution of the habitat enhancement layer is acceptable and does not impact cap performance.

9.2.4 Erosion Protection

Design criteria for the Head of Waterway Area are based on tide and wind-wave erosion forces. Propwash is not considered in the design for this area because the mudline elevations will be too shallow for operation of motorized vessels.

Based on the results of the wind-wave analysis (Appendix C), a D50 armor of 4 inches will be used for the nearshore areas at the Head of Waterway. Additional finer-grained habitat materials (i.e., fish mix) are to be placed over the armor layer to enhance habitat conditions in this area and support the development of eelgrass and macroalgae. The habitat material is not integral to the protectiveness of the cap and is therefore allowed to redistribute under wind-wave forces.

Larger diameter armor will be placed along the inshore side of the cap to protect the area of shoaled sediment located beneath the Roeder Avenue Bridge. This material is required due to the shallower elevation of the under-bridge sediments in comparison to the Head of Waterway Area.

Sources of uncertainty with the wind-wave analysis include terminating fetches at the entrance of the harbor, assuming waves were not obstructed from shallower bathymetry or vessels, and factoring in sea level rise.

9.2.5 Future Maintenance

The Head of Waterway Area is designated for future shallow-water habitat uses. No ongoing maintenance by dredging for navigation is presumed. Therefore, the design criteria for the cap does not include a buffer for future maintenance dredging.

9.2.6 Geotechnical Considerations

Engineered cap design to satisfy minimum cap thickness requirements or final required elevations will depend on the compressibility of the existing surface sediments and those exposed after dredging. A geotechnical analysis will be conducted to evaluate several key engineered cap design parameters. Components of the geotechnical evaluation are attached in Appendix B and include review of the following issues:

- Stability of the engineered capped slopes
- Potential displacements during seismic events
- Bearing capacity of the capped subgrade sediments
- Settlement of the engineered cap from consolidation of the capped subgrade sediments

10 BST Dock Area Design

Contaminated sediments are located within the steep slope portions of the BST Dock Area (Figure 2-2) to depths of up to 6 feet below mudline. Dredging will be performed to remove these contaminated sediments to the extent practicable. Following this removal, a Type 3 cap will be placed over the dredged surface to protect the slope against future erosion and ensure climate resiliency.

Dredging activities for the BST Dock Area are described in Section 6. This section provides additional details regarding the site preparation activities, structure removals, capping, and structure replacements to be performed in this area.

10.1 Anticipated Construction Phasing

Remediation at the BST Dock Area and associated structure removal/replacement will be conducted in phases to comply with permit-required fish windows and to maintain Port terminal operations throughout the cleanup. A preliminary evaluation of potential construction sequencing of associated work at the BST Dock Area is shown in Figures 3-1a through 3-1c. This phasing may be adjusted during final design and permitting.

Phasing is expected to begin with the site preparation, structure removal, sediment remediation, and structure replacement at the North Terminal area and a portion of the Central Terminal. This work is expected to require two seasons to complete. The Central Terminal will remain in operation during this period.

During the final construction season, the remaining portions of the Central Terminal will be remediated. Port activities will be maintained using the newly remediated areas of the Central Terminal and North Terminal.

10.2 Site Preparation and Structure Removals

Most of the North Terminal and Central Terminal dock structures will need to be removed and replaced to support the sediment remediation. In addition, new shoreline stabilization measures will also be required to prevent slope failures during and following the Cleanup. These will include construction of updated bulkheads and ground improvement along the top of slope at the Central and North terminals.

10.2.1 Slope Stabilization

Pre-dredging slope stabilization measures for the North Terminal and Central Terminal will include replacement bulkheads and associated ground improvement.

The existing bulkheads are not adequate to support planned dredging. The Central Terminal bulkhead is a pile-supported concrete wall. The planned dredging will undermine the wall face. Although the North Terminal bulkhead wall includes deeper penetrating steel sheets, its design is not adequate for the deepened dredge surface.

Prior to initiation of dredging activities, a replacement sheet-pile bulkhead will be installed behind (shoreward of) the existing bulkheads. Following dredging, this bulkhead alignment will result in creation of new open-water areas. The alignment and wall design are based on site geotechnical analysis that considers slope stability during construction and post-construction conditions.

Ground improvement will also be required prior to dredging. This will include the use of stone columns to reduce liquefaction risks. The stone columns will be installed in the areas behind the proposed bulkhead alignment.

10.2.2 Structure Removals

Structure removals will occur in phases along with the planned dredging and capping activities. Structure removals include the following:

- **Removal of Log Pond Pier Extension:** The extension of the North Terminal that extends into the Log Pond will be removed as part of the Cleanup. The Port will remove all associated creosote-treated pilings as part of parallel advance mitigation activities. The pier extension will not be replaced following the Cleanup, but its vessel moorage functions will be replaced by new breasting and mooring dolphins as described in Section 10.4.
- **Removal and Realignment of North Terminal Bulkhead:** The outer face of the North Terminal bulkhead will be removed to support the planned dredging and adjusted bulkhead alignment. The warehouse located at the North Terminal may also need to be removed at that time to allow for construction of the revised bulkhead alignment and associated ground improvement activities. The 2013 steel sheet pile bulkhead wall at the North Bulkhead includes a tieback/waler system and concrete cap (WSP USA 2021). A portion of the bulkhead located along the Log Pond shoreline will be preserved and joined to the replacement North Terminal bulkhead.
- **Temporary Removal of North Terminal Dock Structures:** All of the North Terminal pier superstructure will be removed temporarily during the Cleanup. The Port will remove all associated creosote-treated pilings as part of parallel advance mitigation activities. The overall North Terminal Dock is 380 feet in length. Most of the structure is constructed of creosote-treated timber. But the outboard 22 feet of the pier was reconstructed in 1984 with steel plumb piles and batter piles, timber pile caps, stringers, and concrete decking. Top of piles and bracing of the 1984 structure is jacketed with fiberglass and concrete grout. The remaining portion of the original bents have a closer spacing than the 1984 bents and are

constructed with timber piles, pile caps, stringers, and decking. As described in Section 10.4, the removed structures will be replaced following sediment dredging and capping.

- **Temporary Removal of Central Terminal Dock Structures:** The Central Terminal includes two different areas of dock. Both will require temporary removal to accomplish the sediment remediation. Both sections will be replaced following completion of sediment remediation.
  - Deck Removal from Newer Dock Section: The Port recently replaced a portion of the Central Terminal using a dock with removable deck panels. For this newer dock section, the deck panels will be removed temporarily, but the pilings, pile caps, beams, and other dock structures will remain in place. Following remediation, the deck sections will be reinstalled.
  - Removal of older dock section: The remaining portions of the Central Terminal are composed of steel pipe piles, steel wide-flange pile caps, and precast concrete deck panels. All dock and piling structures will be removed. These will be replaced following sediment remediation as described in Section 10.4.

10.3 Sediment Cap Design

A Type 3 cap will be installed along the face of the Central and North terminals following completion of dredging. The cap will extend from the toe of slope up to the adjusted bulkhead alignment to provide protection of the steep slope areas from propwash and wind-wave erosion.

10.3.1 Erosion Protection

This section is pending further completion of engineering design evaluations

10.3.2 Geotechnical Considerations

This section is pending further completion of engineering design evaluations

10.4 Structure Replacements

Both the North Terminal and Central Terminal dock structures will be replaced following completion of sediment remediation:

- **North Terminal Dock Replacement:** The replacement of the North Terminal dock will occur in two phases. First, during construction, replacement breasting and mooring dolphins with associated catwalks will be installed along the berth face. These structures will allow continued operations at the Central Terminal during North Terminal remediation. Following sediment remediation, the remaining portions of the North Terminal will be replaced to restore normal operations. The shoreward portion of the dock will be slightly larger given the increase in aquatic area along the shoreline as a result of the shoreward movement of the bulkhead.

- **Central Terminal Dock Replacement:** The Central Terminal dock will be fully replaced following completion of sediment remediation. For the dock portion with the removable deck, this will include replacement and restoration of the original pier deck. For the remaining portion, this will include construction of a replacement structure occupying the original dock footprint. The shoreward portion of the dock will be slightly larger given the increase in aquatic area along the shoreline as a result of the shoreward movement of the bulkhead.

11 Rail Span Area Design

Dredging activities for the Rail Span Area are described in Section 6. Dredge performance will be verified by bathymetric testing. This section describes the site preparation and capping activities to be performed in the Rail Span Area.

11.1 Structure Removal

Site preparation activities in the Rail Span Area include removal of certain marine structures to facilitate dredging and capping. The structures to be removed include the Former Chemical Dock and the obsolete portion of the Rail Span:

- **Removal of Former Chemical Dock:** Prior to dredging, all of the structures associated with the Former Chemical Dock will be removed. Under the Cleanup, the overwater structures will be removed, including the finger pier, trusses, and catwalks. The Port will remove the creosote-treated timber pilings and dolphins as part of parallel advance mitigation activities.
- **Removal of Obsolete Portions of the Rail Span:** The Rail Span Berth facility is located adjacent to the Chemical Dock structures. This facility consists of a 70-foot-long by 30-foot-wide timber trestle that extends from the shore to a steel-framed rail transfer span. The transfer span is approximately 90 feet long and 30 feet wide and supports three parallel railroad tracks. The transfer span articulates up and down from the end of the trestle and is raised and lowered by two steel-framed hoist towers located near the outboard corners of the span. Each hoist tower is supported by approximately 27 timber piles with a concrete cap encompassing the piles.
  - No demolition will take place for the main Rail Span structure. The main Rail Span structure is to be preserved for future use.
  - Demolition activities will include removal of breasting/mooring dolphins, catwalks, and other superstructure elements that will not be reused in the future. The superstructure elements will be removed as part of the Cleanup. The Port will remove the unneeded creosote-timber pilings and dolphins as part of parallel advance mitigation activities.

11.2 Sediment Cap Design

Following dredging of the Rail Span Area as described in Section 6, the Rail Span Area will be capped and armored to contain remaining contaminated sediments and prevent erosion of the cap from propwash forces.

The thicknesses of engineered caps are based on parameters that include evaluation of contaminant mobility, bioturbation, erosion protection, future maintenance, construction tolerances, and geotechnical considerations. The following sections discuss the design criteria associated with the Rail Span Area.

11.2.1 Contaminant Mobility

As discussed in Section 8.1.1, the cap chemical isolation layer is designed by simulating the transport of dissolved-phase contaminants within an engineered cap to identify a chemical isolation layer configuration (i.e., thickness and composition) that would provide long-term effectiveness in limiting concentrations at the cap surface to which benthic organisms can be exposed. Results of the chemical isolation layer evaluation are described in Appendix J and show that a minimum chemical isolation layer thickness of 1.5 feet of sand would meet the design targets for more than 100 years in Unit 6.

11.2.2 Bioturbation

The Type 1 cap to be placed in the Rail Span Area will have a sand chemical isolation layer with a minimum thickness of 1.5 feet and will include both a gravel filter layer and a surficial armor layer to protect against potential propwash disturbances. With the over-placement allowance, the final cap thicknesses will be over 4 feet. These cap thicknesses provide robust protection of the bioactive zone and also provides protection against periodic deep-burrowing organisms such as ghost shrimp.

11.2.3 Erosion Protection

Cap design considered both wave-induced erosion and propwash. Results of those analyses are summarized in Appendix C.

The propwash analysis was performed using commercial vessels representative of those that may be involved in future barge movements within the Rail Span Area. Relevant parameters for these design vessels include the following:

- *Brian S*. (tug tow)
  - Propeller diameter of 6.7 feet
  - Propeller draft of 13.1 feet
  - hp applied at 20% and 100% of available power (3,000 hp)
- *Kinani H*. (tug tow)
  - Propeller diameter of 8.3 feet
  - Propeller draft of 15.4 feet
  - hp at 20% and 100% of available power (4,800 hp)

Based on results of propwash modeling (Appendix C), a D50 armor of 12 to 16 inches (24-inch to 32-inch thickness) with a D50 gravel underlayer of 2 inches (6-inch thickness) will be used. The proposed armor and underlayer design in these areas provides the protection necessary to address both propwash and additional wind-wave forces in these areas but may need to be refined in later design.

Sources of uncertainty with everyday operations propwash evaluation include power level assumptions, maneuvering area assumptions, and assumptions of future operational criteria. The propwash analysis also excluded emergency operations, as emergency maneuver frequency and intensity are difficult to predict.

11.2.4 Future Maintenance

Water depths in the Rail Span Area are expected to be maintained by periodic navigation dredging. The cap design has a maximum top-of-cap elevation of -17 feet MLLW. This incorporates a 2-foot allowance to support maintenance of the working water depth of -15 feet MLLW without damaging the cap.

11.2.5 Geotechnical Considerations

This section is pending.

11.3 Structure Replacement

Following dredging and capping activities, replacement pilings and dolphins will be installed within the Rail Span Area to preserve existing navigation functions. The replacement pilings and dolphins will consist of steel pilings rather than creosote-timber structures. The location of the replacement structures are shown in Figure 3-3.

12 ASB Shoulder Design

Dredging and backfill will be performed in the area offshore of the ASB (Unit 5B). Dredging activities are described in Section 6. Dredge performance will be verified by both bathymetric and chemical testing. This section describes the backfill activities to be performed subsequent to that verification.

The backfill proposed for Unit 5B is not a sediment cap because dredging will remove contaminated sediments to the clean sediment interface. Rather, the backfill is being performed in order to protect existing shallow-water habitat and sustain eelgrass recolonization within the Unit 5B removal area.

The backfill materials to be used in Unit 5B shall be of similar composition to the existing in situ sediments. This like-for-like replacement will sustain existing coastal engineering properties of the area as well as existing aquatic habitat characteristics.

It is anticipated that the clean sands generated from the Unit 8 and Unit 2B deep dredging activities will be suitable for use for sediment backfill. These materials will be chemically and physically tested prior to use to verify that they are suitable for backfill. They will be transported to Unit 5B by barge and placed with mechanical dredging equipment. Some gravel and cobbles may be added to the materials if necessary to replicate existing pre-dredge substrate conditions. No armoring layers are proposed.

The goal of sediment backfill will be to reestablish pre-dredge elevations to within +/- 1 foot tolerances. The progress of backfill activities will be verified by bathymetric surveys.

13 Anticipated Implementation Schedule

This section provides an overview of the anticipated implementation schedule for Cleanup construction activities within Phase 2 Site Areas, including associated monitoring and ICs.

The dredging, material placement, and construction of the CDF activities described in this EDR are anticipated to be completed within three construction seasons as depicted in Figures 3-1a through 3-1c.

The targeted start date for construction is the third quarter of 2027. Construction phasing is currently assumed to be as follows:

- Construction Season 1 activities will include site preparation activities performed inside the ASB, along with the necessary activities in waterway areas (i.e., new stormwater outfall construction) to allow unhooking of the ASB from area stormwater management. During this first construction season, ASB activities will be focused on site preparation, the construction of the CDF retaining structure, and dredging of soft sediments from the aquatic reuse areas of the ASB. These activities are exempt from normal fish windows because they will be performed exclusively inside of the ASB. Waterway activities will include installation of the new stormwater outfalls, capping of the C-Street Outfall Area, installation of the sediment transloading dolphins adjacent to the ASB, and initial site preparation and demolition activities at the BST North Terminal.
- Construction Season 2 will include completion of transition sand dredging from the aquatic reuse areas inside the ASB, significant dredging activities from the areas outside of the ASB (i.e., Units 1A, 1C, 2C, 3A, 6, and the BST Dock Area) along with placement of RMC and/or cap materials in these areas, the removal and reconstruction of portions of the BST North Terminal and Central Terminal, placing dredged materials within the CDF, excavating clean sands from the ASB for use within the Phase 2 placement activities, and modifying marine structures.
- Construction Season 3 will include completion of dredging activities from the areas outside of the ASB (i.e., Units 1B, 2C, the remaining BST Dock Area, and the GP Dock Area) along with placement of RMC and/or cap materials in these areas, removal of the GP Dock, and removal and reconstruction of the remaining portions of the BST Central Terminal. At the conclusion of Season 3, the ASB Access Channel (Unit 2B) will be opened to the Whatcom Waterway, and the CDF will be capped. Finally, the ASB outfall structure will be removed and the ASB outfall will be decommissioned.

This proposed sequence and estimated duration of construction activities may be refined during final detailed remedial design and permitting.

The in-water work windows, as defined by final Cleanup permits, will govern most Cleanup activities. However, some work within the Phase 2 Site Areas may be appropriately initiated outside of these

in-water work windows. Examples of activities that may occur outside of the in-water work windows include the following:

- Preparation or removal of upland staging and stockpile areas
- Removal of nearshore vegetation, debris, or structures during in-the-dry tidal conditions, subject to applicable permit conditions
- Work activities performed within the ASB prior to its reconnection to the Whatcom Waterway

Work activities that will generally be restricted to the in-water work windows include the following:

- In-water debris, piling, or structure removal
- In-water dredging
- Engineered capping, in-water backfill, or RMC materials placement

The CQAP (Appendix F) defines measurement and verification steps that will be performed to monitor the completion of work activities. These include the following:

- Pre-construction submittal reviews prior to any contractor work activities
- Pre-dredge bathymetric surveys to document conditions immediately prior to construction
- Inspections of materials to be used for engineered capping, armoring, backfill, and RMC
- Inspections of installed structures to verify compliance with Cleanup design criteria
- Progress surveys to verify the placement of clean materials within Cleanup design tolerances
- Inspections of installed retaining structure, fish passage structure, and other elements in the ASB to verify compliance with Cleanup design criteria
- Water quality monitoring consistent with the Cleanup Water Quality Monitoring Plan (Appendix E)
- Post-dredge bathymetric surveys to verify achievement of target design elevations
- Sediment quality verification testing consistent with the CMCRP (Appendix H)

The Institutional Control (IC) Plan will be submitted for Ecology review before construction activities are completed in Phase 2 areas, consistent with the requirements of the Consent Decree (Ecology 2007a), the First Amendment to the Consent Decree (Ecology 2011), and the Second Amendment to the Consent Decree (Ecology 2024). The ICs as outlined in that plan will be filed within 60 days of receiving final Ecology comments on the IC Plan.

The Cleanup as-built report will be prepared for Ecology review 120 days after completion of required construction activities, consistent with the requirements of the Second Amendment to the Consent Decree (Ecology 2024).

Long-term monitoring will be implemented consistent with the schedule as outlined in the CMCRP (Appendix H). Contingency response measures, if required, will be implemented as outlined in that document.

14 References

Able, K.W., M.J. Neuman, and H. Wennhage, 2005. "Ecology of juvenile and adult stages of flatfishes: Distribution and dynamics of habitat associations." *Flatfishes: Biology and Exploitation*. Editor, R.N. Gibson. Hoboken, New Jersey, USA: Blackwell Science Ltd; pp. 164–184. doi: 10.1002/9780470995259.ch8.

Anchor Environmental, 2002. *Draft Supplemental Feasibility Study for the Whatcom Waterway Site*. Prepared for Georgia-Pacific West, Inc. 2002.

Anchor Environmental, 2008. *Final Pre-Remedial Design Investigation Work Plan*. Whatcom Waterway Site Cleanup. Prepared for Port of Bellingham. June 2008.

Anchor Environmental and Hart Crowser, 2000. *Remedial Investigation and Feasibility Study for the Whatcom Waterway Site*. Prepared for GP West. 2000.

Anchor Environmental and Landau Associates, 2003. *Pre-Remedial Design Evaluation Report for the Whatcom Waterway Site*. Prepared for GP West, Port of Bellingham, City of Bellingham, and Department of Natural Resources. 2003.

Anchor QEA, 2010. *Pre-Remedial Design Investigation Data Report*. Whatcom Waterway Site Cleanup. Prepared for Port of Bellingham. August 2010.

Anchor QEA, 2012. *Preliminary Design Concept Report*. Whatcom Waterway Site Cleanup. Prepared for Port of Bellingham. August 2012.

Anchor QEA, 2018. *Final As-Built Report*. Whatcom Waterway Cleanup in Phase 1 Site Areas. Prepared for Port of Bellingham. September 2018.

Anchor QEA, 2019. *Year 1 Compliance Monitoring Report*. Whatcom Waterway Cleanup in Phase 1 Site Areas. Prepared for Port of Bellingham. April 2019.

Anchor QEA, 2020. *Year 3 Compliance Monitoring Report*. Whatcom Waterway Cleanup in Phase 1 Site Areas. Prepared for Port of Bellingham. June 2020.

Anchor QEA, 2021. *Pre-Remedial Design Investigation Data Report Phase 2 Site Areas*. Whatcom Waterway Cleanup. Prepared for Port of Bellingham. May 2021.

Anchor QEA, 2022a. *Year 5 Monitoring Report*. Whatcom Waterway Cleanup in Phase 1 Site Areas. Prepared for Port of Bellingham. April 2022.

Anchor QEA, 2022b. *Work Plan Addendum No. 4 Data Report*. Whatcom Waterway Pre-Remedial Design Investigation. Prepared for Port of Bellingham. April 2022.

Anchor QEA, 2023. *Engineering Design Report: Unit 1C Dredging*. Whatcom Waterway Cleanup in Phase 2 Site Areas. Prepared for Port of Bellingham. November 2023.

Anchor QEA, 2024. *Revised Engineering Design Report: Unit 1C Dredging*. Whatcom Waterway Cleanup in Phase 2 Site Areas. Prepared for Port of Bellingham. June 2024.

Anchor QEA, under development. *Pre-Remedial Design and Investigation Work Plan Amendment No. 5. Whatcom Waterway Cleanup Phase 2 Site Areas*. Prepared for Port of Bellingham.

ASCE, 2010. *Minimum Design Loads for Buildings and Other Structures*. American Society of Civil Engineers Standard 7-10.

Bailey, A., K. Ward, and T. Manning, 1993. *A Field Guide for Characterizing Habitats using A Marine and Estuarine Habitat Classification System for Washington State*. Washington Department of Natural Resources, Division of Aquatic Lands.

Beamer, E., C. Greene, E. Brown, K. Wolf, C. Rice, and R. Henderson, 2016. *An assessment of juvenile Chinook salmon population structure and dynamics in the Nooksack estuary and Bellingham Bay shoreline, 2003-2015*. Report to City of Bellingham under 2013 Interlocal Agreement (Contract# 2014 – 0102). Skagit River System Cooperative, LaConner, Washington.

Berry, H., and R. Ritter, 1997. *Puget Sound Intertidal Habitat Inventory 1996: Vegetation and Shoreline Characteristics Classification Methods*. Washington State Department of Natural Resources, Aquatic Resources Division, Nearshore Habitat Program.

Blaauw, H.G., and E.J. van de Kaa, 1978. Erosion of bottom and sloping banks caused by the screw race of maneuvering ships. Presented at 7th International Harbor Congress Antwerp, May 22–26, 1978. Accessed: December 5, 2023.

Christiaen, B., L. Ferrier, P. Dowty, J. Gaeckle, and H. Berry, 2022. *Puget Sound Seagrass Monitoring Report, monitoring year 2018–2020*. Nearshore Habitat Program. Washington State Department of Natural Resources, Olympia, Washington.

City of Bellingham, 2013. *Title 22 Bellingham Municipal Code Shoreline Master Program*. Available at: https://cob.org/services/planning/environmental/shoreline-program.

Colnar, A.M., and L.G. Wayne, 2007. "Conceptual Model Development for Invasive Species and a Regional Risk Assessment Case Study: The European Green Crab, *Carcinus maenas*, at Cherry Point, Washington, USA." *Human and Ecological Risk Assessment* 13(1):120-155.

Dethier, M.N., 1990. *A Marine and Estuarine Habitat Classification System for Washington State*. Washington Natural Heritage Program. Department of Natural Resources. 56 pp. Olympia, Washington.

Duffy, E.J., D.A. Beauchamp, R.M. Sweeting, R.J. Beamish, and J.S. Brennan, 2010. "Ontogenetic Diet Shifts of Juvenile Chinook Salmon in Nearshore and Offshore Habitats of Puget Sound." *Transactions of the American Fisheries Society* 139(3):803-823.

Duncan and Wright, 2005. *Soil Strength and Slope Stability*. John Wiley & Sons.

Ecology (Washington State Department of Ecology), 2000. Bellingham Bay Comprehensive Strategy. Final Environmental Impact Statement.

Ecology, 2002. *Bellingham Bay Comprehensive Strategy, Draft Supplemental Environmental Impact Statement.* Prepared for Georgia-Pacific West, Inc. and Washington Department of Ecology. March 2002.

Ecology, 2007a. Consent Decree No. 07-2-02257-7 for the Whatcom Waterway Site (with Exhibits). Filed September 24, 2007.

Ecology, 2007b. *Final Supplemental Environmental Impact Statement for the Cleanup of the Whatcom Waterway Site*. Prepared by The RETEC Group, Inc. Prepared for Washington Department of Ecology. September 20, 2007.

Ecology, 2011. First Amendment to the Consent Decree 07-2-02257-7 for the Whatcom Waterway Site (with Exhibits). Filed August 19, 2011.

Ecology, 2013. *Sediment Management Standards*. Washington Administrative Code 173-204. Revised February, 2013.

Ecology, 2021. *Sediment Cleanup Users Manual*. Ecology Publication Number 12-09-057. Revised December 2021.

Ecology, 2024. Second Amendment to the Consent Decree 07-2-02257-7 for the Whatcom Waterway Site. Filed March 27, 2024.

Ehinger, S.I., L. Abernathy, M. Bhuthimethee, L. Corum, N. Rudh, D. Price, J. Lim, M. O'Connor, S. Smith, B. Shorin, and J. Quan, 2023a. Puget Sound Nearshore Habitat Calculator User Guide V1.5. NOAA, editor. Available at: https://www.fisheries.noaa.gov/west[1]coast/habitat-conservation/puget-sound-nearshore-habitat-conservation-calculator.

Ehinger, S.I., P. Cereghino, and J. Chamberlin, 2023b. The Puget Sound Nearshore Habitat Conservation Calculator. National Marine Fisheries Service.

Fairbanks, C., 2016. *Bellingham Bay Forage Fish Spawning Assessment*. Fairbanks Environmental Services. March 2016.

Hansen, J.C., and M. A. Reidenbach, 2012. "Wave and tidally driven flows in eelgrass beds and their effect on sediment suspension." *Marine Ecology Progress Series* 448:271–287. doi:10.3354/meps09225.

Integral, 2023. . Memorandum to: Amy Kraham, City of Bellingham, from: Craig Jones and Kara Scheu, Integral Consulting, Inc. Subject: *C-Street Stormwater Outfall Assessment*. June 4, 2024.

Kramer, 1996. *Geotechnical Earthquake Engineering*. Prentice Hall, Inc.

Lee, C.G., and C.D. Levings, 2007. "The Effects of Temperature and Desiccation on Surf Smelt (*Hypomesus pretiosus*) Embryo Development and Hatching Success: Preliminary Field and Laboratory Observations." *Northwest Science* 81(2):166-171, 6.

Maynord, S., 1998. Appendix A: Armor Layer Design for the Guidance for In-Situ Subaqueous Capping of Contaminated Sediment. EPA 905-B96-004, Great Lakes National Program Office, Chicago, Illinois.

McRoy, C.P., 1974. "Seagrass productivity: Carbon uptake experiments in eelgrass, *Zostera marina*." *Aquaculture* 4:131–137. doi: 10.1016/0044-8486(74)90028-3.

Moffat & Nichol, 2015. *Port of Bellingham Georgia-Pacific Wharf Condition Assessment Report*. Prepared for Port of Bellingham by Moffat & Nichol, Seattle, Washington. October 2015.

Munsch, S.H., J.S. Barber, J.R. Cordell, M. Kiffney Peter, B.L. Sanderson, and J.D. Toft, 2021. "Small invertebrates in bivalve-cultivated and unmodified habitats of nearshore ecosystems." *Hydrobiologia* 848(6):1249-1265.

NCHRP (National Cooperative Highway Research Program), 2008. *National Cooperative Highway Research Program*.

NMFS (National Marine Fisheries Service), 2005. Endangered and Threatened Species; Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho. 70:170. September 2005.

NMFS, 2007. Puget Sound Salmon Recovery Plan. Shared Strategy for Puget Sound. Volume 1.

Officer, C.B., and D.L. Lynch, 1989. "Bioturbation, Sedimentation, and Sediment-Water Exchanges." *Estuarine Coastal and Shelf Science*. 28: 1–12.

Penttila, D.E., 2001. Effects of shading upland vegetation on egg survival for summer spawning surf smelt on upper intertidal beaches in Puget Sound. Proc. Puget Sound Research.

Port of Bellingham, 2021. Port Resolution 1397. A Resolution of the Board of Commissioners of the Port of Bellingham Authorizing the Area Commonly Known as the Aerated Stabilization Basin (ASB) be Reused to Support Multiple Marine Trade Industries Rather than Soley for Marina Purposes. November 2, 2021.

Port of Bellingham, 2024. *2024 Comprehensive Scheme of Harbor Improvement Plan (CSHIP)*. Available at: https://storymaps.arcgis.com/stories/9b420dc261334da98a75da3c0e245b8b.

Quinn, T., K. Krueger, K. Pierce, D. Penttila, K. Perry, T. Hicks, and D. Lowry, 2012. "Patterns of Surf Smelt, *Hypomesus pretiosus*, Intertidal Spawning Habitat Use in Puget Sound, Washington State." *Estuaries and Coasts* 35(5):1214–1228.

Rasmuson, L.K., 2013. "The biology, ecology and fishery of the dungeness crab, *cancer magister*." *Advances in Marine Biology*. Academic Press. pp. 95–148.

Reible, 2023. *CapSim 4.2 Basic Users Manual*. Accessed November 11, 2023. Available at: https://www.depts.ttu.edu/ceweb/research/reiblesgroup/CapSim_4.2_Basic_User_Manual.pdf.

RETEC, 2006. *Supplemental Remedial Investigation and Feasibility Study for the Whatcom Waterway Site*. Prepared for the Port of Bellingham.

Shaffer, J.A., S.H. Munsch, and J.R. Cordell, 2020. "Kelp Forest Zooplankton, Forage Fishes, and Juvenile Salmonids of the Northeast Pacific Nearshore." *Marine and Coastal Fisheries* 12(1):4–20.

Simenstad, C.A., K.L. Fresh, and E.O. Salo, 1982. "The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: An unappreciated function." *Estuarine Comparisons*. Editor, V.S. Kennedy. Academic Press.

USACE (U.S. Army Corps of Engineers), 2018. Policy and Procedural Guidance for Processing Requests to Alter U.S. Army Corps of Engineers Civil Works Cleanups. Circular No. 1165-2-220. September 10, 2018.

Washington Sea Grant, 2019. Available at: https://wsg.washington.edu/egc-chuckanut/.

Washington State Noxious Weed Control Board, 2012. Japanese Eelgrass, *Nanozostera japonica*. Washington State Noxious Weed Control Board.

Waycott, M., C.M. Duarte, T.J.B. Carruthers, R.J. Orth, W.C. Dennison, S. Olyarnik, 2009. "Accelerating loss of seagrasses across the globe threatens coastal ecosystems." *Proceedings of the National Academy of Sciences* 106: 12377–12381. doi: 10.1073/pnas.0905620106.

WCSD-DEM (Whatcom County Sheriff's Department – Department of Emergency Management), 2021. *Whatcom County Natural Hazards Mitigation Plan.* Section 3 Jurisdiction Profiles and Mitigation Strategies – Bellingham. September 30, 2021. Accessed November 9, 2023. Available at: https://www.whatcomcounty.us/DocumentCenter/View/64638/2021-NHMP-BELLINGHAM.

WDFW (Washington Department of Fish and Wildlife), 2024a. Forage Fish Spawning Map – Washington State. Available at: https://wdfw.maps.arcgis.com/home/webmap/viewer.html?webmap=19b8f74e2d41470cbd80b1af8dedd6b3&extent=-126.1368,45.6684,-119.6494,49.0781.

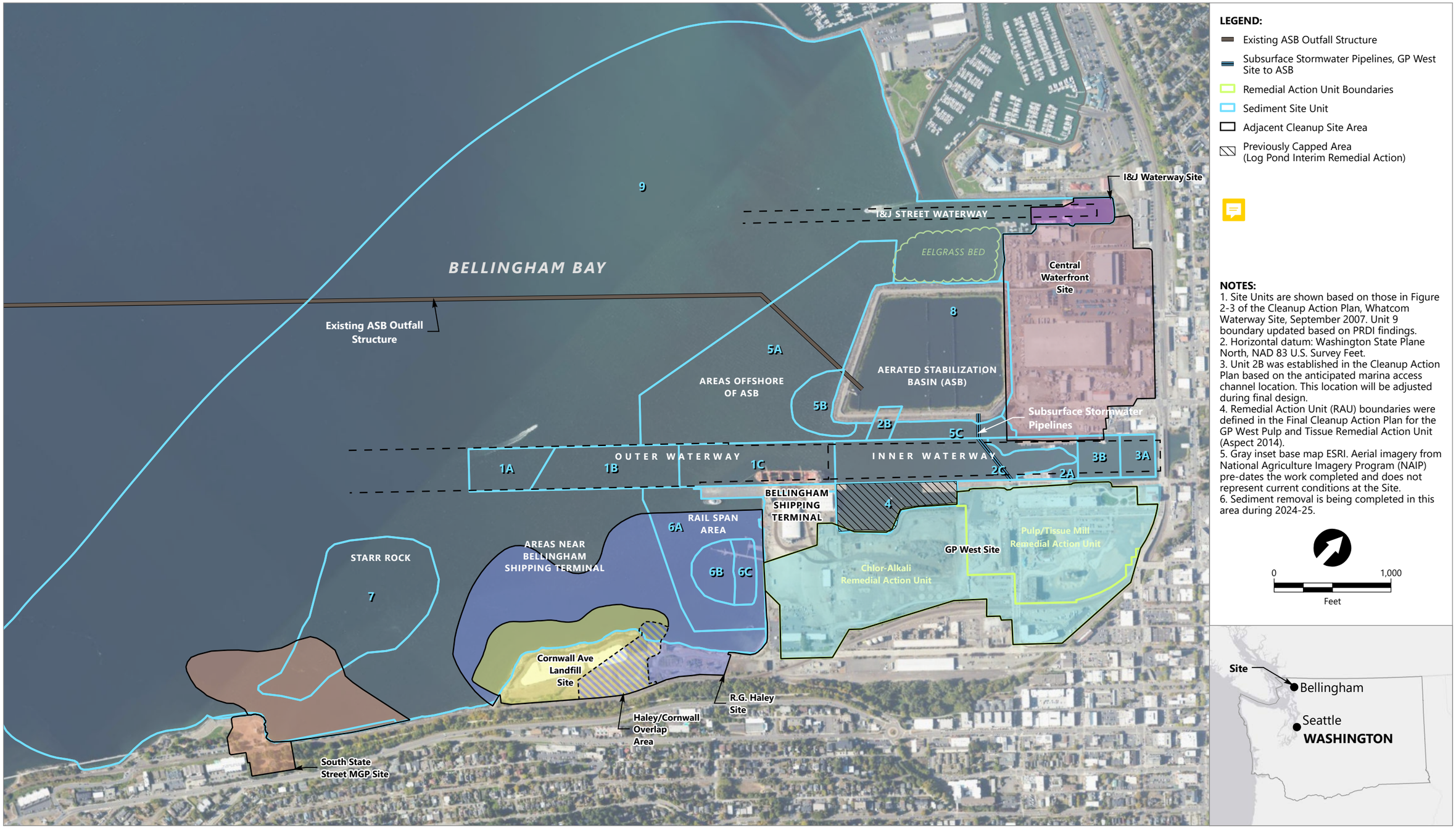
WDFW, 2024b. European Green Crab Hub. Available at: https://wdfw-egc-hub-wdfw.hub.arcgis.com/.

WSDOT (Washington State Department of Transportation), 2011. *Geotechnical Design Manual, M46-03.03*. Washington State Department of Transportation, Olympia, Washington.

WSP USA, 2021. Memorandum to: Mr. Matt Woltman, Principal, Anchor QEA, from: Joe Galloway, PE, WSP, and Colin Eng, PE, WSP. Regarding: Whatcom Waterway Phase 2 Site Cleanup Facility Condition Assessments. January 13, 2021.

Figures

DRAFT



LEGEND:

- Existing ASB Outfall Structure
- Subsurface Stormwater Pipelines, GP West Site to ASB
- Remedial Action Unit Boundaries
- Sediment Site Unit
- Adjacent Cleanup Site Area
- Previously Capped Area (Log Pond Interim Remedial Action)

NOTES:

1. Site Units are shown based on those in Figure 2-3 of the Cleanup Action Plan, Whatcom Waterway Site, September 2007. Unit 9 boundary updated based on PRDI findings.
2. Horizontal datum: Washington State Plane North, NAD 83 U.S. Survey Feet.
3. Unit 2B was established in the Cleanup Action Plan based on the anticipated marina access channel location. This location will be adjusted during final design.
4. Remedial Action Unit (RAU) boundaries were defined in the Final Cleanup Action Plan for the GP West Pulp and Tissue Remedial Action Unit (Aspect 2014).
5. Gray inset base map ESRI. Aerial imagery from National Agriculture Imagery Program (NAIP) pre-dates the work completed and does not represent current conditions at the Site.
6. Sediment removal is being completed in this area during 2024-25.

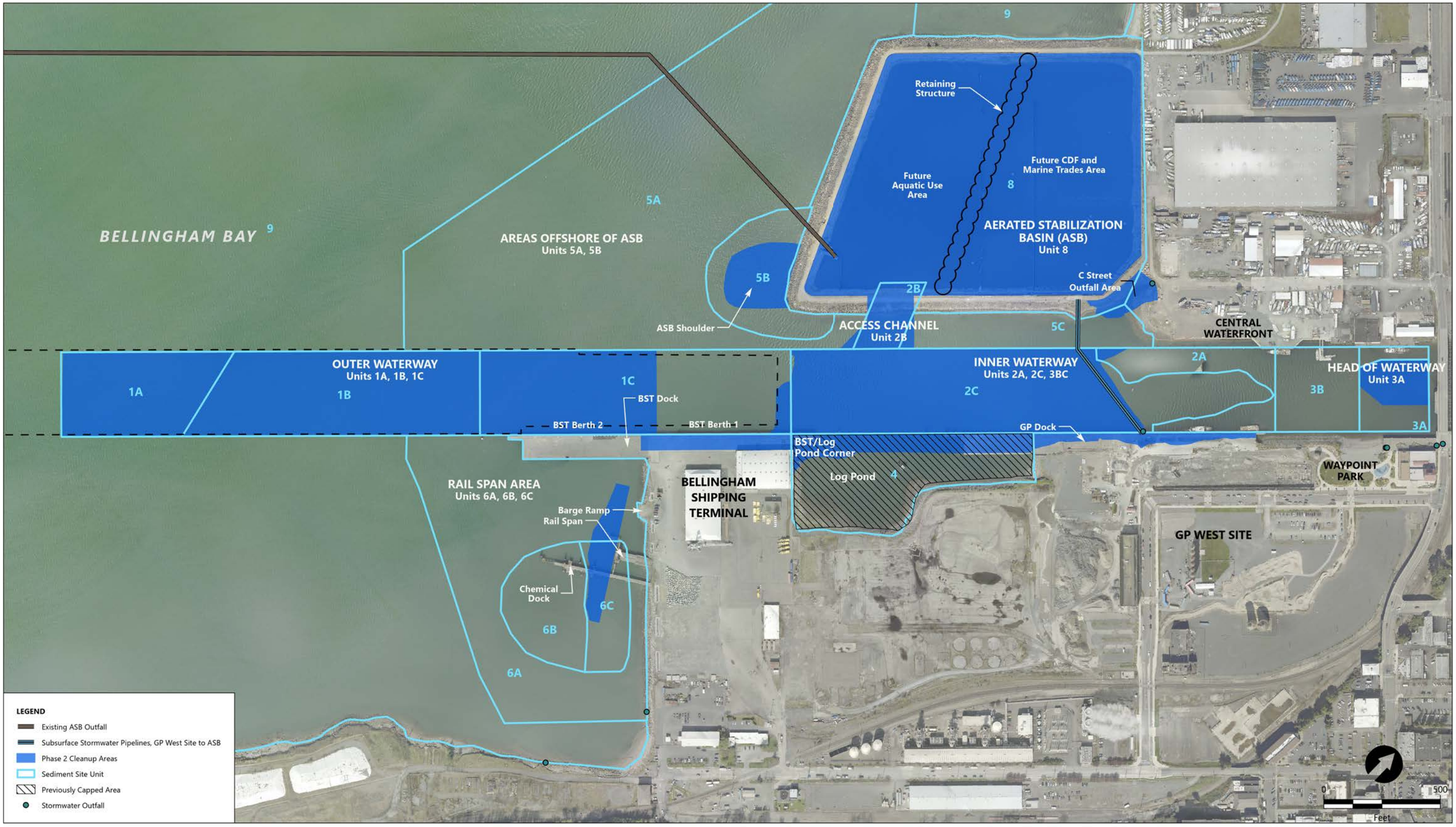
0 1,000
Feet

Publish Date: 2025/05/08, 11:26 AM | User: emueller
Filepath: \\GSTFile01\GIS\Jobs\PortofBellingham_0007\Whatcom_Waterway_Ph2\Maps\Reports\EDR\EDR_figures.aprx | AQ_EDR_Fig1-1_SiteMap

ANCHOR QEA

Figure 1-1
Site Vicinity Map
Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT

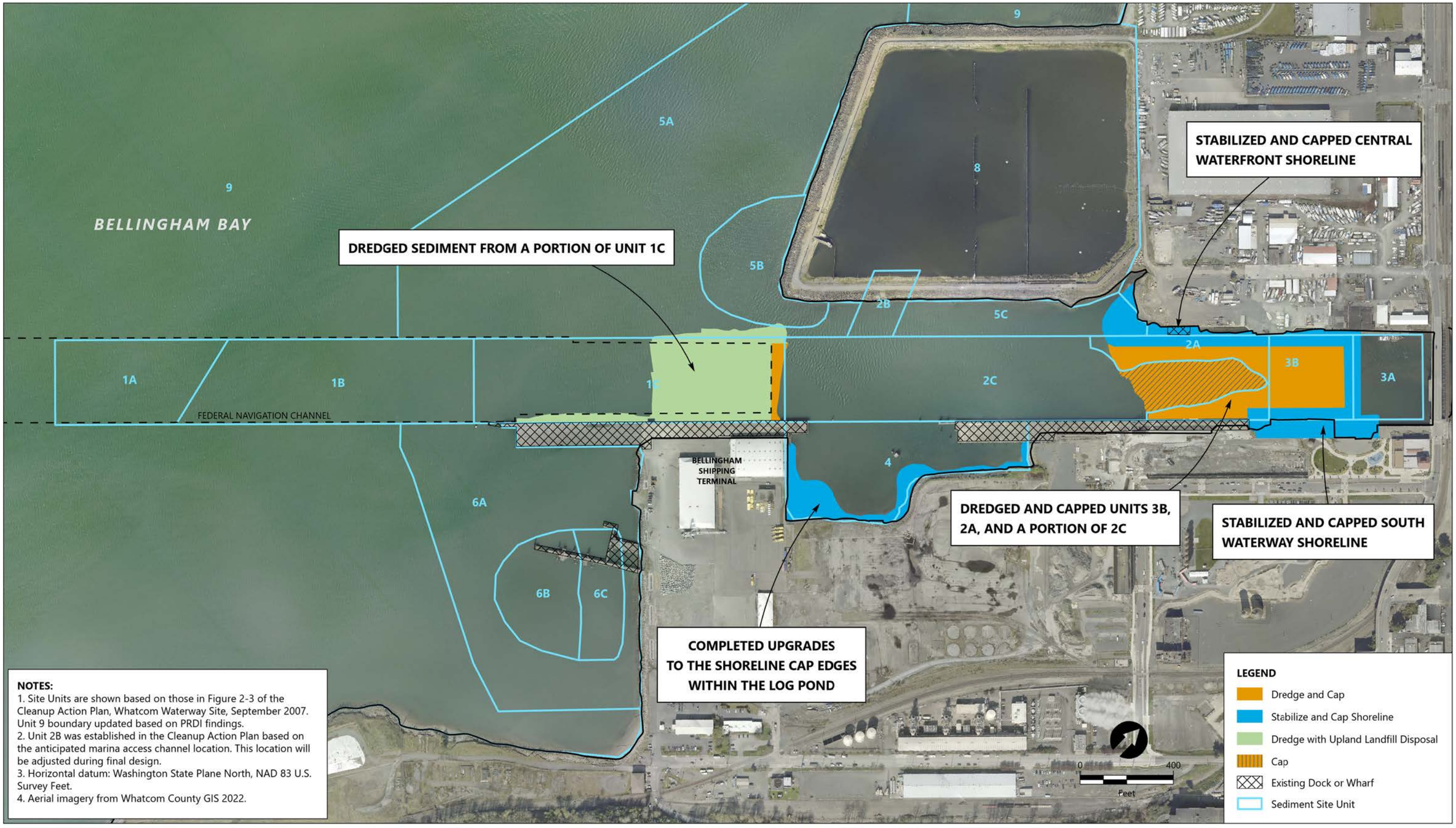


Publish Date: 2024/11/27, 1:05 PM | User: emueller
Filepath: \\GSTFile01\GIS\Jobs\PortofBellingham_0007\Whatcom_Waterway_Ph2\Maps\Reports\EDR\EDR_figures.aprx | AQ_EDR_Fig1-2_CleanupPhase2

ANCHOR QEA

Figure 1-2
Cleanup in Phase 2 Areas
Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



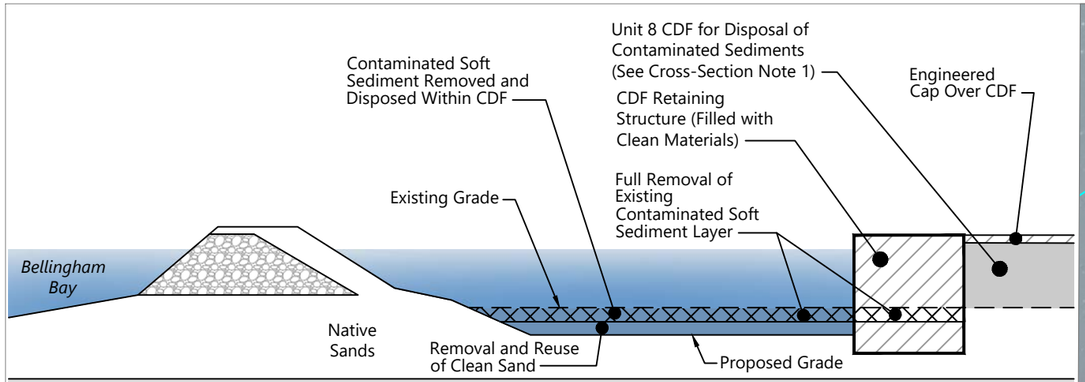
NOTES:
1. Site Units are shown based on those in Figure 2-3 of the Cleanup Action Plan, Whatcom Waterway Site, September 2007. Unit 9 boundary updated based on PRDI findings.
2. Unit 2B was established in the Cleanup Action Plan based on the anticipated marina access channel location. This location will be adjusted during final design.
3. Horizontal datum: Washington State Plane North, NAD 83 U.S. Survey Feet.
4. Aerial imagery from Whatcom County GIS 2022.

Publish Date: 2024/05/08, 1:54 PM | User: emueller
Filepath: \\GSTFile01\GIS\Jobs\PortofBellingham_0007\Whatcom_Waterway_Ph2\Maps\EDR\EDR_figures.aprx | AQ_EDR_Fig2-1_CleanupPhase1

ANCHOR QEA

Figure 2-1
Completed Cleanup in Phase 1 Site Areas
Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



CONCEPTUAL CROSS-SECTION A-A'

Not to Scale

Cross-section is conceptual, the final elevation, composition, and thickness are to be determined during engineering design.

CROSS-SECTION NOTES:

1. Average mercury concentrations within the CDF will be 7.5 mg/kg and average Dioxin/Furan concentrations will be 100 ng/kg.

SOURCE: Aerial from Bing Maps.
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)

NOTES:

1. If the Port obtains grant funding to support the work, the remedy in the Monitored Natural Recovery area in Unit 3A will be upgraded to partial dredging and capping with disposal of the removed dredged material in the Unit 8 CDF.
2. Size and shape of the Unit 8 CDF and ASB access channel (Unit 2B) may be adjusted during final design.
3. The installation of the fish passage structure and the removal of a section of the ASB berm will be performed separately by the Port in coordination with the cleanup action.
4. The Unit 2B boundary will be adjusted during final engineering design and permitting to align with the final ASB access channel.

LEGEND:

- Existing Dock or Wharf
- Site Unit
- Unit 1C Dredging Area (to be Completed 2025)
- Unit 8 Upland Confined Disposal Facility (CDF)
- Approximate Location and Extent of CDF Retaining Structure
- Partial Dredge and Cap with Disposal in Unit 8 CDF
- Full Dredge with Disposal in Unit 8 CDF

0 400 Feet

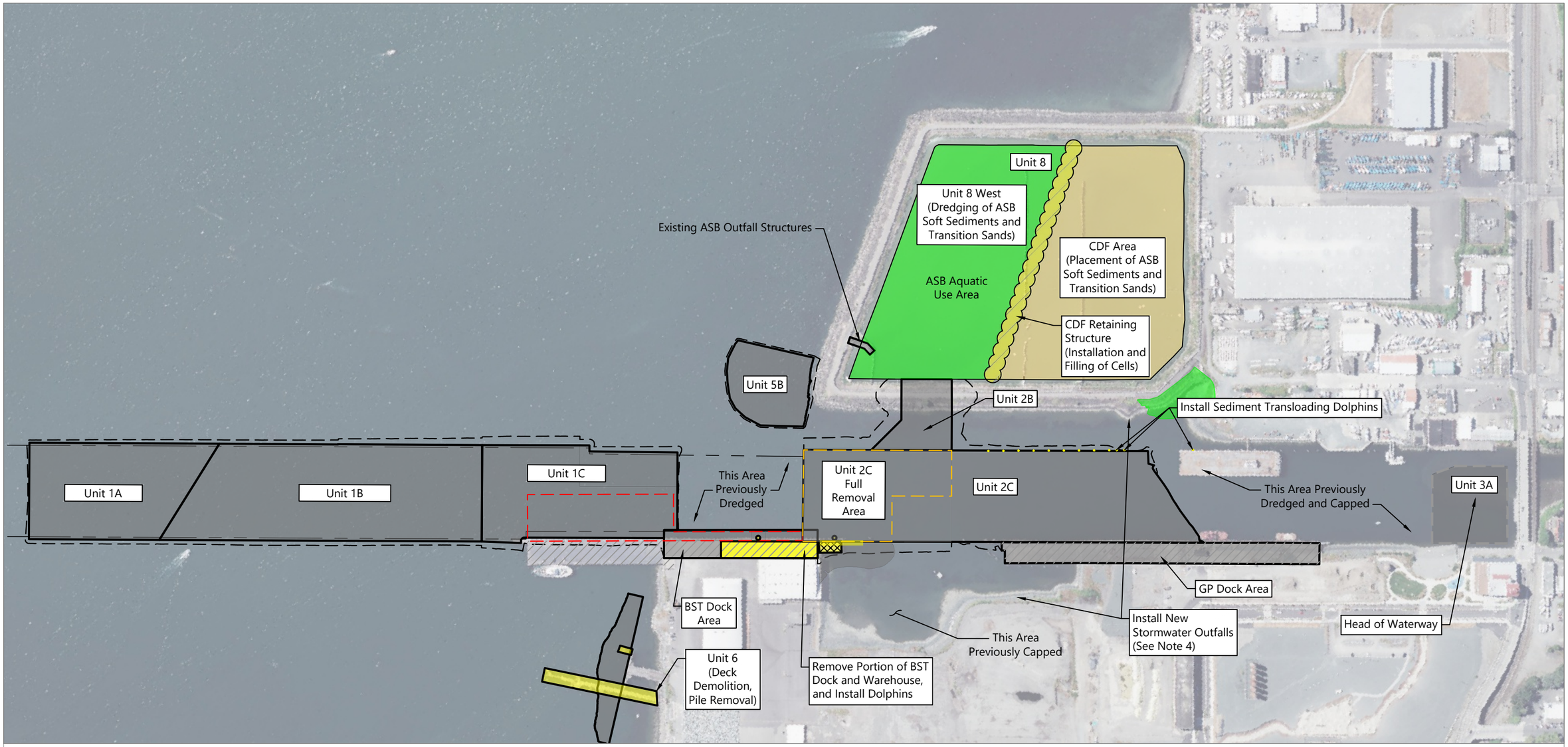
Publish Date: 2024/11/27 9:36 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-037.dwg Figure 2-2

ANCHOR QEA

Figure 2-2
Construction Project for Phase 2 Site Units – Overview

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



SOURCE: Image from ESRI.
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)

NOTES:
1. BST = Bellingham Shipping Terminal
2. CDF = Confined Disposal Facility
3. Sediment material dredged from the Site will be managed in the CDF.
4. Size of the CDF is approximate and may be adjusted during final design.
5. Two new stormwater outfalls will be installed to manage treated stormwater previously managed in the ASB.

LEGEND:
- Federal Navigation Channel
- Dredge Area - Toe of Cut
- Dredge Area Daylight
- Existing Dock or Wharf
- No Planned Work During Construction Season 1
- Unit 1C Dredging Area (To be Completed 2025)
- BST Log Pond Corner Additional Dredging Footprint
- CDF (Sediment Placement Area)
- Approximate Location and Extent of CDF Retaining Structure
- Structural Work (Demolition and/or Replacement)
- Sediment Dredging and/or Placement

0 400 Feet

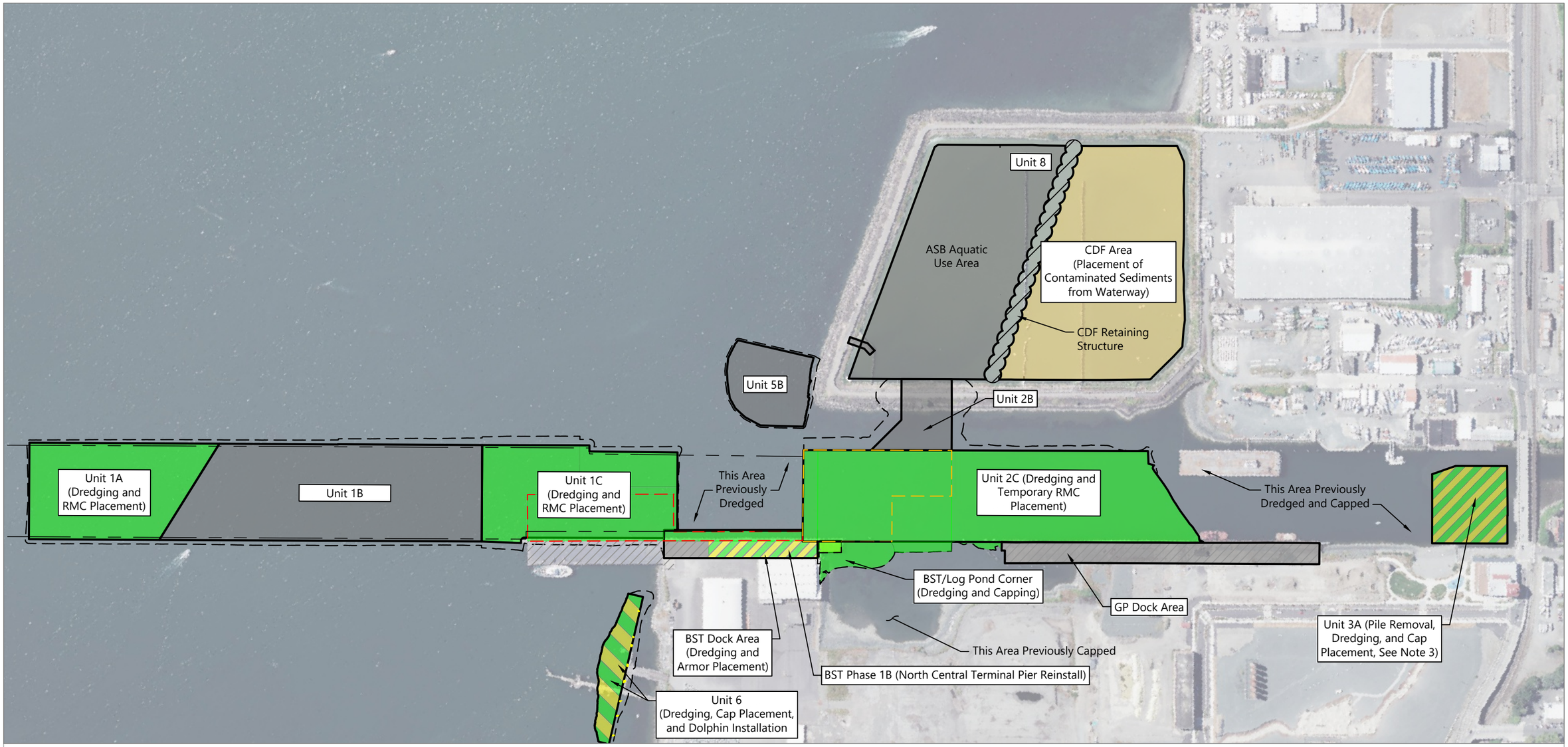
Publish Date: 2025/05/06 10:32 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-038.dwg Figure 3-1a

ANCHOR QEA

Figure 3-1a
Anticipated Construction Season 1

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



SOURCE: Image from ESRI.
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)

NOTES:
1. Sediment material dredged from the Site will be managed in the CDF.
2. Size of the CDF is approximate and may be adjusted during final design.
3. After pile removal by the Port, shallow sediments will be dredged and placed in the CDF. A new cap will be installed with substrate and elevations optimized for aquatic habitat.

LEGEND:
- Federal Navigation Channel
- Dredge Area - Toe of Cut
- Dredge Area Daylight
- Existing Dock or Wharf
- No Planned Work During Construction Season 2
- Unit 1C Dredging Area (To be Completed 2025)
- BST Log Pond Corner Additional Dredging Footprint
- CDF (Sediment Placement Area)
- Approximate Location and Extent of CDF Retaining Structure
- Structural Work (Demolition and/or Replacement)
- Sediment Dredging and/or Placement

0 400
Feet

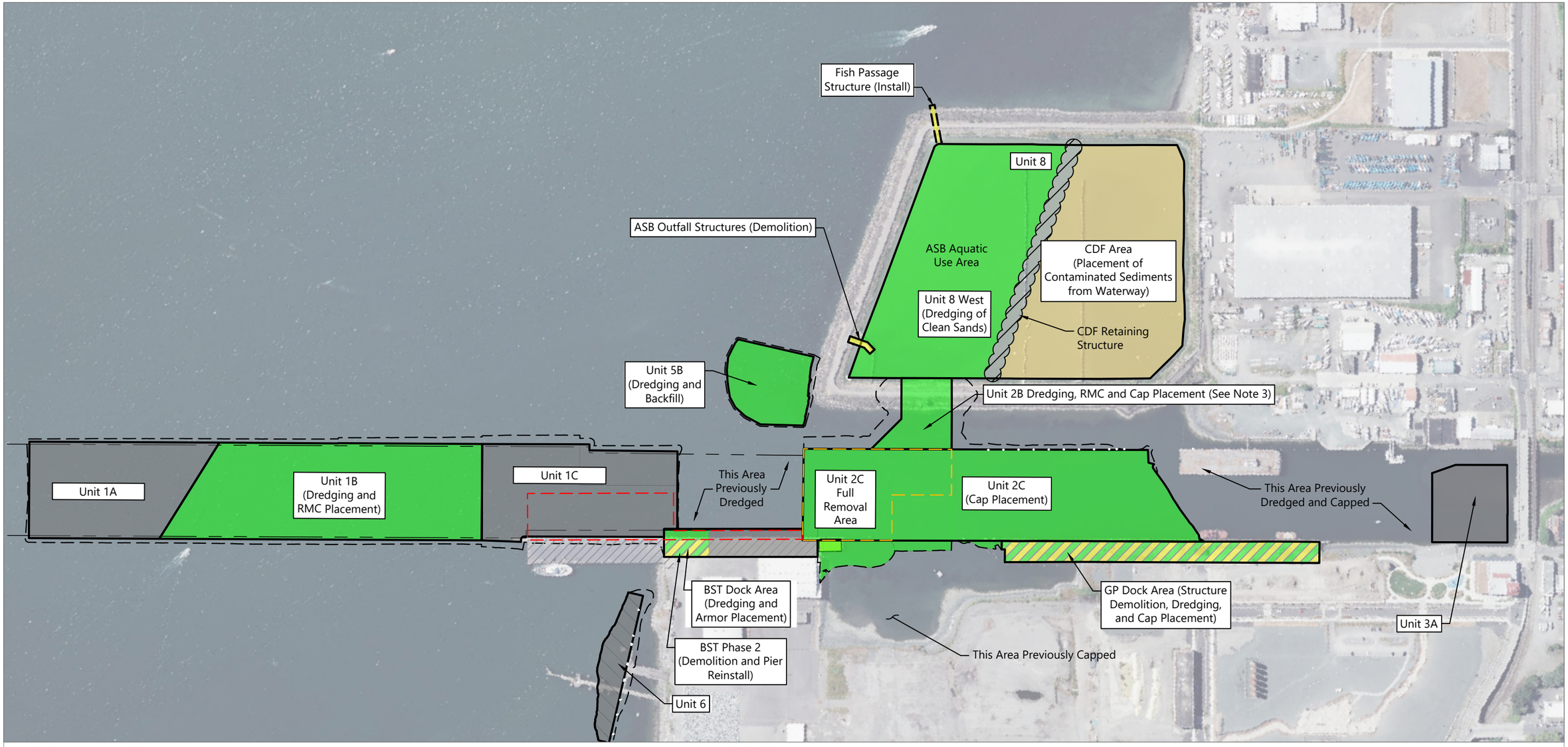
Publish Date: 2025/05/06 10:32 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-039.dwg Figure 3-1b

ANCHOR QEA

Figure 3-1b
Anticipated Construction Season 2

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



SOURCE: Image from ESRI.
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)

NOTES:
1. Sediment material dredged from the Site will be managed in the CDF.
2. Size of the CDF is approximate and may be adjusted during final design.
3. The Unit 2B access channel will be fully dredged, but Type 1 and Type 3 caps will be placed along the side-slopes.

LEGEND:
- Federal Navigation Channel
- Dredge Area - Toe of Cut
- Dredge Area Daylight
- Existing Dock or Wharf
- No Planned Work During Construction Season 3
- Unit 1C Dredging Area (To be Completed 2025)
- BST Log Pond Corner Additional Dredging Footprint
- CDF (Sediment Placement Area)
- Approximate Location and Extent of CDF Retaining Structure
- Structural Work (Demolitionlition and/or Replacement)
- Sediment Dredging and/or Placement

0 400
Feet

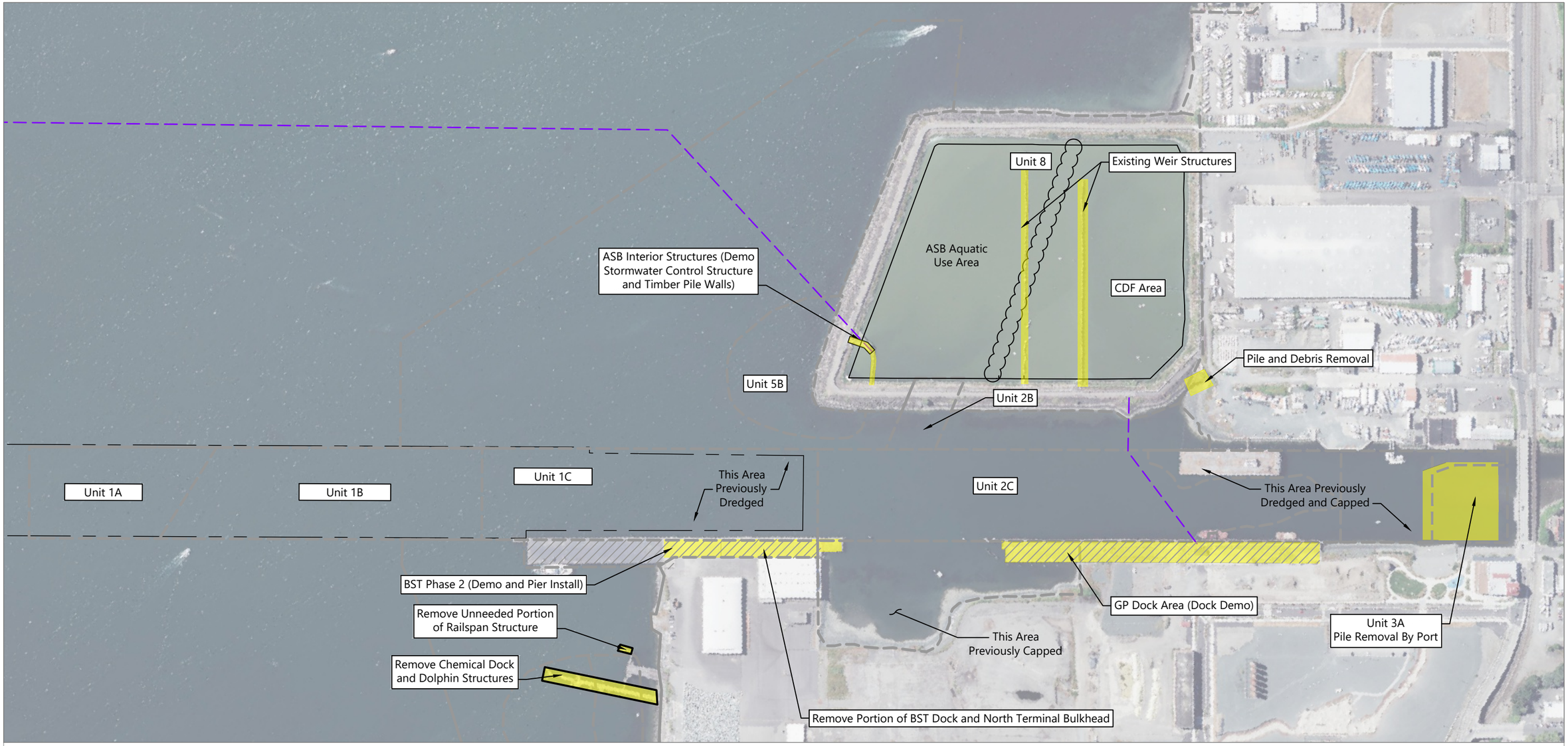
Publish Date: 2024/11/27 9:38 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-040.dwg Figure 3-1c

ANCHOR QEA

Figure 3-1c
Anticipated Construction Season 3

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



SOURCE: Image from ESRI.
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)

LEGEND:

- Federal Navigation Channel
- Existing Dock or Wharf
- Approximate Location and Extent of CDF Retaining Structure
- Demolition Work
- Abandon Stormwater Line

0 400
Feet

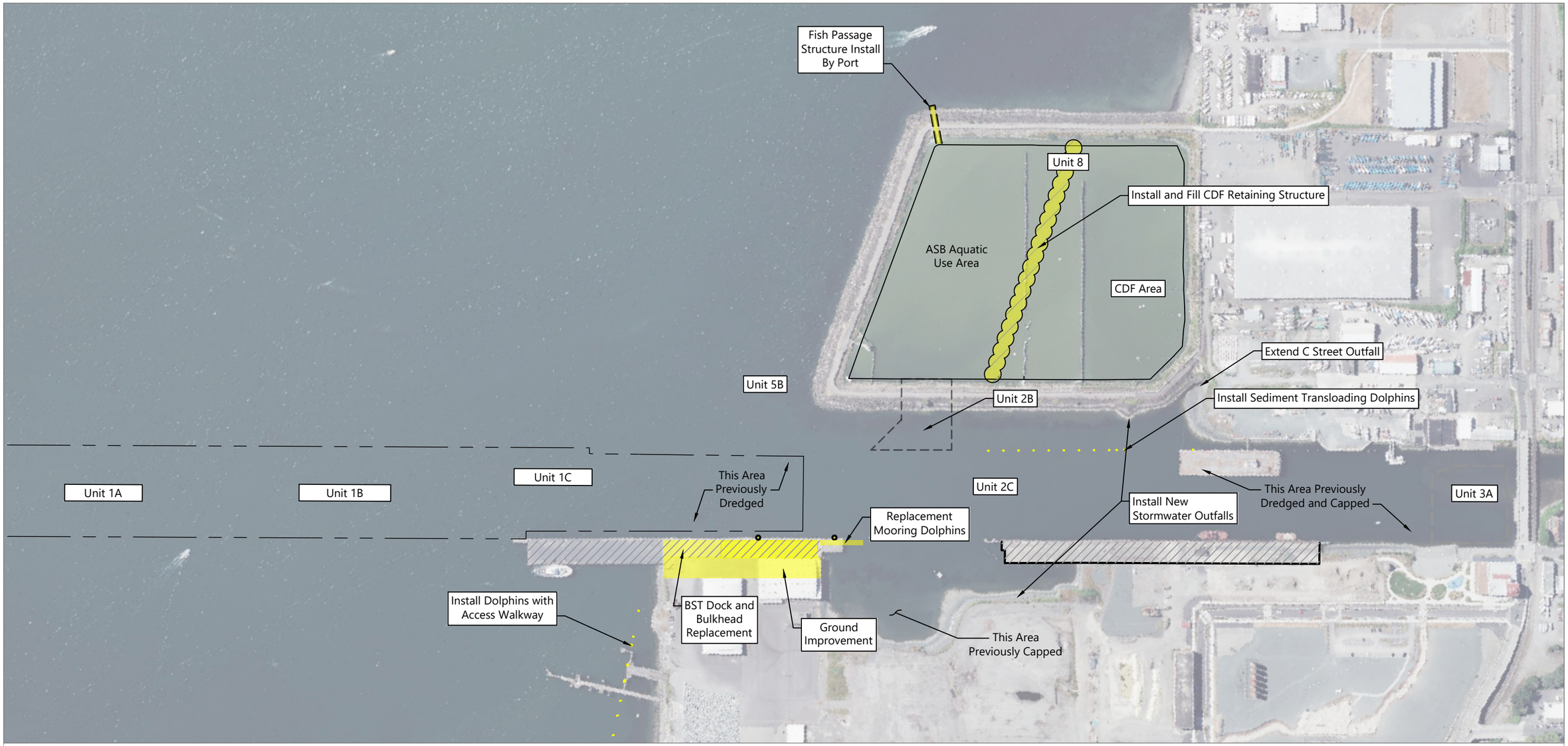
Publish Date: 2025/05/06 10:32 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-038.dwg Figure 3-2

ANCHOR QEA

Figure 3-2
Overview of Marine Structure Demolition

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



SOURCE: Image from ESRI.
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)

LEGEND:

- Federal Navigation Channel
- Existing Dock or Wharf
- Approximate Location and Extent of CDF Retaining Structure
- Replace or Install Marine Structures

0 400
Feet

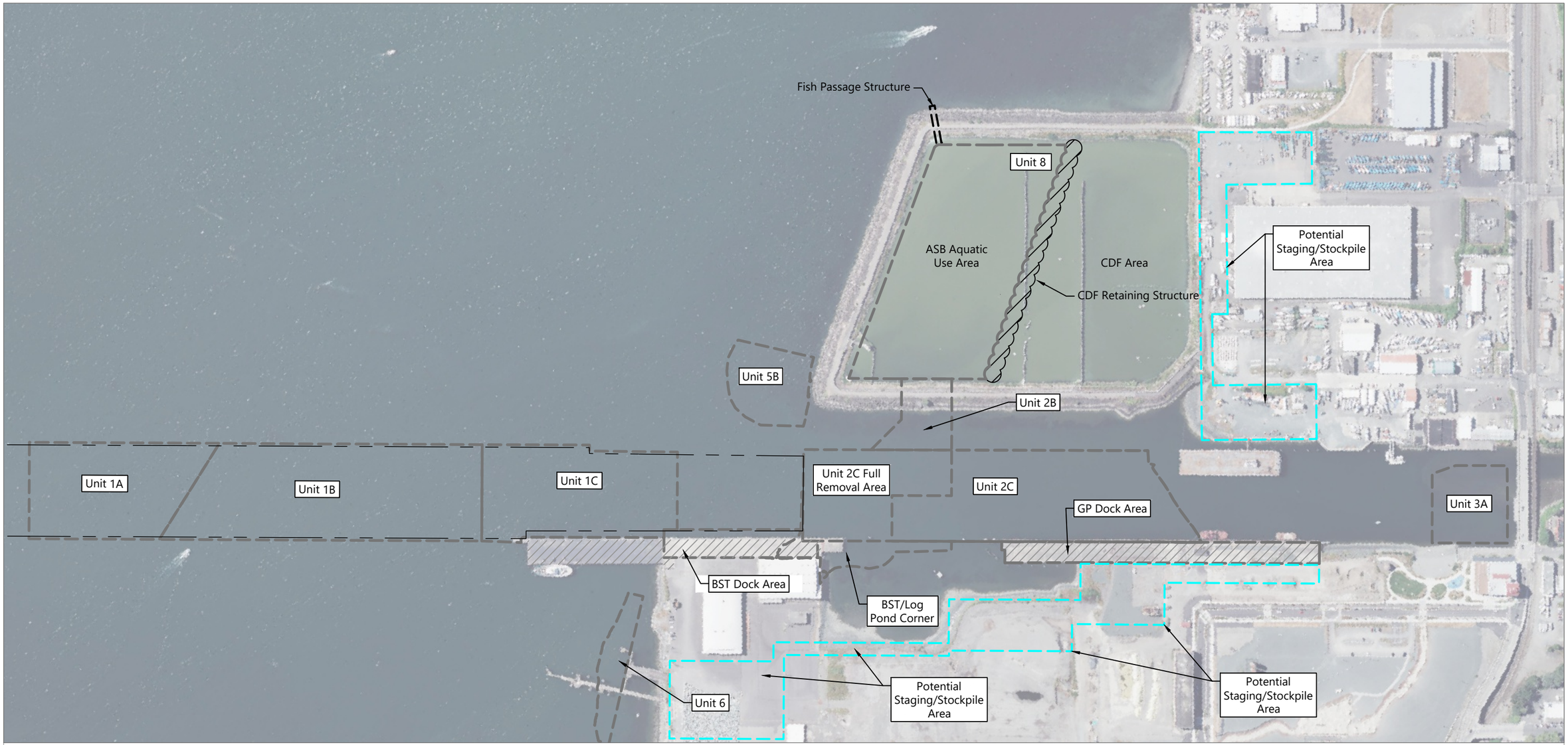
Publish Date: 2024/11/27 9:39 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-038.dwg Figure 3-3

ANCHOR QEA

Figure 3-3
Overview of Structural Work

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



SOURCE: Image from ESRI.
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)
NOTE: Potential staging and stockpile areas may be adjusted as the design is further developed.

LEGEND:

- Federal Navigation Channel
- Phase 2 Sediment Removal or Capping Area
- Existing Dock or Wharf
- Potential Staging/Stockpile Area
- Approximate Location and Extent of CDF Retaining Structure

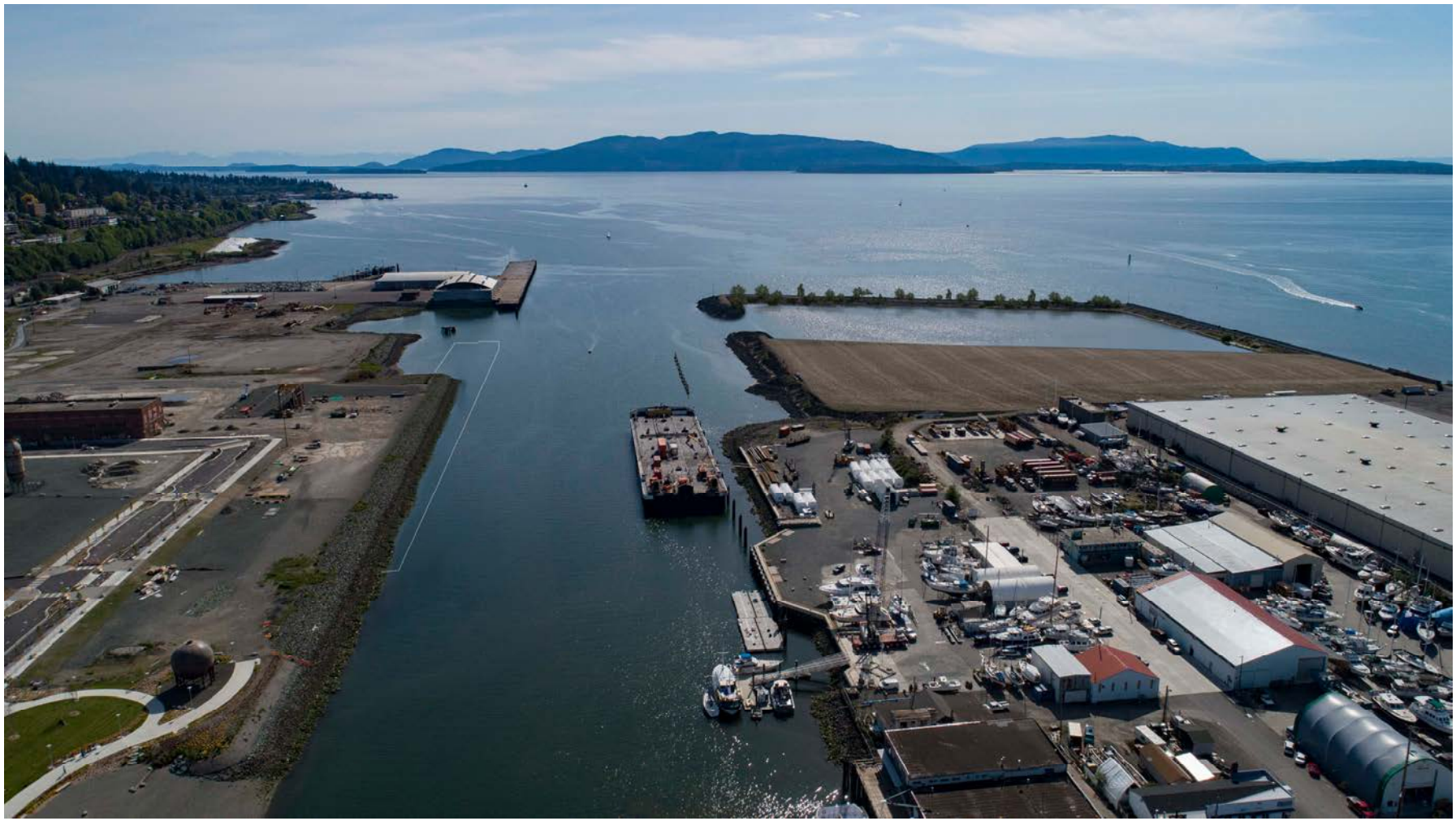
0 400
Feet

Publish Date: 2024/11/27 9:39 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-053.dwg Figure 3-4

ANCHOR QEA

Figure 3-4
Potential Site Staging and Stockpile Areas

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup



Note: Final layout of CDF and CDF retaining structure are subject to revisions during final design and permitting.

Filepath: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\EDR\01 Figures\Figure 3-5_GP Shoreline Illustration.docx

ANCHOR QEA

Figure 3-5
Illustration of GP West Shoreline at Completion
Engineering Design Report
Whatcom Waterway Phase 2 Cleanup



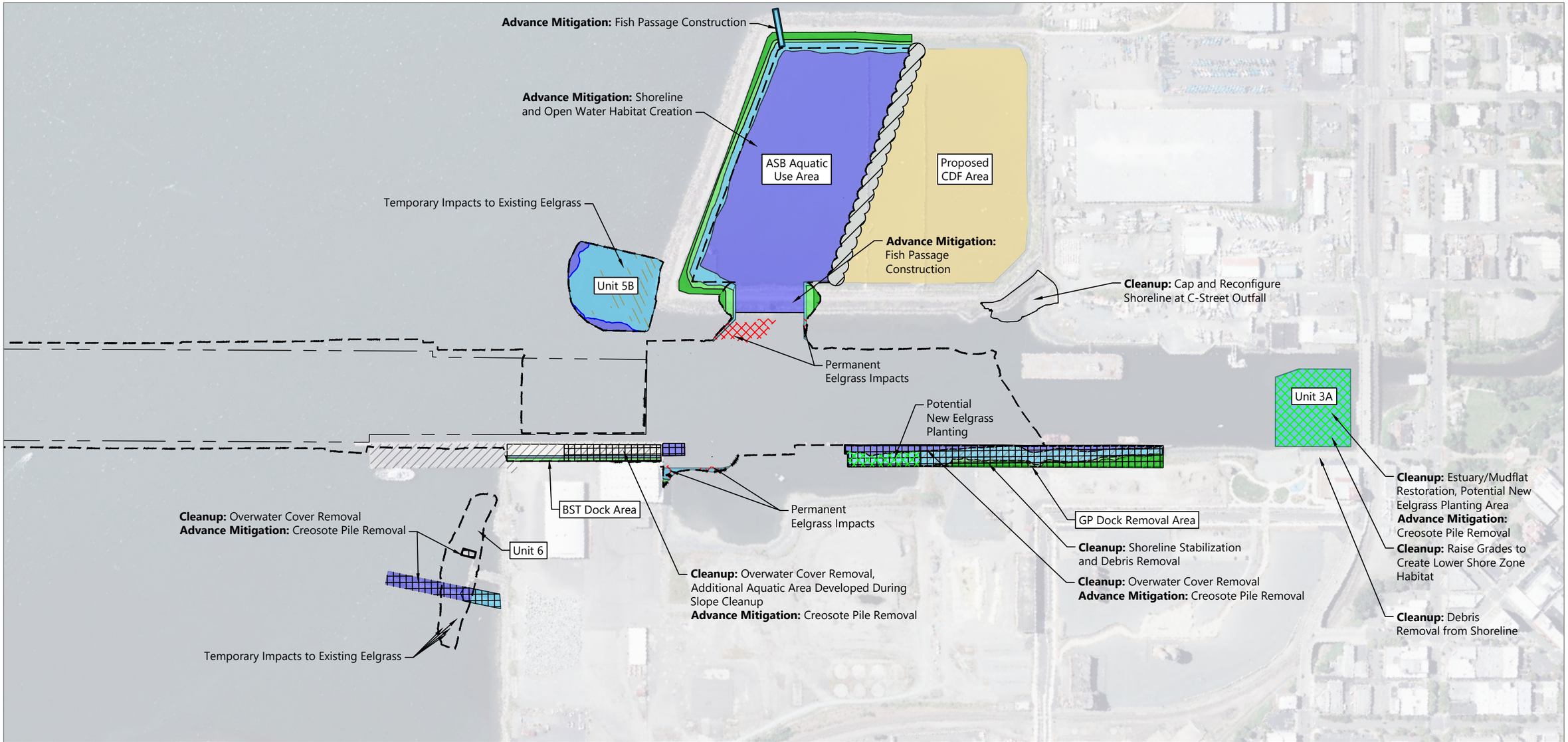
Note: Final layout of CDF, CDF retaining structure, and access channel are subject to revisions during final design and permitting.

Filepath: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\EDR\01 Figures\Figure 3-6_CDF Illustration.docx

ANCHOR QEA

Figure 3-6
Illustration of CDF and Aquatic Use Areas at Completion
Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



SOURCE: Image from ESRI.
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)
NOTES:

1. Additional survey to be conducted to determine precise eelgrass impacts in BST/Log Pond corner dredge footprint. Eelgrass at risk of temporary or permanent impacts are based on data from Gravity, August 2020 and PRDI data report, 2010.

LEGEND:

- Federal Navigation Channel
- Dredge Area
- Existing Dock or Wharf
- Structure to be Permanently Demolished
- Confined Disposal Facility (CDF; Sediment Placement Area)

LEGEND (EELGRASS IMPACTS, SEE NOTE 1)

- Existing Eelgrass (Gravity, August 2020 and PRDI Data Report, 2010)
- Permanent Eelgrass Impacts
- Temporary Eelgrass Impacts/Eelgrass Replanting
- Suitable Eelgrass Planting Area

LEGEND (NEW/IMPROVED HABITATS)

- Riparian (Above +9.7' MLLW)
- Upper Shore Zone (+5 to +9.7' MLLW)
- Lower Shore Zone (-10' to +5' MLLW)
- Deeper Shore Zone (Below -10' MLLW)

0 400
Feet

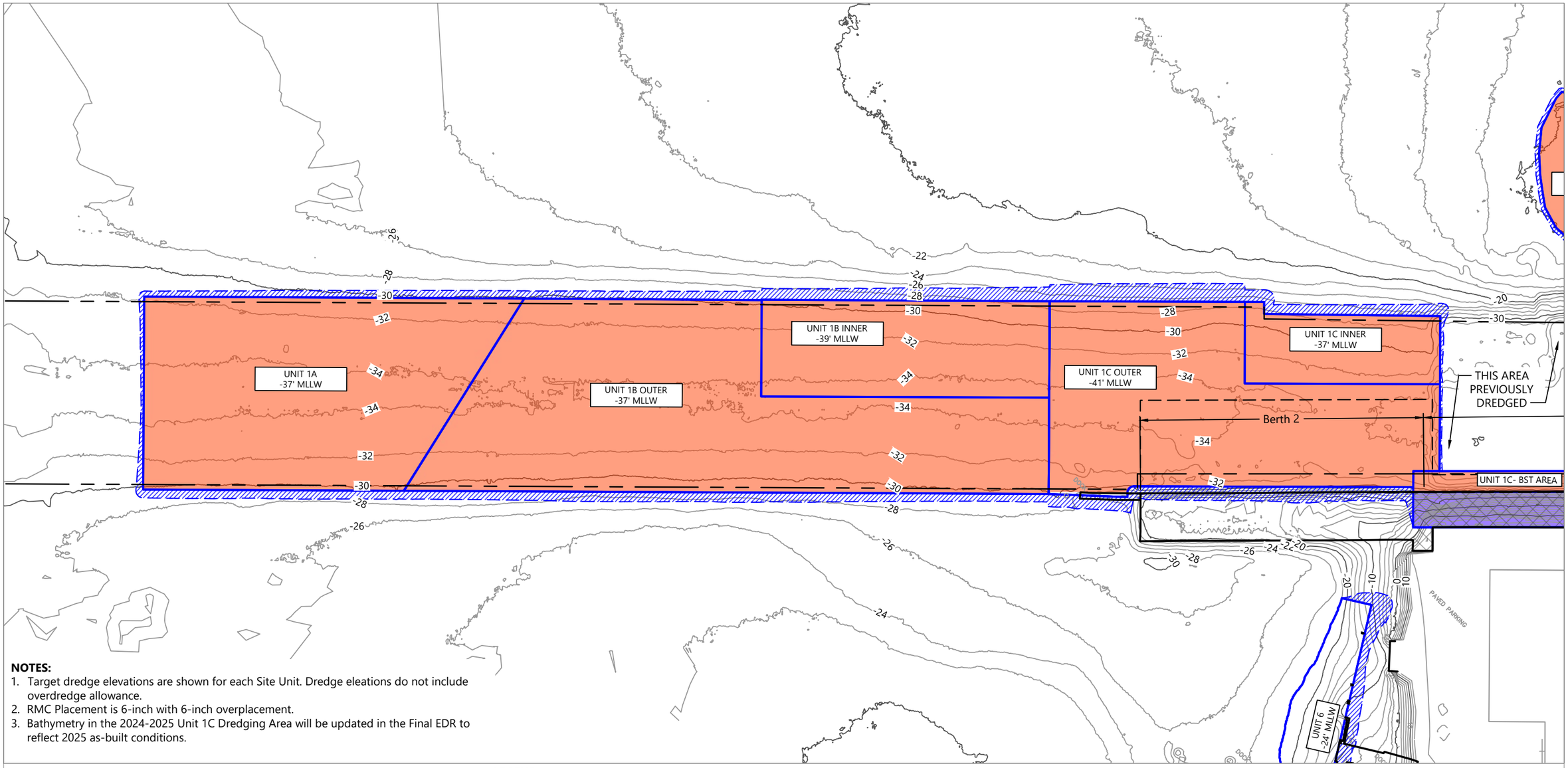
Publish Date: 2025/02/26 3:34 PM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-062 (Section 4).dwg Figure 4-1

ANCHOR QEA

Figure 4-1
Areas of New or Improved Habitat Resulting from Cleanup and Parallel Actions

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



NOTES:
1. Target dredge elevations are shown for each Site Unit. Dredge eleations do not include overdredge allowance.
2. RMC Placement is 6-inch with 6-inch overplacement.
3. Bathymetry in the 2024-2025 Unit 1C Dredging Area will be updated in the Final EDR to reflect 2025 as-built conditions.

SOURCE: Existing bathymetry dated October 2019 and May 2021 (by Northwest Hydro Inc.) and November 2019 and September 2020 (by Wilson Engineering, LLC).
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)

LEGEND:

- Contours (2-foot and 10-foot Intervals)
- Federal Navigation Channel
- Dredge Area - Toe of Cut
- Dredge Area Daylight
- Full Dredge to Clean Contact with RMC Placement
- Side Slope Dredge with RMC Placement
- Unit 1C Dredging Area (To be Completed 2024-2025)

0 200
Feet

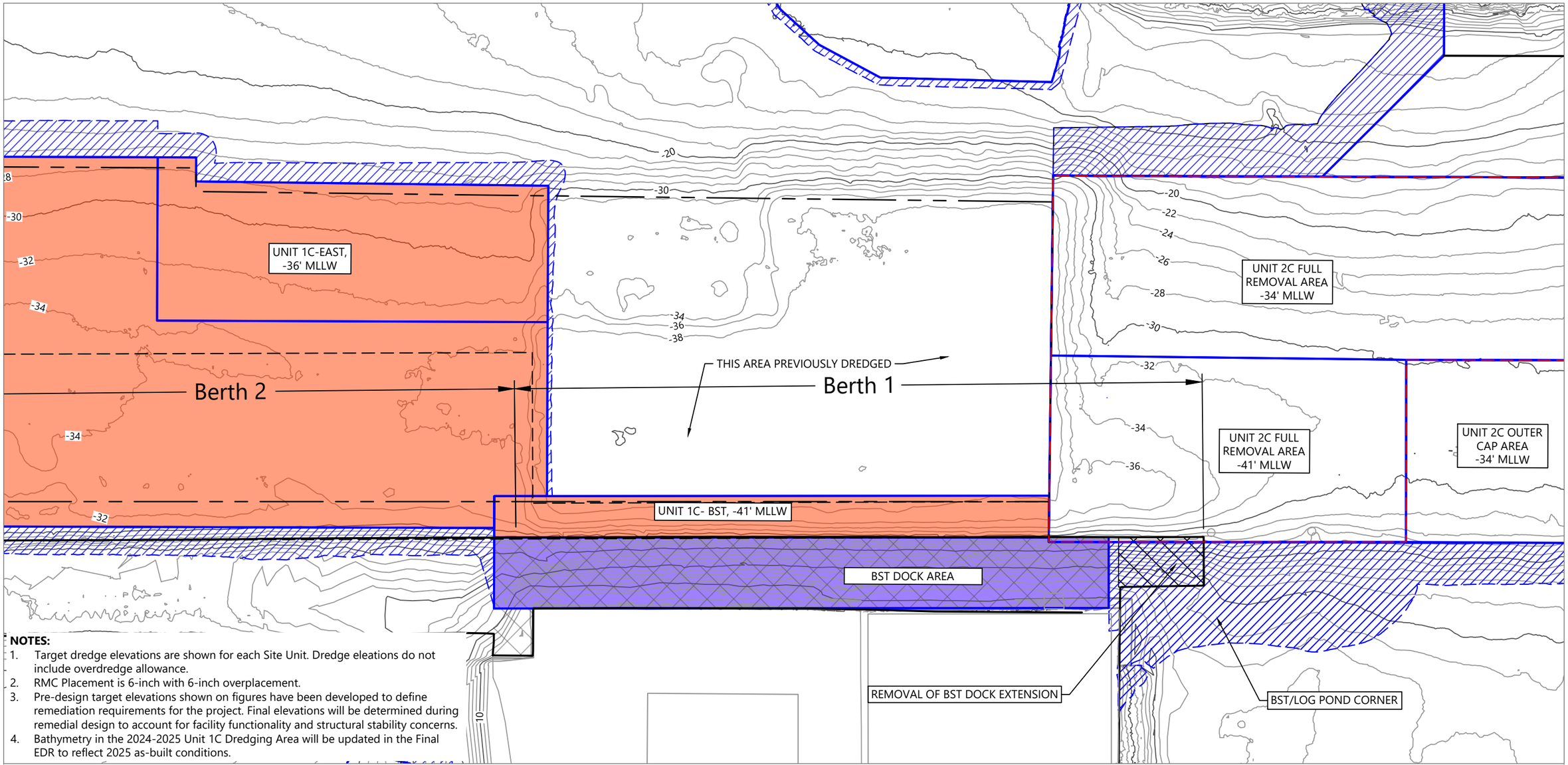
Publish Date: 2024/11/27 9:40 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-054.dwg Figure 6-1a

ANCHOR QEA

Figure 6-1a
Outer Waterway Dredging and Placement Plan

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



NOTES:

1. Target dredge elevations are shown for each Site Unit. Dredge eleations do not include overdredge allowance.
2. RMC Placement is 6-inch with 6-inch overplacement.
3. Pre-design target elevations shown on figures have been developed to define remediation requirements for the project. Final elevations will be determined during remedial design to account for facility functionality and structural stability concerns.
4. Bathymetry in the 2024-2025 Unit 1C Dredging Area will be updated in the Final EDR to reflect 2025 as-built conditions.

SOURCE: Existing bathymetry dated October 2019 and May 2021 (by Northwest Hydro Inc.) and November 2019 and September 2020 (by Wilson Engineering, LLC).
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)

LEGEND:

- Contours (2-foot and 10-foot Intervals)
- Federal Navigation Channel
- Dredge Area - Toe of Cut
- Dredge Area Daylight
- Unit 1C Dredging Area (To be Completed 2024-2025)
- Unit 2C Full Removal Area
- Full Dredge to Clean Contact with RMC Placement
- Side Slope Dredge with Cap or RMC Placement
- Existing Structure to be Demolished
- Removal to the Extent Practicable with Type 3 Cap

0 100 Feet

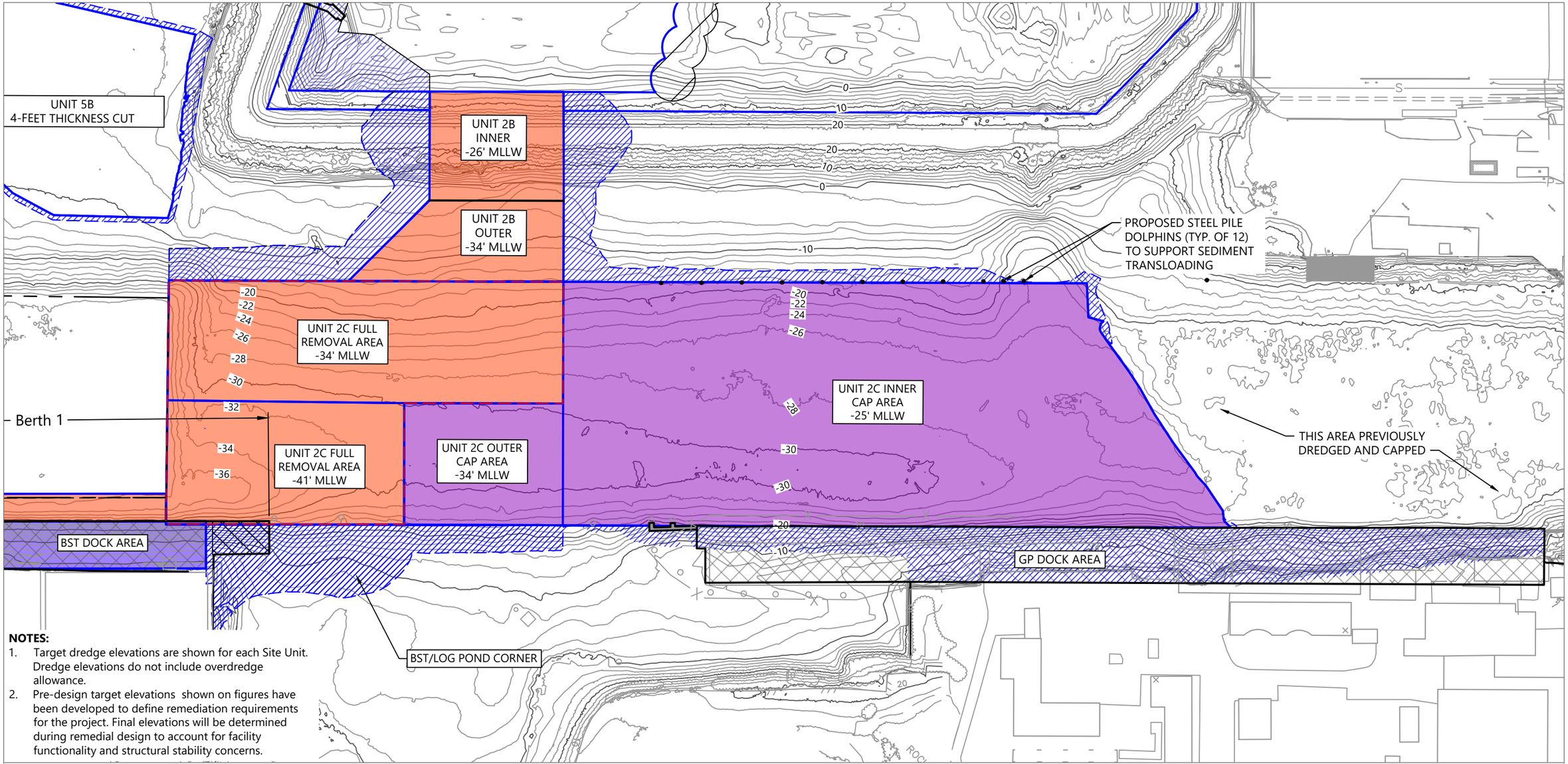
Publish Date: 2024/11/27 9:40 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-054.dwg Figure 6-2a

ANCHOR QEA

Figure 6-2a
BST Dock Area Dredging and Material Placement Plan

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



NOTES:

1. Target dredge elevations are shown for each Site Unit. Dredge elevations do not include overdredge allowance.
2. Pre-design target elevations shown on figures have been developed to define remediation requirements for the project. Final elevations will be determined during remedial design to account for facility functionality and structural stability concerns.

SOURCE: Existing bathymetry dated October 2019 and May 2021 (by Northwest Hydro Inc.) and November 2019 and September 2020 (by Wilson Engineering, LLC)
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)

LEGEND:

- Contours (2-foot and 10-foot Intervals)
- Federal Navigation Channel
- Dredge Area - Toe of Cut
- Dredge Area Daylight
- Site Unit
- Access Channel Deepening Followed by Capping
- Existing Structure to be Demolished
- Unit 2C Full Removal Area
- Partial Dredge to Support Placement of Cap
- Full Dredge with RMC Placement
- Partial Dredge to Prepare Sideslope for Cap Placement

0 150
Feet

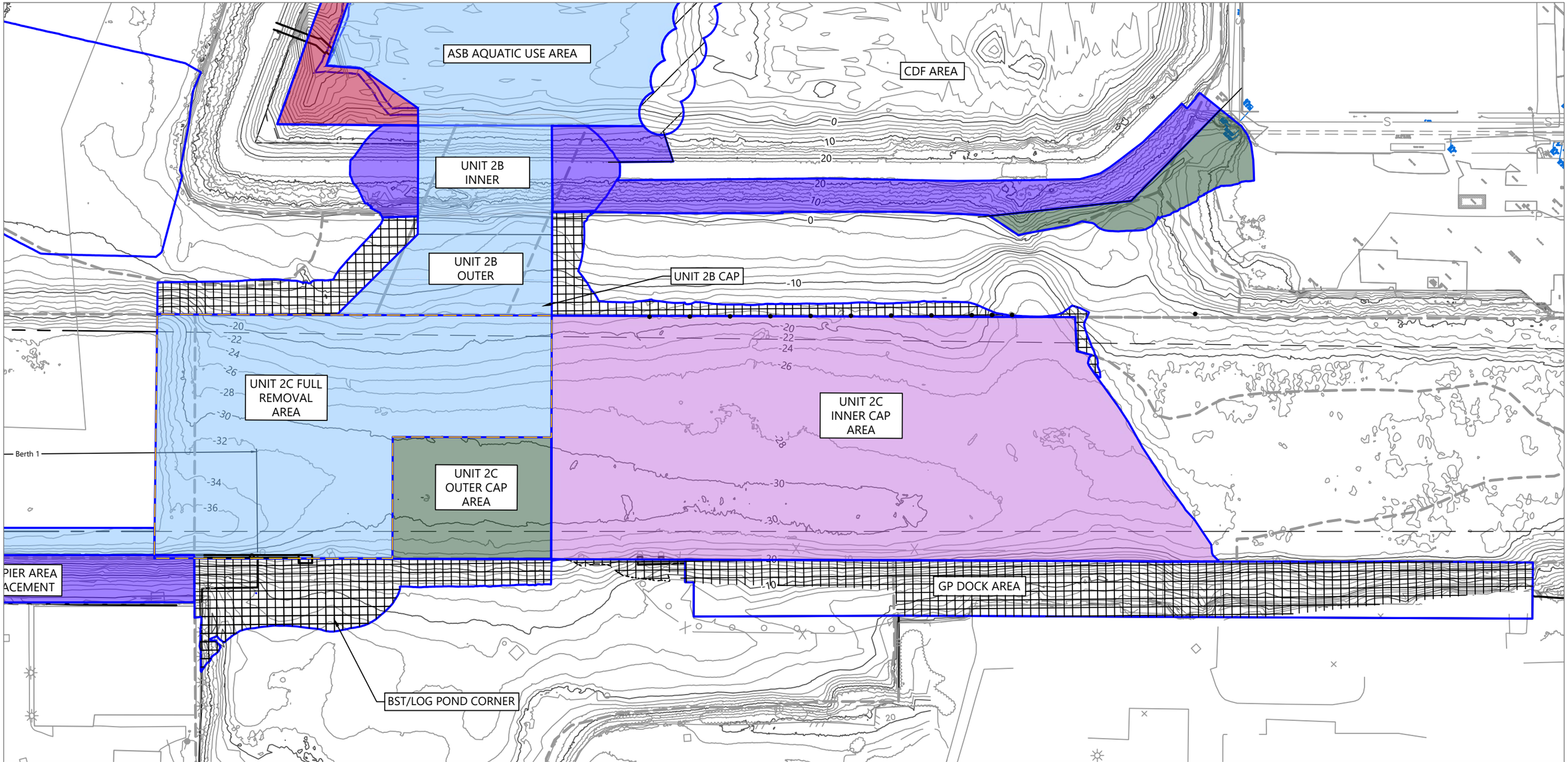
Publish Date: 2024/11/27 9:40 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-054.dwg Figure 6-3a

ANCHOR QEA

Figure 6-3a
Inner Waterway Dredging Plan

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



SOURCE: Existing bathymetry dated October 2019 and May 2021 (by Northwest Hydro Inc.) and November 2019 and September 2020 (by Wilson Engineering, LLC)
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)
NOTES:
1. Type 1 cap is a three-layer cap (sand, gravel filter, armor) for isolation of contaminants.
2. Type 2 cap is a two-layer cap (sand and gravel armor) for isolation of contaminants.
3. 3. Type 3 cap is a two-layer cap (gravel filter and armor) for erosion protection.

LEGEND:

- Contours (2' and 10' Intervals)
- Federal Navigation Channel
- Material Placement Area
- Site Unit
- Log Pond Corner Additional Dredging Footprint
- Approximate Location and Extent of CDF Retaining Structure
- RMC (6" Sandy Material)
- Type 1 Cap
- Sideslope Removal with Type 1 Cap
- Type 2 Cap
- Type 3 Cap
- Type 3 Cap with Habitat

0 150
Feet

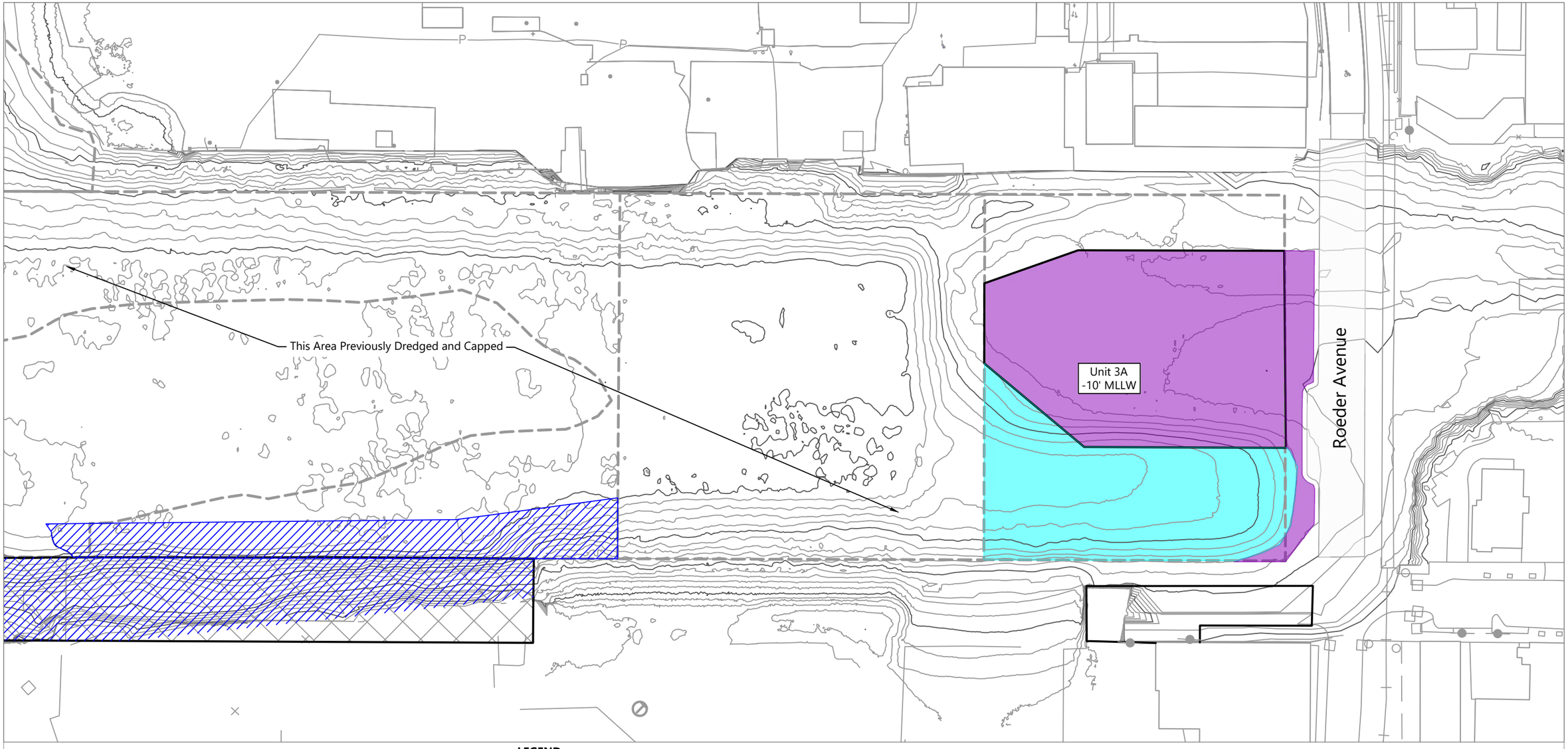
Publish Date: 2024/11/27 9:41 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-055.dwg Figure 6-3b

ANCHOR QEA

Figure 6-3b
Inner Waterway Material Placement Plan

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



SOURCE: Existing bathymetry dated July 2008, March 2016, and October-November 2019.
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)
NOTES:
1. Target dredge elevations are shown for each Site Unit. Dredge elevations do not include overdredge allowance.
2. Type 1 cap is a three-layer cap (sand, gravel filter, armor) for isolation of contaminants.
3. Type 2 cap is a two-layer cap (sand and gravel armor) for isolation of contaminants.

LEGEND:
- Existing Contours (2' and 10' Interval)
- Dredge Area - Toe of Cut
- Dredge Area Daylight
- Site Unit
- Existing Dock Structure to be Demolished
- Pile Removal, Dredging and Type 1 Cap Placement with Habitat Placement
- Side Slope Removal with Type 1 Cap
- Type 2 Cap with Habitat Placement

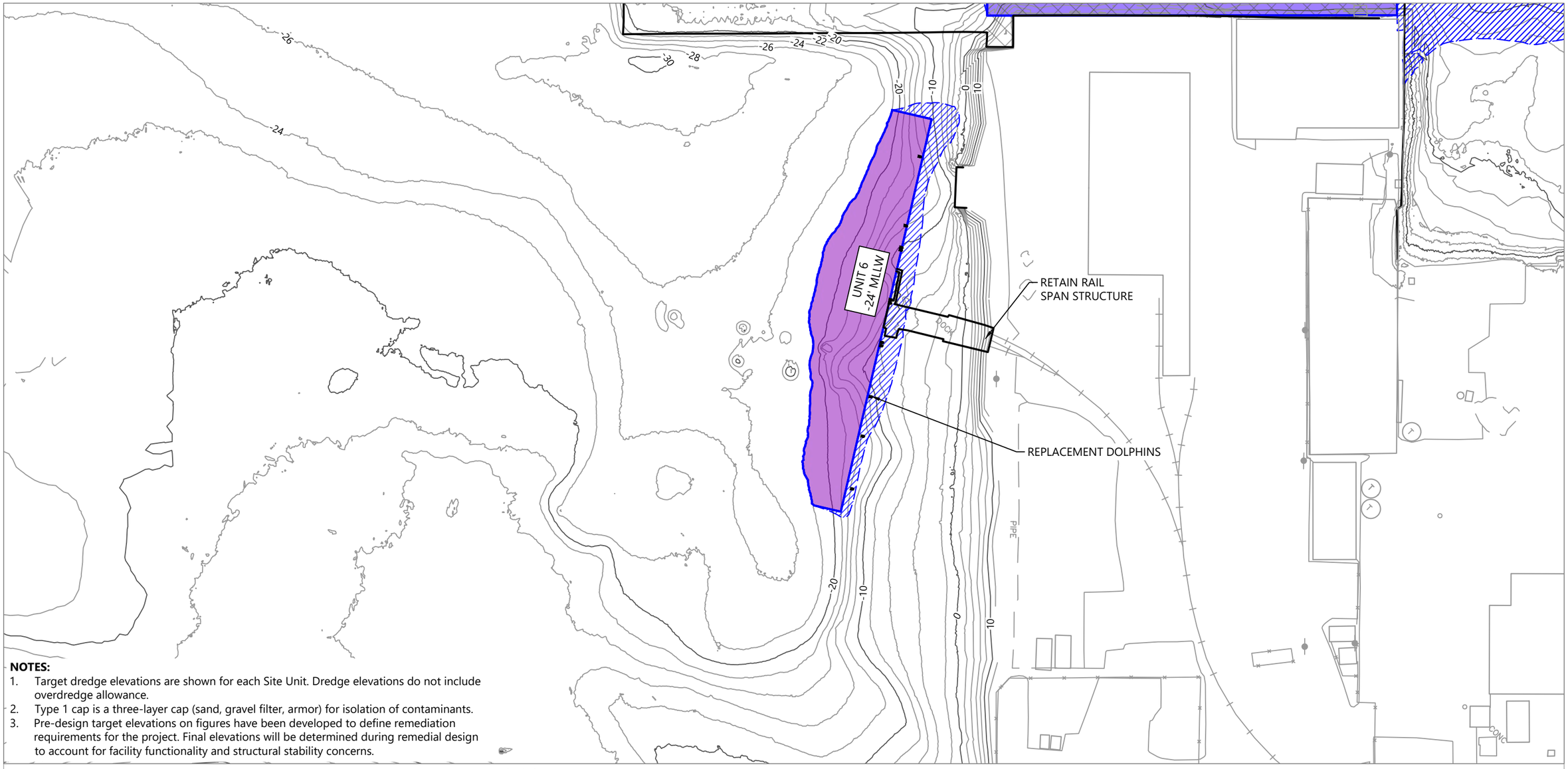
0 100
Feet

Publish Date: 2024/11/27 9:41 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-056.dwg Figure 6-4a

ANCHOR QEA

Figure 6-4a
Head of Waterway Dredging and Material Placement Plan
Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



NOTES:

1. Target dredge elevations are shown for each Site Unit. Dredge elevations do not include overdredge allowance.
2. Type 1 cap is a three-layer cap (sand, gravel filter, armor) for isolation of contaminants.
3. Pre-design target elevations on figures have been developed to define remediation requirements for the project. Final elevations will be determined during remedial design to account for facility functionality and structural stability concerns.

SOURCE: Existing bathymetry dated October 2019 and May 2021 (by Northwest Hydro Inc.) and November 2019 and September 2020 (by Wilson Engineering, LLC)
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)

LEGEND:

- Contours (2-foot and 10-foot Intervals)
- Dredge Area - Toe of Cut
- Dredge Area Daylight
- Site Unit
- Partial Dredging with Type 1 Cap
- Sideslope Removal with Type 1 Cap

0 150
Feet

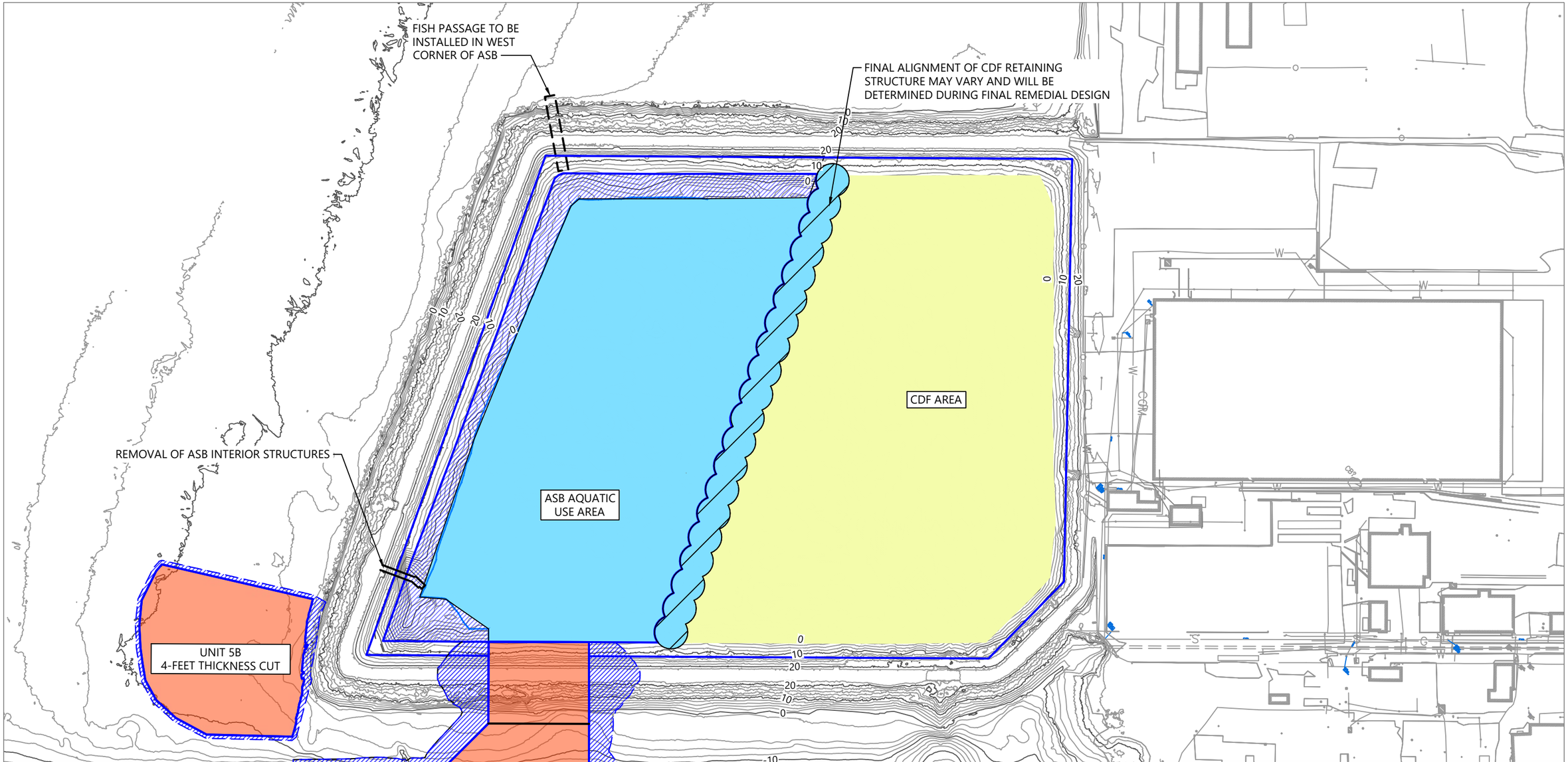
Publish Date: 2024/11/27 9:41 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-054.dwg Figure 6-5a

ANCHOR QEA

Figure 6-5a
Rail Span Area Dredging and Material Placement Plan

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



SOURCE: Existing bathymetry dated October 2019 and May 2021 (by Northwest Hydro Inc.) and November 2019 and September 2020 (by Wilson Engineering, LLC)
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)
NOTES:
1. Target dredge elevations are shown for each Site Unit. Dredge elevations do not include overdredge allowance.

LEGEND:

- Contours (2-foot and 10-foot Intervals)
- Federal Navigation Channel
- Dredge Area - Toe of Cut
- Dredge Area Daylight
- Site Unit
- Sediment Placement Area (CDF)
- Removal of ASB Soft Sediments and Portion of Clean Sand
- Full Dredge with RMC or Backfill
- Approximate Location and Extent of CDF Retaining Structure
- Access Channel Deepening Followed by Capping or RMC
- ASB Working Depth (-25' MLLW)
- Sideslope Removal to Prepare for Cap Placement

0 200
Feet

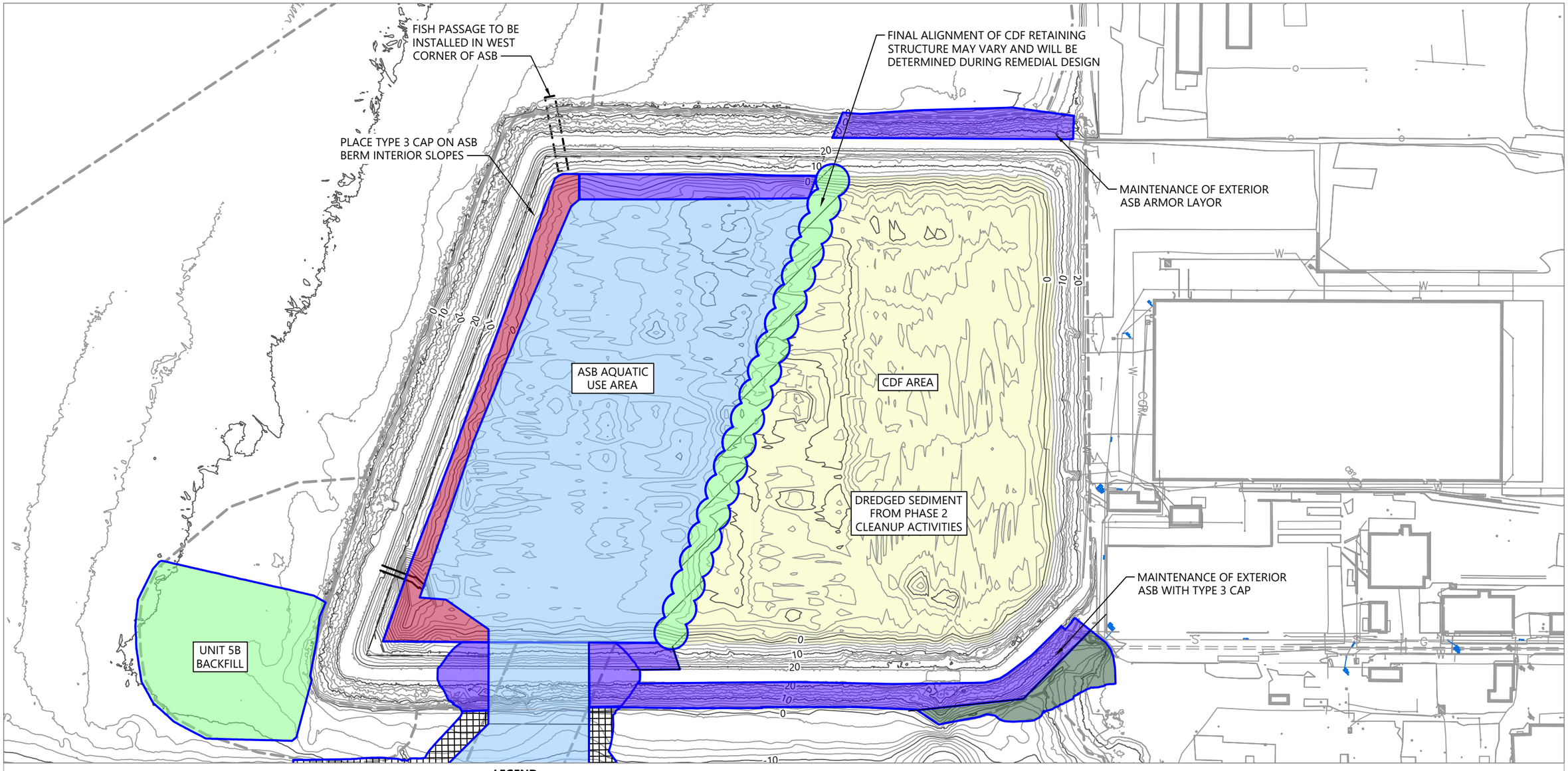
Publish Date: 2024/11/27 9:41 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-054.dwg Figure 6-6a

ANCHOR QEA

Figure 6-6a
ASB and ASB Shoulder Material Dredging Plan

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



SOURCE: Existing bathymetry dated October 2019 and May 2021 (by Northwest Hydro Inc.) and November 2019 and September 2020 (by Wilson Engineering, LLC)
HORIZONTAL DATUM: Washington State Plane North Zone, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM: Mean Lower Low Water (MLLW)
NOTES:
1. Type 1 cap is a three-layer cap (sand, gravel filter, armor) for isolation of contaminants.
2. Type 2 cap is a two-layer cap (gravel filter and armor) for erosion protection.

LEGEND:

- Contours (2' and 10' Intervals)
- Federal Navigation Channel
- Material Placement Area
- Site Unit
- Approximate Location and Extent of CDF Retaining Structure
- RMC (6" Sandy Material)
- Backfill to Grade with Clean Material
- Sideslope Removal with Type 1 Cap
- Type 1 Cap
- Type 3 Cap
- Type 3 Cap with Habitat Placement

0 200 Feet

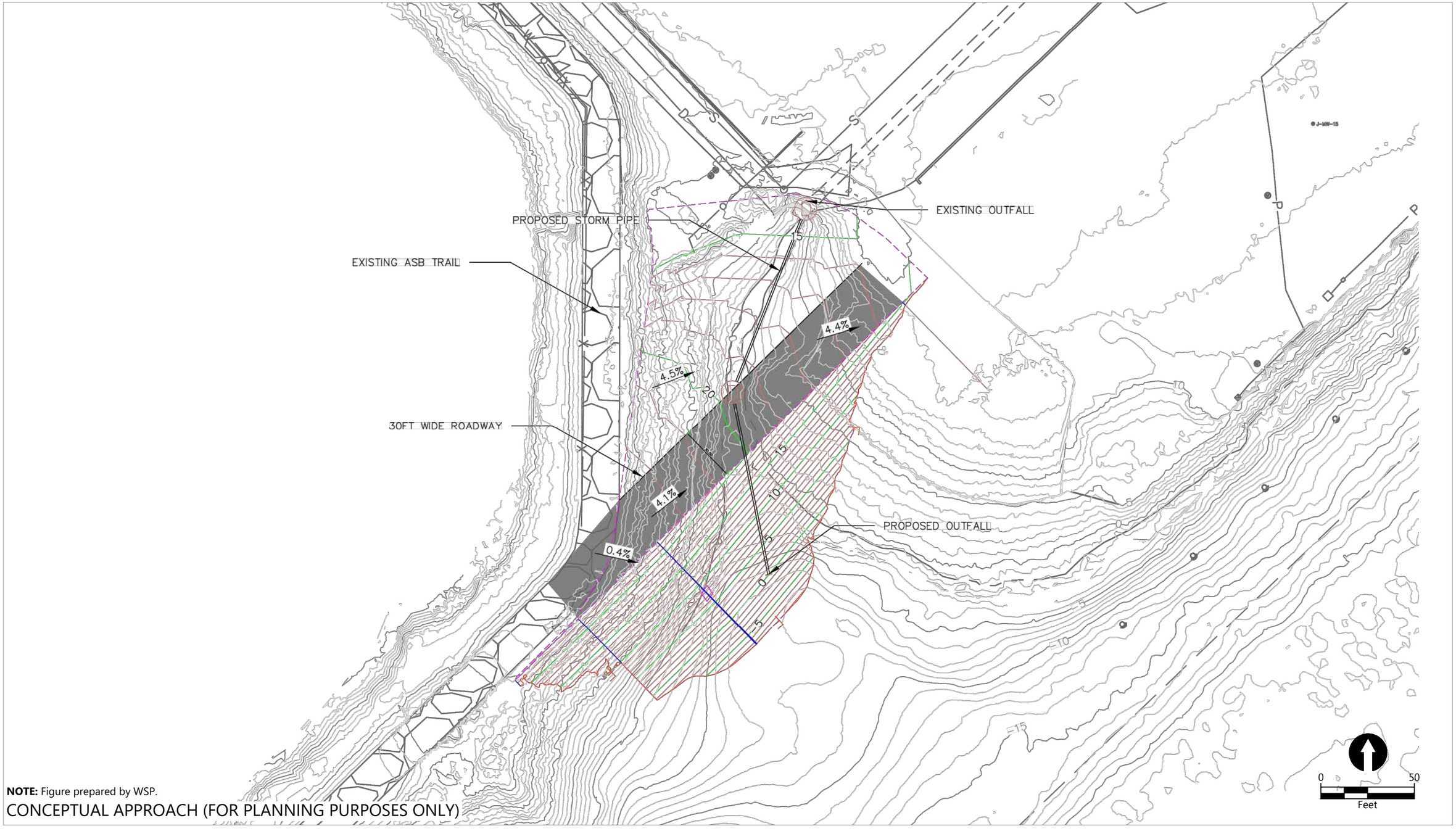
Publish Date: 2024/11/27 9:42 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-055.dwg Figure 6-6b

ANCHOR QEA

Figure 6-6b
ASB and ASB Shoulder Material Placement Plan

Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT



NOTE: Figure prepared by WSP.

CONCEPTUAL APPROACH (FOR PLANNING PURPOSES ONLY)

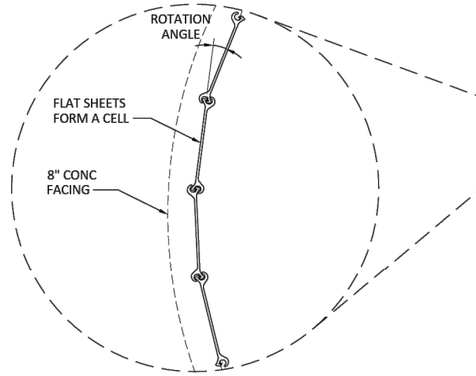
Publish Date: 2024/11/27 9:42 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-014 (CDF Retaining Structure - By WSP).dwg Figure 7-1

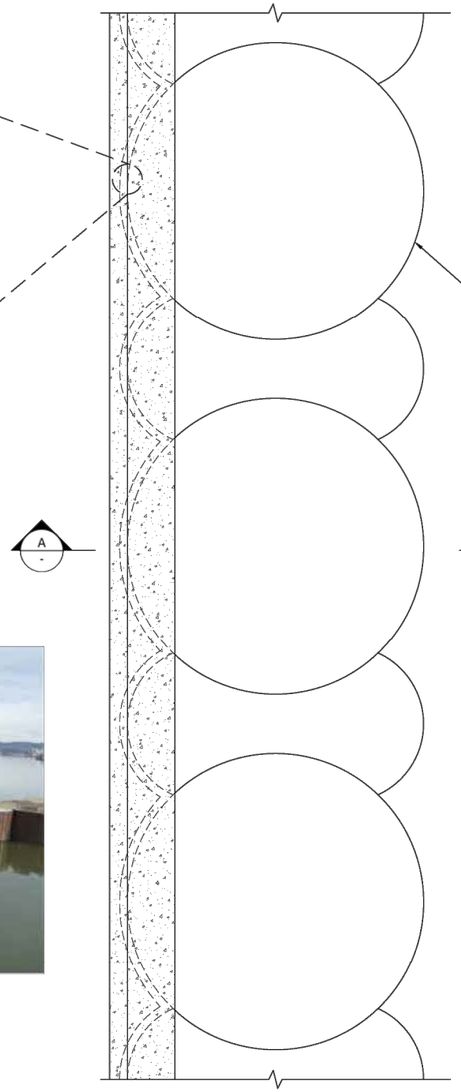
ANCHOR QEA

Figure 7-1
C Street Outfall Plan

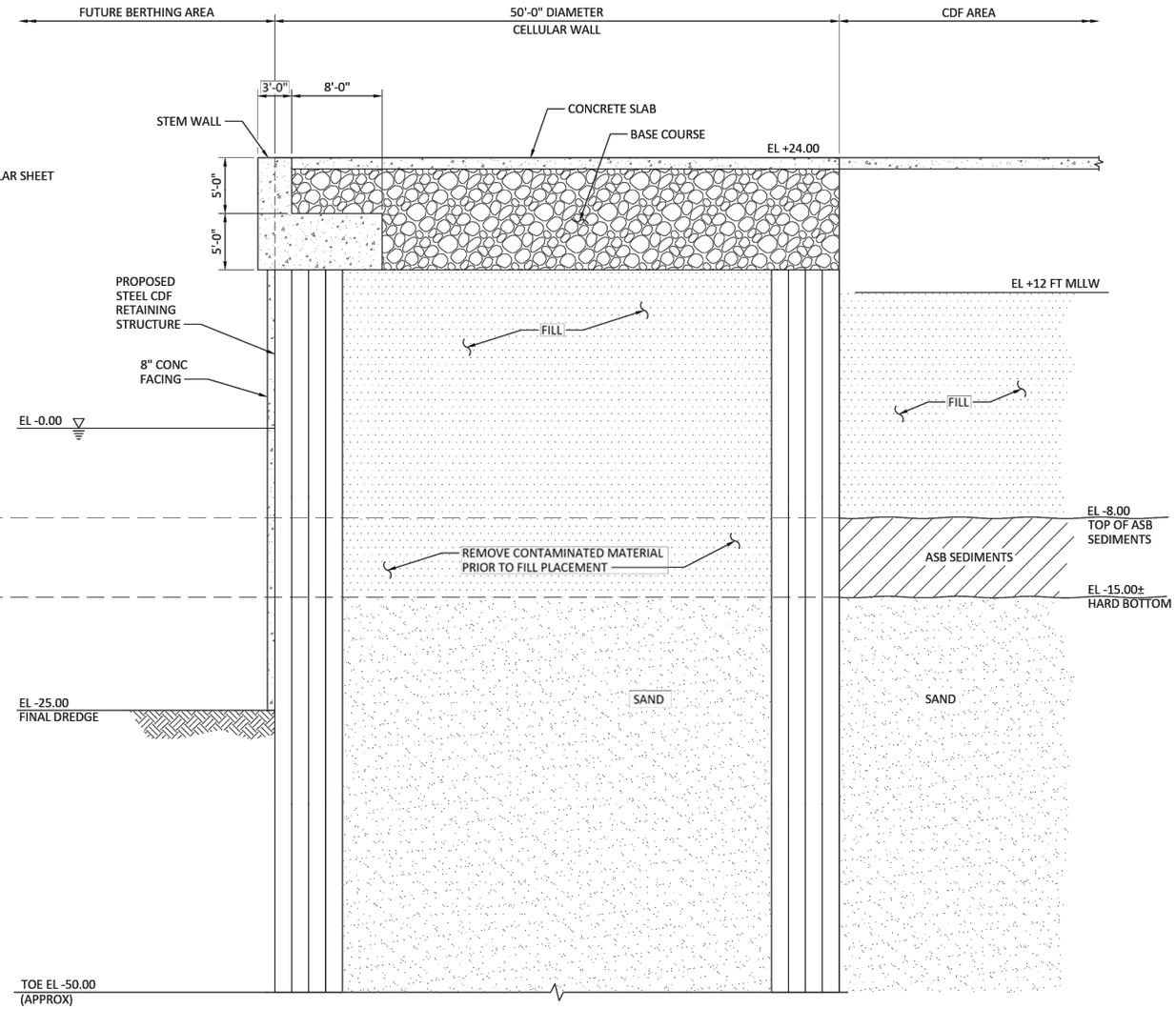
Engineering Design Report
Whatcom Waterway Phase 2 Cleanup

DRAFT





1 - **PLAN - STEM WALL OPTION**
SCALE:



A - **SECTION - STEM WALL OPTION**
SCALE:
1" = 6'
5 0 5 10
scale feet

NOTE: Figure prepared by WSP.

CONCEPTUAL APPROACH (FOR PLANNING PURPOSES ONLY)

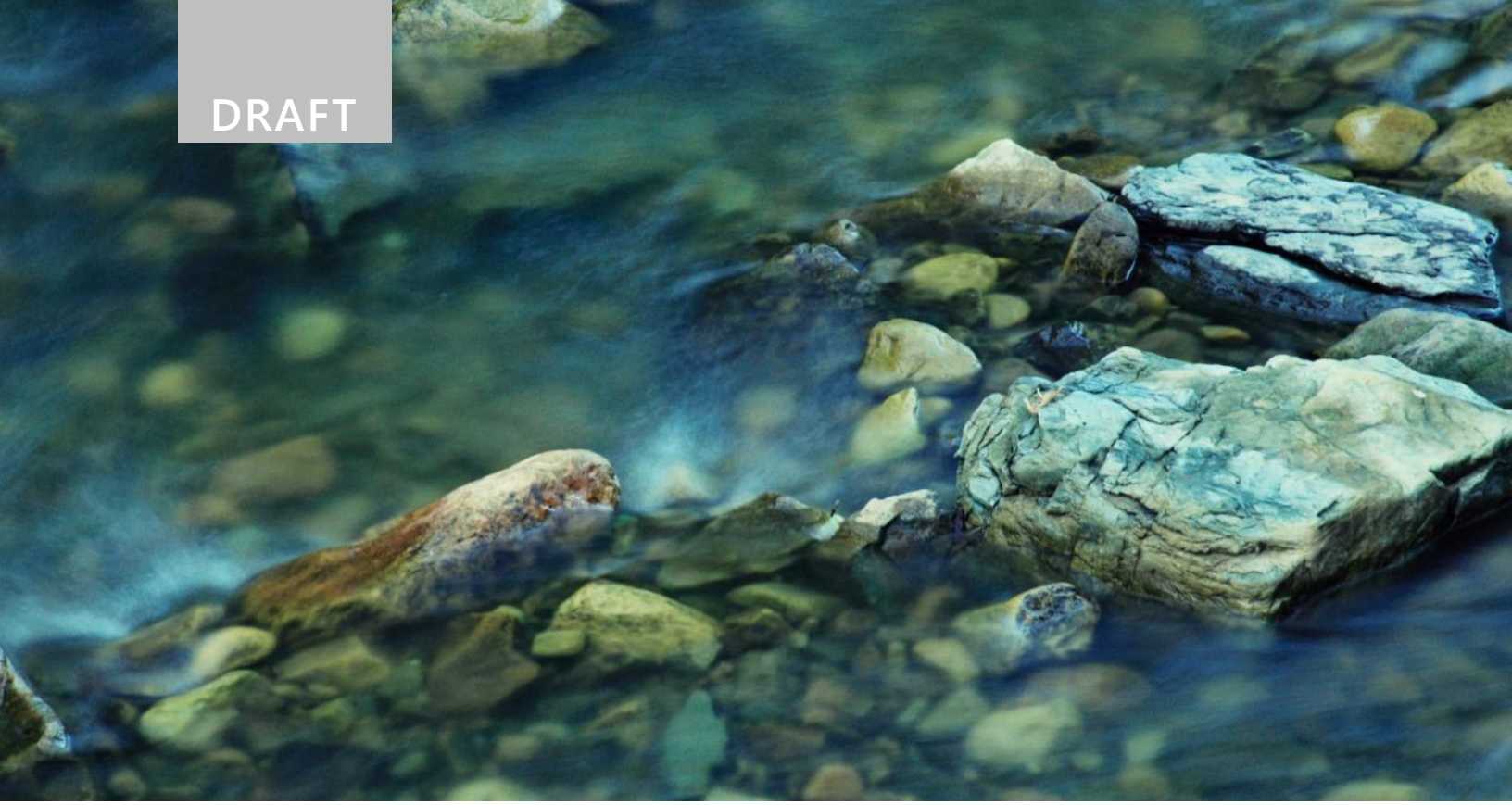
Publish Date: 2024/11/27 9:42 AM | User: chewett
Filepath: K:\Projects\0007 - Port of Bellingham\Whatcom Waterway Phase 2 Cleanup\0007-RP-014 (CDF Retaining Structure - By WSP).dwg Figure 7-2

Appendix A
Post-Cleanup Stormwater Plan
(Placeholder)

Appendix B
Geotechnical Evaluation
(Placeholder)

Appendix C
Coastal and Propwash Evaluation

DRAFT



June 2025
Whatcom Waterway Cleanup in Phase 2 Site Areas

ANCHOR QEA

Appendix C
Coastal and Propwash Evaluation

Prepared for Port of Bellingham

DRAFT

June 2025
Whatcom Waterway Cleanup in Phase 2 Site Areas

Appendix C
Coastal and Propwash Evaluation

Prepared for
Port of Bellingham
1801 Roeder Avenue
Bellingham, Washington 98227

Prepared by
Anchor QEA, Inc.
20 Bellwether Way, Suite 101
Bellingham, Washington 98225

Project Number: 190007-01.01

TABLE OF CONTENTS

1 Introduction 1

2 Site Conditions 2

2.1 Hourly Wind 2

2.2 Tidal Datums 3

2.3 Water Levels and Sea Level Rise 4

3 Coastal Engineering Evaluation 5

3.1 Wind-Generated Waves 5

3.2 Propeller Wash 6

3.3 Cap Armor Size Results 9

3.3.1 Wind-Waves 10

3.3.2 Propeller Wash 12

3.3.3 Summary 15

3.4 Filter Criteria 16

4 Summary and Discussion 18

5 References 19

TABLES

Table C-1 Summary of Data Used for Evaluation 2

Table C-2 Significant Wind Speeds for Return Interval Wind Events, Bellingham International Airport 3

Table C-3 Datum Elevations (NOAA Station No. 9449211) 3

Table C-4 Datum Elevations (NOAA Station No. 9449211) with Sea Level Rise 4

Table C-5 100-Year Return Period Wave Heights 6

Table C-6 Summary of Vessel Information 7

Table C-7 100-Year Wave Height Stable Armor Sizing Summary 11

Table C-8 Linear Wave Theory Stable Armor Sizing Summary 12

Table C-9 Propwash Velocities and Sediment Sizes 13

Table C-10 Summary of Propwash Velocities and Sediment Sizes 15

Table C-11 Summary of Cap Armor Design for Areas Subject to Propwash 15

Table C-12 Summary of Cap Armor Design for Areas Subject 100-year Return Period Wind-Waves 16

Table C-13 Summary of Filter Design Specifications 17

FIGURES

Figure C-1 Wind Rose

Figure C-2 Fetch Distances

Figure C-3 Vessel Positions by Category in the Project Area (January 2018 through November 2023)

Figure C-4 Relative Frequencies of Vessel Types in AOI 1 (January 2018 through November 2023)

Figure C-5 Relative Frequencies of Vessel Types in AOI 2 (January 2018 through November 2023)

Figure C-6 Propwash Evaluation Areas

ATTACHMENT

Attachment C-1 Plots for Peak Bed Velocities and Maximum Stable Armor Size

ABBREVIATIONS

ACES	Automated Coastal Engineering System
AIS	Automated Identification System
ASB	Aerated Stabilization Basin
BST	Bellingham Shipping Terminal
DWT	dead weight tonnage
hp	horsepower
H:V	horizontal to vertical
MHHW	mean higher high water
MLLW	mean lower low water
mph	miles per hour
NOAA	National Oceanic and Atmospheric Administration
propwash	propeller wash
Site	Whatcom Waterway Site
SLR	sea level rise
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency

1 Introduction

This appendix to the *Engineering Design Report* for the Phase 2 Site Areas of the Whatcom Waterway Site (Site) describes the coastal engineering evaluations that were conducted to develop design criteria for nearshore caps and shoreline stabilization within the Inner Waterway, Head of Waterway, and Rail Span areas. The Site is located in Bellingham, Washington, along the Waterfront District. Historically, the Site sediments have been impacted by mercury discharges from the former Georgia-Pacific West, Inc. chlor-alkali plant, wood waste and degradation products from historical log rafting activities, and phenolic compounds from pulp mill wastewater discharges.

This appendix provides the design criteria for shoreline and nearshore armor protection against erosive forces caused by wind-generated waves and propeller jets (propwash). Wind data, water level information, and vessel data were gathered as part of the analysis. The wind-wave evaluation included fetch-limited wave calculations to determine extreme wave heights (i.e., 100-year) and resultant wave orbital velocities and displacements for nearshore and shoreline armor components. The propwash evaluation included calculation of bed level propeller jet velocities for multiple vessel types known to operate within Whatcom Waterway.

The coastal evaluations presented in this appendix include the following:

1. Wind data gathered from the Bellingham International Airport meteorological station (NCEI 2021)
2. Water level data and discussion of sea level rise (SLR)
3. Wind-wave analysis using the Automated Coastal Engineering System (ACES) wave prediction model (USACE 1992)
4. Propwash evaluation using Automated Identification System (AIS) data to gather vessel data (NOAA and USCG 2023)
5. Stable armor stone sizing calculations to protect against both wind-wave and propwash forces

2 Site Conditions

The coastal engineering evaluation for Whatcom Waterway relied on multiple data sources to evaluate wind-wave and hydrodynamic conditions as well as reviewing previously completed coastal engineering evaluations for the design of engineered sediment caps. The various data sources used in these evaluations are provided in Table C-1.

Table C-1
Summary of Data Used for Evaluation

Data Type	Data Source (Author and Date)	Purpose of Data
Hourly Wind	Bellingham International Airport (1948–2021)	Wave calculation input
Tidal Datums	NOAA Tidal Station No. 9449211	Water levels (see Table C-2)
Water Levels and SLR	NOAA Chart – 18424 Public	Wave calculation input

2.1 Hourly Wind

A range of extreme wind speeds for various return intervals, including 1-year, 2-year, 10-year, 20-year, 50-year, and 100-year return periods, were estimated based on the historical wind record dataset from the Bellingham International Airport meteorological station located approximately 4 miles northwest of the Site (NCEI 2021). Hourly wind data measurements for years 1948 to 2021 recorded approximately 10 meters above the ground were obtained per methodology outlined in the U.S. Army Corps of Engineers (USACE) Coastal Engineering Manual (USACE 2006). Figure C-1 illustrates a wind rose of the combined dataset.

The historical wind gage data were compiled into eight directional bins based on the wind rose, each encompassing a 45-degree range starting from 22.5°N. For each directional bin, the maximum annual wind speed was identified. A statistical analysis of the maximum annual wind speed for each directional bin was performed by applying five candidate probability distribution functions (Fisher-Tippet Type I and Weibull distributions with exponent k varying from 0.75 to 2.0). These distributions were fitted to the maximum annual wind speed in each directional bin to estimate each return interval event wind speed in each directional bin. Return-period wind speeds are summarized in Table C-2. Although the dominant wind direction is from the south, the winds from the northwest, west, and southwest yield the largest fetch lengths at the Site (see Figure C-2).

Table C-2
Significant Wind Speeds for Return Interval Wind Events, Bellingham International Airport

Direction	1-Year (mph)	2-Year (mph)	10-Year (mph)	20-Year (mph)	50-Year (mph)	100-Year (mph)
North	12.2	40.3	45.4	52.0	52.0	57.0
Northeast	20.7	33.0	49.7	55.6	63.0	68.2
East	12.8	17.6	36.6	46.6	61.1	72.8
Southeast	22.1	34.1	50.3	56.1	63.2	68.3
South	26.9	36.1	50.7	55.5	61.4	65.7
Southwest	9.5	24.2	44.2	51.4	60.2	66.5
West	14.4	18.3	33.8	41.9	53.7	63.2
Northwest	13.7	16.1	25.3	30.2	37.3	43.0

2.2 Tidal Datums

Tidal heights in the adjacent Bellingham Bay were taken from the closest National Oceanic and Atmospheric Administration (NOAA) tidal station No. 9449211, which was located at the site at the southwest end of the Bellingham Shipping Terminal (BST) North Terminal. Table C-3 summarizes various tidal datums relative to the mean lower low water (MLLW) datum from this station.

Table C-3
Datum Elevations (NOAA Station No. 9449211)

Tide Level	Feet (MLLW)
Highest Observed (1/5/1975)[1]	10.4
Mean Higher High Water	8.5
Mean High Water	7.8
Mean Tide Level	5.1
Mean Sea Level	5.0
Mean Low Water	2.4
Mean Lower Low Water	0.0
Lowest Observed (12/30/1974)	-3.5
North American Vertical Datum of 1988	0.5

Notes:

1. Station No. 9449211 was active from March 30, 1973, to July 21, 1975. Tidal predictions for the area have been higher and lower than those observed.

2.3 Water Levels and Sea Level Rise

The Whatcom County Natural Hazards Mitigation Plan was last updated in October 2021 by the Whatcom County Sheriff's Office Division of Emergency Management. The plan was updated to mitigate damage caused by future natural hazards and natural disasters. Section 3 of the plan includes guidance for SLR considerations for future development. The guidance indicates that infrastructure and development within the Waterfront District will be constructed to accommodate long-term SLR conditions of 50 inches (4.2 feet) over the next 100 years (WCSD-DEM 2021). Based on this magnitude of SLR, Table C-4 summarizes the resultant future tidal levels. Water depths in feet MLLW, reported June 12, 2023, for Bellingham Bay were obtained from NOAA Chart 18424 (NOAA 2023). Note that water depths have been updated (December 12, 2023) for NOAA Chart 18424 since the time the coastal evaluation was conducted, and the chart will be canceled June 5, 2024.

Table C-4
Datum Elevations (NOAA Station No. 9449211)
with Sea Level Rise

Tide Level	Feet (MLLW) + SLR
Mean Higher High Water	12.7
Mean High Water	12.0
Mean Sea Level	9.2
Mean Low Water	6.6
Mean Lower Low Water	4.2
North American Vertical Datum of 1988	4.7

3 Coastal Engineering Evaluation

The coastal engineering evaluation included evaluation of wind-generated waves and propeller wash. This section will describe those evaluations and the resulting recommendation for cap armoring and filter material. Because currents and vessel wakes were not considered to have large values outside Whatcom Waterway, currents and vessel wakes were not reviewed in this evaluation; however, assessment of these erosive forces and processes may be considered in future phases of engineering design.

3.1 Wind-Generated Waves

To evaluate a range of wave conditions that could potentially impact the Site from various directions, wind-generated wave growth was computed along fetch alignments estimated by Anchor QEA. Fetches, shown in Figure C-2, were selected to comprise the longest potential wave paths incidental to the Site. Five fetch lengths were selected allowing the following directions: northwest (293 degrees from north), west-southwest (258 degrees from north), west (270 degrees from north), west-southwest (232 degrees from north), and southwest (212 degrees from north). Water depths in feet relative to MLLW along the fetches were gathered from NOAA Chart 18424 (NOAA 2023a). The water depths along the fetches were averaged and converted to mean higher high water (MHHW) in reference to NOAA Tidal Station No. 9449211 (NOAA 2023b). Total water depths for each fetch were then determined by adding 50 inches of SLR from the projected SLR range for the Waterfront District (WCSD-DEM 2021).

Wind-generated wave growth calculations were performed using the USACE ACES software (USACE 1992). Predicted values of extreme wind speeds from station WPOW1 were used as input into ACES using the Windspeed Adjustment and Wave Growth module (fetch limited) to predict significant wave heights and peak wave periods generated by the extreme winds. The 100-year return interval zero-moment wave height and peak wave period were calculated along each of the five fetch alignments based on the 100-year wind speeds. The fetch lengths, wind direction, and average water depth with added SLR along each fetch are presented in Table C-5.

Table C-5
100-Year Return Period Wave Heights

Fetch Direction	100-Year Wind Speed	Approximate Fetch Length (miles)	Average Water Depth (feet)	100-Year Wave Height (feet)	Peak Wave Period (seconds)
Northwest (293 degrees)	43.0	4.2	13	1.4	2.2
West (270 degrees)	63.2	5.9	16	2.7	3.0
West-southwest (258 degrees)	63.2	6.9	18	3.2	3.2
South-southwest (232 degrees)	66.5	7.8	21	3.7	3.5
Southwest (212 degrees)	66.5	8.4	24	3.9	3.5

Based on the calculated wave heights, the largest waves approach from the southwest with a height of 3.9 feet and a period of 3.5 seconds.

3.2 Propeller Wash

As a vessel or boat moves through the water, the propeller produces a turbulent underwater jet called propeller wash (propwash). Where the jet reaches the mudline, it can contribute to resuspension or movement of bottom particles. Potential propwash impacts were evaluated using the methods presented in U.S. Environmental Protection Agency's (USEPA's) *Armor Layer Design for the Guidance for In-Situ Subaqueous Capping of Contaminated Sediment* (Maynord 1998). This method is based on the relationships developed by Blaauw and van de Kaa (1978) and Verhey (1983). The USEPA model considers physical vessel characteristics (e.g., propeller diameter, depth of propeller shaft, and total engine horsepower [hp]) and operating and site conditions (e.g., applied hp and water depth) to estimate bottom-level propwash velocities at various distances behind the propeller. A site-specific analysis of propwash was conducted for six cross-sectional areas within Whatcom Waterway. It is important to note that when vessels operate at some sailing speed, the duration and magnitude of the propwash acting on the seabed are reduced, but for purposes of this analysis, static vessel conditions for evaluating potential propwash impacts were used to reflect that vessels are moving very slowly while performing navigation and docking/undocking operations.

The propwash analysis consisted of the following components:

1. Representative vessels that are known to operate within Whatcom Waterway were selected for the propwash evaluation.

2. Representative vessel characteristics (e.g., draft, propeller type, dimensions) were obtained.
3. Vessel operating information and assumptions (e.g., operating horsepower and vessel location and orientation) were defined based on guidance documents.
4. Site-specific conditions (e.g., bathymetry) were obtained.
5. Based on the above range of operational and site-specific conditions, the range of stable armor stone size necessary to withstand the erosive forces associated with propwash was computed for each scenario.

Typical vessel operations within Whatcom Waterway were determined by gathering AIS vessel data from 2018 to 2023 from Access AIS (NOAA and USCG 2023) for two areas of interest. The first area of interest was used to observe vessels within Whatcom Waterway, and the second area of interest was used to observe vessels outside Whatcom Waterway. The vessels were selected based on vessel length and frequency of occurrence (Figures C-3, C-4, and C-5). Table C-6 provides a list of the design vessels identified for the propwash evaluation based on the AIS data.

Table C-6
Summary of Vessel Information

Vessel Group	Vessel Name or Class	Length (feet)	Draft (feet)	Propeller Diameter (feet)	Horsepower (hp)
Tug Tow	*Brian S.*	98	13.1	6.7	3,000
Tug Tow	*Kinani H.*	110	15.4	8.3	4,800
Fishing	*The Duchess*	105	9.2	1.3	14
Fishing	*Northern Eagle*	341	23.3	6.2	1,069

The vessels used in this analysis include two tugboats and two fishing vessels. The tugs included the *Brian S.*, a dual-propeller, 98-foot-long tow vessel operated by Harley Marine Services with a maximum engine power of 3,000 hp; and the *Kinani H.*, a dual-propeller, 110-foot-long tow vessel operated by Boyer Towing Inc. with a maximum engine power of 4,800 hp. It was assumed that the *Brian S.* and the *Kinani H.* had two propellers, but for the propwash evaluation only one propeller for each vessel was used, splitting the horsepower to 1,500 and 2,400 hp. The fishing vessels included *The Duchess*, a 105-foot-long commercial fishing vessel with a draft of 9 feet and a maximum engine power of 14 hp; and the *Northern Eagle*, an approximately 341-foot-long vessel with a draft of 23 feet and a maximum engine power of 1,069 hp.

Where available, specific vessel parameters were obtained from MarineTraffic (MarineTraffic 2023) and Tugboat Information (Tugboat Information 2023). A set of equations derived from World Association for Waterborne Transport Infrastructure (PIANC) curves were used to estimate unavailable vessel details (DSI 2021; PIANC 2015). Dead weight tonnage (DWT) was calculated from

vessel length for *The Duchess*. DWT for the *Northern Eagle* was obtained from MarineTraffic (MarineTraffic 2023). Horsepower (hp) was calculated from DWT for both fishing vessels, and propeller diameter was calculated from hp for all three vessels except the *Brian S.*; propeller diameter for the *Brian S.* was obtained from Tugboat Information (Tugboat Information 2023).

The following Site remediation areas (for planned dredging and capping) are subject to propwash forces and were reviewed as part of this evaluation. A plan view of the cross sections (Cross Sections 1 through 8) taken at each site remediation area for the purpose of propwash evaluation is shown in Figure C-6:

6. Unit 6 is located to the south of the BST. Although the Tow Tugs primarily frequent this area, fishing vessels were also evaluated. The bed elevations (pre-dredge and capping) within the capping area (Cross Section 1) ranged from 14.8 to -22 feet MLLW.
7. The BST Dock Area is located within the footprint of the BST Dock north and central terminals, which are near the navigation channel at the entrance of Whatcom Waterway. The bed elevations evaluated for the dredging area (Cross Section 6) ranged from 0.8 to -28.0 feet MLLW.
8. The BST/Log Pond Corner is located adjacent to the BST Dock north terminal. The bed elevations evaluated for the capping area (Cross Section 4) ranged from -5.1 to -32.2 feet MLLW.
9. Unit 2C is located primarily within the central area of Whatcom Waterway between the Aerated Stabilization Basin (ASB) and the BST Dock, Log Pond, and GP Dock. The bed elevations in the capping area (Cross Sections 3 and 7) ranged from -23.0 to -29.6 feet MLLW.
10. Unit 2B is located north of Unit 2C and expands into the ASB Aquatic Use area. The bed elevations in the capping area (Cross Section 2) ranged from -4.6 to -8.5 feet MLLW.
11. The GP Dock Area is located adjacent to the northeast corner of the Log Pond area. The bed elevations in the capping area (Cross Section 8) ranged from 13.8 to -24.4 feet MLLW.

Static vessel conditions for evaluating potential propwash impacts were used to reflect that vessels are moving very slowly while performing docking operations (and start from a still-position when departing).

To assess the propwash effects on the seabed, the Maynord (1998) and Blaauw and van de Kaa (1978) methods were used to compute near-bed velocities. Equation C-2 from Blaauw and van de Kaa (1978) predicts the propeller jet velocity at any location below (z distance) and aft of (x distance) the vessel propeller. The result is a velocity "field" that depicts the propwash jet and the intersection of the jet with the bottom elevation. The predicted propwash jet velocity at the bed elevation behind the propeller was extracted from the velocity field.

Equation C-1

$$V_x = 2.78 \times V_0 \times \frac{D_0}{x} \exp\left(-15.43\left(\frac{z}{x}\right)^2\right)$$

where:

V_x	=	axial velocity in a field point (meters per second [m/s])
D_0	=	initial diameter of slipstream (meters)
x	=	axial distance from propeller plane (meters)
z	=	vertical distance from propeller axis (meters)
V_0	=	axial efflux velocity of propeller (m/s)

Equation C-1 was used to compute propwash velocity for each tug and fishing vessel based on their specifications and operating conditions. Bathymetric survey data in MLLW datum were extracted for seven areas within the Site to analyze propwash velocity field with respect to bed elevation. Assumed vessel operating power was determined based on PIANC guidance (PIANC 2015). The Tow Tugs were assumed to operate at 100% of their total engines' hp. To capture more frequent vessel operations, all vessels were evaluated for 20% of their total engine hp. Evaluations for all vessels started at the left edge of each cap except Cross Section 6, which started at the right edge of the cap. All vessels were offset by 100 feet at Cross Sections 4 and 6 and offset by 50 feet at Cross Section 8.

Specific design vessels, vessel information, vessel parameters, operation locations, and operating conditions used in this evaluation were developed using the best available data and design guidance documents. These evaluations will be confirmed and refined through discussion about site-specific operating conditions during later phases of design.

3.3 Cap Armor Size Results

The armor and shoreline protection stone size requirements for sediment caps that will be constructed as part of remediation are based on the combined influences of waves and propwash, as described in the previous sections of this appendix. This section provides a summary of how selected wind-wave and propwash forces were used to identify stable sediment and rock sizes for design and implementation of the planned remediation activities within Whatcom Waterway.

The criteria for design of armor protection are as follows:

12. Estimate design wave heights and periods
13. Determine stable armor size and thickness due to the identified hydrodynamic forces

3.3.1 Wind-Waves

As waves propagate towards shore, water depth begins to affect the wave properties. Within shallower water, waves will become constricted by the seabed and experience shoaling where the wave slows down, wavelength shortens, and the wave height increases, eventually becoming over steepened and breaking on the shoreline. The area where waves first begin to break defines the waterward boundary of the breaker zone. Areas impacted by wind-generated waves include the shoreline and nearshore zones. The shoreline includes areas within and above the breaker zone that breaking waves may impact. Nearshore areas include areas outside of the breaker zone where impacts from passing waves are still felt by the seabed. Within Unit 3A (Head of Waterway), where vessels are not expected to operate, stable stone sizes were calculated for the nearshore and shoreline areas.

To calculate the stable armor size for the nearshore and shoreline against wind-waves, this evaluation conservatively assumes a wave height of 1.5 times the maximum calculated 100-year wind-generated wave height presented in Table C-5 to account for potential wave reflection that may occur against sloped and armored shorelines.

For waves within the breaking zone that impact the shoreline, stable armor sizes were estimated using the ACES Revetment and Rubble Mound module (USACE 1992). The D_{50} armor and filter sizes and armor thicknesses were calculated for estimated 100-year wave heights and wave periods along a 3-foot horizontal to 1-foot vertical slope (3H:1V). A permeability coefficient of "0.4" and a damage level of "2," which allows for some movement of armor rock under storm events, were used in the modeling. A summary of the 100-year wave height stable armor sizing based on these parameters is provided in Table C-7.

Table C-7
100-Year Wave Height Stable Armor Sizing Summary

Wind Direction	Design Slope	100-Year Wave Height	Reflected 100-Year Wave Height	100-Year Wave Period (seconds)	Stable Armor Stone Size (D_{50}; inches)	Stable Armor Thickness (inches)	Stable Filter Stone Size (D_{50}; inches)
Northwest (293 degrees)	3H:V1	1.4	2.1	2.2	6.5	13	0.8
West (270 degrees)	3H:V1	2.7	4.1	3.0	10.1	20.2	1.2
West-southwest (258 degrees)	3H:V1	3.2	4.8	3.2	11.7	23.4	1.4
South-southwest (232 degrees)	3H:V1	3.7	5.6	3.5	13.7	27.4	1.7
Southwest (212 degrees)	3H:V1	3.9	5.9	3.5	14.3	28.6	1.8

Note:
D_{50}: nominal rock size (diameter) of which 50% of the rocks are smaller.

Outside of the breaking zone, significant wave energy can create large bottom velocities from wave orbitals that oscillate beneath propagating waves. USACE ACES Linear Wave Theory was used to compute peak bottom orbital velocity (USACE 1992). Stable armor stone size for the nearshore was calculated using Equation C-2 (Blaauw et al. 1984). A coefficient C_3 = 1.7 was used, which allows for no sediment movement, as recommended for orbital velocities beneath waves (Maynord 1998).

Equation C-2

$$D_{50} = \frac{{V_b}^2}{{C_3}^2 * g * A}$$

where:

D_{50}	=	median stone size (feet)
V_b	=	maximum horizontal bed level wave orbital velocity (feet/second)
C_3	=	coefficient (1.7 for passing waves)
g	=	gravitational constant (32.3 feet/square second)
A	=	ratio of unit weight of water to buoyant unit weight of stone

The maximum peak orbital velocity for a 5.9 foot wave was 4.4 feet per second, as summarized in Table C-8.

Table C-8
Linear Wave Theory Stable Armor Sizing Summary

Water Depth (feet)	Reflected 100-Year Wave Height (feet)	Peak Orbital Velocity (feet per second)	Stable Armor Stone Size (D_{50}; inches)
8.5	5.9	4.4	3.9 inches (0.3 foot)

The stable armor size required to protect against peak orbital bed velocities in the nearshore zone is 3.9 inches.

3.3.2 Propeller Wash

To protect against propwash forces, the median stone size of the armor component for caps in areas where vessels operate was calculated based on the maximum bed level propeller jet velocities using Equation C-3 (Blaauw et al. 1984). A coefficient C_3 = 0.55 was used, which is recommended for use in harbor areas where repeated attack can be expected and no particle movement is allowed (Maynord 1998).

Equation C-3

$$D_{50} = \frac{{V_b}^2}{{C_3}^2 * g * A}$$

where:

D_{50}	=	median stone size (feet)
V_b	=	maximum bed level propeller jet velocity (feet/second)
C_3	=	coefficient (0.55 for no sediment movement, 0.6 for infrequent attack; 0.7 for small sediment transport and/or infrequent attack)
g	=	gravitational constant (32.3 feet/square second)
A	=	ratio of unit weight of water to buoyant unit weight of stone

The plots for peak bed velocities and maximum stable armor size (D_{50}) for the propwash evaluation are summarized in Table C-9 and can be found in Attachment C-1 (Figures 1a through 1g to 6a through 6g).

Table C-9
Propwash Velocities and Sediment Sizes

Cap Area[1]	Vessel Name	Engine Horsepower (%)	Maximum Bed Level Velocity (feet/sec)	Maximum Stable Armor Stone Size (D_{50}, inches)
Unit 6 (Cross Section 1)	*Brian S.*	20	3.3	8.3
		100	5.6	24.2
	Kinani H.	20	3.8	11.3
		100	6.5	33.1
	The Duchess	20	0.4	0.1
	Northern Eagle	20	13.6	145.5
BST/Log Pond Corner (Cross Section 4)	*Brian S.*	20	1.8	2.4
		100	3.7	10.8
	Kinani H.	20	2.2	3.7
		100	3.0	7.1
	The Duchess	20	0.5	0.2
	Northern Eagle	20	6.2	30.3
BST Dock Area (Cross Section 6)	*Brian S.*	20	2.2	3.7
		100	4.6	16.4
	Kinani H.	20	2.7	5.6
		100	3.7	10.7
	The Duchess	20	0.8	1.0
	Northern Eagle	20	2.2	45.6
Unit 2C (Cross Section 3)	*Brian S.*	20	1.4	1.5
		100	2.4	4.4
	Kinani H.	20	1.7	2.2
		100	2.9	6.4
	The Duchess	20	0.2	0.0
	Northern Eagle	20	6.2	30.3
Unit 2C (Cross Section 7)	*Brian S.*	20	1.4	1.5
		100	2.4	4.4
	Kinani H	20	1.7	2.2
		100	2.9	6.4
	The Duchess	20	0.2	0.0
	Northern Eagle	20	2.4	4.5

Cap Area[1]	Vessel Name	Engine Horsepower (%)	Maximum Bed Level Velocity (feet/sec)	Maximum Stable Armor Stone Size (D_{50}, inches)
Unit 2B (Cross Section 2)	*Brian S.*	20	5.6	24.6
		100	9.6	71.8
	Kinani H.	20	8.8	60
		100	15.0	175.4
	The Duchess	20	0.7	0.4
	Northern Eagle	20	1.7	2.4
GP Dock Area (Cross Section 8)	*Brian S.*	20	1.9	2.8
		100	3.2	8.1
	Kinani H.	20	2.3	4.2
		100	4.0	12.2
	The Duchess	20	0.2	0.0
	Northern Eagle	20	4.5	16.1

Note:
Cross-section locations for each site remediation area are shown in Figure C-6 with associated peak bed velocities and maximum stable armor size (D_{50}) found in Attachment C-1 (Figures 1a through 1g to 6a through 6g).

The results of the propwash evaluation indicate that cobble- to boulder-sized material may be required to protect against erosive forces generated by vessel operations. In some scenarios, very large stone armor sizes were calculated due to the assumed orientations, water depths, and vessel operating conditions. In these cases, vessel operations were assumed to be closer to the shoreline or in very shallow water where propellers were positioned at the mudline while operating at high horsepower. These specific scenarios may not be reflective of appropriate design-level evaluations because they over-conservatively assume vessel operations in areas that may not experience propwash or may not be subject to operations that require up to 100% of the engine's horsepower. Post-capping/dredging elevations may also need to be considered based on future design requirements, especially for the BST Dock Area (dredge area). Table C-10 summarizes the propwash evaluation for each Site area that was evaluated based on the representative vessel scenario considered for each area.

Table C-10
Summary of Propwash Velocities and Sediment Sizes

Unit	Vessel	Percentage of Vessel Horsepower	Maximum Bed Level Velocity (feet/second)	Stable D50 (inches)	Armor Material
Unit 6	*Brian S.*	100%	5.6	16	Boulders
BST/Log Pond Corner	*Brian S.*	100%	3.7	12	Cobbles to small boulders
BST Dock Area	*Brian S.*	100%	4.6	16	Boulders
Unit 2B, Unit 2C	*Brian S.*	100%	3.7	12	Cobbles to small boulders
GP Dock Area	*Northern Eagle*	20%	4.5	16	Boulders

3.3.3 Summary

The results of the propwash and wind-wave evaluations presented in this appendix indicate that the dominant erosive force within Whatcom Waterway is propwash jet velocities. The evaluations presented in this appendix are reflective of areas where vessel operations have been observed previously, although those areas may need refinement as the expected vessel operations following the completion of the remedial design within Whatcom Waterway may dictate different vessel operations than those assumed in this evaluation and may also consider additional Site areas such as the interior of the ASB and at the head of the waterway. In areas where vessels are not expected to operate, propwash is neglected and the armor component of caps in those areas (i.e., Unit 3A) should be sized appropriately to protect against erosive forces due to wind-generated wave action. Tables C-11 and C-12 summarize the stable stone size for armor components of cap design within each area.

Table C-11
Summary of Cap Armor Design for Areas Subject to Propwash

Unit	Stable D50 (Inches)	Armor Thickness (Inches)
Unit 6	16	32
BST/Log Pond Corner	12	24
BST Dock Area	16	32
Unit 2B/2C	12	24
GP Dock Area	16	32

Table C-12
Summary of Cap Armor Design for Areas Subject 100-year Return Period Wind-Waves

Unit	Reflected 100-Year Wave Height (feet)	Water Depth (feet)	Bed Level Velocity (feet/second)	Stable D50 (Inches)	Armor Thickness (Inches)
Unit 3A	5.9 feet	<7.5 (breaking zone)	--	14	28
		>7.5	4.4	4	8

Vessel wakes were not evaluated as part of this analysis, although they are not expected to surpass the 100-year wave heights suggesting shoreline armor for wind-waves will also be protective for vessel wakes.

3.4 Filter Criteria

In most cases, the armor material is too large to place directly onto cap material or native sediment due to the risk of sediment piping, and therefore a filter material layer is needed. The required filter layer details are identified and calculated based on the largest predicted median particle size (D_{50}) required for the armor layer in each area where the sediment cap is being constructed. The standard geotechnical filter criteria presented by Palermo et al. (1998) is used to determine whether fine-grained underlying sediments or underlying cap material is susceptible to piping between void spaces of the overlying erosion protection armor layer. The minimum filter criteria suggest that four times the D_{85} size (85% passing by weight sieve size) of the underlying material should be greater than the D_{15} size (15% passing by weight sieve size) of the overlying material, as shown in Equation 3:

Equation 3

$$\frac{d15(armor)}{d85(\text{filter})} < 4$$

where:

$d_{15(armor)}$ = The 15% passing sieve size of the overlying armor material by weight
$d_{85(\text{filter})}$ = The 85% passing sieve size of the underlying material by weight

The thicknesses of the layers are based on standards outlined in the Coastal Engineering Manual, which states that the thickness of the armor should be two times the D_{50} of the armor stone. Based on the armor criteria, a filter material with a D_{50} of 2 inches (i.e., gravel) is recommended beneath armor material for areas where sediment caps will be constructed (Table C-13) except for the nearshore zone (outside of the wave breaking zone) where stable stone sizes are small enough to be

placed without a filter layer. The suggested minimum thickness for filter material is 3 times median stone size, or 6 inches (USACE 2002).

Table C-13
Summary of Filter Design Specifications

Filter Requirement	Specification
Specified Bottom Filter (D_{50})	0.2 foot (2.0 inches)
Specified Filter Thickness	0.5 foot (6.0 inches)

As evaluations are refined during later phases of design, filter layer requirements should be revisited as changes in armor material sizes may results in changes to filter requirements or different sized filter material for different Site areas.

4 Summary and Discussion

Potential uncertainties may result due to assumptions for this evaluation. The fetches that were used for the wind-driven waves were not evaluated for the specific sediment cap areas and were instead terminated at the entrance of the harbor. Wind-generated waves may also be obstructed by shallower bathymetry along the fetches within Bellingham Bay and vessels operating throughout Whatcom Waterway. Therefore, the wind-generated wave forces—including increased wave heights to account for SLR, calculated for this initial design evaluation—could be conservatively overestimated and not be representative of actual conditions.

Additional uncertainties associated with the propwash modeling include defining transitions between operational areas, understanding the duration of each operation (e.g., how long the vessel uses its bow thruster at 100% power), and the choice of representative water depths for the simulations. Simulations assumed steady state conditions for vessels transiting Whatcom Waterway (i.e., infinite duration of operations in one location), and water depths chosen for the simulations in each of the operational areas were conservatively low (i.e., shallower depths within each operational area).

The assumptions and conclusions used to support this initial design evaluation (for development of the 30% engineering design for the project) will be revisited as the design effort progresses. The design team may elect to utilize different assumptions as additional information is considered, which may lead to different conclusions and design recommendations for stabilization of shoreline and sediment cap areas within the Site boundary.

5 References

Blaauw, H. G. and van de Kaa, E. J., 1978. Erosion of bottom and sloping banks caused by the screw race of manoeuvring ships. Presented at 7th International Harbor Congress Antwerp, May 22-26, 1978. Accessed: December 5, 2023.

Blaauw, H.G., van der Knapp, F.C.M., de Groot, M.T., and Pilarcyk, K.W. 1984 "Design of Bank Protection of Inland Navigation Fairways," Publication No. 1984 "Design of Bank Protection of Inland Navigation Fairways, "Publication No. 320, Delft Hydraulics Laboratory.

DSI, LLC, 2021. EFDC+Propeller Wash Module White Paper. Accessed: December 22, 2023. Available at: https://www.eemodelingsystem.com/efdc-insider-blog/estimating-ship-engine-power-for-efdc-propeller-wash-simulations

MarineTraffic, 2023. Northern Eagle. Accessed: December 22, 2023. Available at: https://www.marinetraffic.com/en/ais/details/ships/shipid:454243/mmsi:368085000/imo:6701462/vessel:NORTHERN_EAGLE

Maynord, S., 1998. Appendix A: Armor Layer Design for the Guidance for In-Situ Subaqueous Capping of Contaminated Sediment. EPA 905-B96-004, Great Lakes National Program Office, Chicago, Illinois.

NOAA (National Oceanic Atmospheric Administration), 2023. "NOAA Chart 18424. Bellingham Bay." Accessed November 9, 2023.

NOAA and USCG (National Oceanic Atmospheric Administration and U.S. Coast Guard), 2023. AIS Data: 2018 -2023. Accessed: December 6, 2023. Available at: https://marinecadastre.gov/accessais/

PIANC, 2015. "Guidelines for protecting berthing structures from scour caused by ships." Marcom Report 180, Permanent International Association of Navigation Congresses Secrétariat Général, Bruxelles, Belgium.

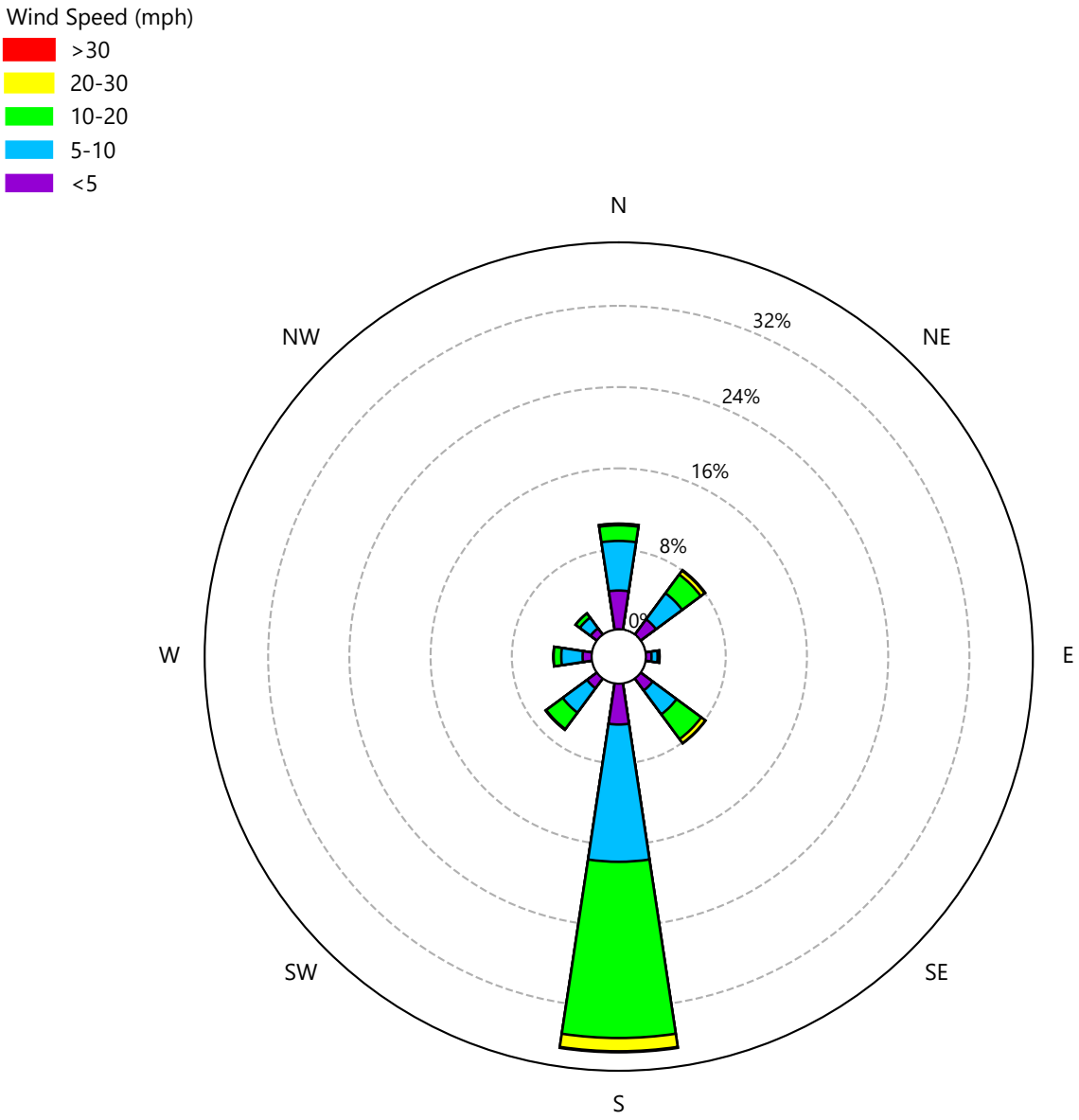
USACE (U.S. Army Corps of Engineers),1992. *Automated Coastal Engineering System (ACES).* Technical Reference by D.E. Leenknecht, A. Szuwalski, and A.R. Sherlock, Coastal Engineering Research Center, Department of the Army, Waterways Experiment Station, Vicksburg, MS.

USACE, 2002. *Coastal Engineering Manual.* Engineer Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington, D.C. (in 6 volumes). April 2002.

Verhey, H.J., 1983. "The Stability of Bottom and Banks Subjected to the Velocities in the Propeller Jet Behind Ships." Delft, Publication No. 303, Delft Hydraulics Laboratory, Netherlands.

WCSD-DEM (Whatcom County Sheriff's Department – Department of Emergency Management), 2021. *Whatcom County Natural Hazards Mitigation Plan*. Section 3 Jurisdiction Profiles and Mitigation Strategies – Bellingham. September 30, 2021. Accessed: November 9, 2023. Available at: https://www.whatcomcounty.us/DocumentCenter/View/64638/2021-NHMP-BELLINGHAM

Figures



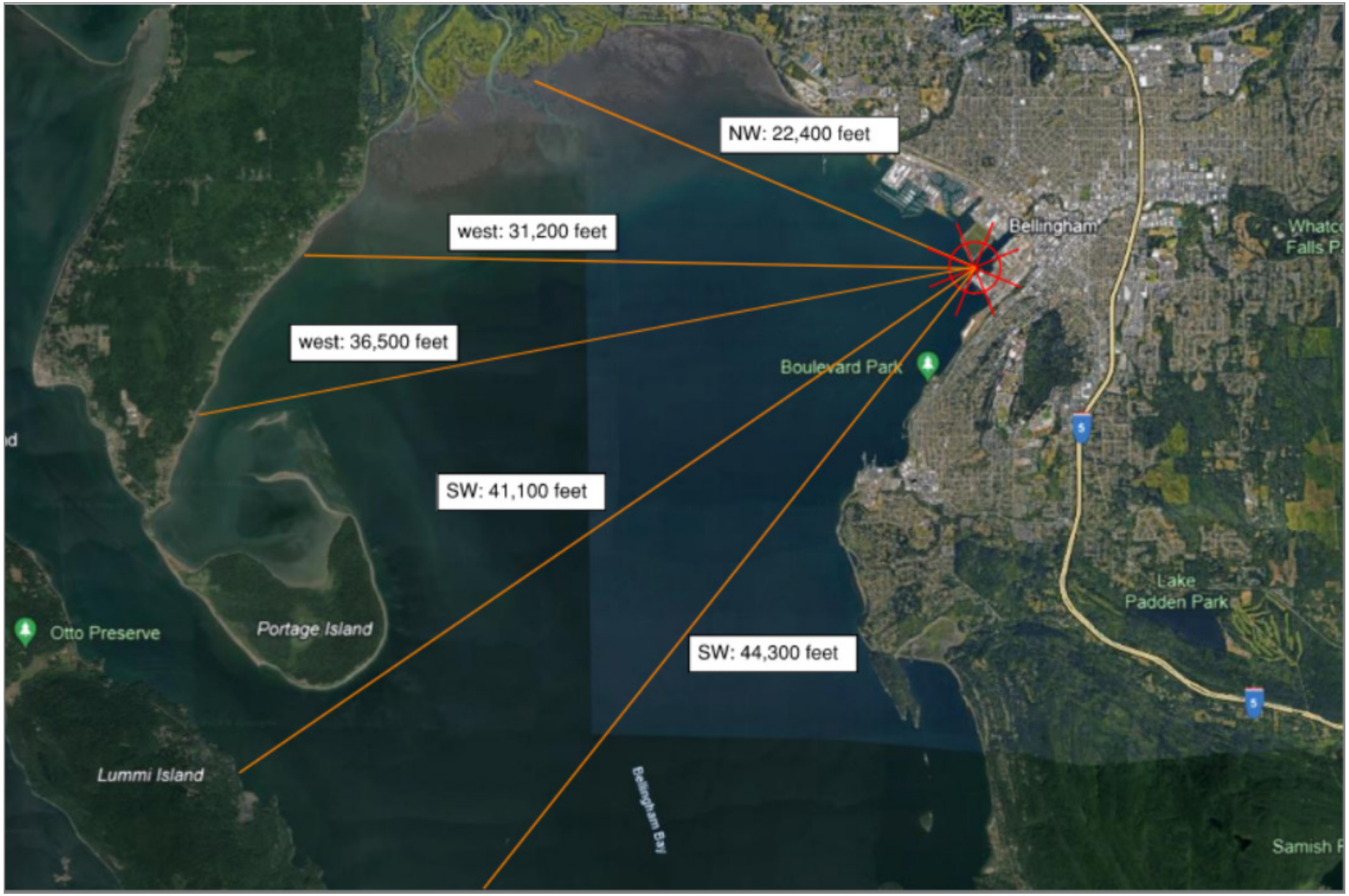
Notes:
1. Hourly Wind Data Obtained from Bellingham, Washington for Years 1948 through 2021
2. Calm and Variable Winds: 20.3%
3. Maximum Recorded Wind Speed: 67.8 mph
4. Wind data are presented as the "blowing from" direction.

Publish Date: 02/20/2024 12:53 PM | User: SG
File Path: \\fuji\anchor\Projects\Port of Bellingham\FMIP\5_Coastal\Wind\wind_rose_FMIP.py

ANCHOR QEA

Figure C-1
Wind Rose for Bellingham, Washington
Appendix C: Coastal Evaluation
Whatcom Waterway Phase 2

DRAFT



Filepath: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\EDR\03 Appendices\App C_Coastal and Propwash Evaluation\Figures

ANCHOR QEA

Figure C-2
Fetch Distances
Appendix C Coastal and Propwash Evaluation
Whatcom Waterway Phase 2 Cleanup

DRAFT



Notes: Basemap Source: Google Satellite Imagery, AOI: Area of Interest, NA: not applicable, NAD83: North American Datum of 1983

AOI 1	Fishing	Passenger
AOI 2	NA	Pleasure Craft/Saling
Cargo	Other	Tug Tow

Publish Date: 12/21/2023 18:47 PM | User: JH
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\AIS data\plot_vessel_positions.py

ANCHOR QEA

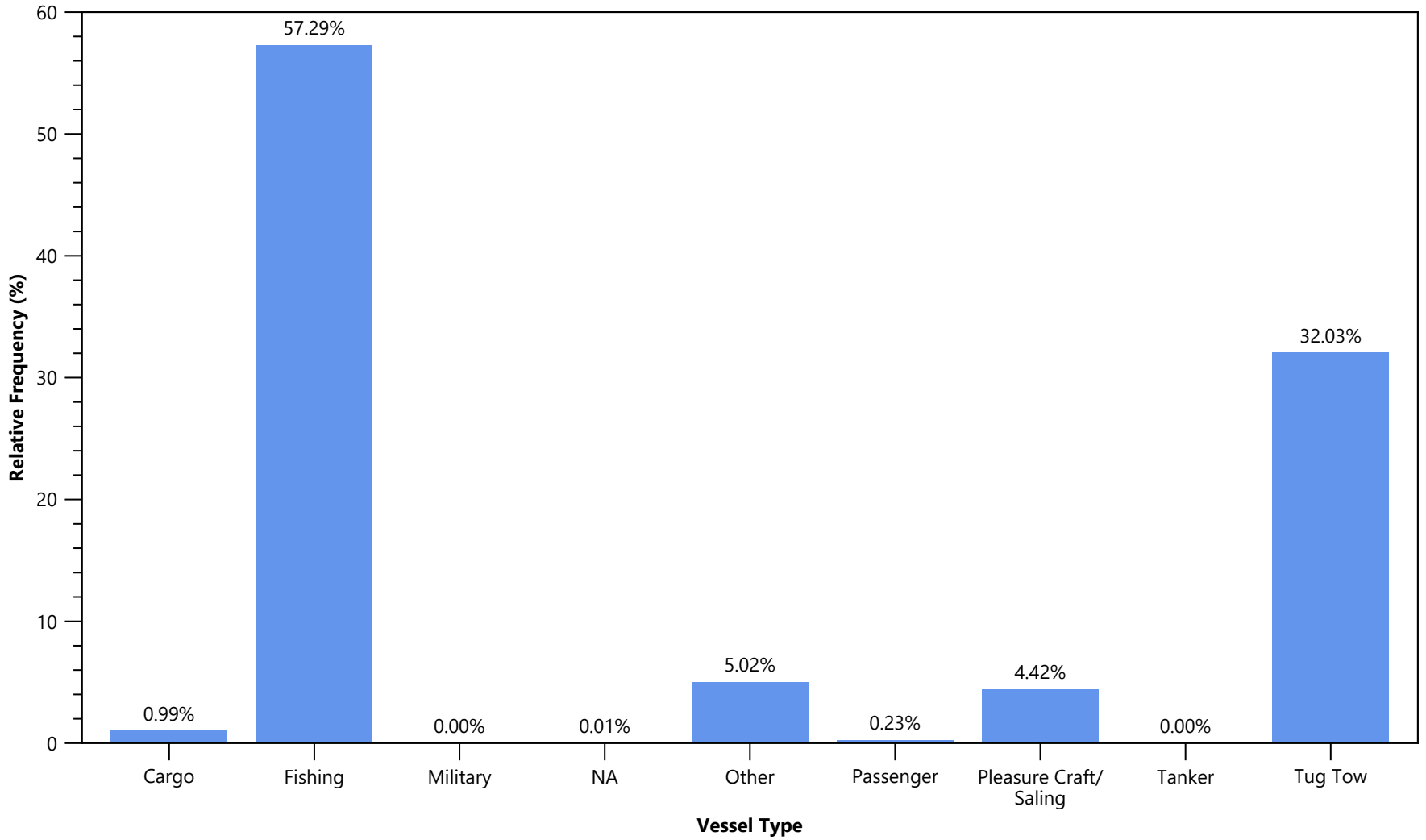
Figure C-3

Vessel Positions by Category in the Project Area (January 2018 through November 2023)

Appendix C Coastal and Propwash Evaluation

Whatcom Waterway Phase 2 Cleanup

DRAFT



Notes: AOI: Area of Interest, NA: not applicable

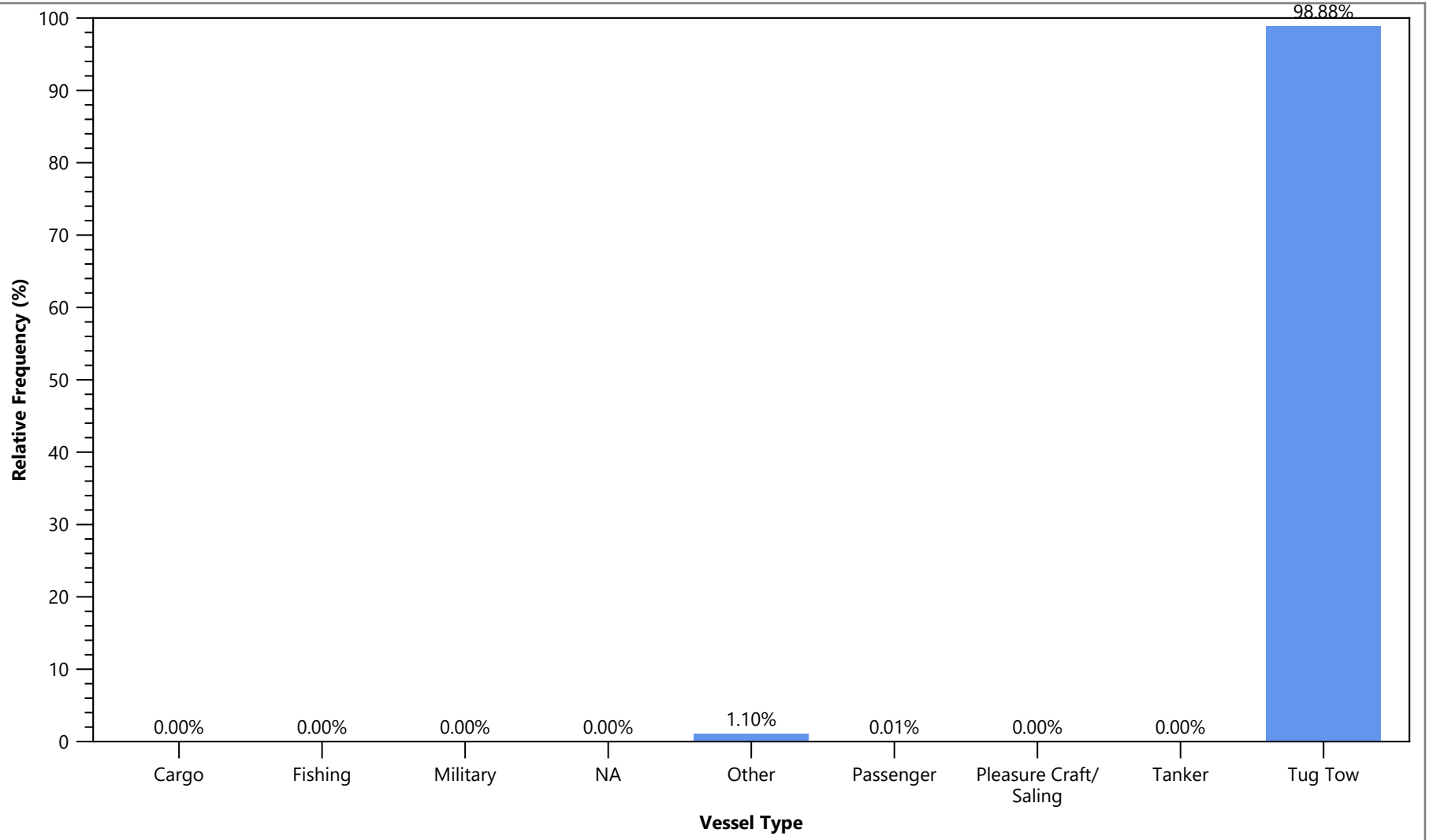
Relative Frequency of Vessel Category

Publish Date: 12/22/2023 09:29 AM | User: JH
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\AIS data\plot_vessel_cat_bar_chart.py

ANCHOR QEA

Figure C-4
Relative Frequencies of Vessel Types in AOI 1 (January 2018 through November 2023)

DRAFT



Notes: AOI: Area of Interest, NA: not applicable

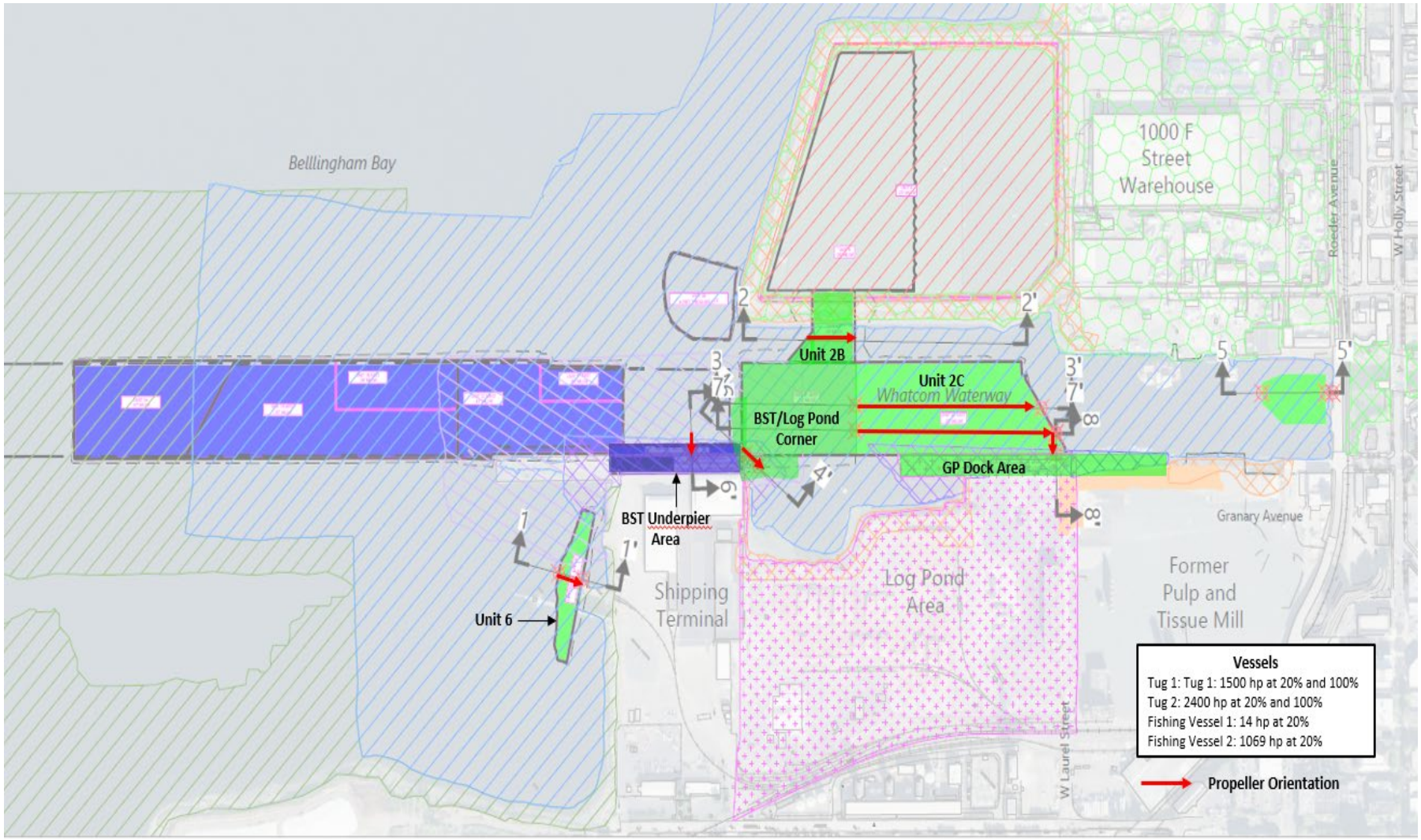
Relative Frequency of Vessel Category

Publish Date: 12/22/2023 09:29 AM | User: JH
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\AIS data\plot_vessel_cat_bar_chart.py

ANCHOR QEA

Figure C-5
Relative Frequencies of Vessel Types in AOI 2 (January 2018 through November 2023)

DRAFT

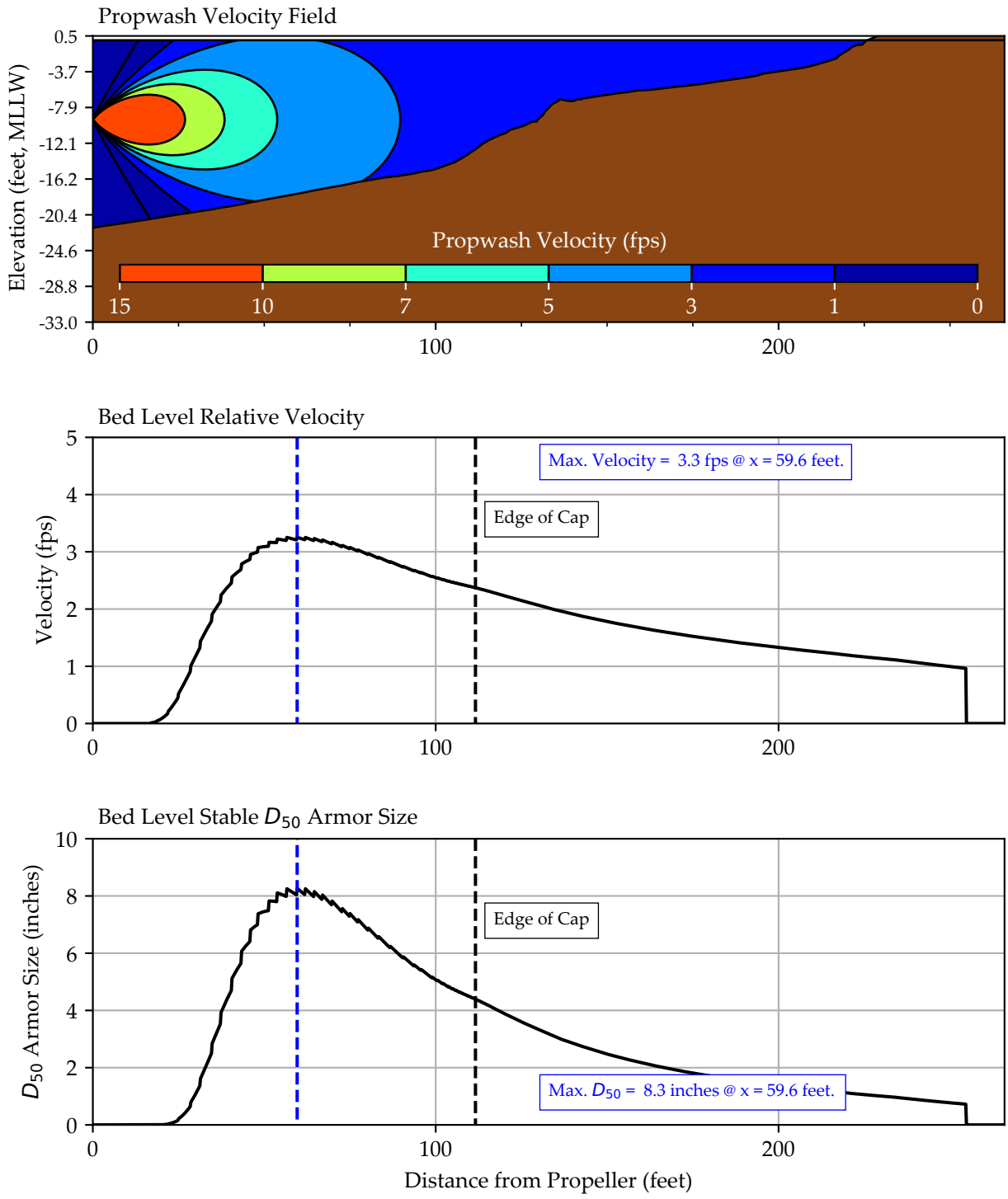


Filepath: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\EDR\03 Appendices\App C_Coastal and Propwash Evaluation\Figures

ANCHOR QEA

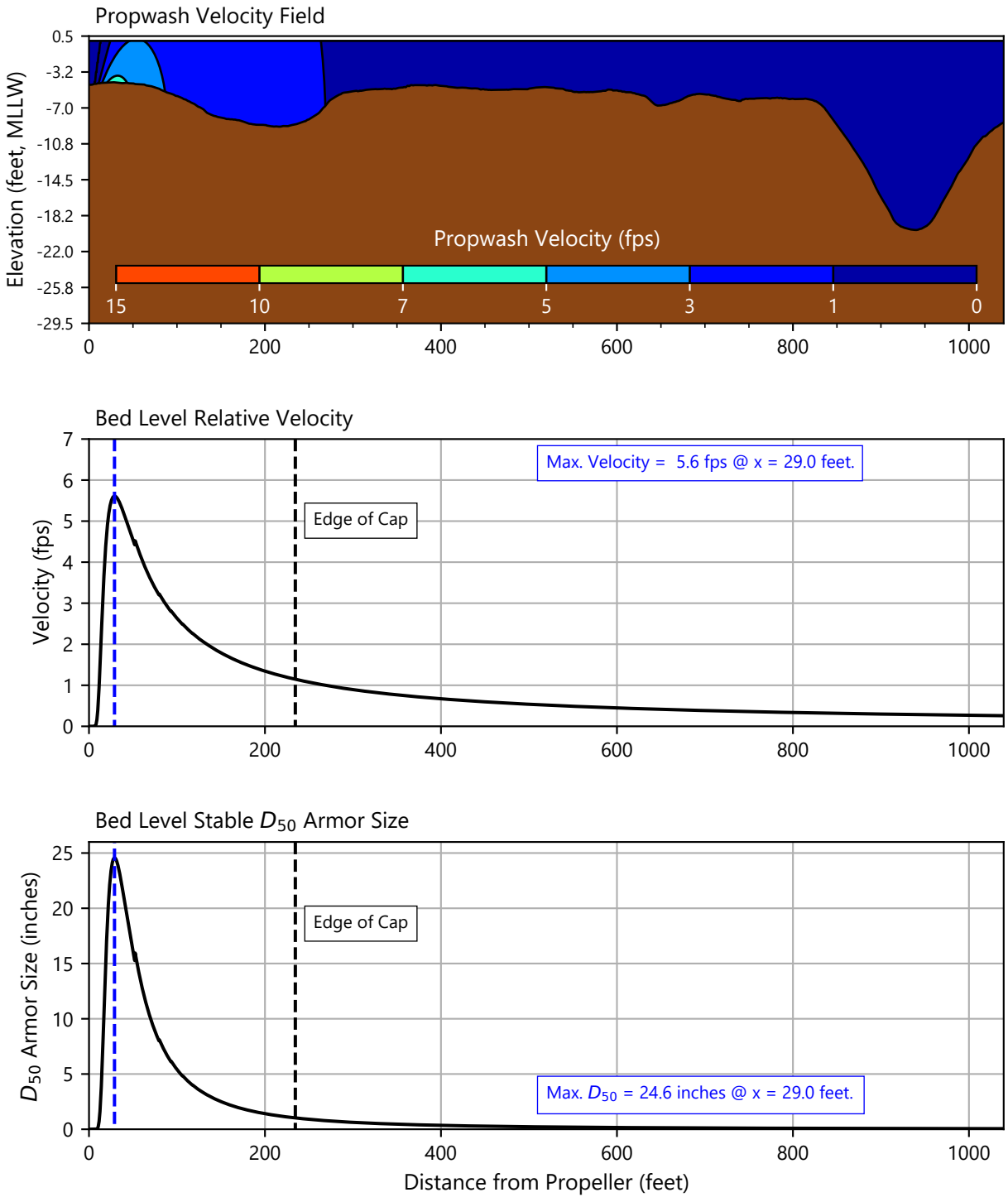
Figure C-6
Propwash Evaluation Areas
Appendix C Coastal and Propwash Evaluation
Whatcom Waterway Phase 2 Cleanup

Attachment C-1
Plots for Peak Bed Velocities and Maximum Stable Armor Size



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/19/2024 18:39 PM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

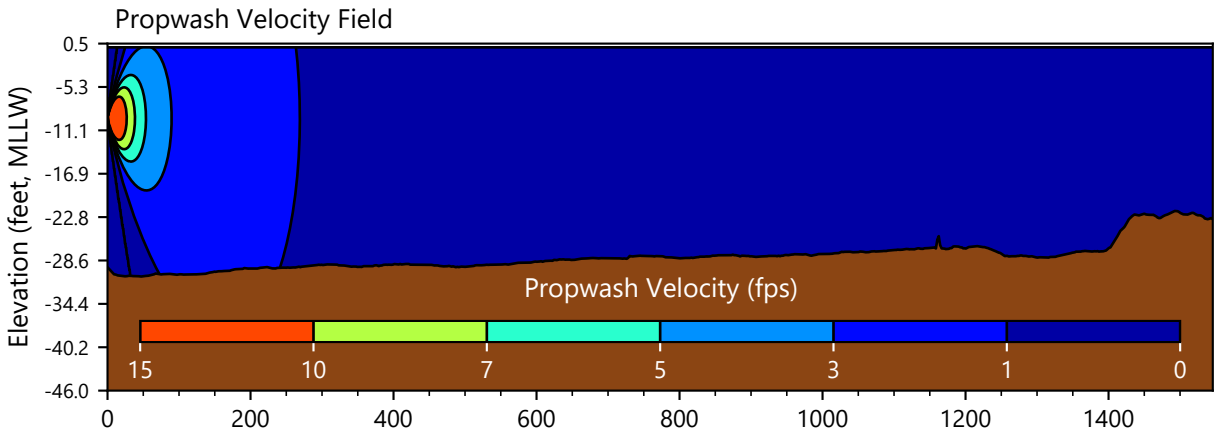


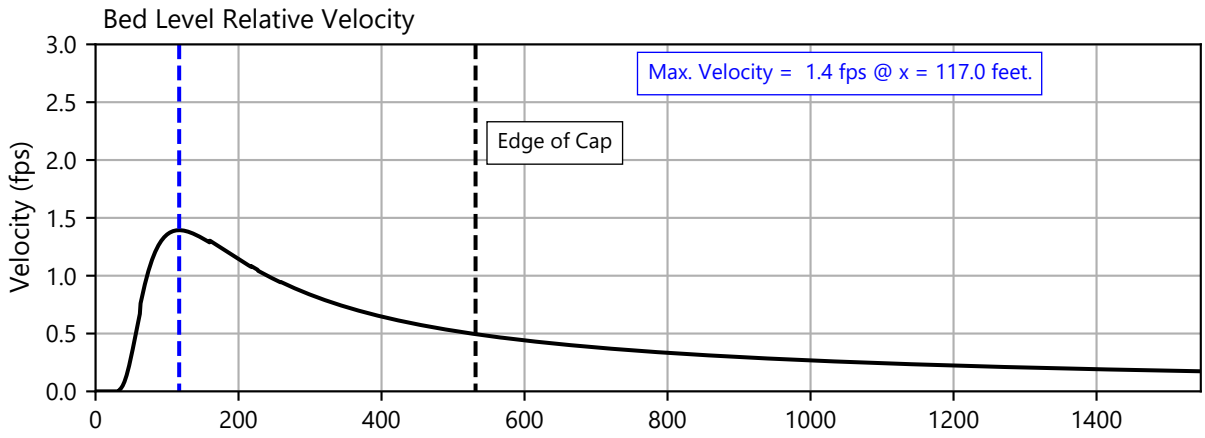
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

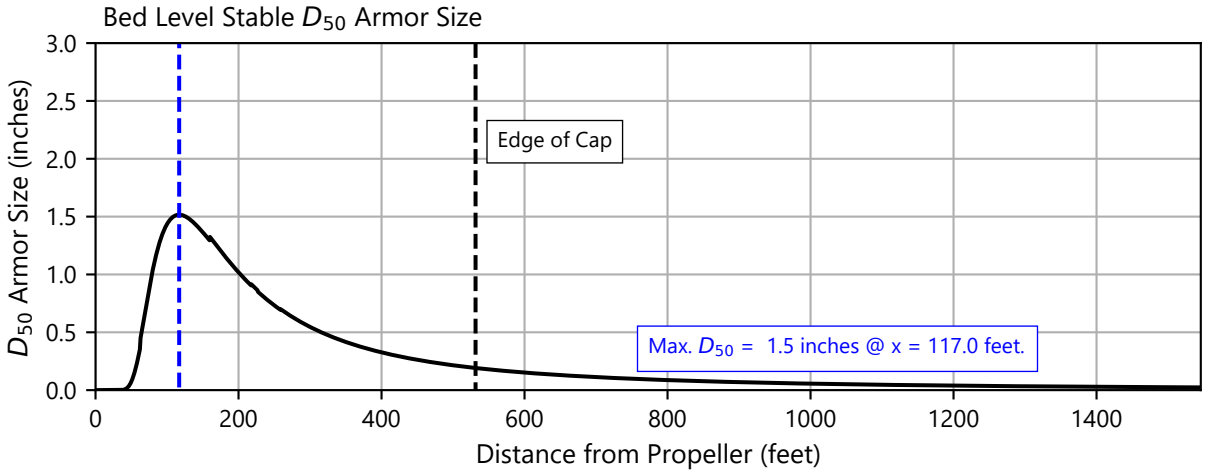
Publish Date: 01/19/2024 18:39 PM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

ANCHOR QEA

Figure 1b
Brian S. Tug at 0 knots, using 20% Applied PowerTransect: Section 2 at MLLW
Appendix C Coastal and Propwash Evaluation
Whatcom Waterway Phase 2 Cleanup

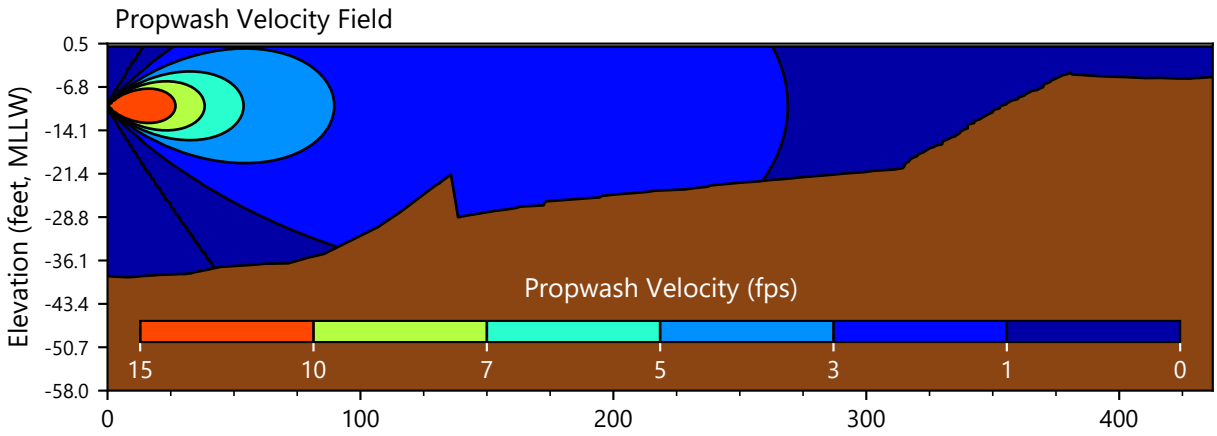


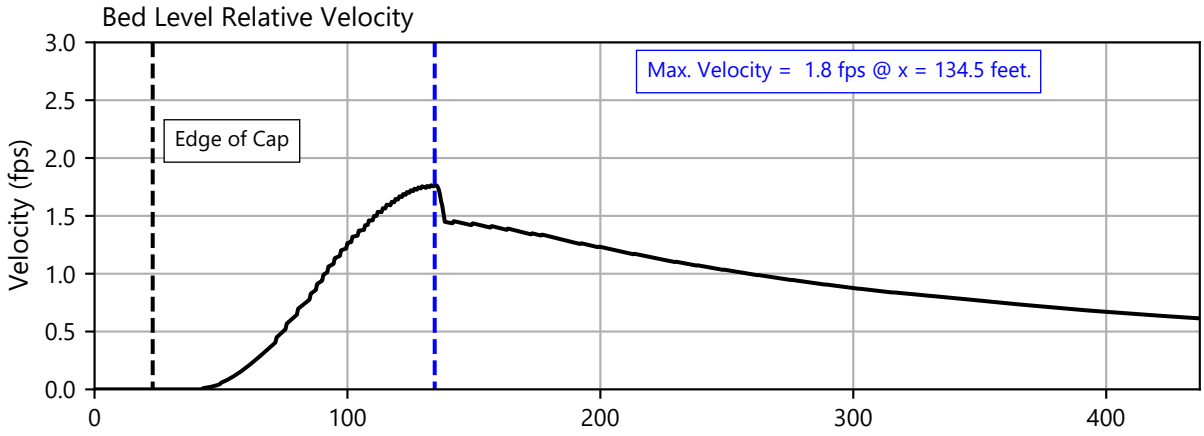


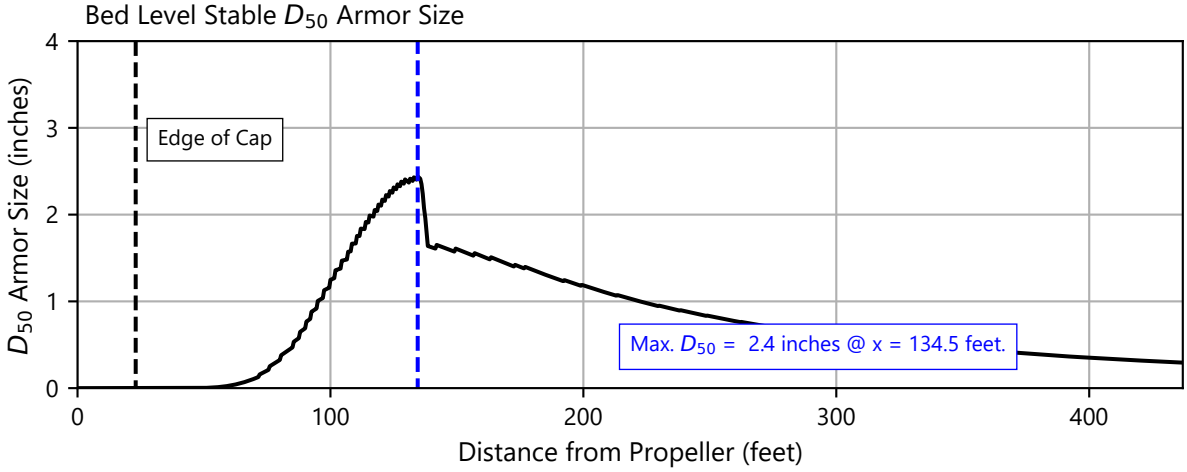


Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/19/2024 18:39 PM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



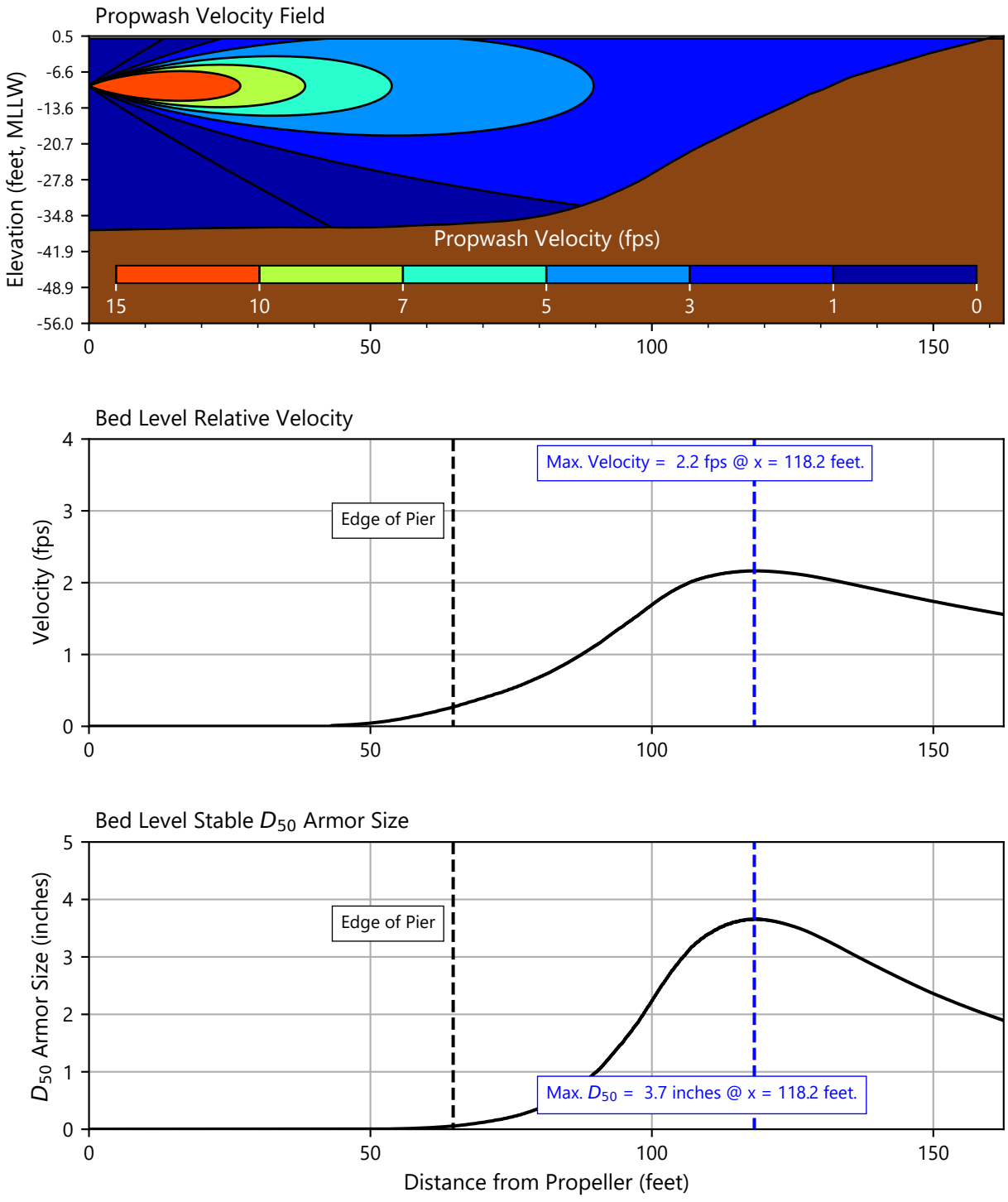




Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/19/2024 18:39 PM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

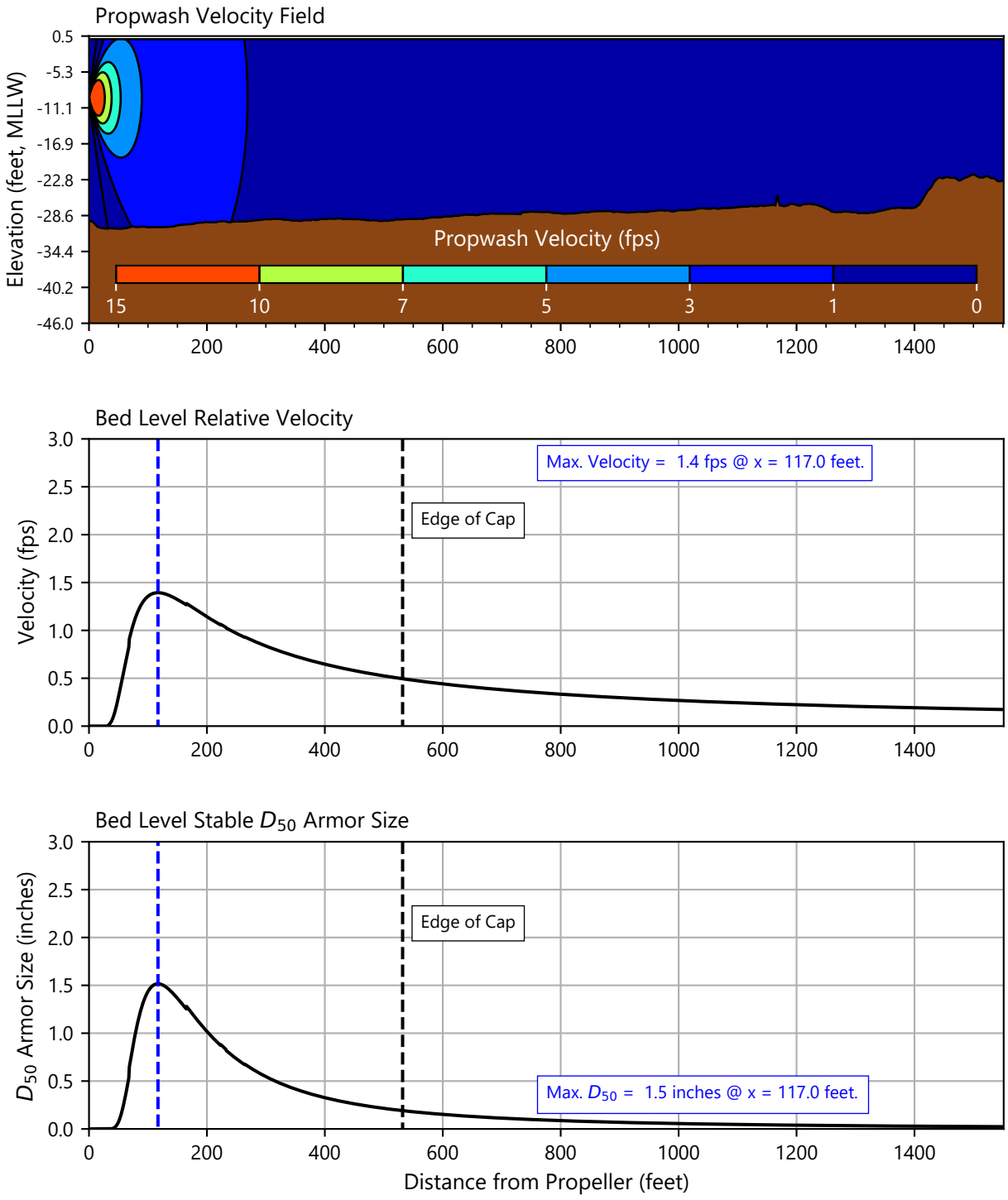
Figure 1d
Brian S. Tug at 0 knots, using 20% Applied PowerTransect: Section 4 at MLLW



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

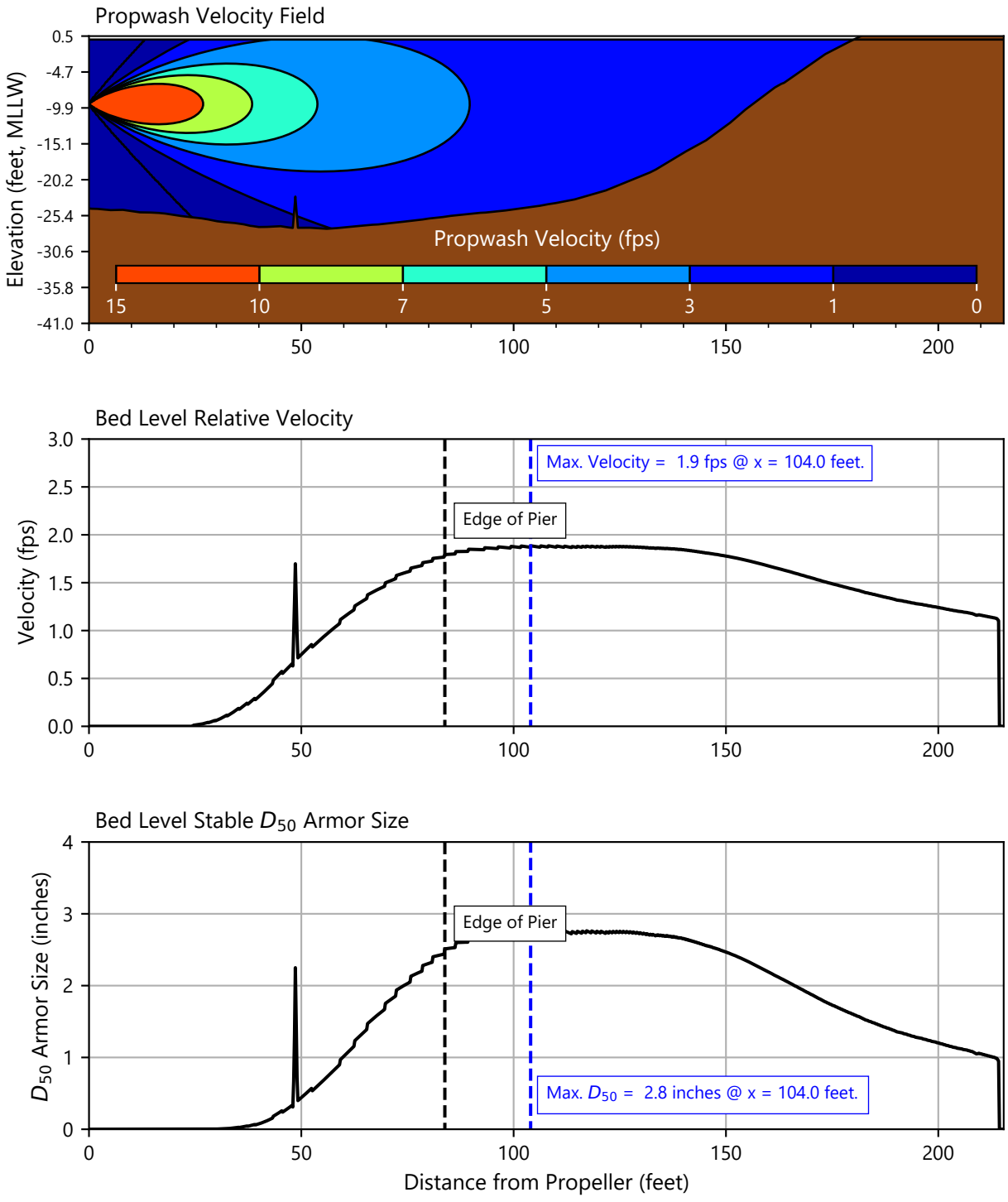
Publish Date: 01/19/2024 18:39 PM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

Figure 1e
Brian S. Tug at 0 knots, using 20% Applied PowerTransect: Section 6 at MLLW



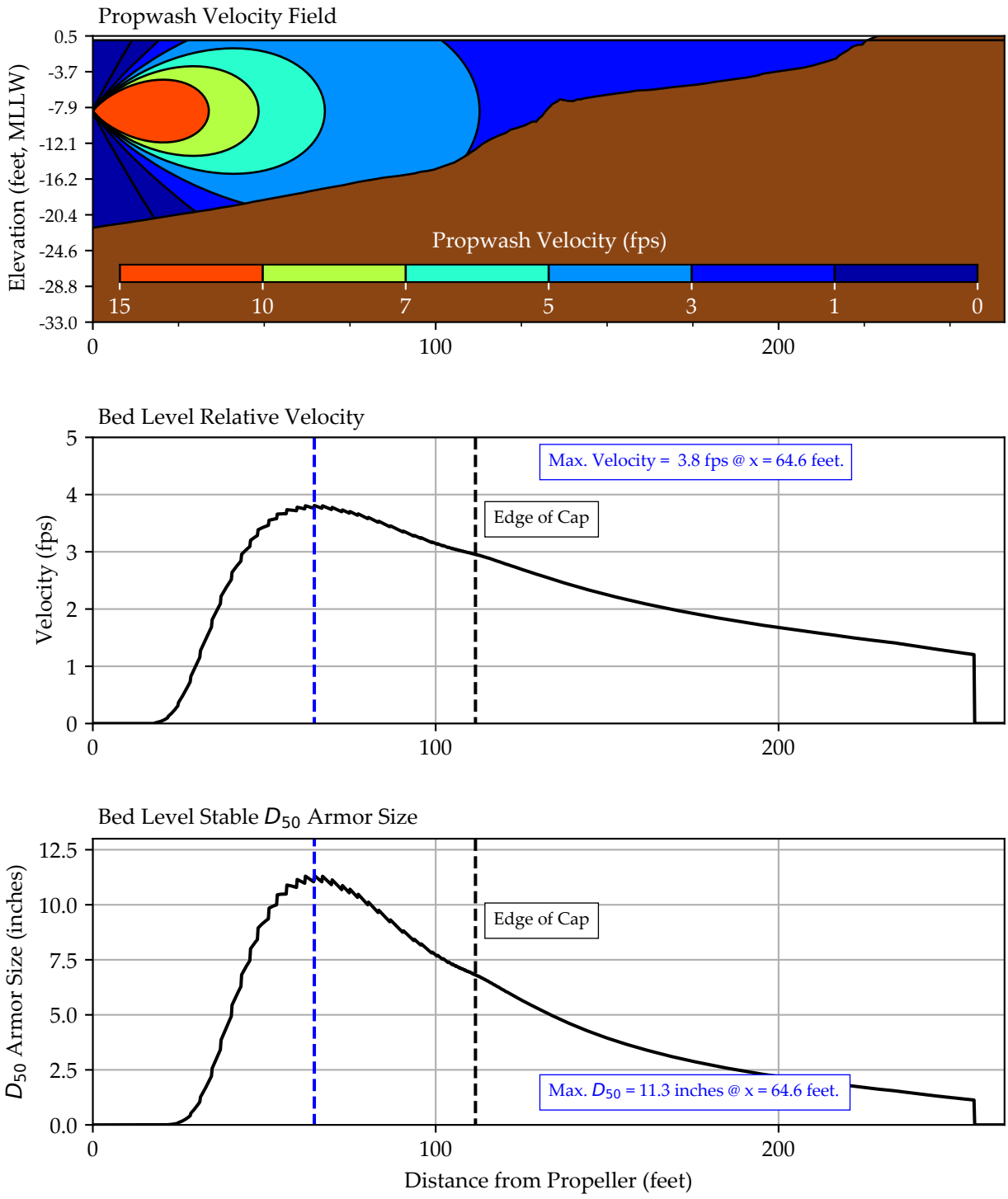
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/19/2024 18:40 PM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

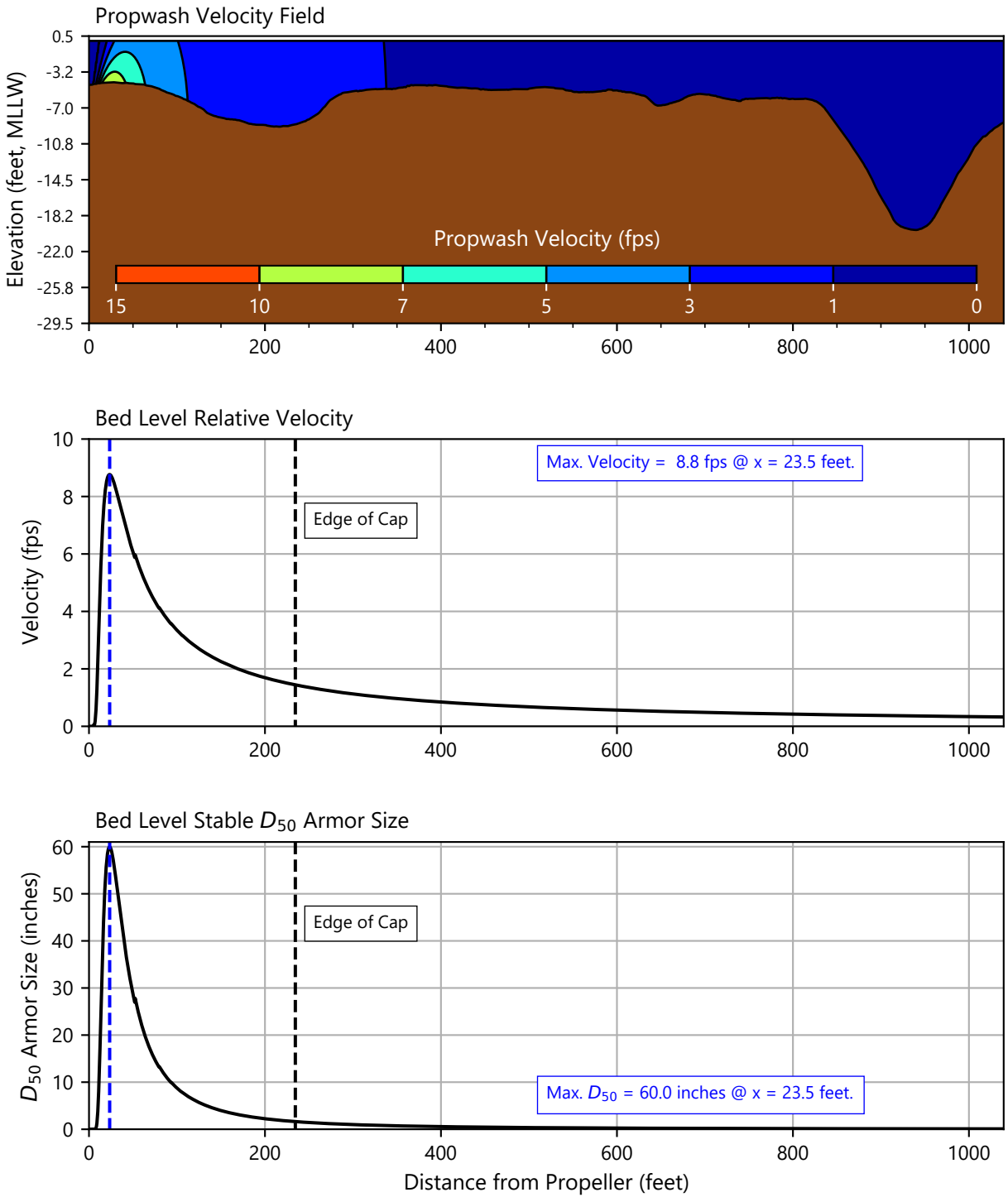
Publish Date: 01/19/2024 18:40 PM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

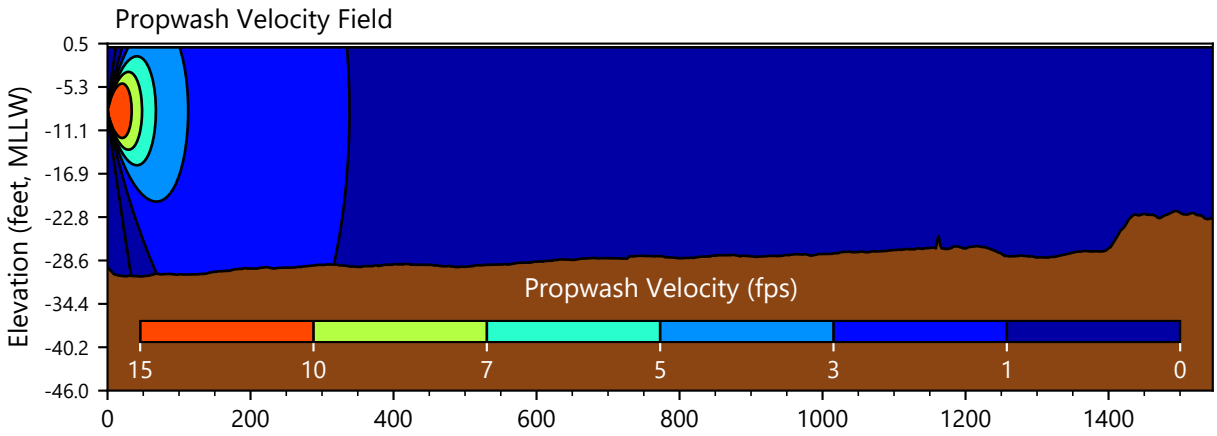
Publish Date: 01/24/2024 08:53 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

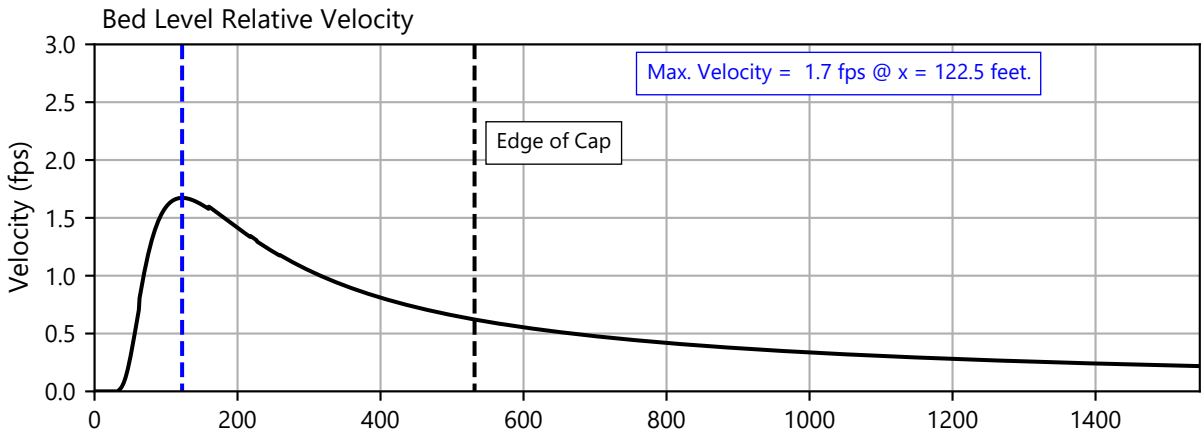
Figure 2a
Kinani H Tug at 0 knots, using 20% Applied PowerTransect: Section 1 at MLLW
Appendix C Coastal and Propwash Evaluation
Whatcom Waterway Phase 2 Cleanup

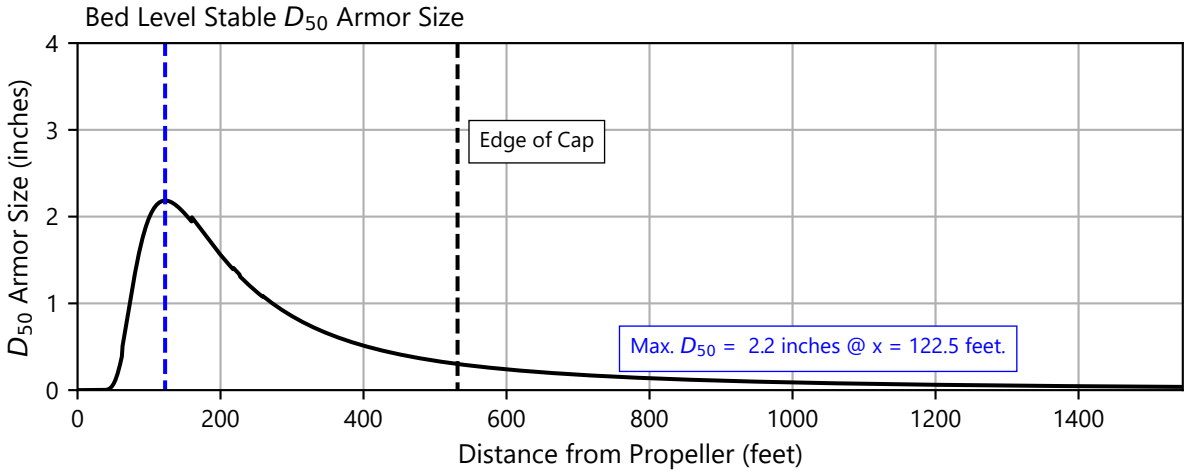


Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 08:53 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



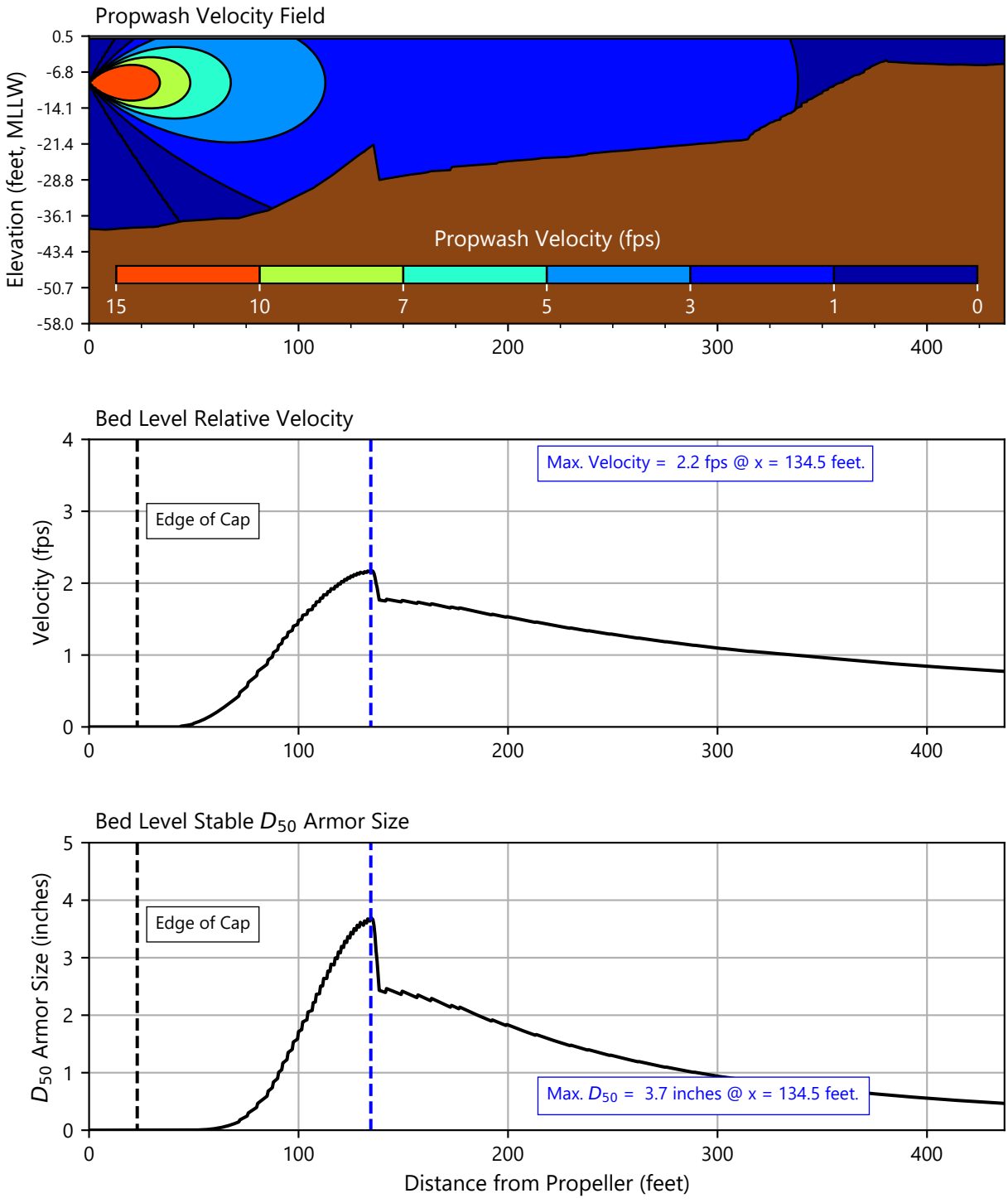




Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

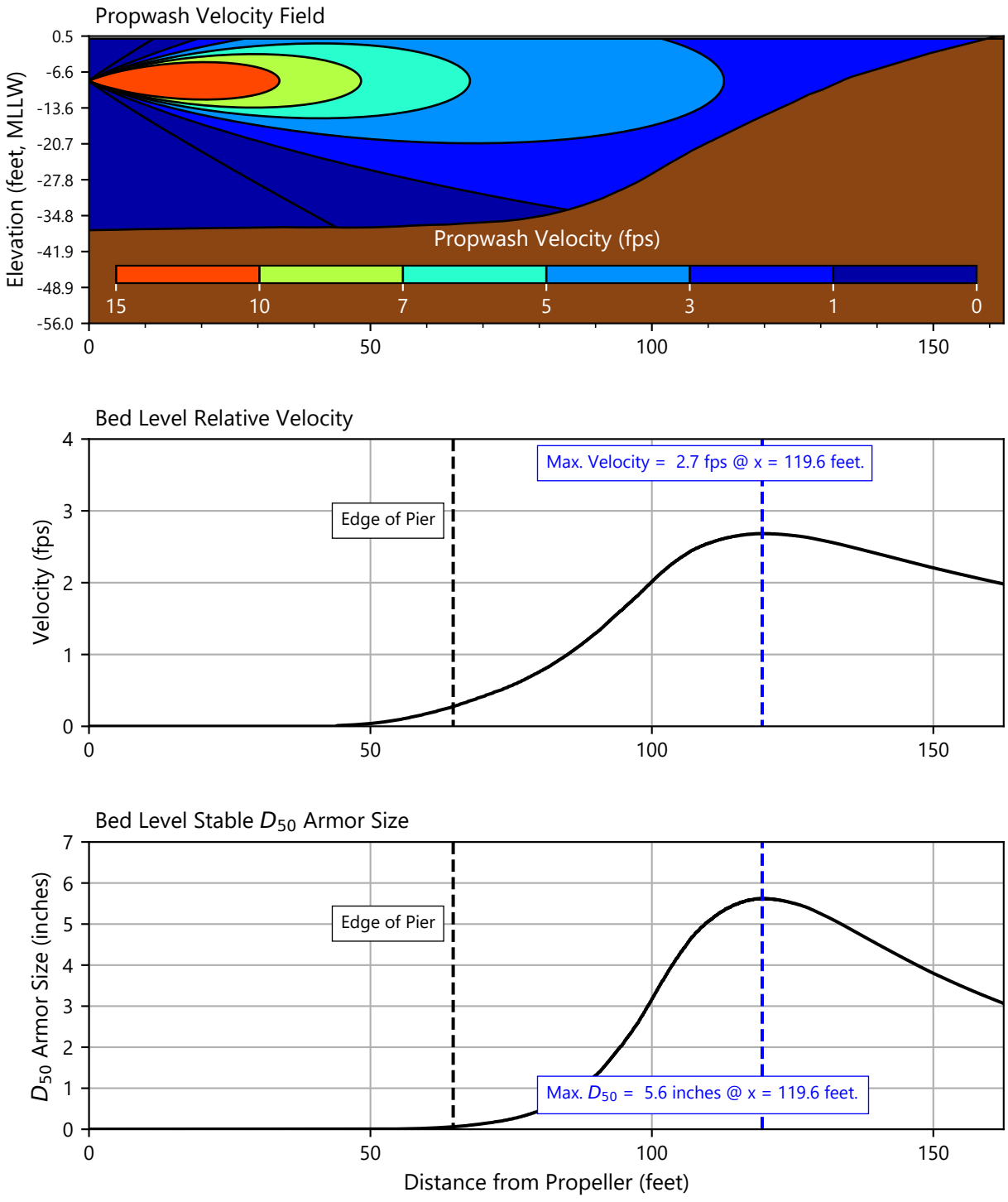
Publish Date: 01/24/2024 08:53 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

Figure 2c
Kinani H Tug at 0 knots, using 20% Applied PowerTransect: Section 3 at MLLW
Appendix C Coastal and Propwash Evaluation
Whatcom Waterway Phase 2 Cleanup



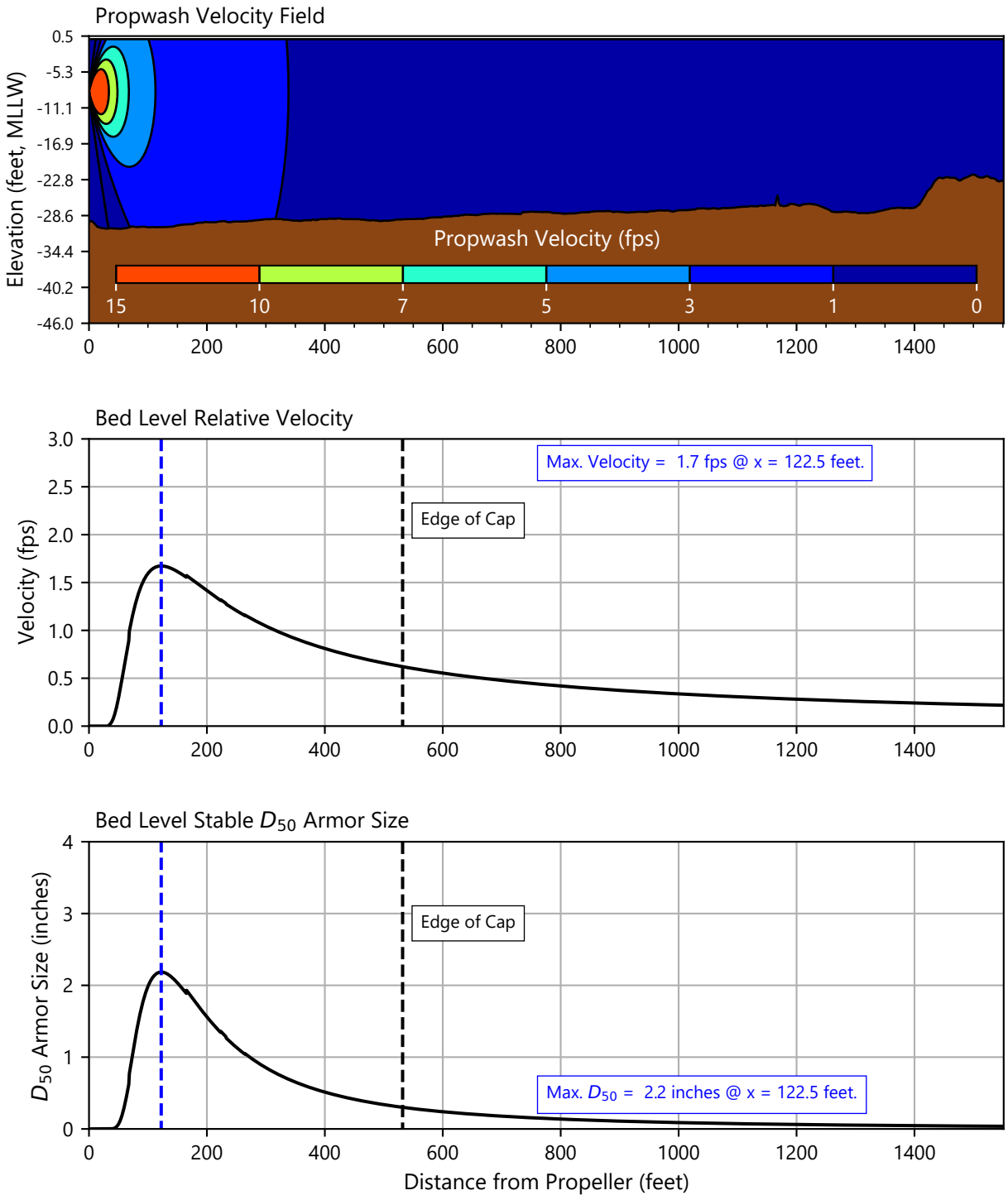
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 08:53 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



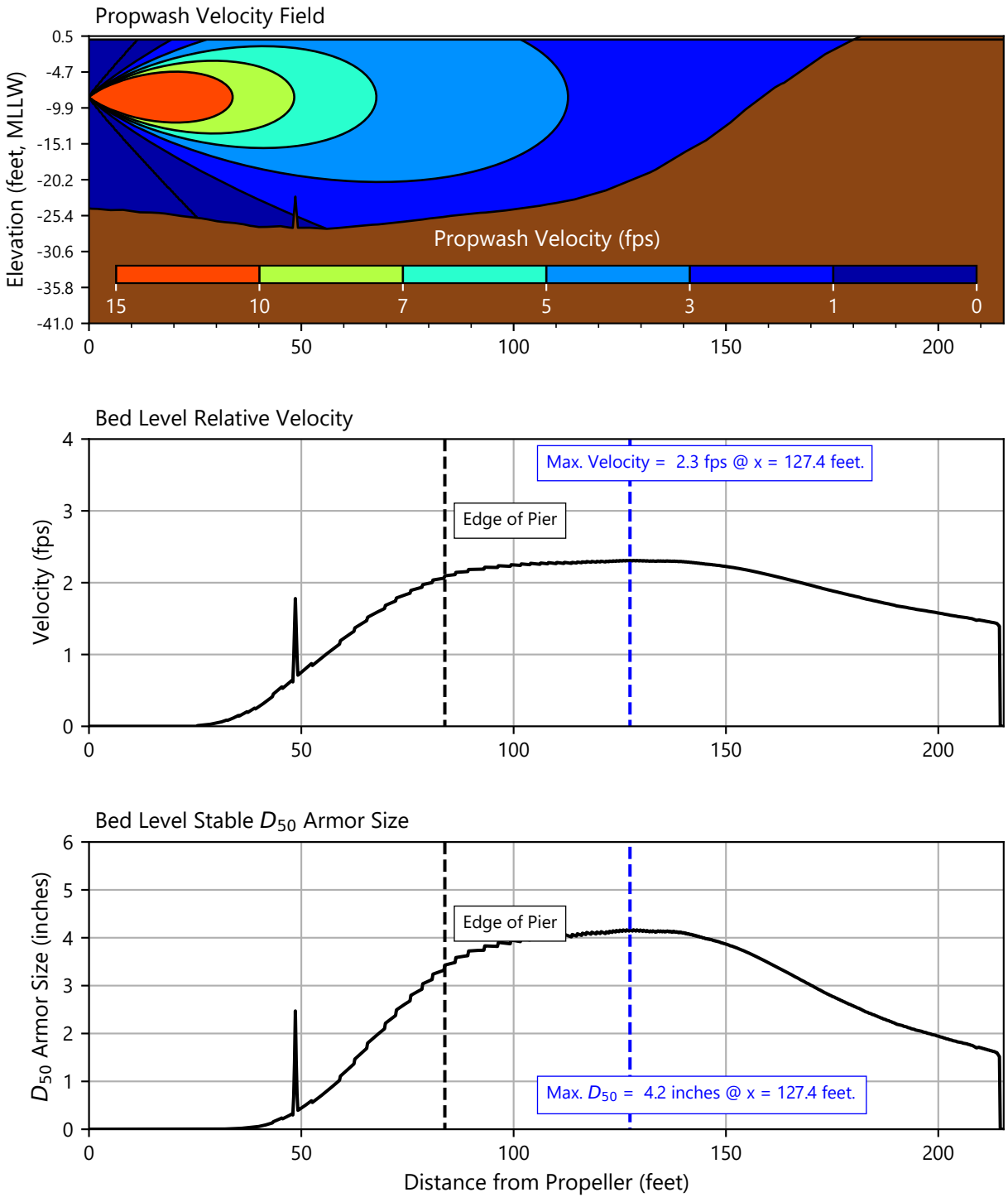
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 08:53 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



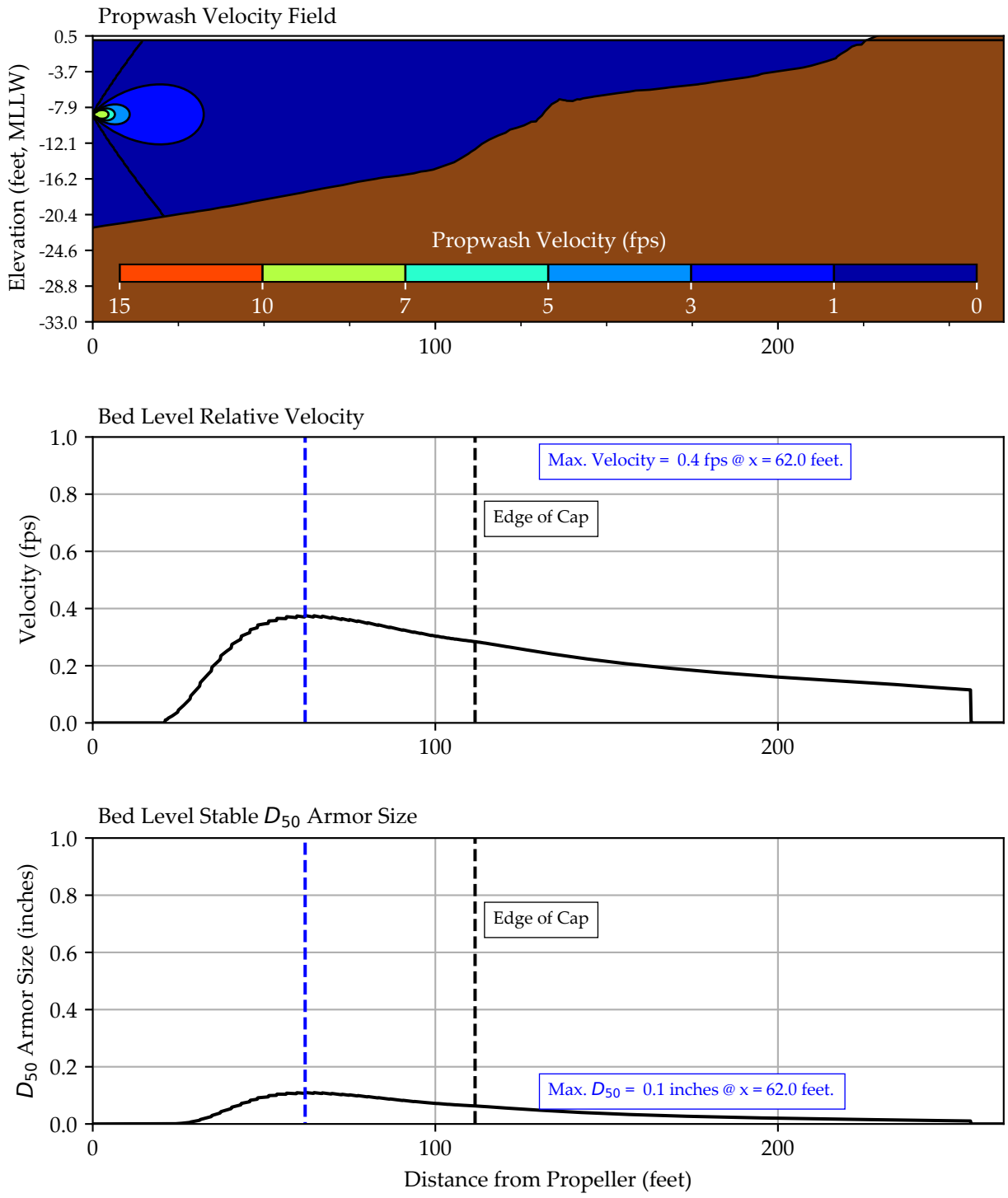
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 08:53 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

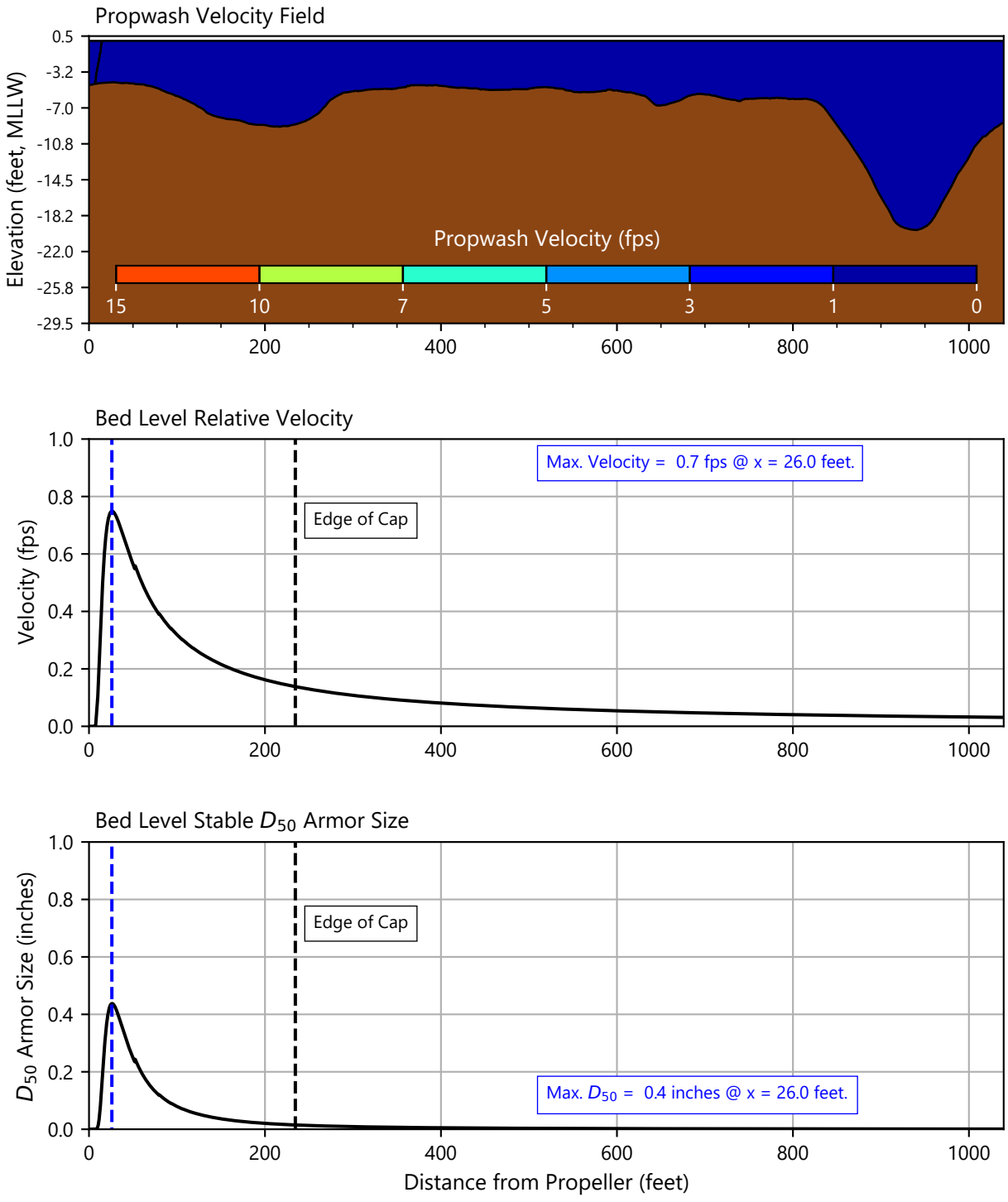
Publish Date: 01/24/2024 08:53 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:04 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

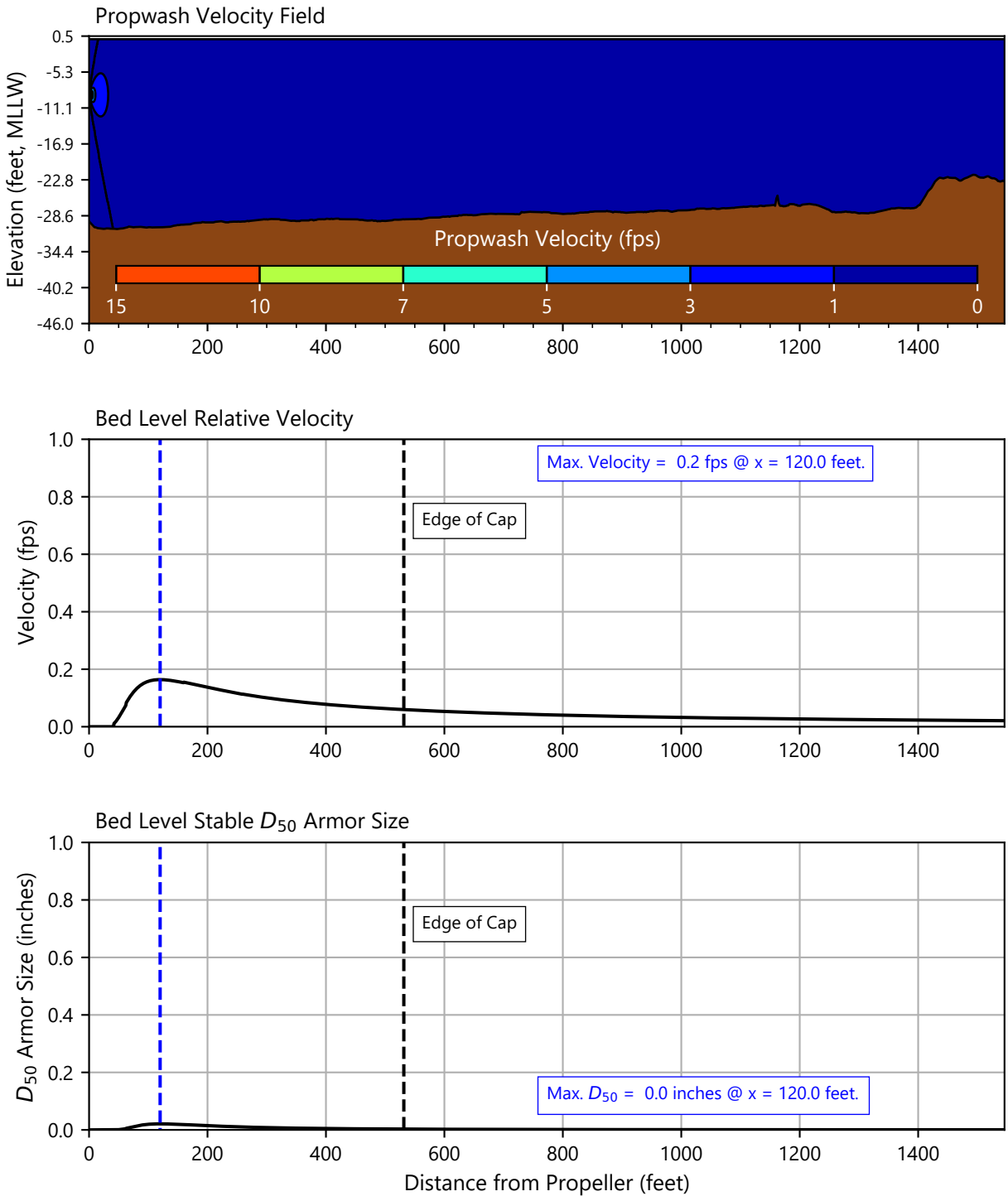
Figure 3a
The Duchess Fishing Boat at 0 knots, using 20% Applied PowerTransect: Section 1 at MLLW



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:04 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

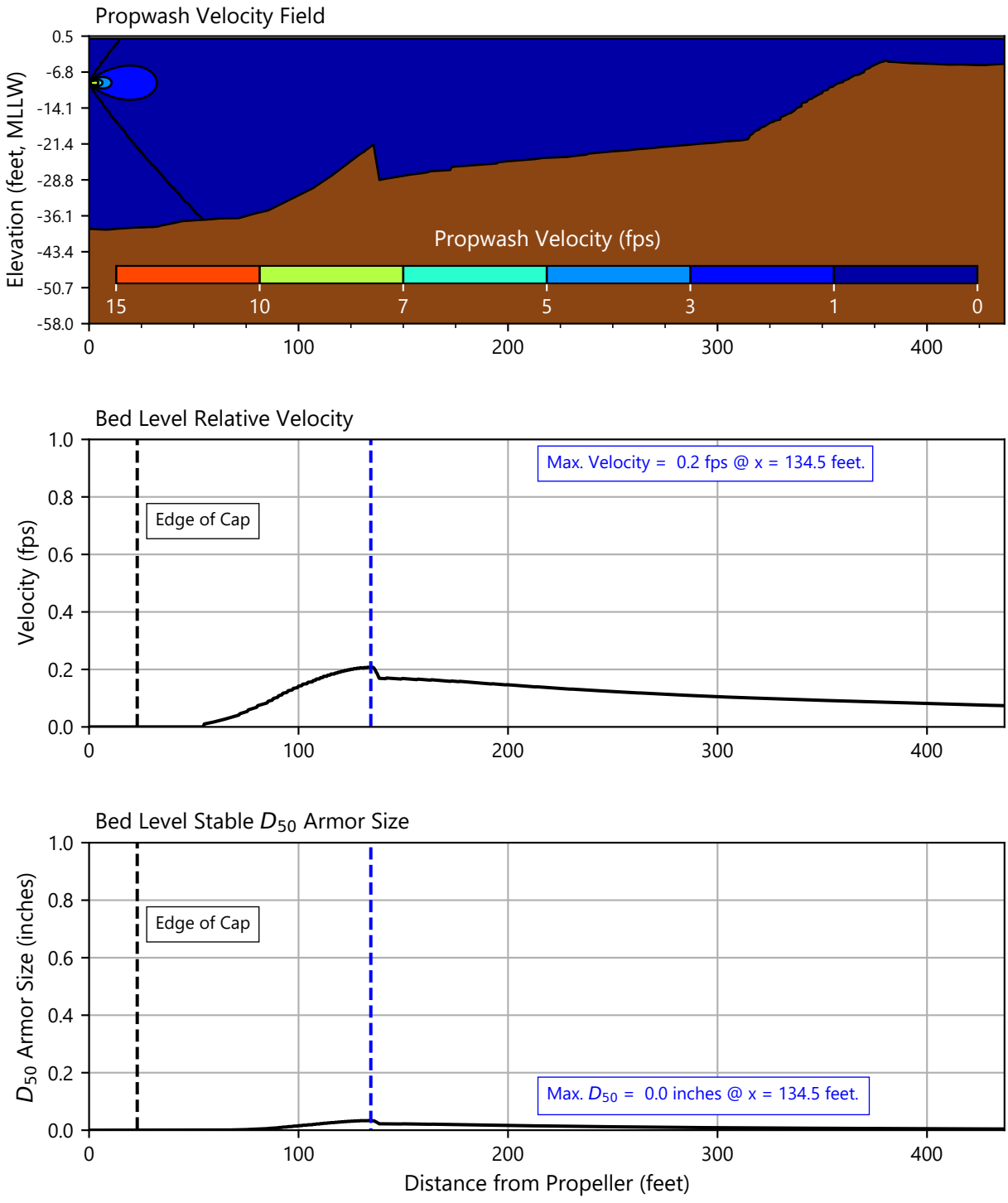
Figure 3b
The Duchess Fishing Boat at 0 knots, using 20% Applied PowerTransect: Section 2 at MLLW



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:04 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

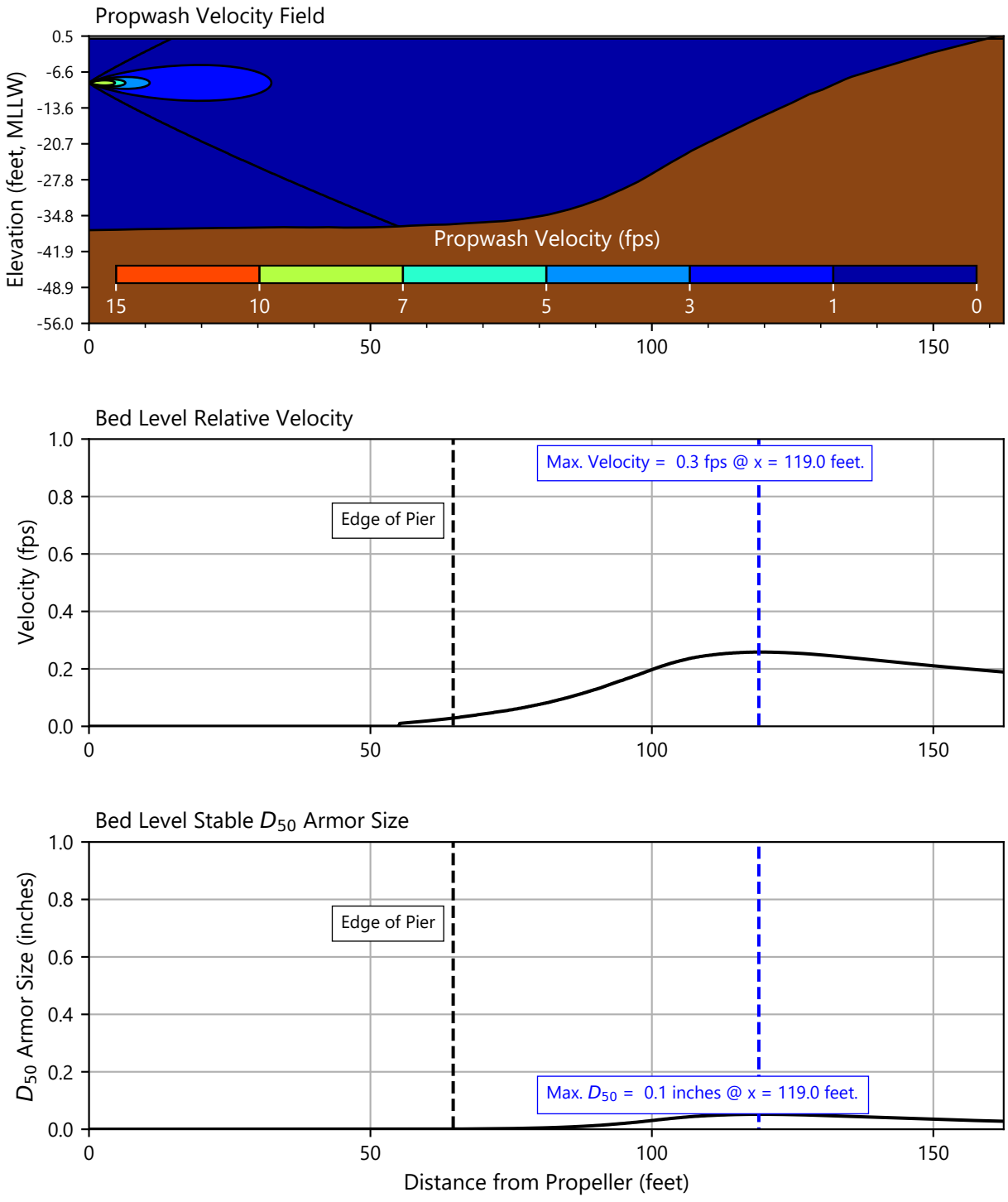
Figure 3c
The Duchess Fishing Boat at 0 knots, using 20% Applied PowerTransect: Section 3 at MLLW



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

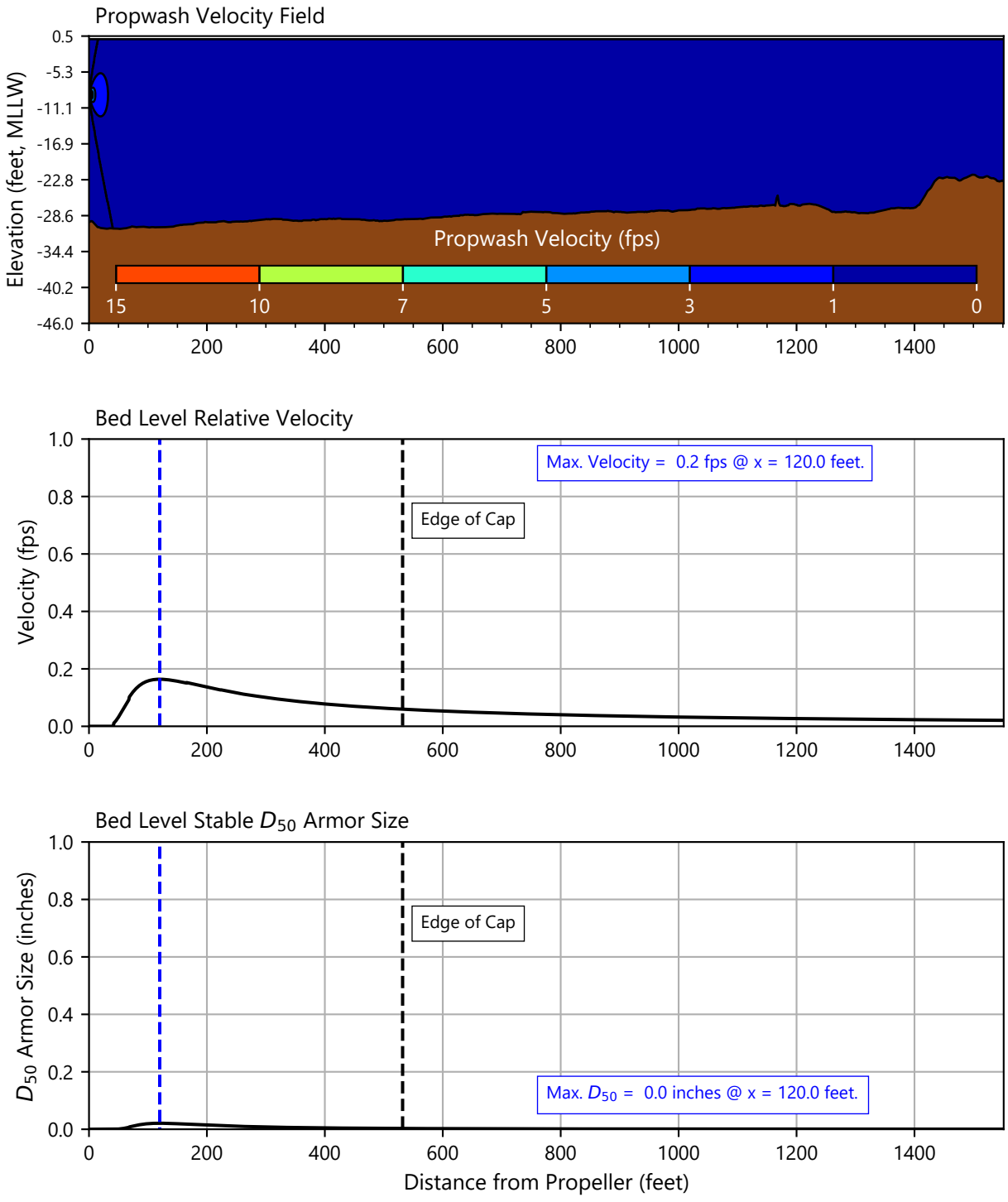
Publish Date: 01/24/2024 09:04 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

Figure 3d
The Duchess Fishing Boat at 0 knots, using 20% Applied PowerTransect: Section 4 at MLLW
Appendix C Coastal and Propwash Evaluation
Whatcom Waterway Phase 2 Cleanup



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

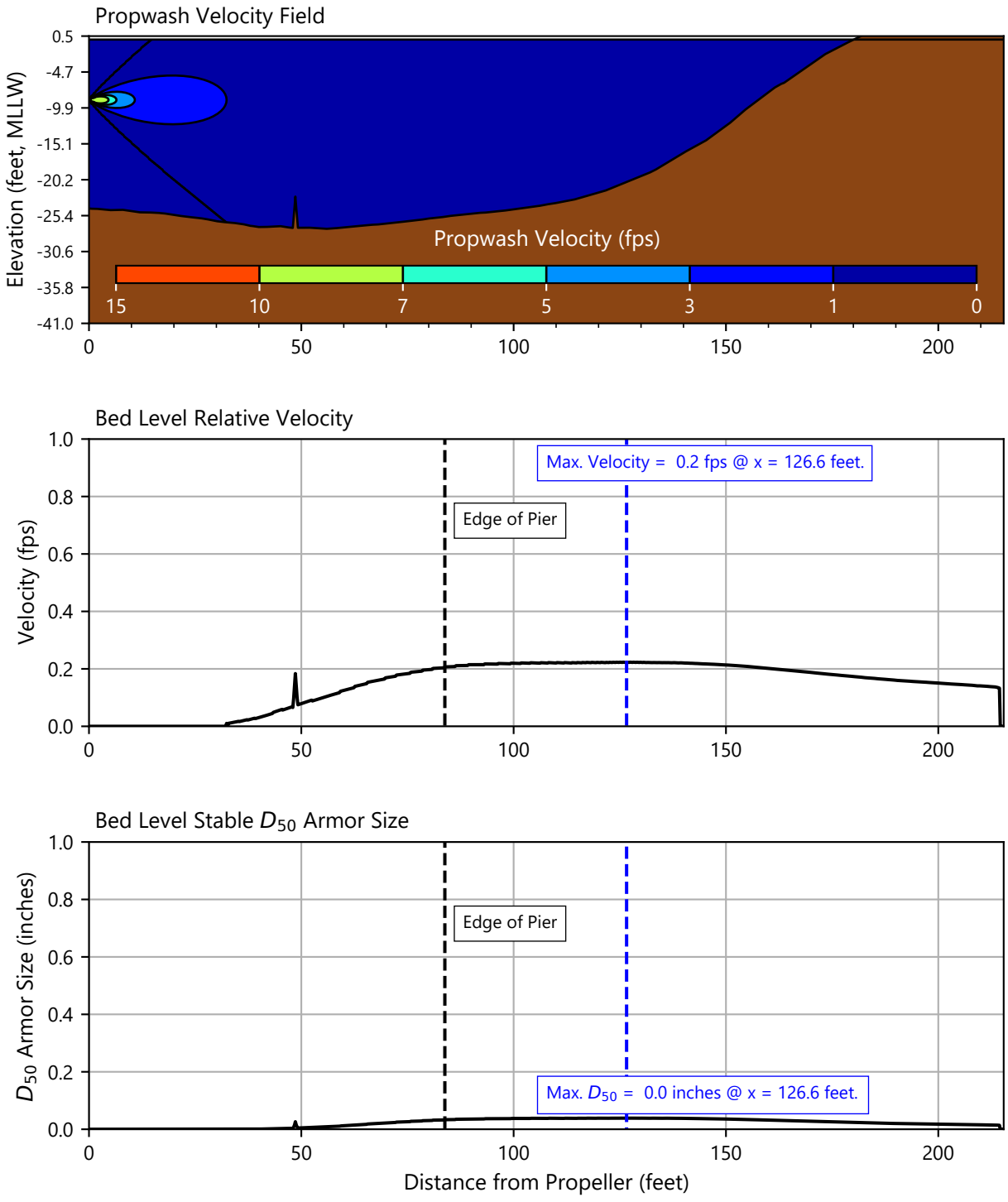
Publish Date: 01/24/2024 09:04 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

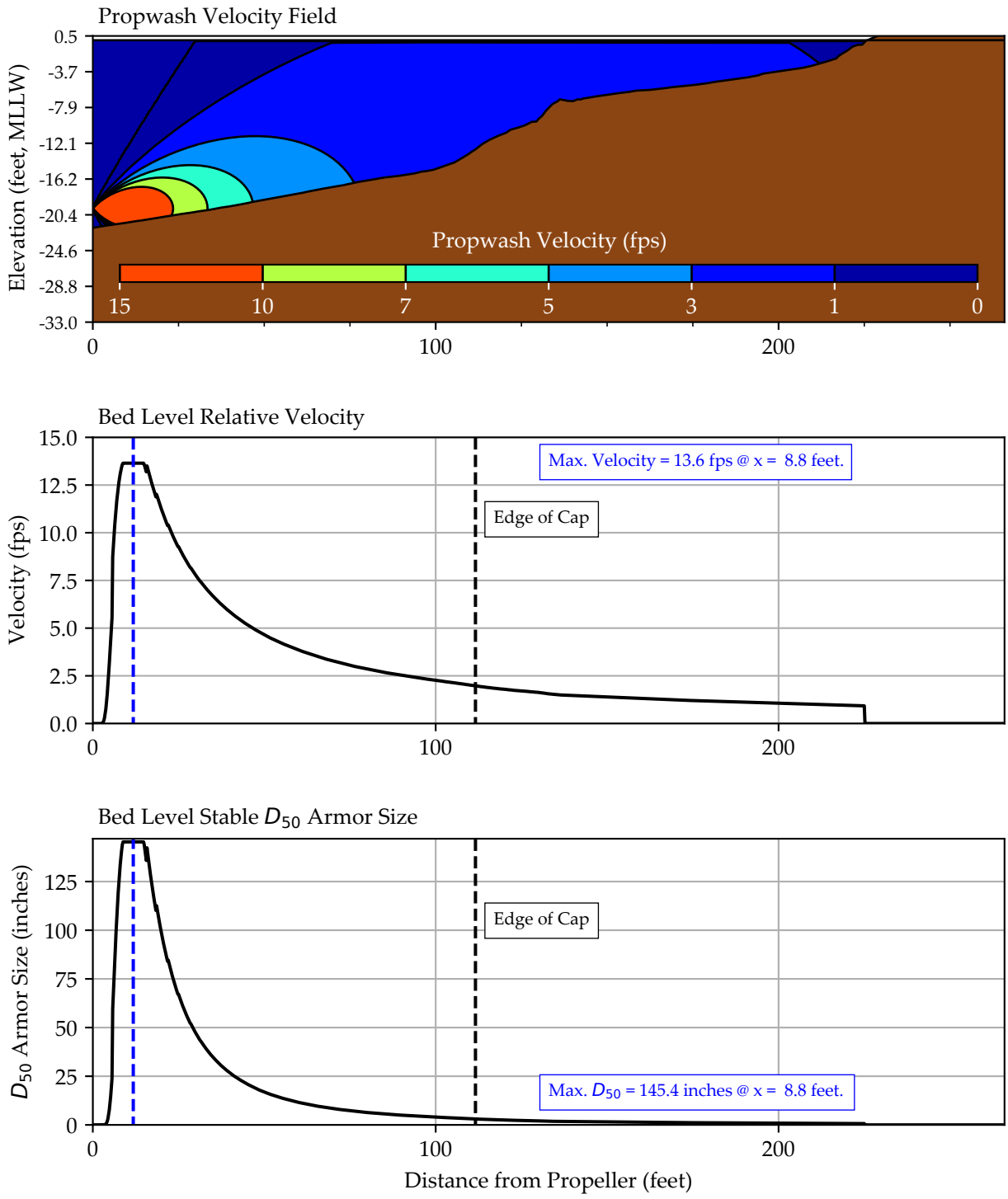
Publish Date: 01/24/2024 09:04 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

Figure 3f
The Duchess Fishing Boat at 0 knots, using 20% Applied PowerTransect: Section 7 at MLLW



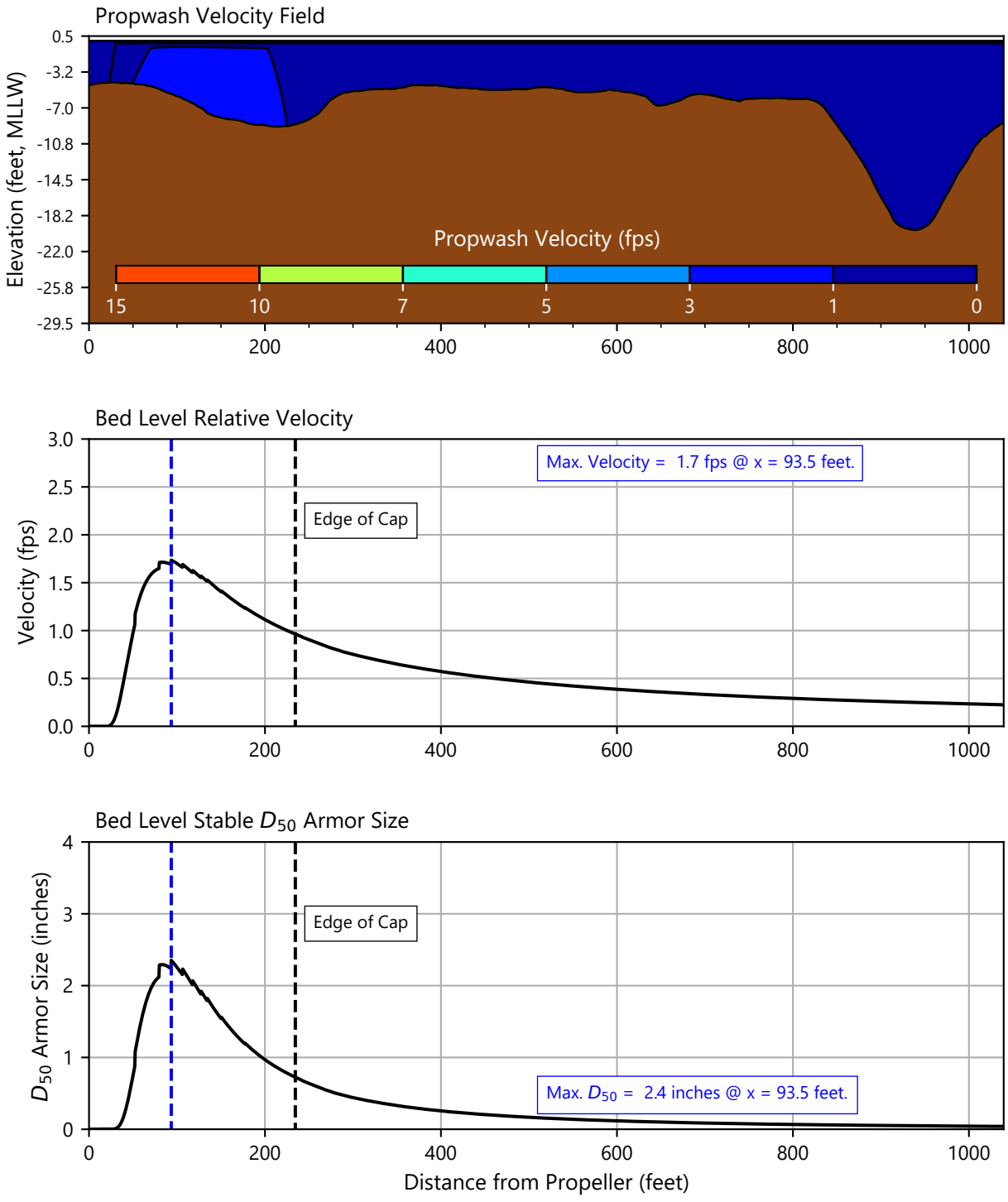
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:04 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

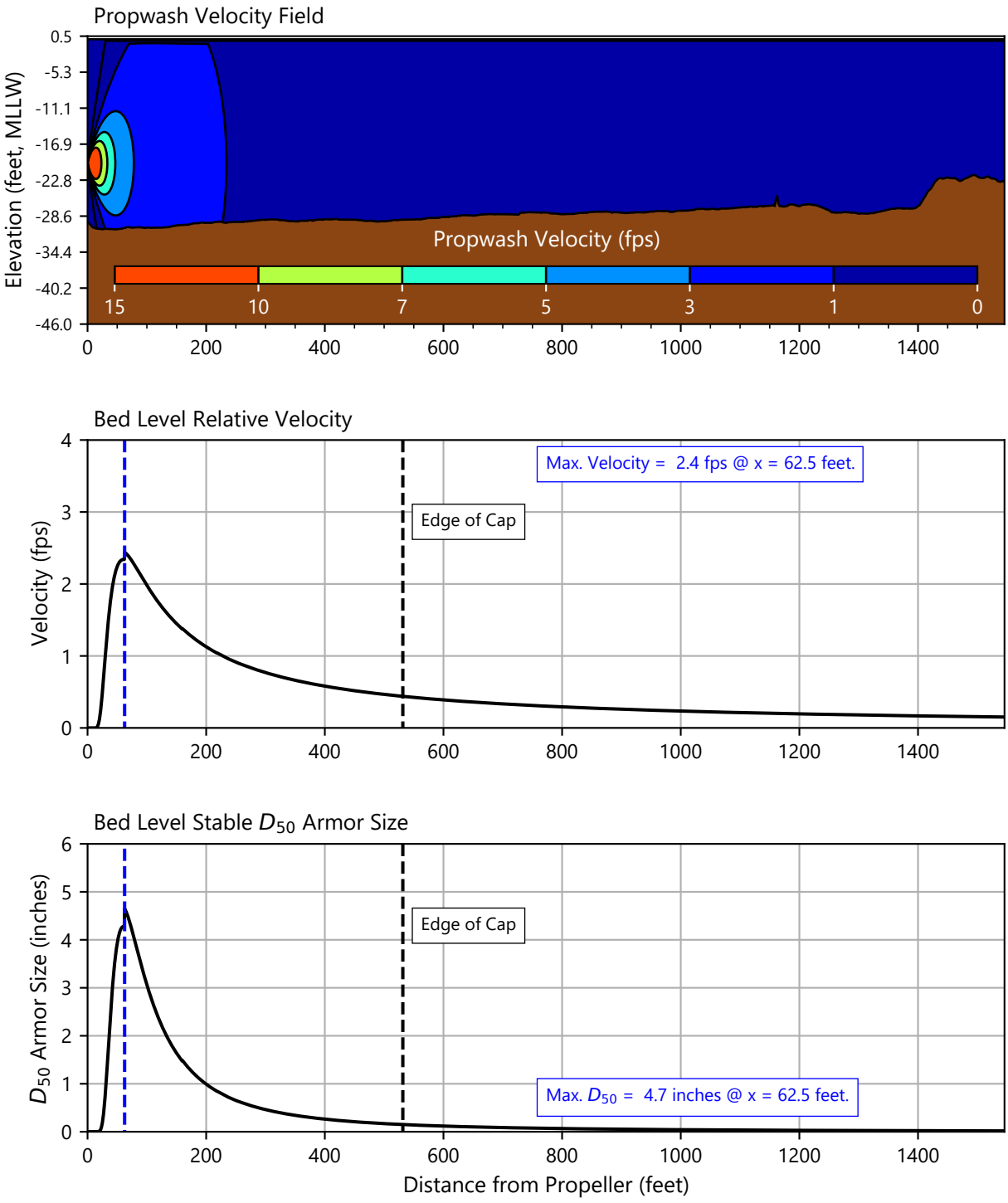
Publish Date: 01/24/2024 09:19 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:19 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

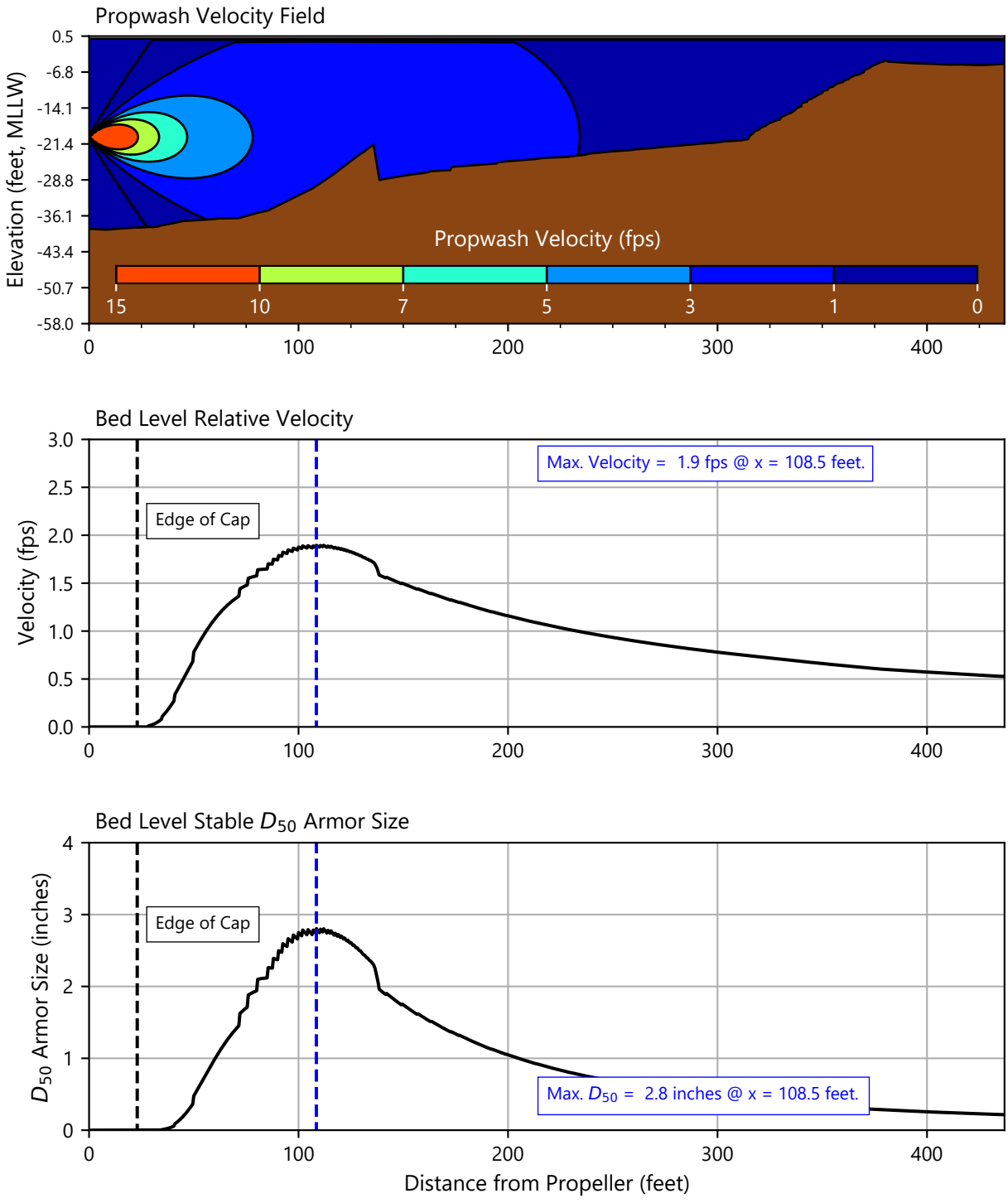
Figure 4b
Northern Eagle Fishing Boat at 0 knots, using 20% Applied PowerTransect: Section 2 at MLLW
Appendix C Coastal and Propwash Evaluation
Whatcom Waterway Phase 2 Cleanup



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:19 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

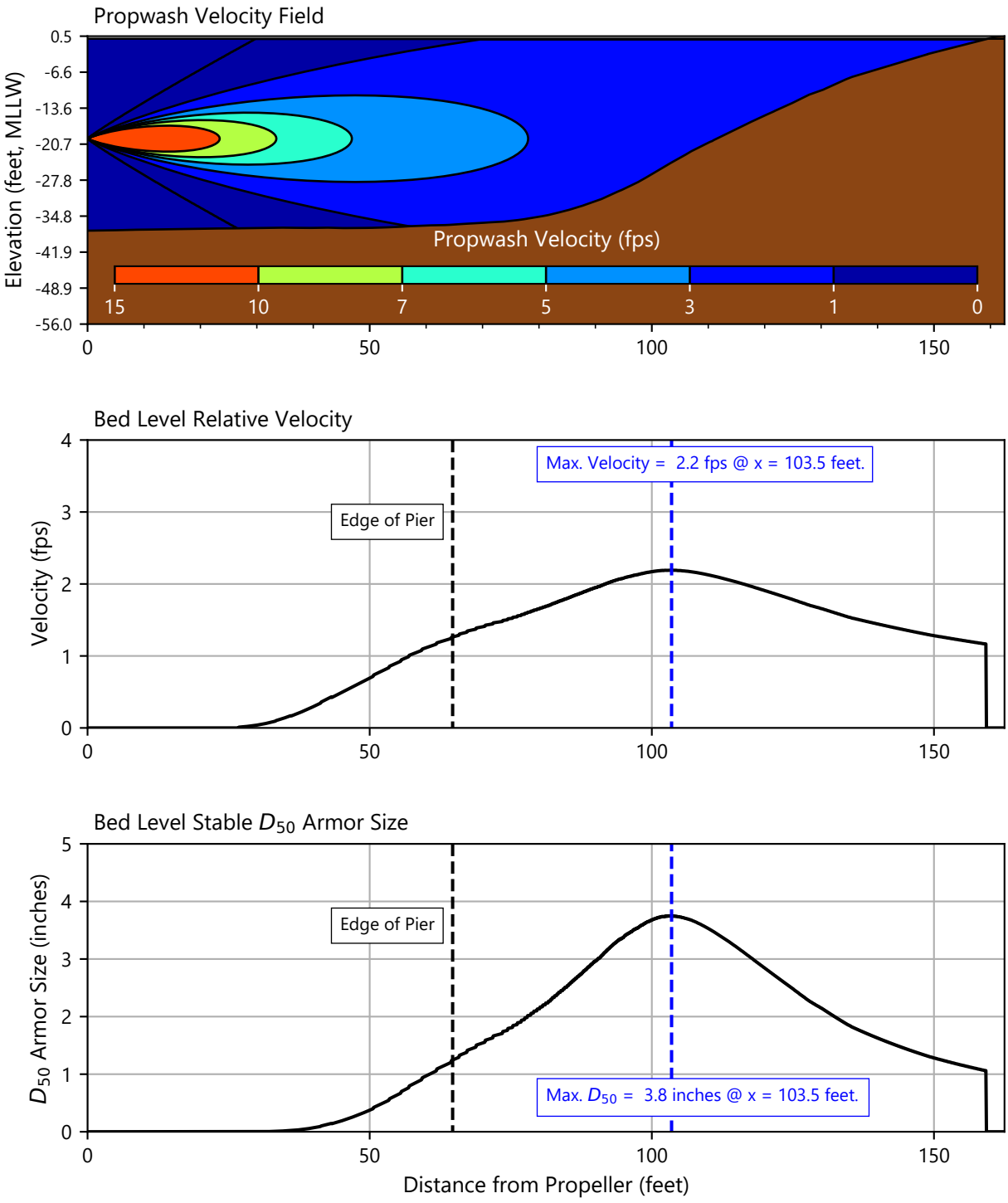
Figure 4c
Northern Eagle Fishing Boat at 0 knots, using 20% Applied PowerTransect: Section 3 at MLLW



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:19 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

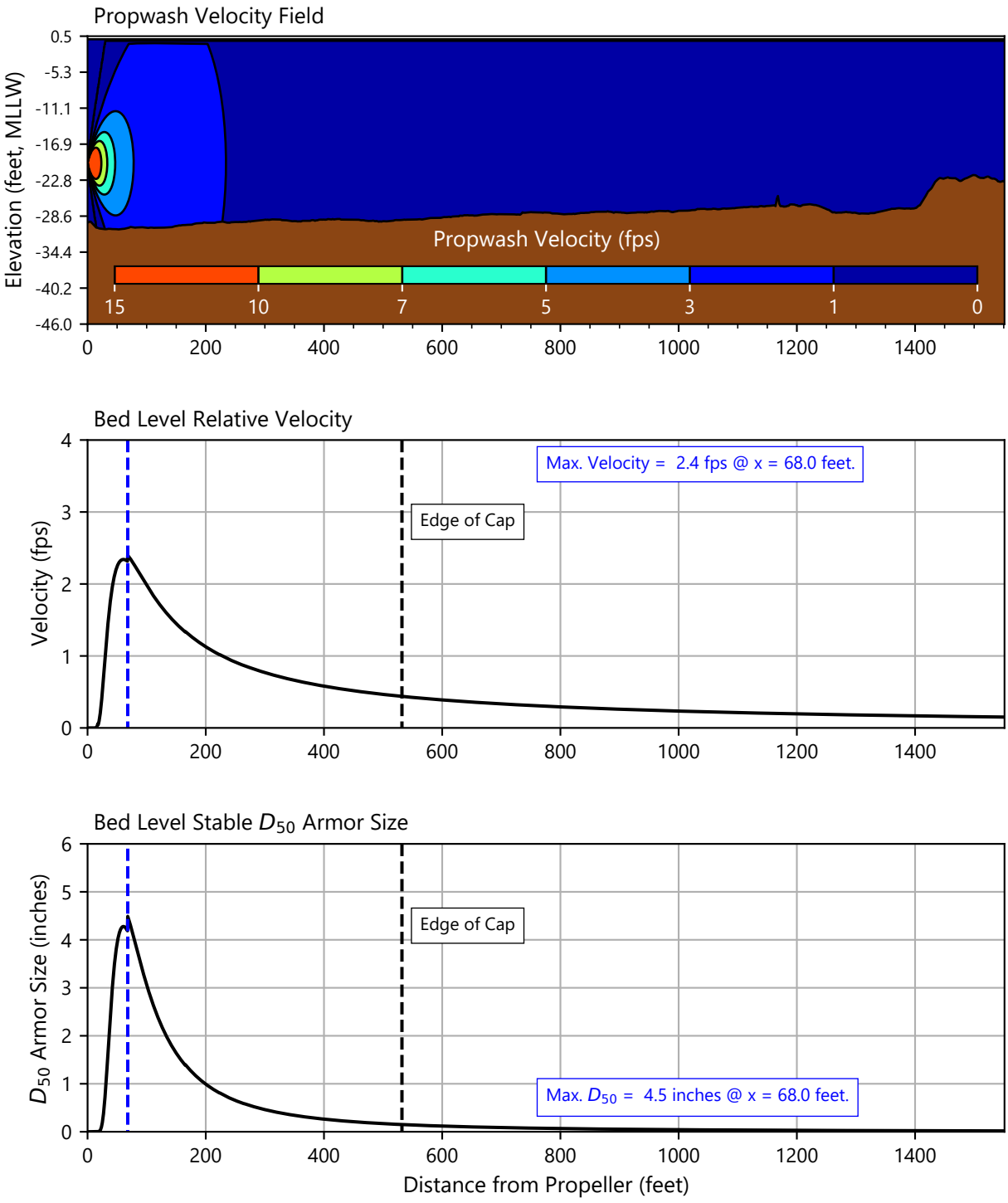
Figure 4d
Northern Eagle Fishing Boat at 0 knots, using 20% Applied PowerTransect: Section 4 at MLLW
Appendix C Coastal and Propwash Evaluation
Whatcom Waterway Phase 2 Cleanup



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:19 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

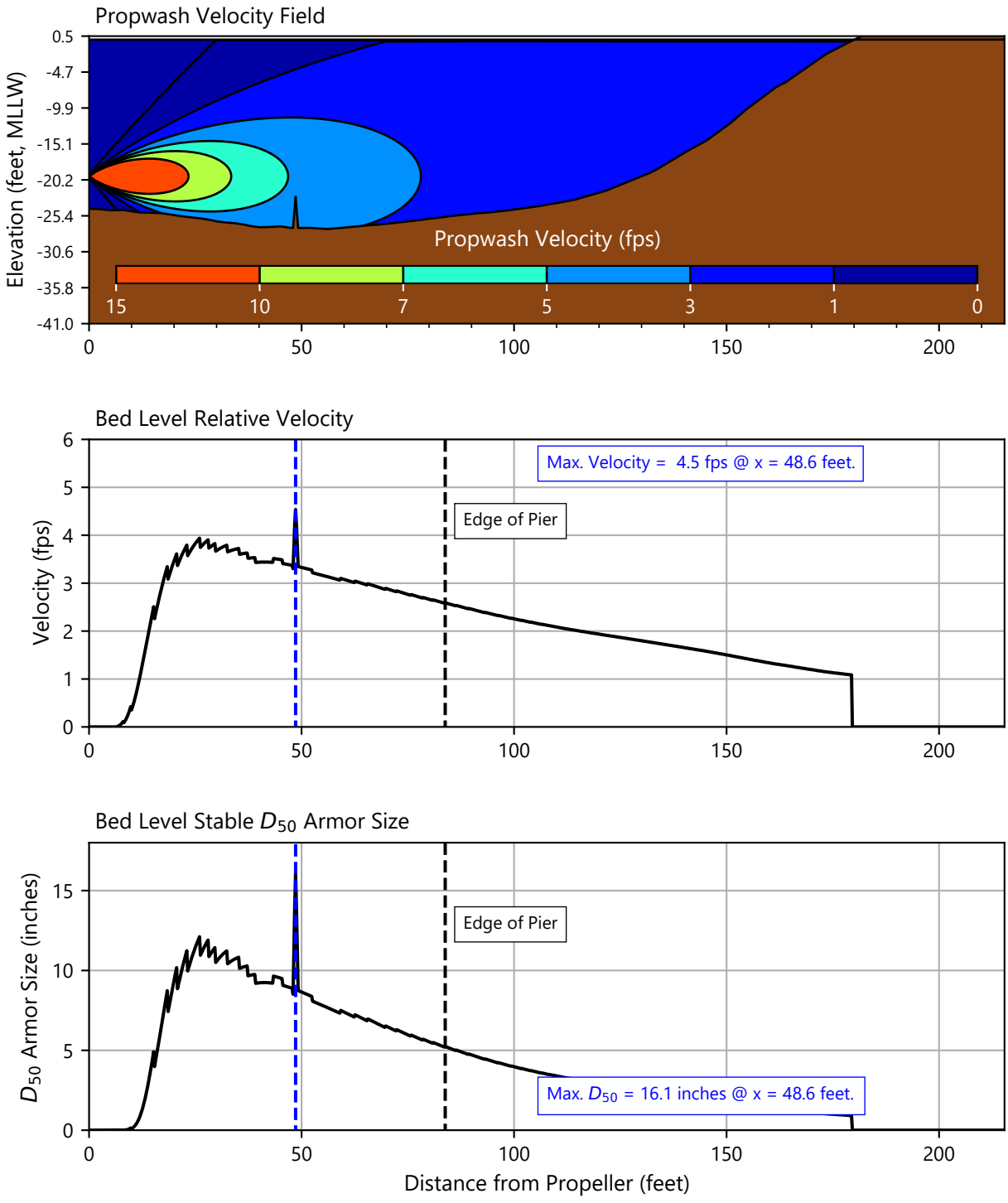
Figure 4e
Northern Eagle Fishing Boat at 0 knots, using 20% Applied PowerTransect: Section 6 at MLLW
Appendix C Coastal and Propwash Evaluation
Whatcom Waterway Phase 2 Cleanup



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:19 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

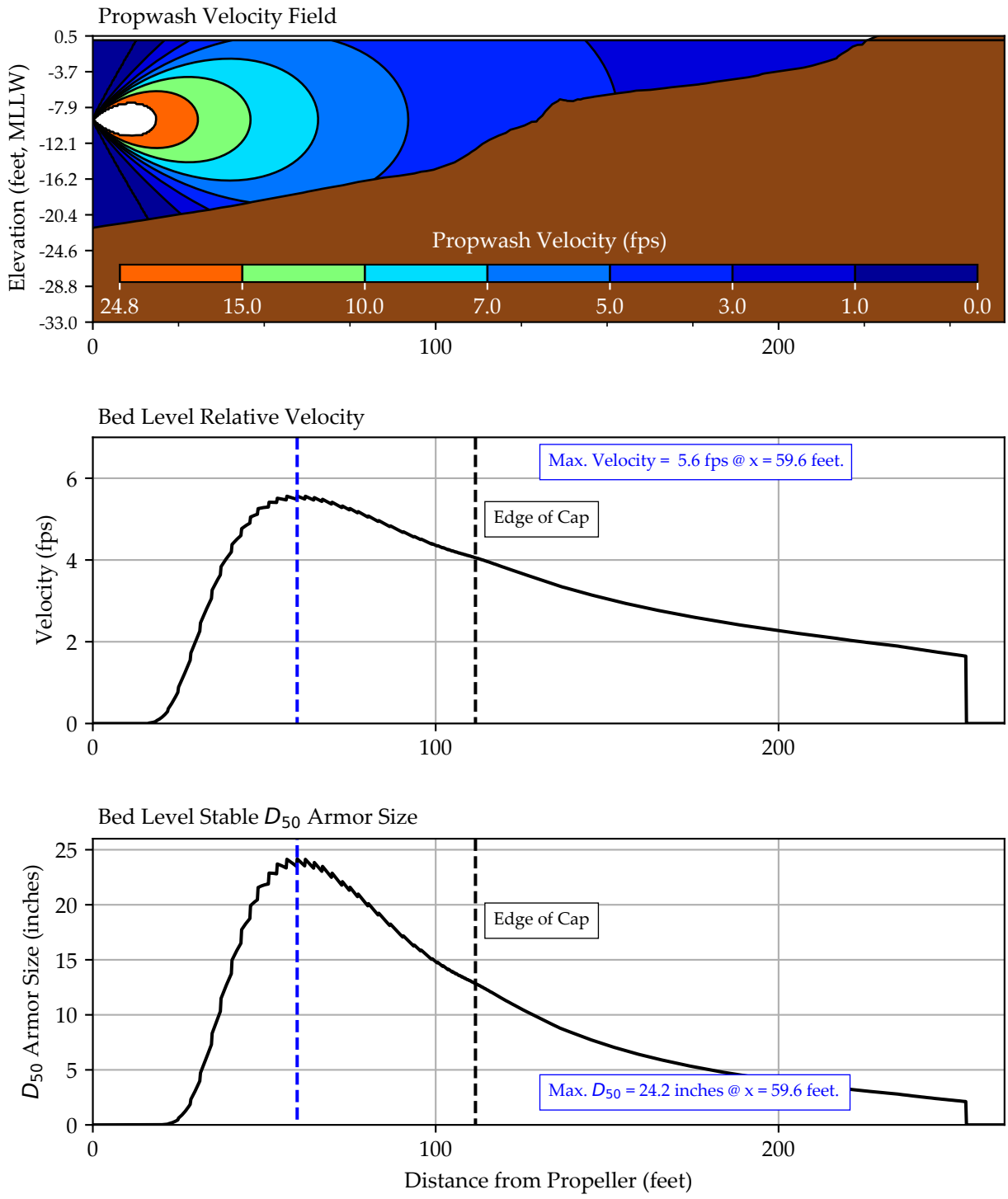
Figure 4f
Northern Eagle Fishing Boat at 0 knots, using 20% Applied PowerTransect: Section 7 at MLLW



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:19 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

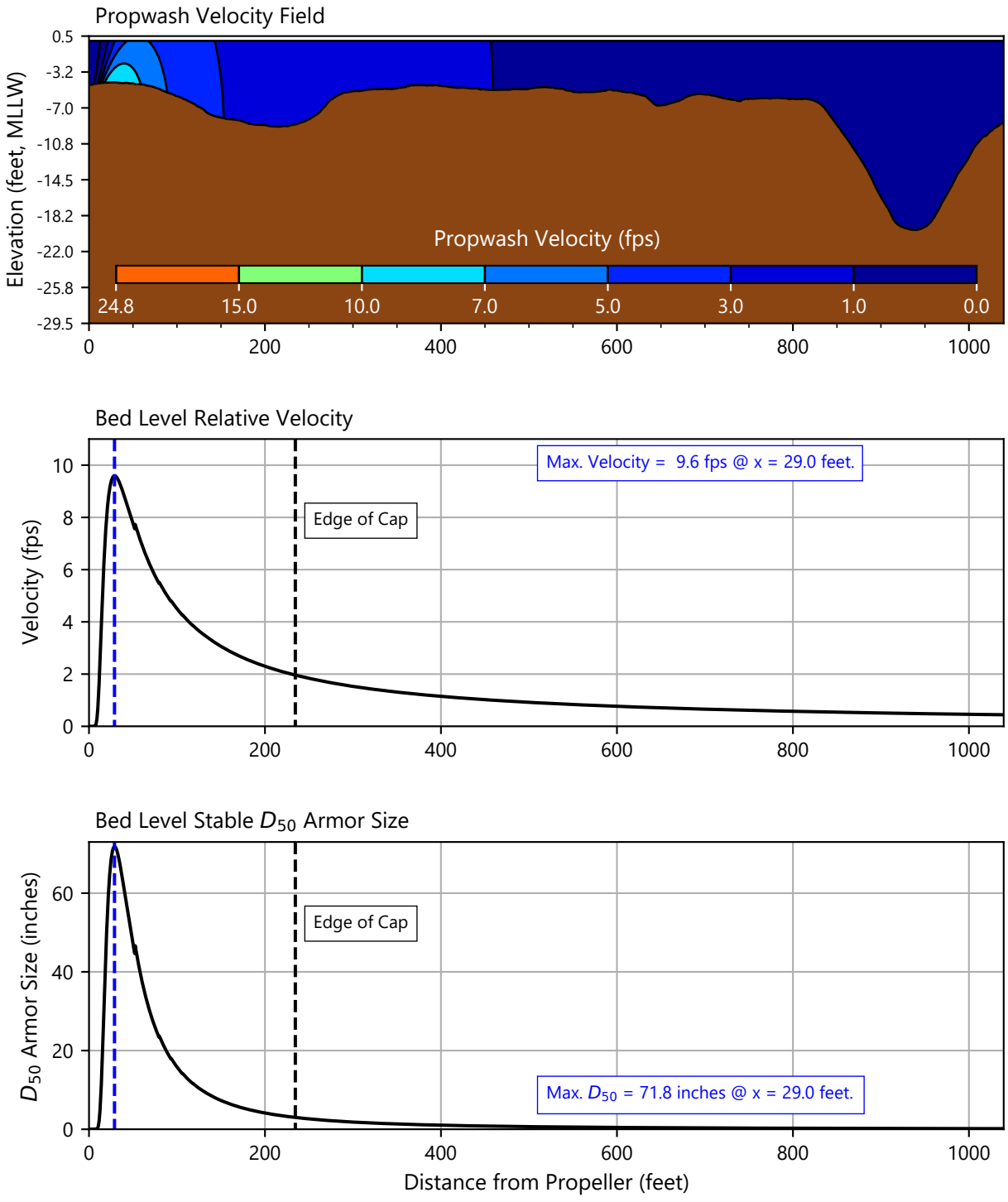
Figure 4g
Northern Eagle Fishing Boat at 0 knots, using 20% Applied PowerTransect: Section 8 at MLLW



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

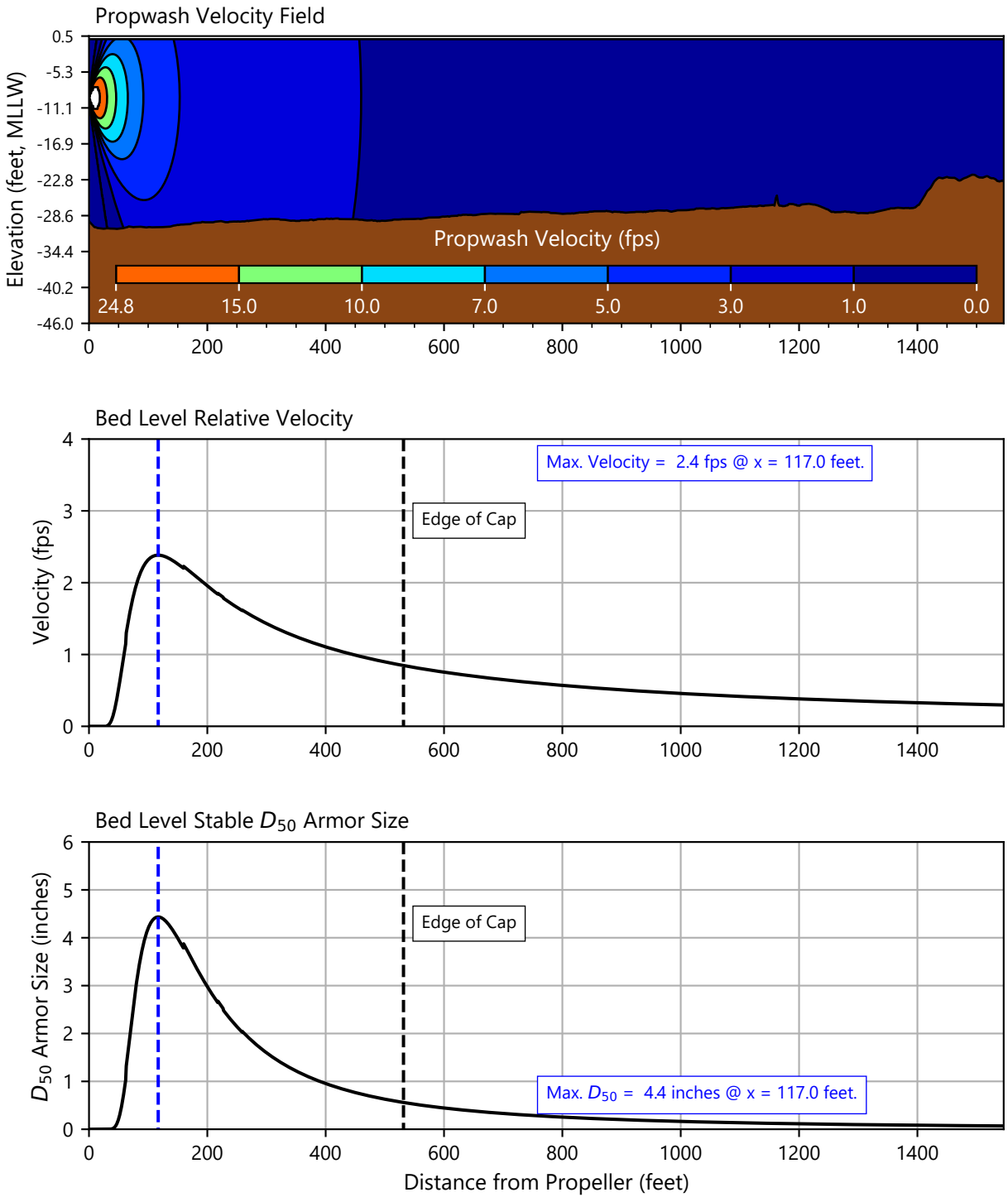
Publish Date: 01/24/2024 09:30 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

Figure 5a
Brian S. Tug at 0 knots, using 100% Applied PowerTransect: Section 1 at MLLW
Appendix C Coastal and Propwash Evaluation
Whatcom Waterway Phase 2 Cleanup



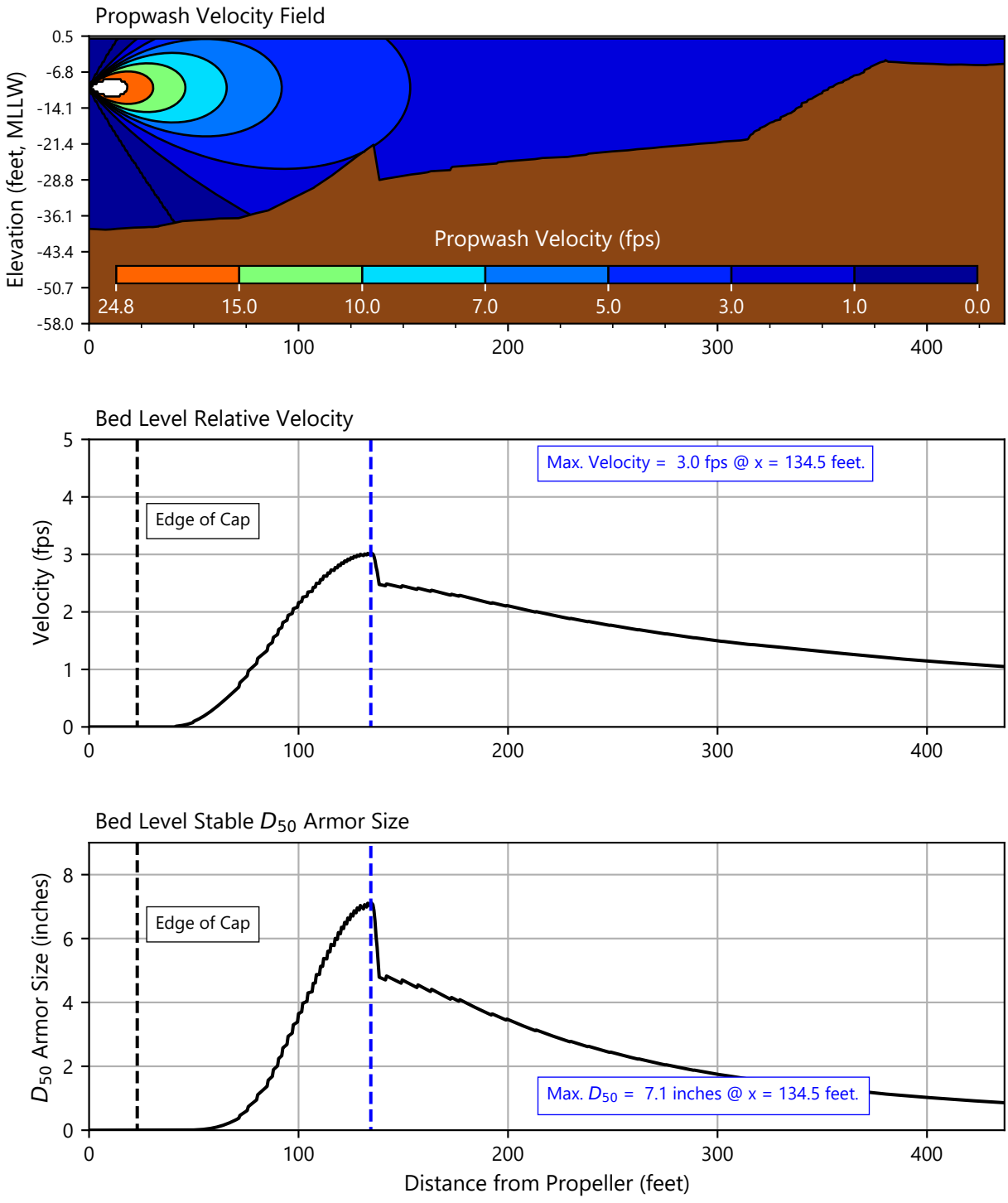
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:30 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



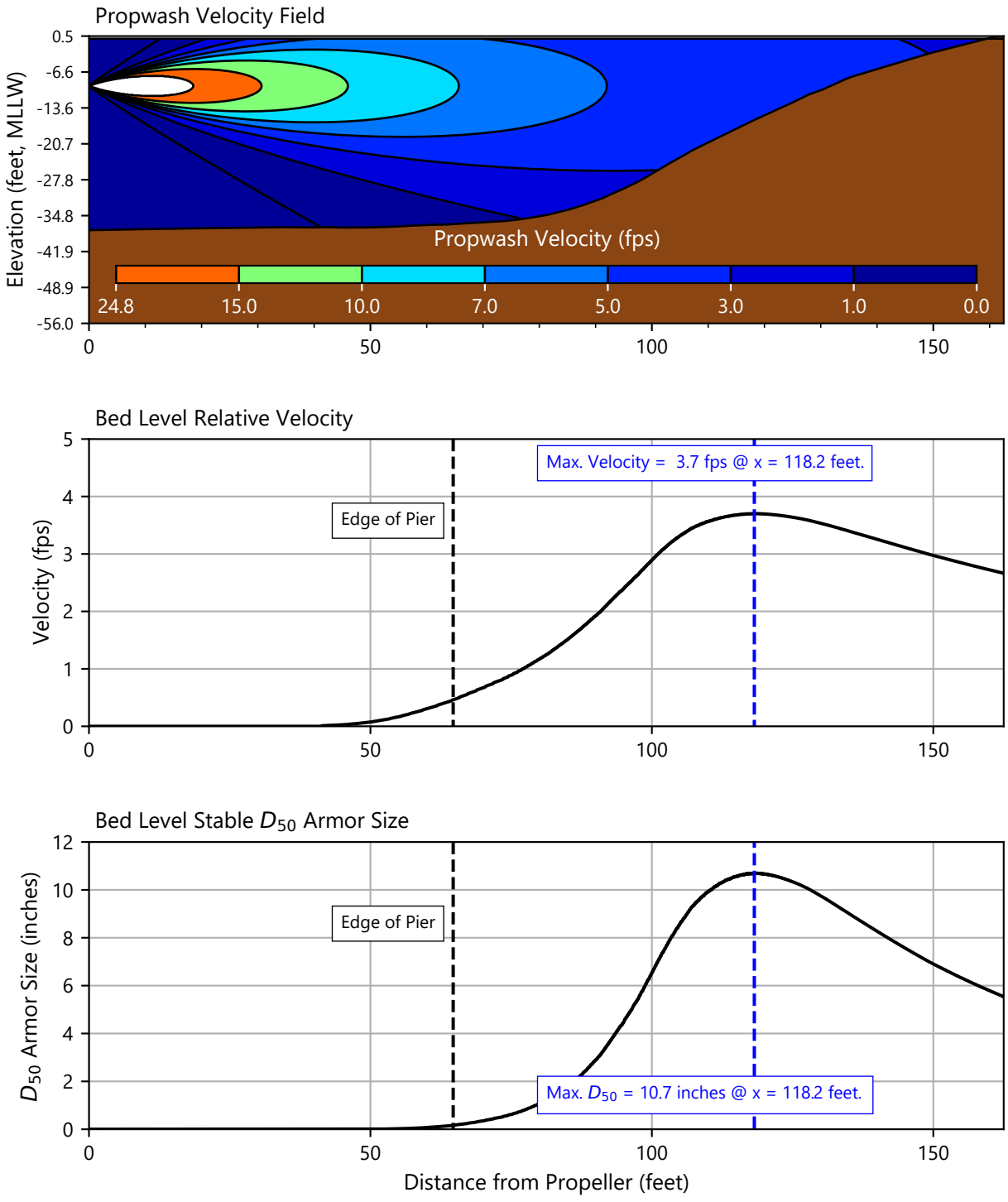
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:30 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

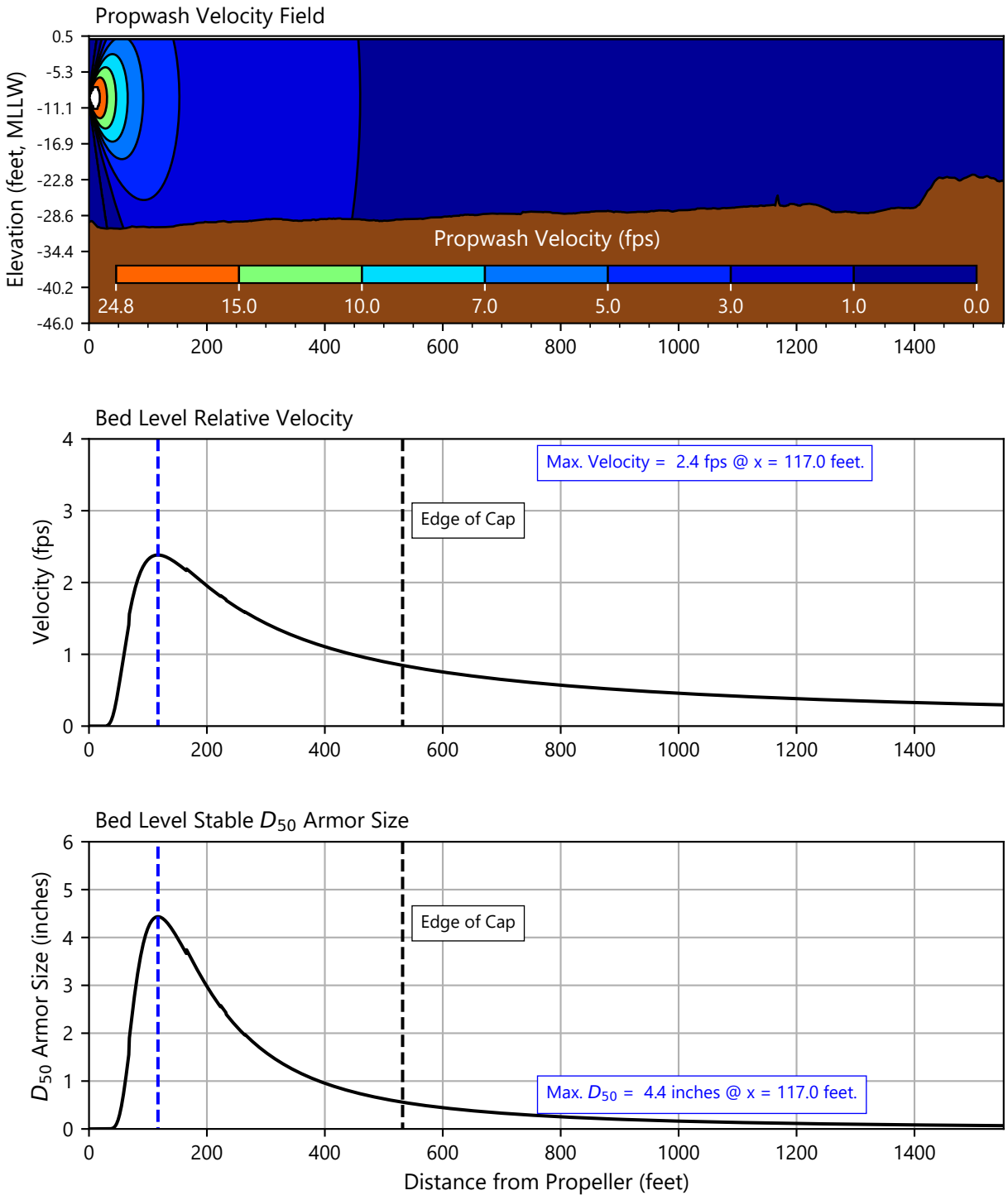
Publish Date: 01/24/2024 09:30 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

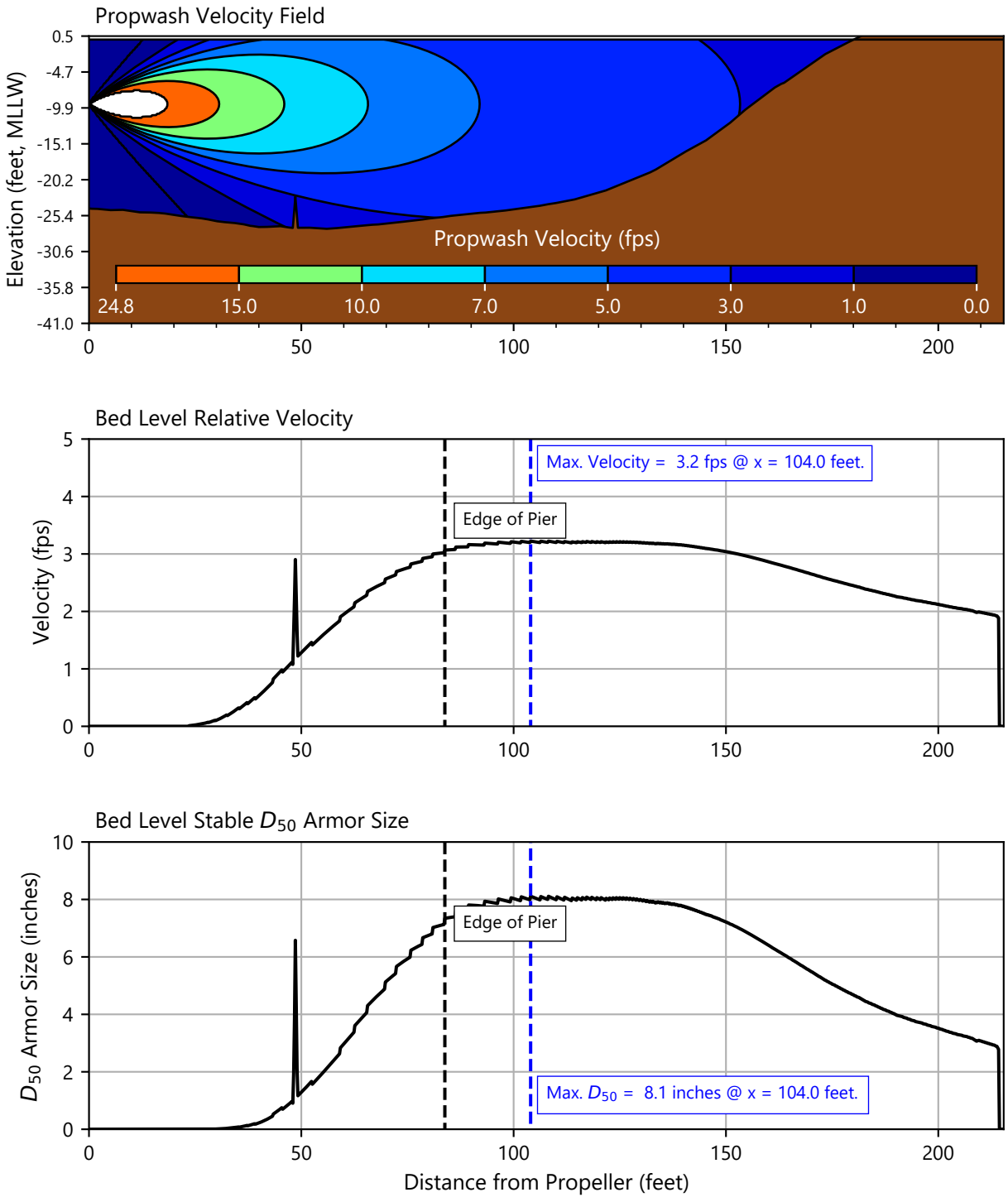
Publish Date: 01/24/2024 09:30 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

Figure 5e
Brian S. Tug at 0 knots, using 100% Applied PowerTransect: Section 6 at MLLW
Appendix C Coastal and Propwash Evaluation
Whatcom Waterway Phase 2 Cleanup



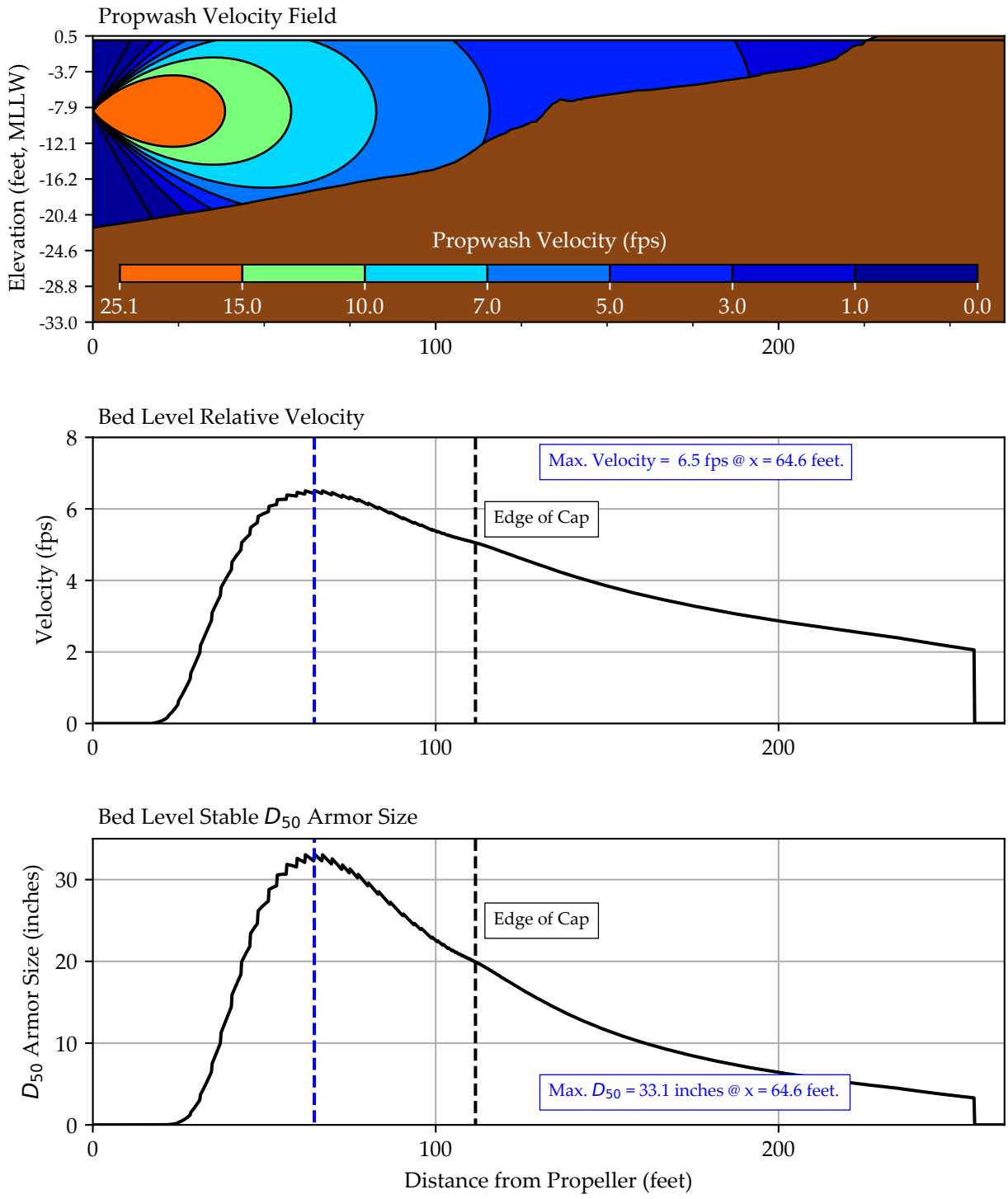
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:30 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



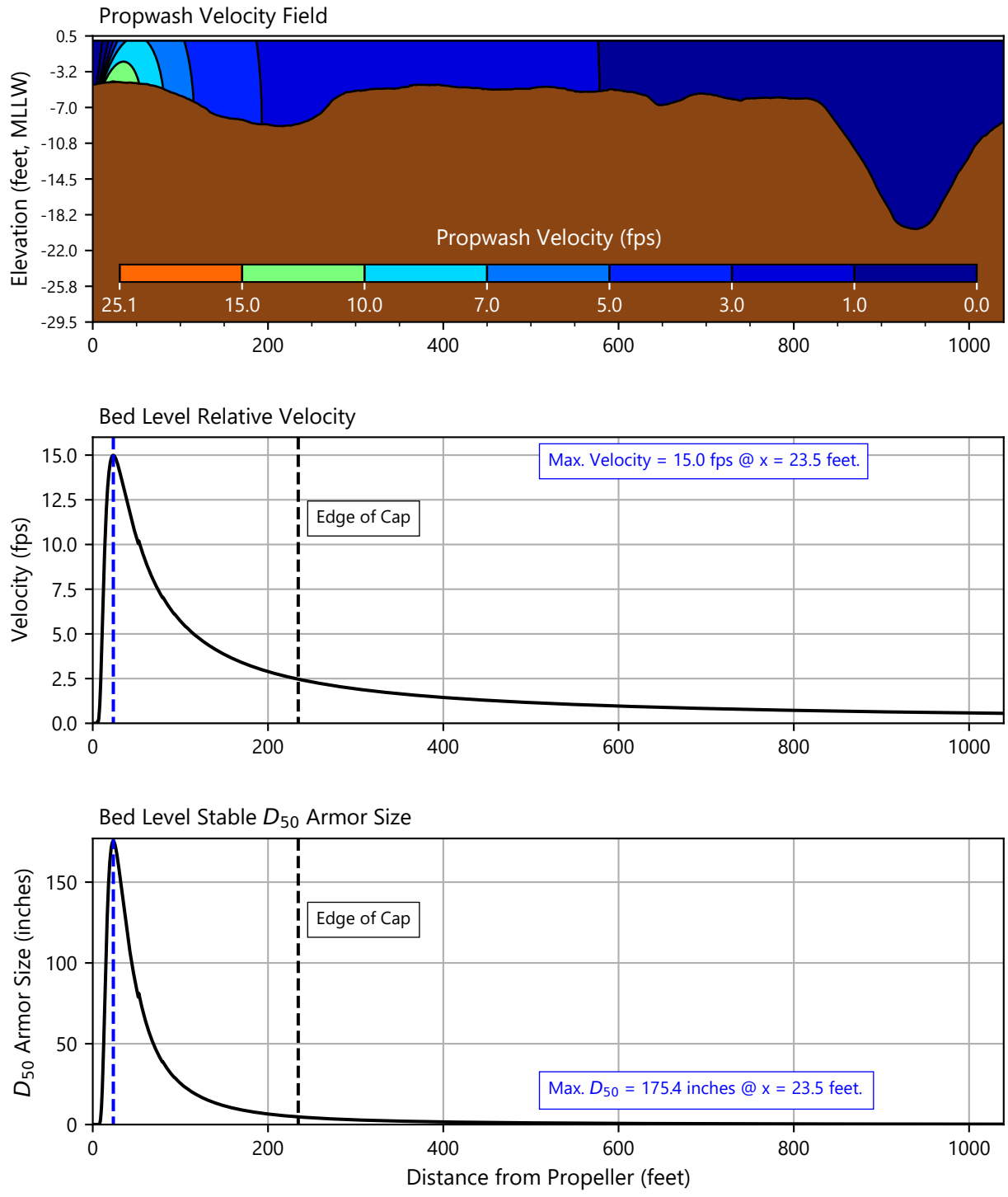
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:30 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



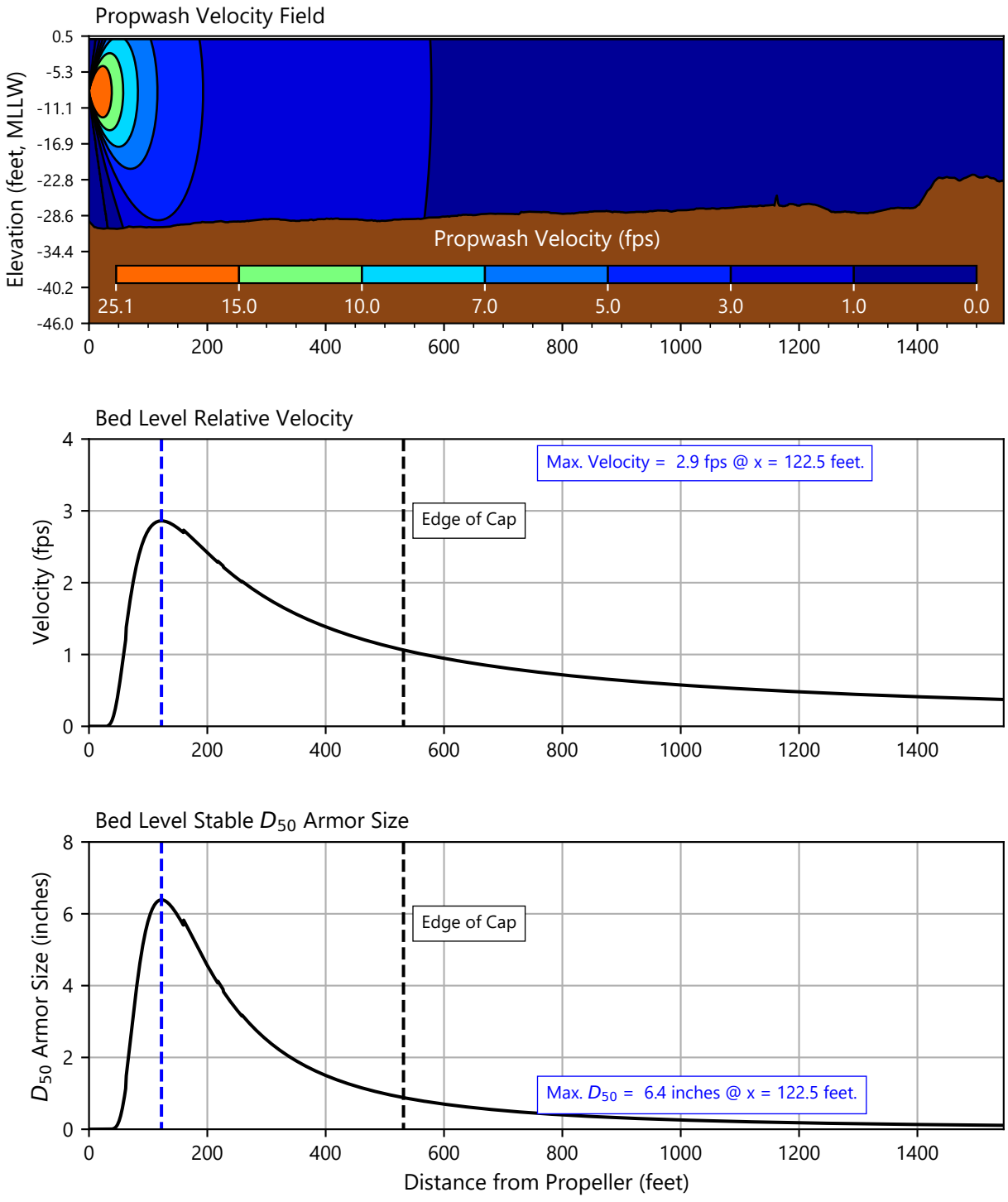
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:42 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



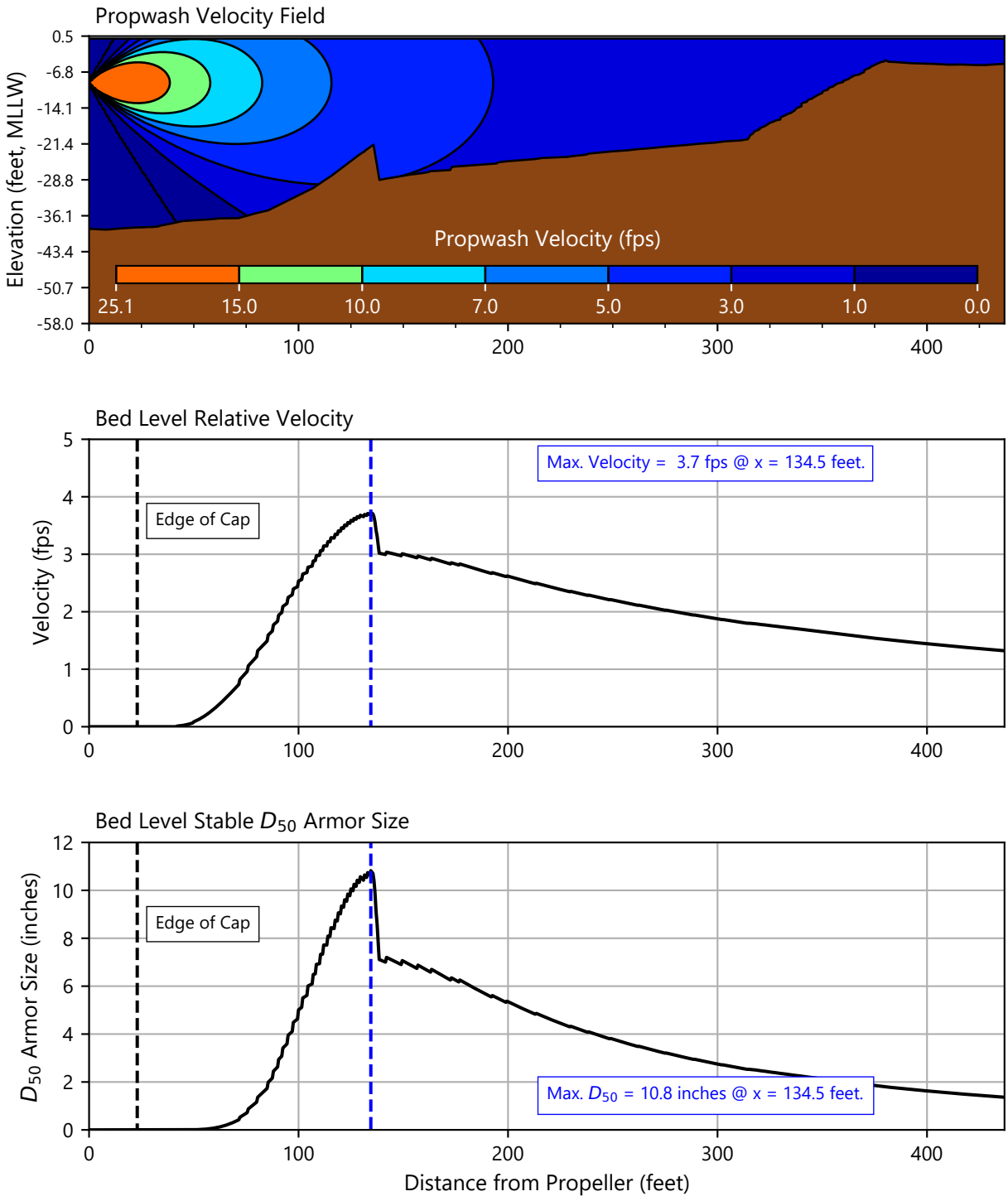
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:42 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



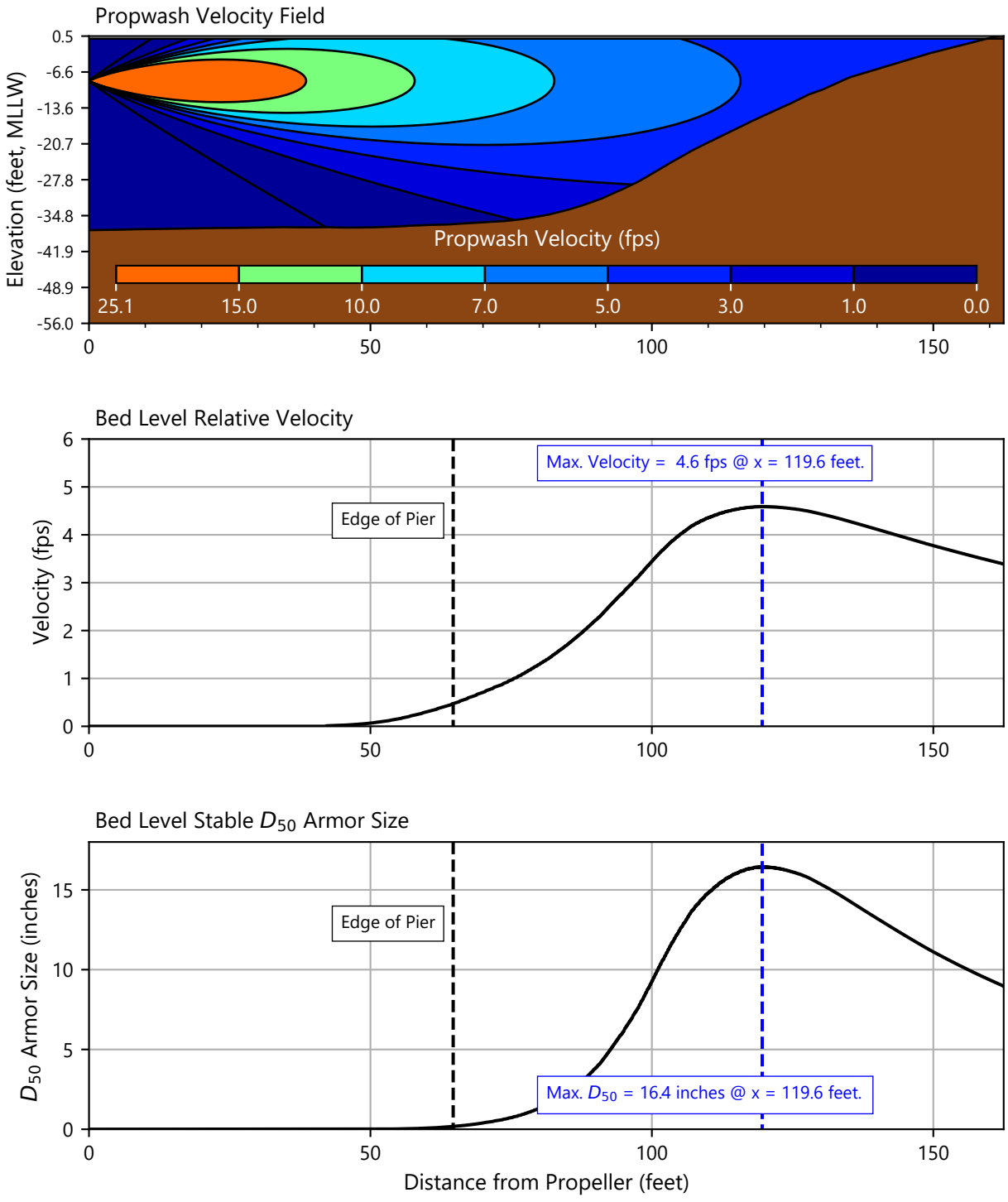
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:42 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



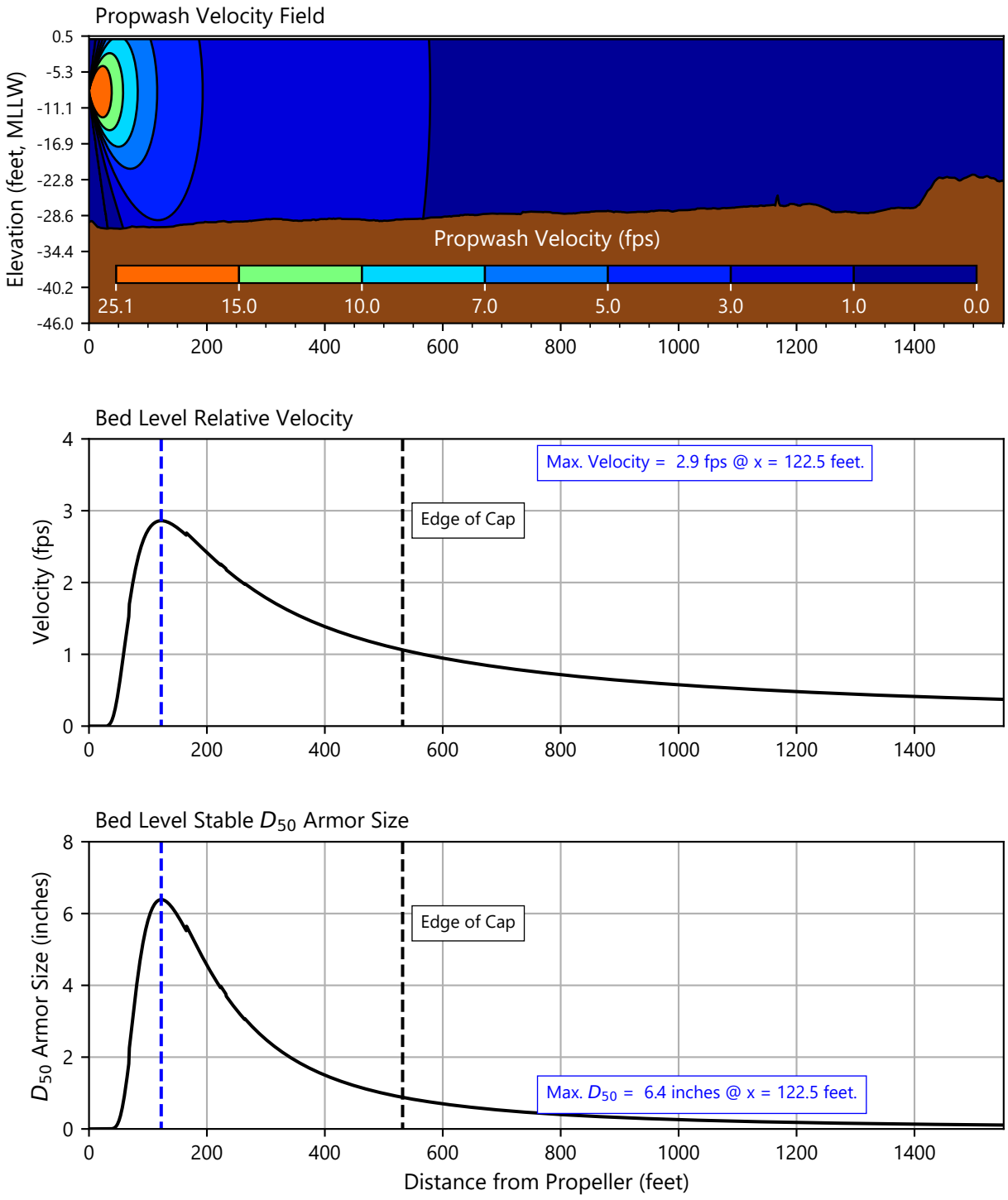
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:42 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



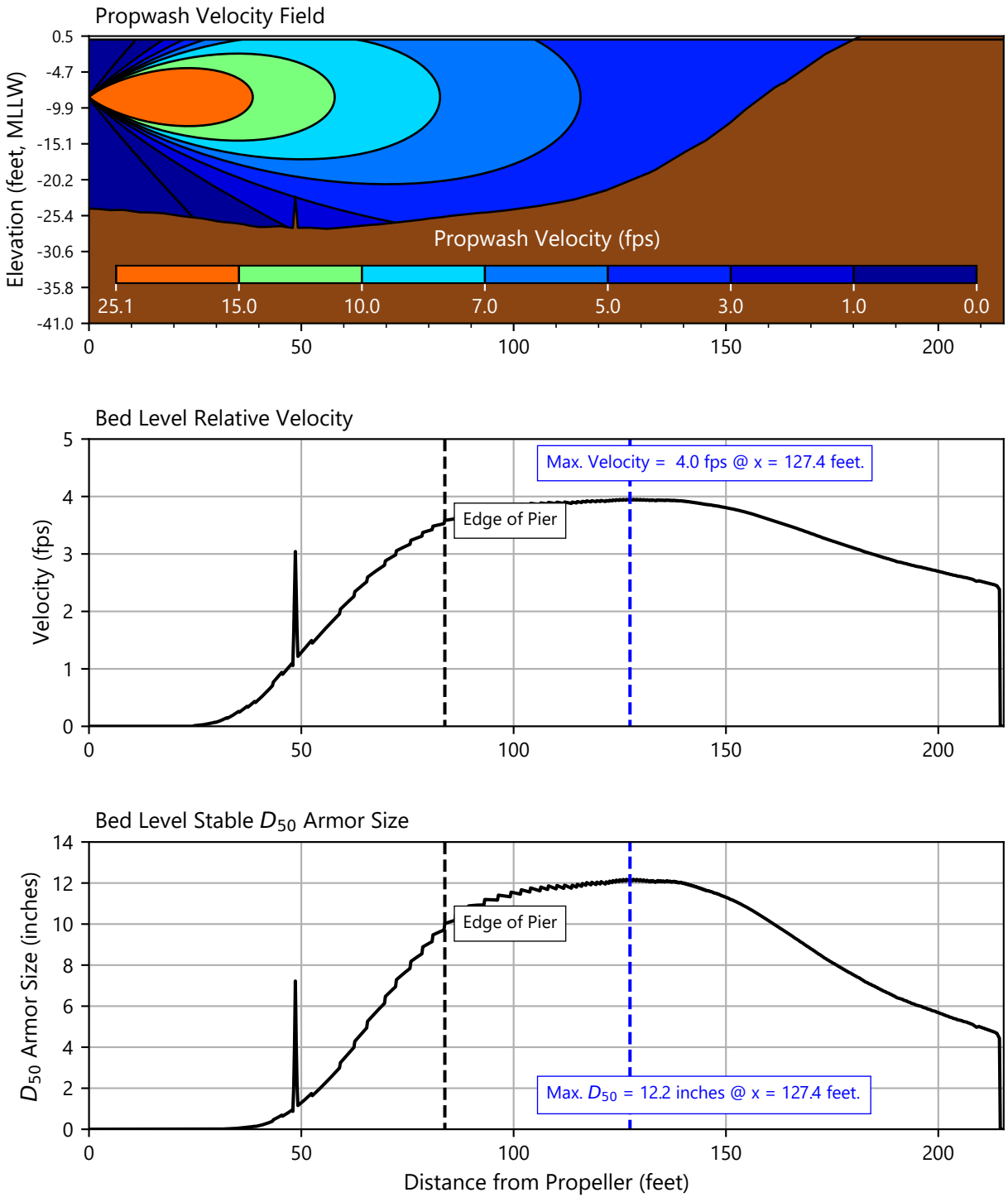
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:42 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:42 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K



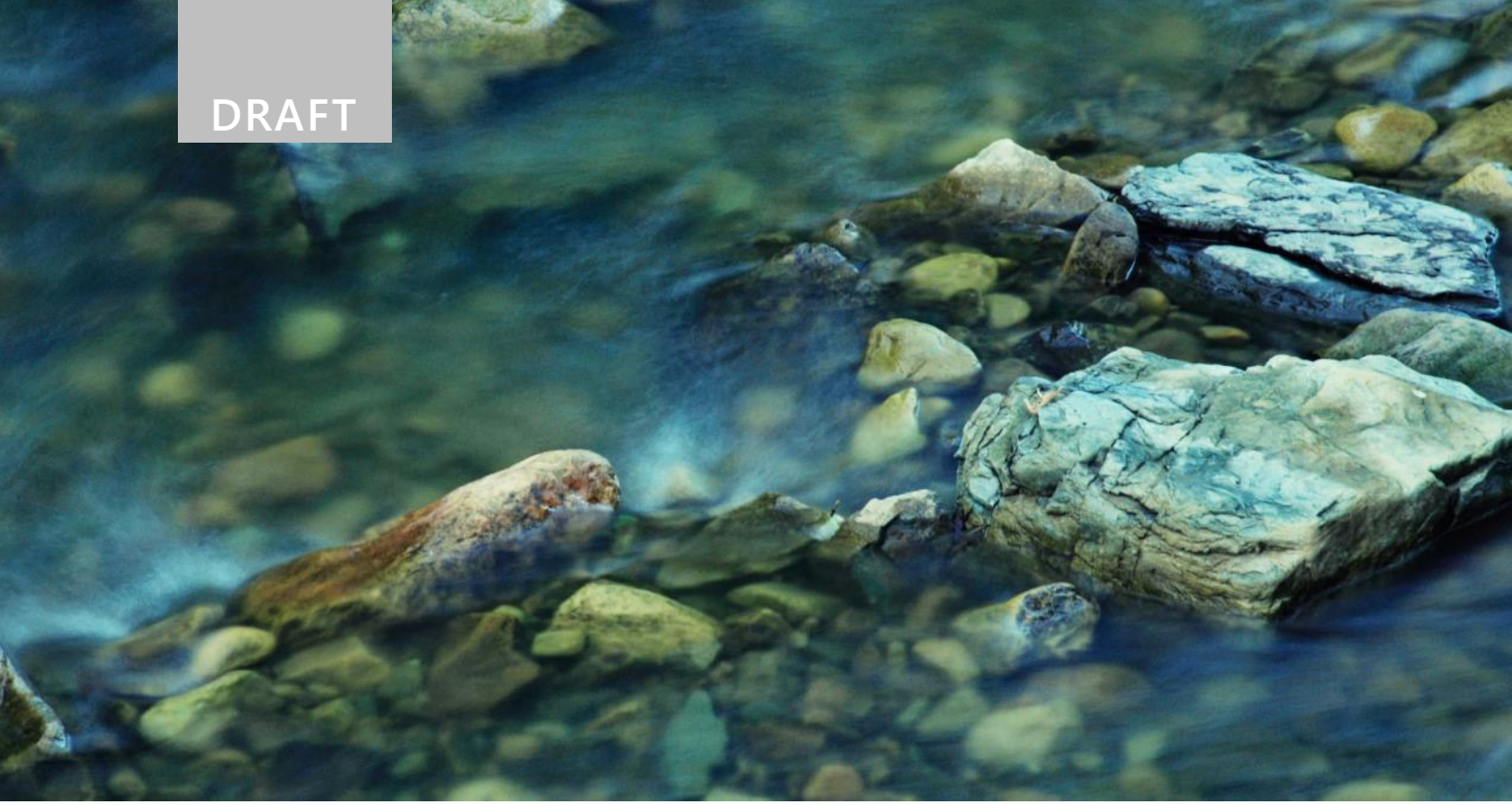
Notes:
The propwash analysis is based on the Maynord 1998 capping methodology.
The C_3 coefficient = 0.55 for no sediment movement.

Publish Date: 01/24/2024 09:42 AM | User: AQ-DELFT3D3
File Path: \\fuji\Anchor\Projects\Port of Bellingham\190007-01.01 Whatcom Waterway Phase 2 Cleanup\9_Engineering Design Report\Design Evaluation Updates\Coastal Engineering\Propwash Calcs\Blaaw_and_K

Figure 6g
Kinani H Tug at 0 knots, using 100% Applied PowerTransect: Section 8 at MLLW
Appendix C Coastal and Propwash Evaluation
Whatcom Waterway Phase 2 Cleanup

Appendix D
Best Management Practices

DRAFT



June 2025
Whatcom Waterway Cleanup in Phase 2 Site Areas

ANCHOR QEA

Appendix D
Proposed Best Management Practices

Prepared for Port of Bellingham

DRAFT

June 2025
Whatcom Waterway Cleanup in Phase 2 Site Areas

Appendix D
Proposed Best Management Practices

Prepared for
Port of Bellingham
1801 Roeder Avenue
Bellingham, Washington 98227

Prepared by
Anchor QEA
20 Bellwether Way, Suite 101
Bellingham, Washington 98225

Project Number: 190007-01.01

TABLE OF CONTENTS

1 Introduction 1

2 Notifications and Work Windows 2

Notifications 2

In-Water Work Timing 2

3 BMPs for Dredging and Material Placement 3

Water Quality Monitoring and Control 3

Barge Operations 4

Dredging, Residuals Management Cover, and Cap Placement 4

Sediment Transloading to the Confined Disposal Facility 4

Handling and Disposal of Debris and Contaminated Soils 5

Decontamination of Dredging Equipment 5

4 BMPs for Structural Work 7

Water Quality Monitoring and Control 7

Pile Removal, Handling, and Disposal 7

Piling and Dolphin Installation 9

Installation of Steel Sheetpile Structures 9

Installation of New Stormwater Outfalls 10

Pipeline and Outfall Infrastructure Abandonment 10

5 Resource Protection BMPs 11

Spill Prevention 11

Eelgrass Protection 12

Upland Stormwater Management 12

Cultural and Historic Resources 12

6 References 14

ABBREVIATIONS

ASB	Aerated Stabilization Basin
BMP	best management practice
CDF	Confined Disposal Facility
City	City of Bellingham
Cleanup	Whatcom Waterway Cleanup in Phase 2 Site Areas
dB	decibel
Ecology	Washington State Department of Ecology
HPA	Hydraulic Project Approval
IDP	Inadvertent Discovery Plan
NPDES	National Pollutant Discharge Elimination System
RCW	Revised Code of Washington
SEL	sound exposure level
SPCC	Spill Prevention, Control, and Countermeasure
SWPPP	Stormwater Pollution Prevention Plan
USACE	U.S. Army Corps of Engineers
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife

1 Introduction

This document summarizes the best management practices (BMPs) to be employed during implementation of the Whatcom Waterway Cleanup in Phase 2 Site Areas (Cleanup).

BMPs are management practices that are determined to be effective, practical, and sustainable means of achieving an environmental performance objective (e.g., compliance with water quality criteria) during Site cleanup. BMPs will be used to meet these performance objectives during construction and to limit potential adverse construction impacts.

Final BMPs will be updated where necessary to incorporate additional BMPs if defined during final permits or substantive requirements.

2 Notifications and Work Windows

Notifications

- The Washington Department of Fish and Wildlife (WDFW) Area Habitat Biologist, the U.S. Army Corps of Engineers (USACE) regulatory lead, the Washington State Department of Ecology (Ecology) regulatory lead, and the City of Bellingham (City) regulatory lead for the Cleanup will be notified of the project start date.
- Notice will be provided to the USACE Bellingham Harbor Operations Manager 10 days prior to commencing work within the federally authorized channel.
- If at any time, as a result of project activities, fish are observed in distress, a fish kill occurs, or water quality problems develop (including equipment leaks or spills), the Washington Emergency Management Division will be immediately contacted at 1-800-258-5990.

In-Water Work Timing

- In-water work will be performed consistent with the joint regulatory agency-approved fish protection work windows for the Cleanup as determined during the permitting approvals for the Cleanup.
- The anticipated in-water work windows are as follows (to be updated if necessary following receipt of permits):
  - Work below the ordinary high water and mean higher high water lines must not occur from March 15 through July 15 of any year for the protection of migrating juvenile salmonids.
  - Work below the ordinary high water and mean higher high water lines must only occur in the dry from July 16 through July 31 of any year for the protection of migrating juvenile salmonids.
  - Work below the ordinary high water and mean higher high water lines is allowed in the dry and in-water from August 1 through March 14 of any year.
    - From February 16 through March 14, the only in-water work allowed is clean material placement (i.e., no dredging, pile driving, or other in-water activities).

3 BMPs for Dredging and Material Placement

Water Quality Monitoring and Control

- Turbidity and other water quality parameters will be monitored to ensure construction activities are in compliance with Washington State Surface Water Quality Standards (173-201A Washington Administrative Code [WAC]) and in accordance with the Water Quality Monitoring Plan (Appendix E of the *Engineering Design Report*).
- Appropriate BMPs will be employed to minimize sediment loss and turbidity generation during dredging. BMPs may include, but are not limited to, the following:
  - Removing large debris where practicable prior to dredging in known debris areas
  - Avoiding overfilling of the dredge bucket
  - Eliminating multiple bites while the bucket is on the seafloor
  - No stockpiling of dredged material below the ordinary high water line and mean higher high water line
  - No seafloor leveling
- Depending on the results of the water quality monitoring program, enhanced BMPs may also be implemented to further control turbidity. Enhanced BMPs may include, but are not limited to, the following:
  - Slowing the velocity (i.e., increasing the cycle time) of the ascending loaded clamshell bucket through the water column
  - Pausing the dredge bucket near the bottom while descending and near the water line while ascending
  - Using surface or near-surface silt curtains during dredging operations

  Barges will be managed such that the dredged sediment load does not exceed the capacity of the barge. The load will be placed in the barge to maintain an even keel and avoid listing. All barges handling dredged materials within the site will have hay bales and/or filter fabric placed over the barge scuppers to help filter suspended sediment from the barge effluent. The contractor will not allow effluent to overflow or bypass these turbidity controls. If sealed barges are used within the site (rather than using the treatment BMPs), no overflow of untreated water or suspended sediment from the sealed barges shall be permitted within the Site.
- Haul barges will be loaded evenly to maintain barge stability.
- Haul barges will be filled to less than 90% capacity to reduce the potential for spillage or overflow.
- Once the barge is loaded and stabilized, it will be inspected for sediment adhered to the outside of the barge that could fall off the barge during transport. Contractor personnel will conduct a visual inspection around the entire barge deck area to remove such sediment before moving the barge out of the Site.

- All barges handling dredged materials within the Site will have hay bales and/or filter fabric placed over the barge scuppers to help filter suspended sediment from the barge effluent.
- Barges leaving the Site will be sealed such that no discharge of water or suspended sediment occurs in the receiving waters.
- No petroleum products or other deleterious materials will enter surface waters.
- Cleanup activities will not degrade water quality to the detriment of fish life.

Barge Operations

- Barges will be restricted to tide elevations adequate to prevent grounding of the barge.
- Barge anchors will not be placed in contaminated sediments unless specified by Ecology.
- Whenever feasible, the barge location will be fixed through the use of methods that do not disturb contaminated sediments (e.g., mooring dolphins, docks, piers, upland structures, and anchoring in non-contaminated areas). Where these methods are not feasible, spuds may be used. The use of walking spuds will not be permitted.
- Live boating will be held to an absolute minimum.
- Motorized vessel operation will be restricted to tidal elevations adequate to prevent prop scour disturbance to the contaminated sediments.
- Minimal propulsion power will be used when maneuvering barges or other vessels to prevent prop scour disturbance to the contaminated sediments.

Dredging, Residuals Management Cover, and Cap Placement

- Mechanical dredging equipment will be used for the dredging and sediment handling activities with the exception of sediment transloading and placement within the Confined Disposal Facility (CDF).
- Slope dredging will be initiated at the top of the slope and then proceed in the down-slope direction.
- For placement of capping materials and residual cover layers, the following measures will be observed:
  - The placement of material will generally occur starting at lower elevations and working to higher elevations.
  - Set volume, tonnage, lead line measurements, and bathymetry information or similar will be used to confirm adequate coverage during and following material placement.
  - Imported materials will be pre-approved by Ecology and consist of clean, granular material free of roots, organic material, contaminants, and all other deleterious material.

Sediment Transloading to the Confined Disposal Facility

The following BMPs will be applied during transloading of contaminated sediments into the CDF:

- Transloading will be conducted using the purpose-built facilities established for that purpose as part of the Cleanup. Those facilities provide appropriate engineering controls (e.g., enclosed pipelines and/or spill aprons) for containment of sediment and entrained waters during transloading from the haul barges to the CDF.
- The contractor shall comply with maximum material placement elevations for sediment and waters throughout the filling of the CDF to maintain protective freeboard elevations and prevent discharge of sediment or untreated waters into Bellingham Bay.
- Transloading equipment will be operated to prevent dredged material spillage when transferring materials between the haul barge and the CDF. Enclosed pipelines and/or spill aprons will direct any sediment or water spillage back into the CDF or into the haul barges and not into Whatcom Waterway.
- Water may be utilized during sediment transloading (e.g., waters used to assist pumping of contaminated sediments into the CDF), provided that such waters are treated and reused to the extent practicable to minimize overall water generation rates. After transloading contaminated sediments, the contractor shall also remove excess water from the contaminated sediment haul barges (i.e., be transloading it into the CDF) prior to transporting the empty barges away from the Site.
- The contractor shall maintain Aerated Stabilization Basin (ASB) water levels between the minimum and maximum design elevations during the construction of the ASB Retaining Structure and filling of the CDF. Excess waters generated during sediment transloading and filling of the CDF shall be treated and discharged to the ASB Outfall in compliance with the Port of Bellingham's National Pollutant Discharge Elimination System (NPDES) permit.

Handling and Disposal of Debris and Contaminated Soils

- Only contaminated sediments approved by Ecology shall be disposed of within the CDF. Contaminated soils and debris generated during the Cleanup will be managed using Ecology-approved off-site recycling, treatment, or disposal facilities.
- If required, staging facilities installed for management of debris and/or contaminated soils are intended only for temporary use during the Cleanup. After the Cleanup is completed, these temporary facilities will be completely removed unless otherwise approved in writing by Ecology.

Decontamination of Dredging Equipment

- At the completion of the dredging work and prior to any clean material placement, the dredging buckets will be pressure-washed over the last haul barge and the wash water will be managed for off-site disposal consistent with the barge dewatering effluents. Similarly, the dredged material haul barges will be decontaminated prior to any other use.

- Decontamination of the dredge, excavation equipment (where applicable), and haul barges will be conducted at the completion of the Site remedial activities. The haul barges will be swept and pressure-washed (including all portions of the barge where sediment is visually present) such that no sediment or dredge return water is released to the Whatcom Waterway. The remaining sediment and water inside the barge will be collected and treated in accordance with state and federal requirements prior to being discharged.

4 BMPs for Structural Work

Water Quality Monitoring and Control

Turbidity will be monitored during the removal of pilings, dolphins, and bulkhead structures to ensure construction activities are in compliance with Washington State Surface Water Quality Standards (173-201A WAC). That monitoring shall be conducted and in accordance with the Water Quality Monitoring Plan (Appendix E of the *Engineering Design Report*).

Pile Removal, Handling, and Disposal

The following pile removal BMPs adapted from U.S. Environmental Protection Agency guidance (USEPA 2007) and Washington Department of Natural Resources (WDNR 2007) will be employed for pile removal:

- The removal of the creosote-treated piles will be consistent with conditions issued as part of the Derelict Creosote Pile Removal Project Hydraulic Project Approval (HPA), issued to the Washington Department of Natural Resources Northwest Region (Control Number 106389 – 3, Issued August 8, 2007).
- The contractor will initially vibrate piles to break the friction bond between piles and soil.
- To help minimize turbidity, the contractor will engage the vibrator to the minimum extent required to initiate vertical pile movement and will disengage the vibrator once piles have been mobilized and are moving upward.
- The piles will be removed in a single, slow, and continuous motion to the extent possible.
- Upon removal from the substrate, piles will be moved expeditiously from the water to a barge and then offloaded for disposal or recycling if possible.
- Piles will be removed slowly and in a direction that is an extension of the longitudinal centerline of each pile to minimize the disturbance of the bed and the suspension of contaminated sediments into the water column.
- Extracted piles will be placed immediately in a pile containment basin constructed on the barge or adjacent upland to capture and contain the extracted piles, adhering sediments, and water.
- The extracted piles will not be shaken, hosed off, left hanging to drip, or made subject to any other action intended to clean or remove adhering material from the pile.
- Holes in the bed resulting from the extraction of the piles will be covered with clean cap or residuals management cover materials consistent with the project design.
- Every attempt will be made to completely remove the piling in its entirety; however, pile cut-off will be an acceptable alternative where vibratory extraction or pulling is not feasible, as described below. In addition, if a pile is broken or breaks during vibratory extraction, the contractor will employ the following methods:

  - A chain will be used if practicable to attempt to entirely remove the broken pile.
  - If the entire pile cannot be removed, the pile may be cut at elevations at or below 1) the dredging neat-line elevation (full removal and Type 1 or Type 2 capping areas), or 2) the design capping elevations (Type 3 capping areas).
  - Pile cut-off will also be an acceptable alternative in shoreline capping areas where removal of the existing piles may result in adverse impact to slope stability.
  - If a pile cannot be removed or breaks off at or near the existing substrate, then the pile will be cut off using a pneumatic underwater device or a clamshell bucket as close to the bed as possible while minimizing unnecessary sediment disturbance.
- Cut-off pile stubs will be captured whenever feasible, removed, and deposited in the pile containment basin constructed on the barge or adjacent upland.
- Sawdust from cutting pile stubs will be captured whenever feasible, removed, and deposited in the containment basin constructed on the barge or adjacent upland.
- A floating surface boom will be installed around the pile extraction site to capture floating pile debris. Floating pile debris will be removed and deposited in a pile containment basin constructed on the barge or adjacent upland.
- The floating surface boom will be equipped with absorbent pads to contain any oil sheens. The absorbent pads will be removed and deposited in the pile containment basin constructed on the barge or adjacent upland.
- A pile containment basin will be constructed on the barge deck or adjacent upland to receive the piles, pile stubs, water, sawdust, and any sediment.
- The pile containment basin will be constructed of durable plastic sheeting with sidewalls supported by hay bales or support structure.
- To the extent possible, pile extraction in shoreline areas will be conducted during periods when the water currents are low.
- The piles, pile stubs, sawdust, and absorbent pads from the floating surface boom will be removed and disposed of in accordance with applicable federal and state regulations.
- The water captured in the pile containment basin will be removed and disposed of in accordance with applicable federal and state regulations.
- The pile containment basin will be removed and disposed of in accordance with applicable federal and state regulations.
- Extracted piles within the containment basin or disposal container will be cut to size as required by container and disposal contractors. All sawdust and cuttings will be contained within the pile containment basin or disposal container.
- The cut-up piles, sediments, sawdust, water, absorbent pads from the floating surface boom, and plastic from the containment basin will be packed into a disposal container and transported to an approved upland disposal site.

The use of a boom and the other measures listed above to contain and properly dispose of debris will also be employed during removal of creosote-treated wooden bulkhead or dock structures. Specific removal methods for these structures will be appropriate to the structure and location (e.g., a backhoe or clamshell may be used rather than a vibratory hammer or chain to remove sections of treated wood from a dock or bulkhead).

Piling and Dolphin Installation

- Sound attenuation methods are required for the driving or proofing of steel piles with an impact hammer below the ordinary high water line. For impact driving of steel piles that exceed the following criteria, a bubble curtain or other WDFW-approved sound attenuation device will be used. The specific criteria include sound pressure levels of the following:
  - Greater than or equal to 206 decibels (dB) (one microPascal squared per second) peak
  - Greater than or equal to 187 dB (one microPascal squared per second) accumulated sound exposure level (SEL) for fish greater than or equal to 2 grams
  - Greater than or equal to 183 dB (one microPascal squared per second) SEL for fish less than 2 grams
- A bubble curtain will be installed and properly functioning around the pile during all impact driving operations. The bubble curtain will distribute air bubbles around 100% of the perimeter of the piles over the full length of the pile in the water column.
- New steel piling, dolphins, and fender piles exposed to potential vessel abrasion will be protected with a rubbing surface, rubbing strip, or rubber energy absorption fenders.

Installation of Steel Sheetpile Structures

- Steel sheets to be installed within the ASB (i.e., components of the CDF Retaining Structure) shall be constructed prior to reopening the ASB to Bellingham Bay.
- Replacement sheetpile bulkheads to be installed in the BST Dock Area will be constructed in the dry to the extent practicable. These sheetpile bulkheads will be installed to the extent possible with a vibratory hammer. If an impact hammer is required to drive or proof the new steel sheetpile bulkheads, then a bubble curtain will be installed and properly functioning around the sheetpile bulkheads.
- Wet concrete used to construct a concrete cap on top of the steel sheetpile bulkheads will be prevented from entering waters of the state. Forms will be constructed to prevent leaching of wet concrete. Impervious materials will be placed over any exposed concrete not lined with the forms that will come in contact with state waters. Forms and impervious materials will remain in place until the concrete is cured.
- The contractor will be required to collect and manage soil cuttings generated during drilled tie-back anchor installation such that no cuttings are allowed to discharge to Bellingham Bay during drilling operations.

Installation of New Stormwater Outfalls

- The new outfalls to be installed along the Log Pond and ASB shorelines will be constructed in the dry to the extent practicable.
- Each of the new outfalls shall be fitted with an approved tide flap or gate complying with project permit requirements.
- During construction, the new outfalls shall be temporarily plugged to prevent inadvertent discharge of untreated construction stormwater prior to completion of upland construction activities.

Pipeline and Outfall Infrastructure Abandonment

The following BMPs will be applied during abandonment of the ASB Outfall and associated infrastructure following termination of its use during the Cleanup.

- Underwater piping to be temporarily or permanently abandoned in place shall first be disconnected from all sources and supplies of water.
- Piping to be removed shall be cut at the locations and elevations contained in the approved project plans. Any debris produced from cutting will be prevented from entering waters of the state.
- Prior to removal of the ASB Outfall Building, the ASB Outfall section located beneath the ASB Outer Berm will be plugged with clean, approved grout-like materials to permanently eliminate the exchange of water between the ASB and the ASB Outfall.
- The Outfall Building and associated structures shall be removed to elevations below the elevations in the approved project plans. Any debris produced from the removal will be prevented from entering waters of the state.
- Permanent decommissioning of the ASB Outfall (the section offshore of the ASB) shall be conducted using methods documented in project permits and regulatory approvals.
- Materials to be used for sealing/plugging the pipelines and outfall terminus will be pre-approved by Ecology and consist of clean material (e.g., bentonite chips or other control density fill mix) and free of roots, organic material, contaminants, and all other deleterious material.
- The contractor will dispose of debris from the demolition of the ASB Outfall Building and other piping and outfall abandonment activities. Such disposal shall utilize approved and permitted off-site disposal facilities, and the contractor shall obtain certificates of disposal.

5 Resource Protection BMPs

Spill Prevention

- Dredge vessel personnel will be trained in hazardous material handling and spill response and will be equipped with appropriate response tools, including absorbent oil booms. If a spill occurs, spill cleanup and containment efforts will begin immediately and will take precedence over normal work.
- The U.S. Coast Guard's Bellingham office will be notified immediately if a spill occurs.
- The dredging contractor will inspect fuel hoses, oil or fuel transfer valves, and fittings on a regular basis for drips or leaks in order to prevent spills into the surface water.
- The contractor will contain all visible floating oils with booms, dikes, oil-absorbent pads, or other appropriate means and remove from the water prior to discharge into state waters.
- The contractor will immediately contain all visible oils on land using dikes, straw bales, or other appropriate means; remove using sand, ground clay, sawdust, or other absorbent material; and properly dispose of the waste material.
- The contractor will temporarily store waste materials in drums or other leak-proof containers after cleanup and during transport to disposal.
- The contractor will dispose of waste materials off property at an approved and permitted disposal facility and obtain certificates of disposal.
- The contractor will be responsible for the preparation of a Spill Prevention, Control, and Countermeasure (SPCC) Plan to be used for the duration of the Cleanup. The SPCC Plan will be submitted to the Project Engineer prior to the commencement of any construction activities. A copy of the SPCC Plan, and any updates, will be maintained at the work site by the contractor and will include the following:
  - The SPCC Plan will identify construction planning elements and recognize potential spill sources at the work site. The SPCC Plan will outline responsive actions in the event of a spill or release and will describe notification and reporting procedures. The SPCC Plan will outline contractor management elements such as personnel responsibilities, project site security, site inspections, and training.
  - The SPCC Plan will outline what measures will be taken by the contractor to prevent the release or spread of hazardous materials, either found on site and encountered during construction but not identified in contract documents, or any hazardous materials that the contractor stores, uses, or generates on the construction site during construction activities. These items include, but are not limited to, gasoline, oils, and chemicals. Hazardous materials are defined in Revised Code of Washington (RCW) 70.105.010 under "hazardous substance."
  - The contractor will maintain at the job site the applicable equipment and material designated in the SPCC Plan.

- Upland construction equipment will be fueled in a designated area that separates fueling operations and protects the environment from accidental spills during fueling.
- The contractor will maintain spill kits on site in the event that a leak develops from their equipment. In the event of a spill, all other work will stop until the contractor has adequately cleaned up the spill.

Eelgrass Protection

- The existing eelgrass beds located in portions of Units 2B, 3A, 4, 5B, and 6 and that are not designated for dredging or capping shall be protected to the extent practicable. These areas will be buoy-marked prior to initiating in-water construction activities in these areas.
- Impacts to the existing eelgrass habitat identified above will be held to the absolute minimum necessary to successfully implement the Cleanup.

Upland Stormwater Management

- The contractor shall be responsible for maintaining a Stormwater Pollution Prevention Plan (SWPPP) throughout completion of the Cleanup. The SWPPP shall clearly identify upland work areas and differentiate those between 1) areas that drain to the ASB and that are regulated under the NPDES Permit for the ASB, 2) areas that drain to Bellingham Bay, and 3) no discharge areas.
- The contractor shall maintain and comply with a Construction Stormwater General Permit and associated Ecology Order for all upland areas utilized for the Cleanup that are not zero discharge areas and that are not managed under the Port of Bellingham's NPDES Permit for the ASB.
- The contractor shall maintain and update the SWPPP during performance of the Cleanup so that it accurately reflects the work being performed, including any phasing and applicable changes to stormwater basins and stormwater management procedures.

Cultural and Historic Resources

The contractor shall have an Inadvertent Discovery Plan (IDP) on site describing the actions to be taken if potential cultural resources (e.g., archaeological artifacts or human remains) are identified during the dredging.

- If any previously unknown historic, cultural, or archaeological remains and artifacts are discovered during construction, the Port of Bellingham will immediately notify the District Engineer of what was found, and to the maximum extent practicable, avoid construction activities that may affect the remains and artifacts until the required coordination has been completed. The USACE District Engineer will initiate the federal, tribal, and state coordination required to determine if the items or remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

- Work will immediately stop and notification will be provided to the USACE District Engineer within 24 hours if, during the course of conducting authorized work, human burials, cultural resources, or historic properties, as identified by the National Historic Preservation Act, are discovered.

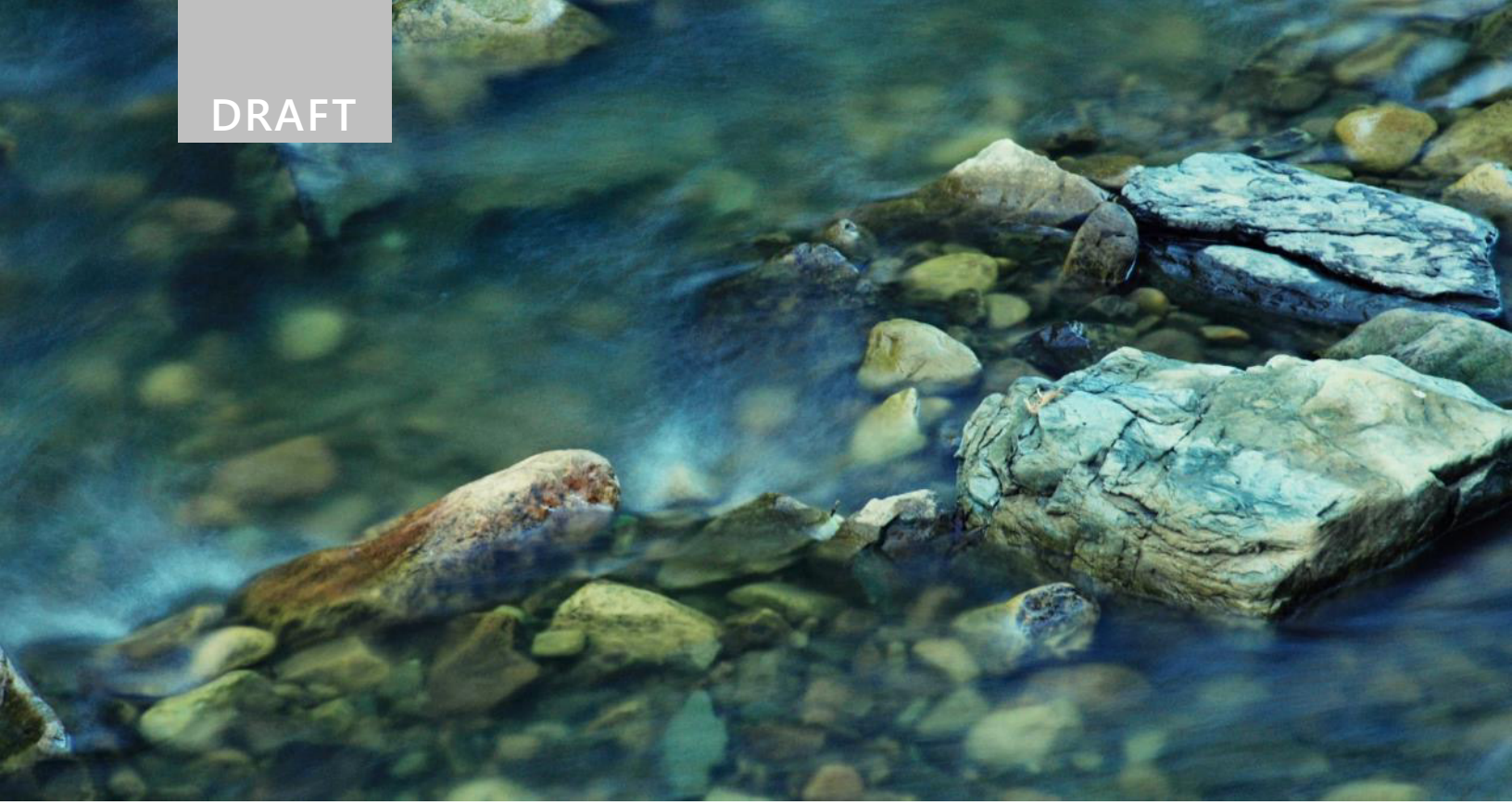
6 References

USEPA (U.S. Environmental Protection Agency), 2007. Best Management Practices for Pile Removal & Disposal (White Paper). March 2007.

WDNR (Washington Department of Natural Resources), 2007. Puget Sound Initiative—Derelict Creosote Piling Removal Best Management Practices For Pile Removal & Disposal. Washington Department of Natural Resources. Control Number 106389 – 3, Issued August 2007.

Appendix E
Water Quality Monitoring Plan

DRAFT



June 2025
Whatcom Waterway Cleanup in Phase 2 Site Areas

ANCHOR QEA

Appendix E
Water Quality Monitoring Plan

Prepared for Port of Bellingham

DRAFT

June 2025
Whatcom Waterway Cleanup in Phase 2 Site Areas

Appendix E
Water Quality Monitoring Plan

Prepared for
Port of Bellingham
1801 Roeder Avenue
Bellingham, Washington 98227

Prepared by
Anchor QEA
20 Bellwether Way, Suite 101
Bellingham, Washington 98225

Project Number: 190007-01.01

TABLE OF CONTENTS

1 Introduction 1
1.1 Purpose 1
1.2 Report Organization 2

2 Water Quality Criteria 3

3 Monitoring Locations and Depths 4
3.1 Early Warning Station 4
3.2 Compliance Station 5
3.3 Background Station(s) 5
3.4 Conventional Monitoring Depths 5

4 Monitoring Methods 6
4.1 Monitoring Methods and Equipment 6
4.2 Monitoring Frequency and Schedule 6

5 Contingency Measures and Response Actions 8
5.1 Stop Work Criteria 8
5.2 Contingency Measures 8
5.3 Water Quality Exceedance at Early Warning Station 8
5.4 Water Quality Exceedance at Compliance Station 9

6 Quality Control 12

7 References 13

TABLES

Table E-1 Water Quality Standards 3
Table E-2 Monitoring Type, Location, Depth, and Frequency 4

FIGURE

Figure E-1 Proposed Water Quality Monitoring Locations

ATTACHMENT

Attachment E-1 Water Quality Monitoring Log

ABBREVIATIONS

ASB	Aerated Stabilization Basin
BMP	best management practice
Cleanup	Whatcom Waterway Cleanup in Phase 2 Site Areas
CSGP	Construction Stormwater General Permit
Ecology	Washington State Department of Ecology
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity unit
Port	Port of Bellingham
QC	quality control
WAC	Washington Administrative Code
WQMP	Water Quality Monitoring Plan

1 Introduction

This Water Quality Monitoring Plan (WQMP) was developed on behalf of the Port of Bellingham (Port) for use during implementation of the Whatcom Waterway Cleanup in Phase 2 Site Areas (Cleanup).

This WQMP is an appendix to the *Engineering Design Report* prepared in accordance with Consent Decree No. 07-2-02257-7 (Ecology 2007) as amended by the Washington State Department of Ecology (Ecology) with the First Amendment to the Consent Decree (Ecology 2011) and the Second Amendment to the Consent Decree (Ecology 2024).

This plan describes the water quality monitoring locations, methods, and frequency to verify compliance with applicable water quality criteria. Contingency measures to be implemented based on the monitoring findings are also described. Any modifications to this WQMP must be reviewed and approved by Ecology.

1.1 Purpose

This WQMP will be used during in-water work to assess the contractor's adherence to permit conditions and federal, state, and local regulations pertaining to water quality. The contractor is responsible for providing quality control (QC) of its work to meet applicable and relevant water quality criteria. This water quality monitoring program is intended to provide quality assurance that the contractor's operations are in compliance with water quality criteria.

Based on previous water quality monitoring for in-water work conducted in Bellingham Bay during the Cleanup in Phase 1 (Anchor QEA 2015) and maintenance dredging at the Bellingham Shipping Terminal (Moffatt & Nichol 2022), Phase 2 monitoring during in-water work will consist of turbidity monitoring.

The work covered by this WQMP includes in-water dredging, capping and residuals management cover placement, and marine structure (i.e., pilings and dolphins) removal work to be performed during the Cleanup. This does not include initial construction activities conducted within Unit 8 (the Aerated Stabilization Basin [ASB]) prior to reconnection of the ASB to the Whatcom Waterway. Those initial construction activities within Unit 8 are not considered in-water work until the ASB has been reconnected to Bellingham Bay by opening of the ASB Access Channel in Unit 2B.

This WQMP does not address the monitoring of Cleanup-related wastewater or stormwater to be treated and discharged to Bellingham Bay via the ASB Outfall under the Port's existing National Pollutant Discharge Elimination System (NPDES) permit. Those waters will be monitored as defined in that permit.

This WQMP also does not cover the monitoring of Cleanup-related construction stormwater. Monitoring of Cleanup-related construction stormwater will be conducted in compliance with the Construction Stormwater General Permit (CSGP) and associated Ecology requirements.

1.2 Report Organization

The information contained in this report has been organized in the following manner:

- **Section 2 – Water Quality Criteria.** Section 2 provides the designated uses and quality of Bellingham Bay and the applicable criteria for turbidity as the water quality parameter of concern for the Cleanup.
- **Section 3 – Monitoring Locations and Depths.** Section 3 summarizes the water quality monitoring type, location, depth, and frequency for turbidity during the in-water work.
- **Section 4 – Monitoring Methods, Equipment, Frequency, and Schedule.** Section 4 provides the methods for water quality monitoring, including definitions of the two monitoring intensity levels and their associated monitoring schedules.
- **Section 5 – Contingency Measures and Response Actions.** Section 5 describes the stop work criteria and contingency measures for water quality monitoring during in-water work, including the required sequence of responses if a water quality exceedance is observed at the early warning station or the compliance station.
- **Section 6 – Quality Control.** Section 6 states the quality control objective and the need for monitoring to follow appropriate field procedures.
- **Section 7 – References.** Section 7 provides references for sources cited in this WQMP.

2 Water Quality Criteria

The designated uses for Bellingham Bay, inclusive of the Phase 2 Site Areas, include aquatic life uses, shellfish harvesting, primary contact recreation, and other miscellaneous uses (i.e., wildlife habitat, harvesting, commerce and navigation, boating, and aesthetics) (Washington Administrative Code [WAC] 173-201A-210 and 173-201A-612). The waters of Bellingham Bay are designated as excellent quality marine waters by the State of Washington (WAC 173-201A-612).

Turbidity is the primary water quality parameter of concern for the Cleanup during dredging, and during the placement of caps or residuals management cover.

For marine waterbodies classified as excellent, turbidity will not exceed 5 nephelometric turbidity units (NTU) over background turbidity when the background turbidity is 50 NTU or less, or there will not be more than a 10% increase in turbidity when the background turbidity is more than 50 NTU, as shown in Table E-1.

Table E-1
Water Quality Standards

Parameter	Background Level	Water Quality Criteria
Turbidity (NTU)	If less than or equal to 50 NTU	Background turbidity plus 5 NTU
	If greater than 50 NTU	Background turbidity plus 10%

Note:
Turbidity criteria based on WAC 173-201A-210(1)(e).

3 Monitoring Locations and Depths

A summary of stations and distances from construction activities is shown in Table E-2. Examples of typical water quality monitoring locations are shown in Figure E-1. Water quality monitoring will be performed at points located at specific distances from the respective construction activities, measured using radii of 100 feet (early warning station) and 150 feet (compliance station). Monitoring will also be performed at a background reference location located at least 500 feet from the respective construction activities.

The actual positions of early warning, compliance, and background stations will be adjusted in the field using the best professional judgment of the water quality monitoring crew. These adjustments will be based on the location of active in-water work, the tidal cycle, and observations of the current. The actual positions will be recorded in the field documentation.

Table E-2
Monitoring Type, Location, Depth, and Frequency

Parameter	Type	Station and Distance from Construction Activities	Depths	Frequency
Turbidity	Instrument	Early warning station 100 feet	• For water less than 5 feet deep, midpoint only • For water between 5 and 10 feet deep, surface and bottom • For water greater than 10 feet deep, surface, midpoint, and bottom	• Intensive – Dredging or Capping: Twice per day for 5 days, then moving to routine if no exceedances are observed. • Intensive – Piling/Dolphin Removal: twice per day for 2 days, then moving to routine if no exceedances are observed. • Routine: Twice per day, 2 days per week, but return to intensive if exceedance is observed.
		Compliance station 150 feet		
		Background station(s) Minimum of 500 feet[1]		

Notes:

1. A second background station shall be added if differences in background conditions are observed between Bellingham Bay and discharges from Whatcom Creek. If multiple background stations are included, they shall each be at least 500 feet distant from the construction activity and in opposite directions, as shown in Figure E-1.

3.1 Early Warning Station

Turbidity measurements at the 100-foot distance serve as an interim indicator of water quality closer to the construction activity but do not trigger any required contingency response action by the contractor. Elevated measurements at the 100-foot early warning station (EW-1) might indicate the potential for subsequent exceedance at the compliance boundary and will serve as an early warning to allow modification of the construction operation to potentially avoid water quality exceedances at the compliance boundary.

3.2 Compliance Station

Compliance monitoring will be located 150 feet from the construction activity (COMP-1; Figure E-1). A confirmed water quality exceedance at the compliance boundary will require contingency response action from the contractor to bring its operations back into compliance with water quality criteria. A description of the contingency measures that will be implemented if exceedances are confirmed is provided in Section 5.

3.3 Background Station(s)

At least one representative background station (BG-1) will be sampled during each monitoring event. The background monitoring station will be located a minimum of 500 feet from active in-water work in an area unaffected by the active work. The background station may be positioned toward the inner or outer part of the waterway depending on tidal flows (i.e., flood versus ebb tides; Figure E-1).

Sometimes different background conditions are observed between Bellingham Bay and the discharges from Whatcom Creek. If these conditions are observed, then a second background station (BG-2) shall be added. If multiple background stations are included, they shall each be at least 500 feet distant from the construction activity and in opposite directions, as shown in Figure E-1.

3.4 Conventional Monitoring Depths

At each station monitored, turbidity measurements will be made based on the depth of the water column as follows:

- For water less than 5 feet deep: midpoint only
- For water between 5 and 10 feet deep: surface and bottom
- For water greater than 10 feet deep: surface, midpoint, and bottom

The three depths in the water column include the following:

- Surface (1 meter below the surface)
- Midpoint (midpoint of the water column)
- Bottom (1 meter above the mudline)

Water depth will be determined using either a lead line or fathometer at the monitoring location and will be recorded onto the field data monitoring log (Attachment E-1). The range of turbidity measurements in the construction area will be compared to the range of turbidity measurements at the background station to determine if the turbidity at the construction site exceeds the background range by more than 5 NTU (if less than 50 NTU background) or more than 10% (if greater than 50 NTU background).

4 Monitoring Methods

4.1 Monitoring Methods and Equipment

In situ turbidity will be measured with a Hydrolab water quality meter (or equivalent) or turbidometer. Continuous in situ profiling tools are preferred to retrieving water samples and measuring parameters on deck. Turbidity data for each monitoring event and respective location will be recorded on the water quality monitoring log (Attachment E-1), as well as weather and tidal observations. Monitoring will be completed by dredging contractor personnel, the environmental manager, or a designated water quality technician (herein collectively referred to as the water quality monitoring crew) using the monitoring log, which will include dates and times, the relevant construction activity (i.e., dredging or placement), readings, and any exceedances, if applicable (Attachment E-1).

These records will be maintained in project files and provided to Ecology, if requested. The dredging contractor will submit the water quality monitoring results to Ecology's site manager on a weekly basis (via email) during dredging and placement activities and at the conclusion of the monitoring period. Additional reporting and notifications are discussed in Section 5.4.

4.2 Monitoring Frequency and Schedule

The frequency and schedule of the turbidity monitoring during the in-water work is divided into two levels of intensity, described as follows:

- **Intensive**
  - Collection of turbidity measurements will occur twice per day during in-water work.
  - First monitoring will start 1 hour after dredging or placement begins.
  - Intensive monitoring for dredging or material placement activities will continue for 5 days per week until 5 consecutive days without exceedances at the compliance station are recorded, at which time routine monitoring can be performed.
  - Intensive monitoring for in-water removal of marine structures (i.e., pilings or dolphins) will continue for 2 consecutive days without exceedances at the compliance station are recorded, at which time routine monitoring can be performed
- **Routine**
  - Collection of turbidity measurements will occur twice per day, twice per week.
  - First monitoring will start 1 hour after dredging or placement begins.

During dredging or capping activities, monitoring will first be conducted on an intensive schedule. If no exceedances at the compliance station occur during the intensive monitoring, monitoring will be reduced to a routine schedule, unless otherwise directed by Ecology.

The occurrence of turbidity exceedances, significant visual turbidity plumes, or a significant change in construction equipment or operations (e.g., dredging, capping) will trigger a transition back to intensive monitoring to confirm that no water quality impacts are occurring.

5 Contingency Measures and Response Actions

5.1 Stop Work Criteria

The following conditions require a stop work response:

- Evidence of a significant oil sheen
- Evidence of distressed or dying fish
- Confirmed exceedance of water quality criteria at the 150-foot compliance boundary and decision by Ecology to stop work following consultation between the Port and Ecology

If at any time, as a result of Project activities, fish are observed in distress, a fish kill occurs, or water quality problems develop (including equipment leaks or spills), the water quality monitoring crew will report immediately to the Washington Emergency Management Division at 1-800-258-5990. The National Response Center (800-424-8802), Washington Emergency Management Division (800-258-5990 or 800-OILS-911), and U.S. Coast Guard Puget Sound Sector (206-217-6001) will be notified immediately if a spill occurs.

5.2 Contingency Measures

If a turbidity elevation above the water quality standard is confirmed at the early warning boundary or if an exceedance of a water quality standard is confirmed at the compliance boundary, contingency measures will be taken to mitigate the exceedance. For the proposed dredging and related in-water construction work, these measures are largely focused on reducing sediment resuspension and turbidity in the water column.

Possible contingency measures include but are not limited to the following:

- Operational best management practices (BMPs):
  - Slowing the speed of the dredge bucket through the water column
  - Avoiding overfilling of the bucket
  - Allowing water to drain from the bucket at the surface
  - Not overfilling the dredge scow
  - Avoiding critical tidal or current conditions
- Structural BMPs:
  - Modifying equipment to better control sediment resuspension
  - Installing a sediment barrier such as a silt curtain

5.3 Water Quality Exceedance at Early Warning Station

Observation of a visible turbidity plume beyond the 100-foot early warning boundary will trigger instrument monitoring to confirm whether water quality measurements are out of compliance with water quality standards.

If water quality standards for turbidity are exceeded at the 100-foot early warning station, the following sequence of responses will be initiated:

1. If an initial exceedance is measured at the 100-foot early warning boundary, the work will stop, and the water quality monitoring crew will wait 30 minutes to retake measurements at the station. The water quality monitoring crew will visually assess the station vicinity for potential outside influences, including malfunctioning dredging or capping equipment, activities other than dredging or capping, and/or storm drain discharges.
    a. If water quality passes the turbidity criteria during the remeasurement, and the exceedance is not confirmed, the water quality monitoring crew will resume the normally scheduled monitoring program.
    b. If the turbidity criteria exceedance is confirmed (two exceedances in 30 minutes), the contractor will be notified and the contractor will be requested to consider modifying its work activity using BMPs. The contractor will assess the current work methodology to determine if adjustments can be made to correct the problem. Potential contractor BMPs are listed in Section 5.2.
2. The water quality monitoring crew will wait at least 30 minutes to 1 hour after contractor BMPs are implemented and retake measurements at the 100-foot early warning station.
    a. If no exceedances are confirmed at the 100-foot early warning station after remeasurement, work can continue, and the water quality monitoring crew will continue the monitoring schedule.
    b. If water quality exceedances continue, the work will be stopped. The contractor will be notified that exceedances at the early warning station are still being observed and that additional enhancements to BMPs are warranted. The water quality monitoring crew will continue monitoring the early warning and compliance stations at 1-hour intervals until either the water quality impact dissipates at the early warning boundary, or the impact expands to the compliance boundary. In the latter case, the contingency response procedures described in Section 5.4 will be followed.

5.4 Water Quality Exceedance at Compliance Station

If water quality standards (i.e., turbidity; see Section 2) are exceeded at the 150-foot compliance station, the following sequence of responses will be initiated:

1. If an initial exceedance is measured at the 150-foot compliance boundary, the work will stop, and the water quality monitoring crew will wait 30 minutes to retake measurements at the station. The water quality monitoring crew will visually assess the station vicinity for potential outside influences, including malfunctioning dredging or capping equipment, activities other than dredging or capping, and/or storm drain discharges.

a. If water quality passes the turbidity criteria during the remeasurement, and the exceedance is not confirmed, the water quality monitoring crew will confirm at the 100-foot early warning boundary and resume the normally scheduled monitoring program.
b. If the turbidity criteria exceedance is confirmed (two exceedances in 30 minutes), work will not continue. The contractor will also be informed and will be required to implement BMPs to bring its operations back into compliance with water quality criteria. An extended work stoppage may be necessary to further evaluate potential sources of the exceedance, identify effective mitigation measures, and allow the water column to recover.
    i. In the event of a confirmed water quality exceedance for turbidity at the 150-foot compliance station, the contractor will take appropriate corrective action (beyond those taken to modify the work activity for 100-foot early warning station exceedances) as necessary in order to meet turbidity standards.
    ii. The contractor will submit its contingency response action(s) to the Port within 1 hour. The contractor will be required to implement its contingency measures within 1 hour of notification of a confirmed exceedance. The Port will communicate the contractor's contingency response plan to Ecology within 2 hours of the confirmed exceedance.
    iii. The water quality monitoring crew will take measurements hourly starting 1 hour after the contractor has implemented its contingency measures in order to allow time for the contingency measures to take effect. Measurements will continue until compliance is met or sunset, whichever occurs first.
    iv. If no exceedances are confirmed at the 150-foot compliance station 1 hour after contingency measures have been implemented, the exceedance will have been deemed under control; however, the intensive monitoring schedule will be reset.

In the event that the contractor's contingency response actions do not achieve compliance with the water quality criteria, the Port will do the following:

- Immediately take action to curtail the activity causing the turbidity.
- Report the exceedance to Ecology's site manager, Julia Schwarz, by phone at 425-515-5992 or by email at julia.schwarz@ecy.wa.gov.
- In consultation with Ecology, determine whether a temporary stoppage of work may be necessary while the problem is being resolved.
- Meet with the contractor and Ecology to discuss the water quality monitoring observations, discuss contingency response actions taken by the contractor, and identify additional contingency response actions that the contractor could implement to comply with the water quality criteria. Ecology could also determine that it is appropriate to adjust the dimensions of the compliance boundary for this cleanup action.

- Submit a detailed written report to Ecology within 5 days, or as otherwise specified in the Section 401 Water Quality Certification, which will include the following information:
  - Nature and extent of the water quality exceedance, including visual observations and field measurements
  - Identification of the likely cause of the exceedance
  - BMPs implemented to mitigate the exceedance
  - Agency notifications, including agency name, personnel contacted, and date and time of contact
  - Documentation of BMP effectiveness at mitigating the water quality exceedance and stabilizing the environmental conditions in the affected area

6 Quality Control

The QC objective for this water quality monitoring effort is to verify that the data collected are of known and acceptable quality so that the goals of the water quality program can be achieved. Appropriate field QC procedures will be followed. These procedures include performing routine field instrument calibration and following standard instrument operation procedures.

7 References

Anchor QEA, 2015. *Water Quality Monitoring Plan – Appendix L. Whatcom Waterway Final Engineering Design Report*. Whatcom Waterway Site Cleanup Phase 1. February 2015.

Ecology (Washington State Department of Ecology), 2007. Consent Decree No. 07-2-02257-7 for the Whatcom Waterway Site (with Exhibits). Filed September 24, 2007.

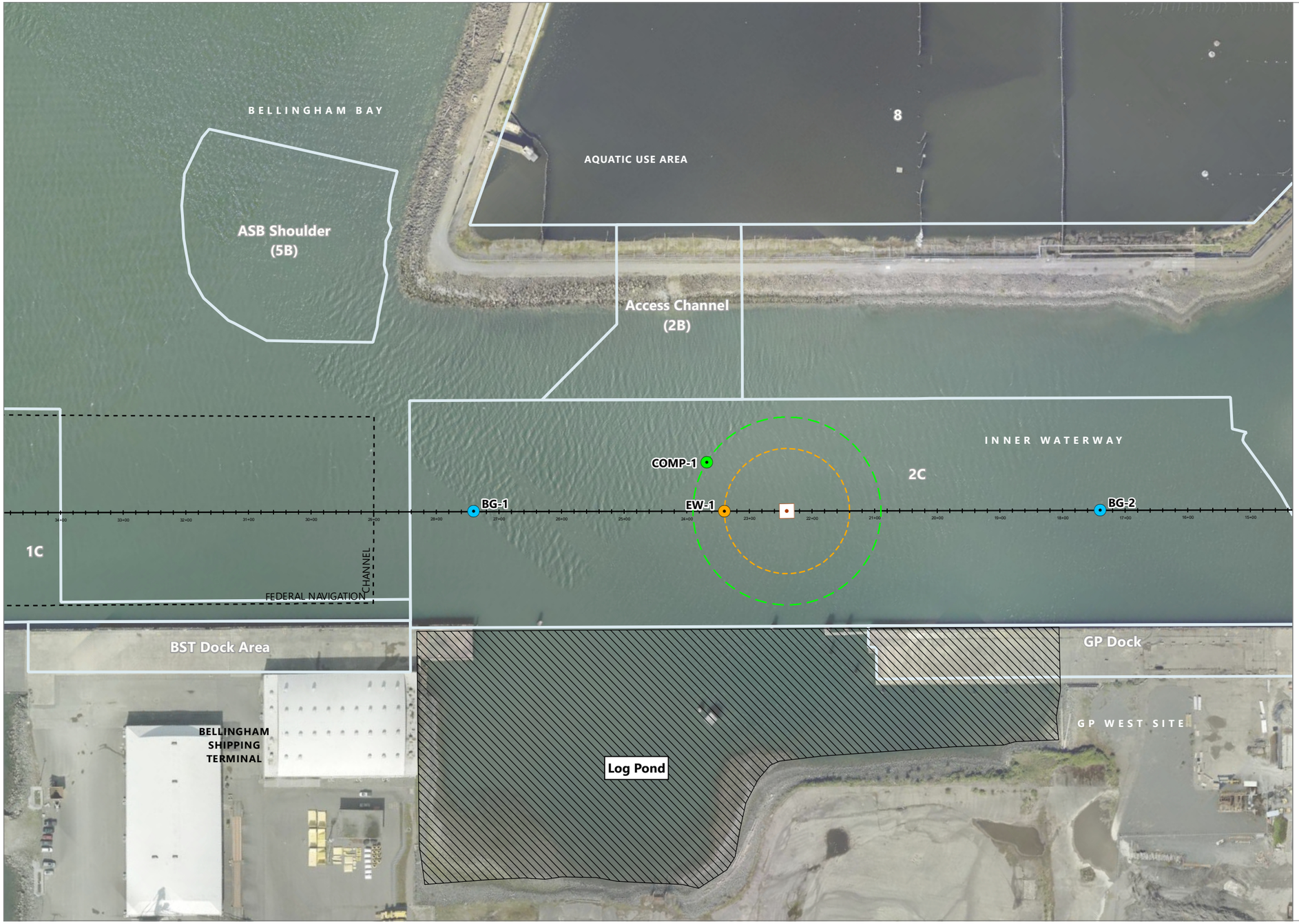
Ecology, 2011. First Amendment to the Consent Decree 07-2-02257-7 for the Whatcom Waterway Site (with Exhibits). Filed August 19, 2011.

Ecology, 2024. Second Amendment to the Consent Decree No. 07-2-02257-7 for the Whatcom Waterway Site (with Exhibits). Filed March 27, 2024.

Moffatt & Nichol, 2022. *Water Quality Monitoring Plan*. Port of Bellingham: Bellingham Shipping Terminal Maintenance Dredging. Revision 4. May 2022.

Figure

DRAFT



LEGEND:

- Federal Navigation Channel
- Previously Capped Area
- Site Unit
- Example Location of Dredging or Capping Activities
- 500-Foot Minimum Background Monitoring Location
- 150-Foot Compliance Boundary Monitoring Location
- 100-Foot Early Warning Boundary Monitoring Location
- 150-Foot Compliance Monitoring Boundary
- 100-Foot Early Warning Monitoring Boundary

Horizontal Datum: NAD83
Vertical Datum: NAVD88

NOTES:
1. Image from Whatcom County.
2. Water quality monitoring locations are shown relative to location of work and will move with project progress.
3. A minimum of one background station is required. A second background station is recommended to account for potential differences in background conditions that can occur between Bellingham Bay and Whatcom Creek.

0 400
Feet

Publish Date: 2024/12/13, 1:17 PM | User: emueller
Filepath: \\GSTFile01\GIS\Jobs\PortofBellingham_0007\Whatcom_Waterway_Ph2\Maps\Reports\EDR_archive\AQ_EDR_FigE-1_WQM.mxd

ANCHOR QEA

Figure E-1
Proposed Water Quality Monitoring Locations
Appendix E: Water Quality Monitoring Plan
Whatcom Waterway Phase 2 Cleanup: Engineering Design Report

Attachment E-1
Water Quality Monitoring Log

ANCHOR QEA

1201 3rd Avenue, Suite 2600, Seattle, Washington 98101

Phone 206.287.9130 www.anchorqea.com

Whatcom Waterway Cleanup in Phase 2 Site Areas: Water Quality Monitoring Log

Date	Activity (Dredging, Placing)	Monitoring Period		Background Turbidity (see note)			Early Warning Turbidity			Compliance Turbidity			Exceed	Notes (weather, calibration, tide stage, depth of water)	Personnel
		Intensive or Routine	Day of Period	Time	Reading (NTU)	Depth (feet)	Time	Reading (NTU)	Depth (feet)	Time	Reading (NTU)	Depth (feet)	Y/N		

Water Quality Standard: Turbidity shall be <5.0 NTU above BG when BG ≤ 50 NTU, and less than 10% over BG when BG is >50 NTU.

Stations:

Early Warning Station = EW-1 (100 feet or 30.48 meters)

Compliance Station = COMP-1 (150 feet or 45.72 meters)

Background Station = BG-1 (500 feet or 152.4 meters in an area unaffected by in-water work location). In some cases a second background station may be required (label as BG-2) and locate 500 feet in opposite direction from BG-1.

Monitoring Depths:

For water less than 5 feet deep: mid-point only

For water between 5 and 10 feet deep: surface and bottom

For water greater than 10 feet deep: surface, mid-point, and bottom

Depths:

Surface (1 meter below the surface)

Mid-point (mid-point of the water column)

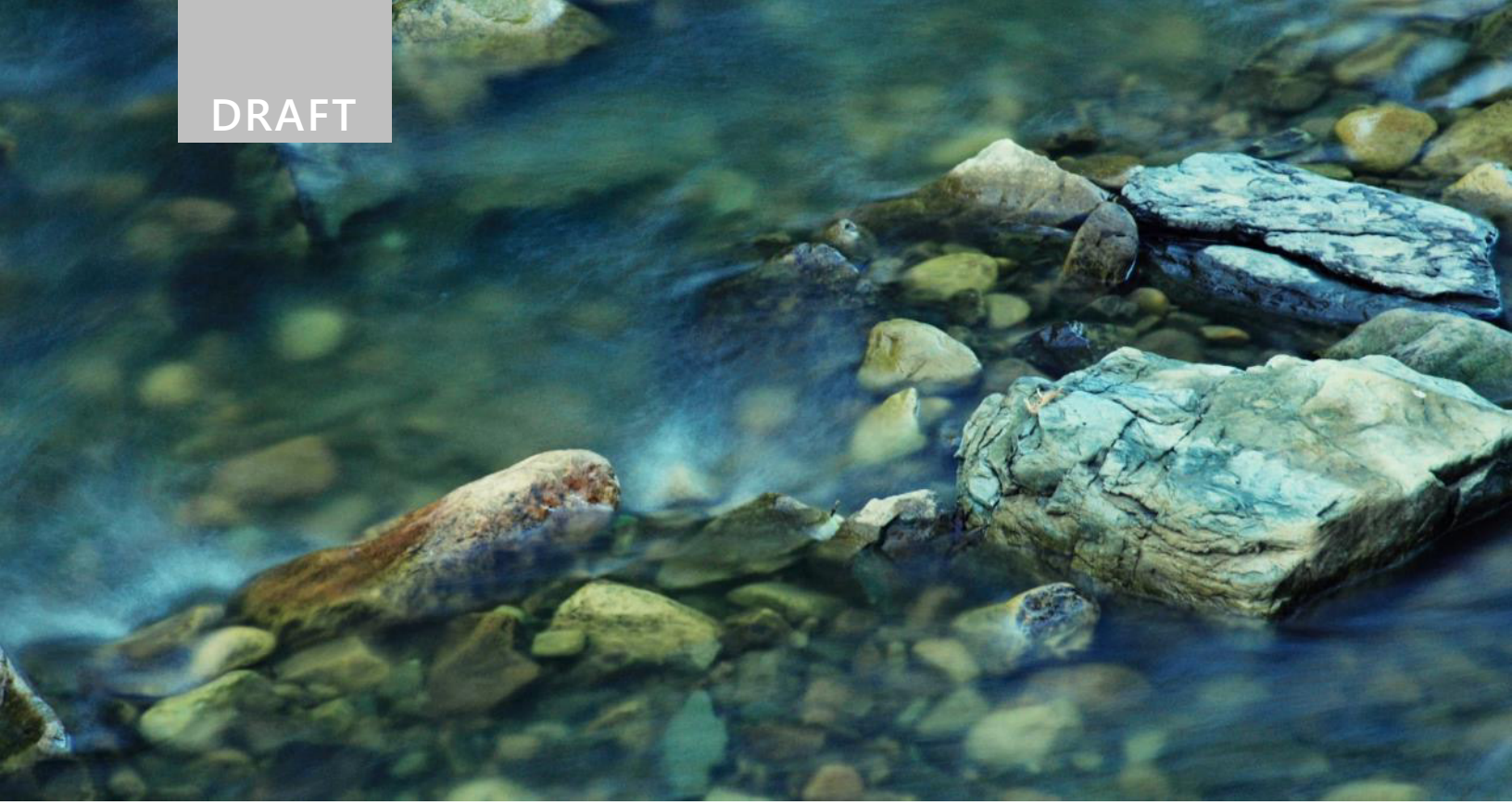
Bottom (1 meter above the mudline)

Appendix F
Construction Quality Assurance Plan (Placeholder)

Appendix G
Management of Dredging Residuals

Appendix H
Compliance Monitoring and Contingency Response Plan

DRAFT



June 2025
Whatcom Waterway Cleanup in Phase 2 Site Areas

ANCHOR QEA

Appendix H
Compliance Monitoring and Contingency Response Plan

Prepared for Port of Bellingham

DRAFT

June 2025
Whatcom Waterway Cleanup in Phase 2 Site Areas

Appendix H
Compliance Monitoring and Contingency Response Plan

Prepared for
Port of Bellingham
1801 Roeder Avenue
Bellingham, Washington 98227

Prepared by
Anchor QEA, Inc.
20 Bellwether Way, Suite 101
Bellingham, Washington 98225

Project Number: 190007-01.01

TABLE OF CONTENTS

1 Introduction 1
1.1 Purpose 1
1.2 Phase 2 Compliance Monitoring Requirements 1
1.3 Ongoing Phase 1 Confirmation Monitoring 2

2 Background 3
2.1 Site Description 3
2.2 Sediment Cleanup Levels 4
2.3 Cleanup Monitoring Locations 5

3 Project Roles and Responsibilities 6

4 Performance Monitoring in Phase 2 Site Areas 7
4.1 Bathymetric and Topographic Surveys 7
4.2 Visual and Structural Surveys 7
4.3 Post-Dredge Sediment Testing in Full Dredge Areas 8
4.3.1 Testing Locations and Methods 9
4.3.2 Chemical Testing 10
4.3.3 Contingency Response Actions 10
4.4 Sediment Testing After Residuals Cover Placement 10
4.4.1 Testing Locations and Methods 10
4.4.2 Sediment Chemistry 11
4.4.3 Contingent Bioassay Testing 11
4.4.4 Contingency Response Actions 11

5 Confirmation Monitoring in Phase 2 Site Areas 12
5.1 Cap Integrity Monitoring 12
5.1.1 Bathymetric and Topographic Surveys 12
5.1.2 Visual and Structural Surveys 12
5.1.3 Contingency Response Actions 13
5.2 Surface Sediment Quality Monitoring 13
5.2.1 Sampling and Analysis Approach 14
5.2.2 Contingent Bioassay Testing 14
5.2.3 Contingency Response Actions 14
5.3 Confined Disposal Facility Groundwater Monitoring 15
5.3.1 Sample Collection and Analysis 15

5.3.2 Contingency Response Actions 15
5.4 Supplemental Monitoring Following Extreme Events 16

6 Ongoing Monitoring in MNR and Phase 1 Site Areas 17
6.1 Phase 1 Cap Integrity Monitoring 17
6.2 Surface Sediment Quality Monitoring 17
6.3 Subsurface Mercury Testing in Site Monitored Natural Recovery Areas 18
6.4 Porewater Testing in Log Pond Nearshore Areas 18

7 Reporting 21

8 References 22

TABLES

Table H-1 Overview of Phase 2 Performance and Compliance Monitoring Activities
Table H-2 Phase 2 Performance Monitoring Locations and Test Parameters for Full Dredge Areas
Table H-3 Phase 2 Confirmation Monitoring Locations and Test Parameters
Table H-4 Overview of Ongoing Phase 1 and MNR Confirmation Monitoring Activities
Table H-5 Phase 1 and MNR Confirmation Monitoring Locations and Test Parameters

FIGURES

Figure H-1 Vicinity Map
Figure H-2 Phase 1 and MNR Compliance Monitoring Locations
Figure H-3 Construction Elements for Phase 2 Site Areas
Figure H-4 Phase 2 Post-Dredge Performance Monitoring Locations
Figure H-5 Phase 2 Surface Sediment and Groundwater Compliance Monitoring Locations

ABBREVIATIONS

µg/kg	microgram per kilogram
ASB	aerated stabilization basin
BSL	bioaccumulation screening level
BST	Bellingham Shipping Terminal
CDF	Confined Disposal Facility
cm	centimeter
CMCRP	*Compliance Monitoring and Contingency Response Plan*
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CQAP	Construction Quality Assurance Plan
D/F	dioxin/furan
DQO	data quality objective
Ecology	Washington State Department of Ecology
EDR	*Engineering Design Report*
EPA	U.S. Environmental Protection Agency
FC	Field Coordinator
GP West	Georgia-Pacific West, Inc.
LiDAR	Light Detection and Ranging
mg/kg	milligrams per kilogram
mL	milliliter
MNR	monitored natural recovery
ng/kg	nanogram per kilogram
NMDS	nylon mesh diffusion sampler
Phase 1 SQAPP	*Sampling and Quality Assurance Project Plan for Compliance Monitoring*
PLP	Potentially Liable Party
Port	Port of Bellingham
PSEP	Puget Sound Estuary Program
SAP	Sampling and Analysis Plan
SCO	sediment cleanup objective
Site	Whatcom Waterway Site
SMS	Sediment Management Standards
SQS	Sediment Quality Standard
SWAC	site-wide surface-weighted average concentration
TEQ	toxic equivalency quotient
TOC	total organic carbon
TS	total solids
USACE	U.S. Army Corps of Engineers

USGS	U.S. Geologic Survey
WAC	Washington Administrative Code

1 Introduction

This *Compliance Monitoring and Contingency Response Plan* (CMCRP) describes the compliance monitoring and associated contingency response actions that will be implemented after construction and cleanup within Phase 2 areas of the Whatcom Waterway Site (Site) in Bellingham, Washington. That cleanup is being led by the Port of Bellingham (Port) in accordance with Consent Decree No. 07-2-02257-7 (Ecology 2007) as amended by the Washington State Department of Ecology (Ecology) with the First Amendment to the Consent Decree (Ecology 2011) and the Second Amendment to the Consent Decree (Ecology 2024). Other participating Potentially Liable Parties (PLPs) include the City of Bellingham, the Washington Department of Natural Resources, and Meridian Pacific Highway LLC.

The CMCRP is an appendix to the *Engineering Design Report* (EDR). It will be implemented in accordance with Washington Administrative Code (WAC) 173-340-410, Compliance Monitoring Requirements. A *Sampling and Analysis Plan* (SAP) will be provided as part of the Final EDR documenting the detailed sampling and analysis methods to be used to implement this CMCRP.

1.1 Purpose

This document describes the environmental monitoring activities that will be confirm that cleanup standards are met and long-term effectiveness of the cleanup is maintained.

This CMCRP identifies the performance and confirmation monitoring activities to be performed during and after the implementation of the cleanup in Phase 2 Site Areas. It also describes ongoing confirmation monitoring activities that were initiated following implementation of the cleanup in Phase 1 Site Areas and will continue.

Protection monitoring activities will include water quality monitoring. That work is described separately in the *Water Quality Monitoring Plan* (Appendix E of the EDR). Additional water quality monitoring will be performed for treated cleanup waters discharged to Bellingham Bay via the existing aerated stabilization basin (ASB) outfall in compliance with the Port's National Pollutant Discharge Elimination System permit, which is to be updated as part of design and permitting activities.

1.2 Phase 2 Compliance Monitoring Requirements

Monitoring activities to be conducted for the Phase 2 Site Areas are described in Sections 4 and 5 of this CMCRP and include the following:

- **Performance Monitoring:** Performance monitoring is implemented during construction to confirm that the cleanup action has met the requirements of the design. Section 4 describes the physical, chemical, and bioassay performance monitoring activities to be conducted as

part of performance monitoring. These include the following: 1) bathymetric testing to document that dredging and capping activities have achieved target elevations; 2) post-dredge testing to document that contaminated materials have been adequately removed and that dredging residuals are not excessive; and 3) post-construction monitoring to document sediment quality following placement of residuals management cover.

- **Confirmation Monitoring:** Confirmation monitoring is used to confirm the long-term effectiveness of the cleanup action. Section 5 describes the long-term confirmation monitoring to be performed following completion of the Phase 2 cleanup activities. Activities described in that section include the following: 1) visual and bathymetric surveys of cap areas; 2) structural surveys of the Confined Disposal Facility (CDF) retaining structure; 3) sediment quality monitoring throughout the Phase 2 Site Areas; and 4) groundwater monitoring within the CDF retaining structure.

1.3 Ongoing Phase 1 Confirmation Monitoring

Construction of the cleanup in Phase 1 Site Areas was completed during early 2016. Since that time, confirmation monitoring has been conducted in accordance with the *Sampling and Quality Assurance Project Plan for Compliance Monitoring* for Whatcom Waterway Cleanup in Phase 1 Site Areas (Phase 1 SQAPP; Anchor QEA 2016).

Long-term monitoring activities defined in the Phase 1 SQAPP included monitoring of both the Phase 1 dredging and capping areas as well as the monitored natural recovery (MNR) areas located within the Site. Monitoring events for Years 1, 3, and 5 have been completed. Ongoing monitoring activities for Years 10, 20, and 30 will be performed as described in Section 6 of this document. These include the following: 1) bathymetric and visual surveys in capped areas (Year 10); 2) surface sediment sampling in capping and MNR areas (Years 10, 20, and 30); 3) porewater testing in Log Pond shoreline areas (Year 10); and 4) subsurface sediment testing in MNR areas (Years 10, 20, and 30).

2 Background

This section provides a concise overview of the Site, the required cleanup, and the areas to be monitored.

2.1 Site Description

The Site is located within Bellingham Bay in Washington State (Figure H-1). It includes sediments that have been impacted by contaminants historically released from industrial waterfront activities, including mercury discharges from the former Georgia-Pacific West, Inc. (GP West), chlor-alkali plant, wood waste and degradation products from historical log-rafting activities, phenolic compounds from pulp mill wastewater discharges, and other industrial releases. Surface sediment contamination from other historical industrial activities is commingled with Site contamination in several areas.

Ecology has designated several other cleanup sites throughout the Bellingham Bay waterfront areas, including the Central Waterfront site, I&J Waterway site, Cornwall Avenue Landfill site, the former South State Street Manufactured Gas Plant site, and the R.G. Haley site. The cleanup action for the Site is being coordinated with these separate site cleanups by the Port and Ecology.

The primary contaminant of concern for the Site cleanup is mercury. The chlor-alkali plant was constructed by GP West in 1965 to produce chlorine and sodium hydroxide for use in bleaching and pulping wood fiber. The chlor-alkali plant discharged mercury-containing wastewater into Whatcom Waterway during the late 1960s and 1970s. Mercury discharges from the chlor-alkali plant were subsequently reduced through source controls and wastewater treatment and were terminated with the closure of the facility in 1999. The remediation of the upland chlor-alkali plant site is being addressed under the Model Toxics Control Act as the separate GP West cleanup site. The Site cleanup addresses contaminated marine sediments associated with the historical chlor-alkali plant discharges.

Dioxin/furan (D/F) compounds are also known to be present in surface and subsurface sediments throughout most of Bellingham Bay and other urban bays within Puget Sound. The full range of sources for these compounds in Bellingham Bay has not yet been determined and may include contributions from many sources throughout the bay, including former combustion sources, former GP West pulp and paper mill operations, former wood-treating facilities, historical and ongoing stormwater and wastewater discharges, and atmospheric deposition.

Since execution of the First Amendment to the Consent Decree in 2011, Ecology conducted work to determine whether regional background concentrations of certain bioaccumulative chemicals existed in Bellingham Bay (Ecology 2015). That work identified a regional background D/F concentration of 15 nanograms per kilogram toxic equivalency quotient (TEQ).

2.2 Sediment Cleanup Levels

Sediment cleanup levels and points of compliance are defined in the Cleanup Action Plan and Consent Decree (Ecology 2007) for the Site. These cleanup levels were amended in the Second Amendment to the Consent Decree (Ecology 2024). Site cleanup levels and points of compliance include the following:

- **Cleanup Levels for Protection of the Benthic Community:** Sediment cleanup levels for protection of the benthic community (i.e., sediment-dwelling organisms) were established at the Sediment Quality Standards criteria applicable at the time of the Consent Decree. These criteria remain unchanged, but under the updated Sediment Management Standards (SMS) regulations (Ecology 2013) these values are now referred to as the sediment cleanup objective (SCO) benthic criteria. Compliance with cleanup levels protective of the benthic community is determined using a combination of chemical testing and contingent bioassay testing. Samples that exceed the chemical SCO value but pass bioassay testing are considered to comply with the SCO, consistent with Washington's SMS regulations and associated guidance (Ecology 2021).
- **Cleanup Levels for Protection of Human and Ecological Health:** Site-specific cleanup levels protective of human and ecological health have also been established for bioaccumulative compounds, including mercury and D/F compounds.
  - Mercury: The site-specific cleanup level (the bioaccumulation screening level [BSL]) for mercury was established in the Consent Decree (Ecology 2007) at a value of 1.2 milligrams per kilogram (mg/kg). Compliance with the BSL is measured on a point-by-point basis.
  - D/F Compounds: For D/F compounds, the cleanup level was established at 9.8 nanograms per kilogram (ng/kg) TEQ in the Second Amendment to the Consent Decree (Ecology 2024), based on an analysis of what is technically possible to achieve given the presence of ongoing recontamination sources for D/F compounds. Compliance with this cleanup level is measured on a SWAC basis throughout the Site.
  - cPAH Compounds: An evaluation was also conducted for carcinogenic polycyclic aromatic hydrocarbon (cPAH) compounds. As described in the Second Amendment to the Consent Decree (Ecology 2024), the current surface-weighted average concentration (SWAC) of cPAH (67.8 microgram per kilogram [µg/kg] TEQ) is less than the risk-based threshold (229 µg/kg) established by Ecology.
- **Sediment Points of Compliance:** Compliance with the sediment cleanup levels is measured based on the thickness of the sediment biologically active zone. In Bellingham Bay, this thickness is the upper 12 centimeters (cm) of the sediment bed (RETEC 2006; Ecology 2007). Compliance with cleanup levels protective of the benthic community are measured on a point-by-point basis, as is compliance with the mercury BSL. Compliance with cleanup levels protective of human and ecological health for cPAH and D/F compounds are measured on a SWAC basis throughout the Site.

2.3 Cleanup Monitoring Locations

Figure H-2 shows the overall Site, the site units, and the locations for ongoing Phase 1 and MNR compliance monitoring established in the Phase 1 SQAPP (Anchor QEA 2016). The sediment monitoring locations will be sampled in Years 10, 20, and 30. Porewater testing in the Log Pond will be conducted in Year 10.

Phase 2 Site Areas and the nature of cleanup work to be performed are shown in Figure H-3 as follows:

- **Monitoring in Full Dredge Areas:** The blue areas in Figure H-3 are to be fully dredged to remove contaminated sediments. During construction of the cleanup, performance monitoring will be performed in these dredge areas to confirm that contaminated sediments have been removed to the extent practicable and that cleanup levels have been met following residuals management activities. These post-dredge monitoring locations are shown in Figure H-4. During long-term confirmational monitoring, a smaller number of locations will be monitored to document sediment equilibrium concentrations for D/F compounds within these same areas. These long-term confirmation monitoring locations are shown in Figure H-5 and will be tested in parallel with the Phase 1 Year 20 and Year 30 monitoring events in 2036 and 2046, respectively.
- **Monitoring in Sediment Cap Areas:** The green areas in Figure H-3 are to be capped with clean sediment, with partial dredging as necessary to construct the cap at target design elevations. Performance monitoring for capping areas will be limited to post-dredge and post-capping bathymetric surveys. Confirmational monitoring will be performed as shown in Figure H-5 to document sediment quality on top of the caps over the long term. This monitoring will be performed in the year following placement of the caps (i.e., during 2032) and then again in parallel with the final two rounds of Year 20 and Year 30 Phase 1 confirmational monitoring events scheduled for 2036 and 2046, respectively.
- **Monitoring of the CDF:** The Phase 2 cleanup includes the construction of a CDF in the inner portion of the ASB (Site 8). Performance monitoring will include structural surveys to document construction of the CDF retaining structure and bathymetric/topographic surveys to document construction of the CDF to target elevations. Once completed, groundwater monitoring wells will be constructed within the CDF retaining structure as shown in Figure H-5. Groundwater mercury concentrations will be monitored at these locations to confirm that mercury is being geochemically immobilized within the CDF consistent with the CDF design. Depending on the results of monitoring in adjacent areas of the Central Waterfront cleanup site, these wells may also be used for contingent monitoring of Central Waterfront site contaminants of concern to verify that these contaminants are not transported through the CDF.

3 Project Roles and Responsibilities

The monitoring described in this document will be led by the Port in coordination with the other participating PLPs. The Port, or its designated representatives, will be responsible for implementing the monitoring program. The Port will manage the contractor performing the required monitoring activities. Some monitoring activities may also be performed by Port staff as appropriate.

The monitoring contractor's project manager will provide overall project coordination, including production of all project deliverables and administrative coordination to ensure timely and successful completion of the project.

The Field Coordinator (FC) will supervise field collection of all samples and will also be responsible for positioning for sample collection accurately; recording sample locations, depths, and identification; ensuring conformance to sampling and handling requirements, including field decontamination procedures; physical evaluation and logging of samples; and completing chain of custody forms. The FC will be responsible for the submittal of environmental samples to the designated laboratories for bioassay, chemical, and physical analyses.

The Laboratory Project Manager at each laboratory will provide analytical support and will be responsible for providing certified, pre-cleaned sample containers and sample preservatives (as appropriate) and for ensuring that all chemical analyses meet the project data quality objectives (DQOs) and other quality specifications of the SAP.

The Port will review all work products prepared by its contractors and consultants and will communicate to the Ecology project coordinator any concerns that may arise regarding the implementation of the Phase 2 monitoring activities.

4 Performance Monitoring in Phase 2 Site Areas

This section describes the performance monitoring to be conducted during implementation of the cleanup action in Phase 2 Site Areas. Performance monitoring activities were completed previously in the Phase 1 Site Areas during 2015 and 2016.

Performance monitoring activities are summarized in Figure H-4 and in Tables H-1 and H-2.

4.1 Bathymetric and Topographic Surveys

Bathymetric surveys will be used to verify that dredging and capping activities achieve required target elevations as defined in the EDR. The surveys will be performed using multi-beam survey methods. These surveys will be implemented immediately following completion of work in each Site Area and will include the following:

- Post-dredge surveys to verify that sediments have been removed to their target elevations
- Surveys following placement of residuals management cover in full dredge areas to document that appropriate placement and coverage was achieved
- Surveys following placement of sediment caps to verify that cap placement was consistent with EDR requirements

Bathymetric and topographic surveying will be conducted using the following methods:

- Bathymetric surveys will be conducted by a licensed surveyor using multi-beam survey equipment and will meet or exceed the accuracy standards for a U.S. Army Corps of Engineers (USACE) Navigation and Dredging Support Survey as referenced in the *Engineering and Design – Hydrographic Surveying* manual (USACE 2013).
- In shoreline capping areas, drone-based topographic surveys will be performed at low tide to document cap elevations in above-water areas. These surveys will be performed using either drone-based topographic surveys (most areas) or a Light Detection and Ranging (LiDAR) survey (under-pier areas).

4.2 Visual and Structural Surveys

Visual surveys will be conducted throughout construction activities to document the construction of shoreline caps and marine structures required for implementation of the cleanup as follows:

- **Visual Surveys of shoreline Cap Areas:** Visual surveys will be conducted at low tide by a principal engineer in shoreline capping areas to document that construction has been completed consistent with the remedial design. These surveys will supplement information available from the shoreline topographic surveys. Visual surveys will be completed in the shoreline capping areas in the Unit 1C under-dock areas (at Bellingham Shipping Terminal [BST]), Unit 2C (former GP West dock areas), Unit 3A (head of the Whatcom Waterway), Unit 4

(the Log Pond), Unit 5C (C-Street Outfall Area) and in the capping areas along the Unit 8 interior and exterior shorelines (ASB shoreline). Visual survey findings will be documented with photographs, a map of photograph locations, and a narrative summarizing the findings for each capping area.

- **Structural Surveys for Marine Structures:** Structural surveys will be performed to document the condition of each of the marine structures to be installed or replaced as part of the cleanup in Phase 2 Site Areas. These surveys will be performed by a licensed civil or structural engineer and will certify completion of the work in accordance with the *Construction Quality Assurance Plan* (CQAP; currently in development). Marine structural surveys will include the replacement dock, bulkheads and piling/dolphins in Unit 1C (at BST), the sediment offloading dolphins in Unit 2C (alongside the ASB), the new outfall along the Log Pond shoreline (Unit 4), the extension of the C-Street Outfall (Unit 5C), the structural modifications in Unit 6 (Rail Span Area), and in Unit 8 the CDF retaining structure and new stormwater outfall along the ASB shoreline (Unit 8). Structural survey findings will be documented with photographs, a map of photograph locations, and a narrative summarizing the findings for each set of structures consistent with the requirements of the CQAP (currently in development).

4.3 Post-Dredge Sediment Testing in Full Dredge Areas

One round of post-dredge sediment testing will be performed as part of performance monitoring in each of the full dredge areas (Figure H-4 and Table H-2) prior to placement of residuals management cover. In these full dredge areas, dredging is intended to achieve removal of contaminated sediments from the base of each dredge prism. Post-dredge performance monitoring will be used to verify that dredging residuals thickness and sediment quality are within design parameters and that contaminated sediments have been fully removed. These data will be used to inform potential contingency actions as follows:

- If dredging residuals are excessively thick, or if contaminant levels are higher than expected, then contingency actions may include the following 1) contingency re-dredging to reduce the dredging residuals; or 2) increasing the thickness of residuals cover material.
- If sampling of the undisturbed sediments demonstrates that contaminated sediment remains at the base of the dredge prism, then contingency actions may include implementation of contingency re-dredging to remove the remaining contaminated sediments.

4.3.1 Testing Locations and Methods

Testing locations for the full dredge areas are shown in Figure H-3. Testing will include two separate rounds of testing at each location as follows:

- **Post-Dredge Sampling:** At the conclusion of dredging in each site unit, stratified grab samples will be collected to provide two sets of samples. Both sets of samples will be analyzed for total mercury, D/F compounds, total solids (TS), and total organic carbon (TOC):
  - The upper sample will be collected of the apparent residuals layer to document its thickness and composition. The depth of this sample will vary with the residuals layer thickness but is expected to be approximately 0 to 5 cm.
  - A second, deeper sample will be collected of undisturbed native sediment. This sample will be used to confirm that all contaminated sediments have been removed. This sample will be collected in the undisturbed sediment layer approximately 10 to 20 cm below the apparent residuals layer.
- **Sampling After Placement of Residuals Cover:** Following placement of the residuals cover material, the post-dredge sampling locations will be reoccupied. Grab samples will be recollected in the surface (0 to 12 cm) sediment interval. These samples will be analyzed for mercury, D/F compounds, TS, and TOC. Sediments will be archived for contingent bioassay testing in the event that mercury concentrations exceed the SCO (0.41 mg/kg).

Surface and shallow subsurface sediment will be collected using a hydraulic Van Veen sampling device at the locations shown in Figure H-4 and listed in Table H-2. At each location, samples will be collected from the dredging residual layer, which is expected to be up to approximately 5 cm thick and consist of poorly consolidated materials. Samples will also be collected from the sediment underlying the residuals layer. These sediments will be collected from the base of the Van Veen sampler, approximately 10 to 20 cm below the dredging residuals layer.

The thickness of the residuals layer will be measured in the grab sample, and a subsample of this layer will be submitted for the sediment chemical analyses described below. The overlying material will then be removed from the Van Veen sampler to expose the underlying sediments. These are expected to consist of consolidated native sand materials. A sample of this material will be collected from the base of the sampler, approximately 10 to 20 cm below the contact with the dredging residuals layer. The sample will be collected and submitted for sediment chemical analyses described in the following section for verification that dredging has reached the base of chemical contamination. Sufficient volume will be collected for sediment chemical analyses and potential re-analyses.

The methods and quality assurance/quality control procedures for Van Veen sampling will be defined in the project SAP. The SAP will be submitted along with the Final EDR and will be subject to

Ecology review and approval prior to implementation of sampling activities. Table H-2 lists the sampling locations, sample depths, and analyses.

4.3.2 Chemical Testing

The post-dredging samples will be analyzed for mercury, D/F, TS, and TOC. Analytical methods, DQOs, and performance criteria for these analytes will be documented in the project SAP. As detailed in Appendix G of the EDR, mercury concentrations in samples of undredged sediment from beneath the dredging residuals will be compared to the Sediment Quality Standard (SQS) of 0.41 mg/kg per WAC 173-204-320, and D/F concentrations will be compared to the site-wide SWAC cleanup level of 9.8 ng/kg TEQ.

4.3.3 Contingency Response Actions

Subject to and consistent with the provisions of the Consent Decree as amended, if the post-dredging sampling indicates that the thickness and/or chemical composition of the residuals layer are greater than evaluated in Appendix G of the EDR, residuals management calculations will be repeated and the findings discussed with Ecology. If necessary to appropriately manage dredging residuals and comply with cleanup levels specified in the Consent Decree as amended, contingency response actions could include increasing the minimum thickness of residuals cover (i.e., from 6 to 12 inches) in appropriate areas, conducting a cleanup pass, or both.

If sampling of sediments beneath the residuals layer indicates the potential presence of "missed inventory," results shall be discussed with Ecology. Contingency response measures could include conducting follow-up sediment coring to verify the thickness of the missed inventory layer, initiation of cleanup pass dredging in appropriate areas, or adjustment of the residuals management cover thickness as described above.

4.4 Sediment Testing After Residuals Cover Placement

Sediment testing will be performed in full dredge areas following placement of residuals management cover or sediment backfill materials. This testing will document final surface sediment quality at the completion of construction.

4.4.1 Testing Locations and Methods

The sediment testing locations will be the same as those shown in Figure H-4. Retesting at these locations will confirm the effects of residuals management activities on sediment quality.

At each of the testing locations, surface sediment (0 to 12 cm biologically active zone) will be collected using a hydraulic Van Veen sampling device (Table H-2 and Figure H-4). Only the bioactive zone sediments will be tested.

Sufficient volume will be collected for both sediment chemical analyses and contingent bioassay tests, should they be necessary. Table H-2 lists the sampling locations, sample depths, and analyses.

4.4.2 Sediment Chemistry

Surface sediment samples will be analyzed for mercury, D/F, TS, and TOC as part of performance monitoring. Analytical methods, DQOs, and performance criteria for these analytes will be documented in the project SAP. Point-by-point testing will compare mercury concentrations to the benthic SCO criteria of 0.41 mg/kg with the potential for contingency bioassay testing. Additionally, concentrations in surface sediment will be compared to the site-specific BSL of 1.2 mg/kg for mercury (RETEC 2006) and the site-wide SWAC cleanup level of 9.8 ng/kg TEQ for D/F (Ecology 2024).

4.4.3 Contingent Bioassay Testing

If mercury exceeds its respective benthic SCO criteria, contingent bioassay testing will be initiated. Specifically, the following Puget Sound Estuary Program (PSEP) sediment bioassay tests will be performed if there are SQS criteria exceedances (PSEP 1995):

- 10-Day Acute Toxicity Amphipod Test (*Ampelisca abdita*, *Eohaustorius estuarius*, or *Rhepoxynius abronius*, depending on grain size of sediments to be tested)
- Larval Bivalve Development Test (*Mytilus galloprovincialis* or *Dendraster excentricus*)
- 20-Day Juvenile Polychaete Chronic Toxicity Test (*Neanthes arenaceodentata*)

Bioassay testing will be performed in accordance with PSEP protocols (PSEP 1995) by an Ecology-accredited laboratory and as updated during the Sediment Management Annual Review Meeting process. Methods for bioassay tests will be defined in the SAP. Final sediment test species will be selected in coordination with Ecology and based on grain size, salinity, and collection season prior to test initiation.

4.4.4 Contingency Response Actions

If there are exceedances of the benthic SCO for mercury (as measured with chemical and/or confirmatory bioassay tests) or the BSL, contingency response measures will be evaluated and discussed with Ecology. D/F TEQ concentrations will also be screened against the site-wide cleanup level, taking into account the applicable averaging areas.

Initial contingency response actions for cleanup level exceedances would include sampling to verify results and the extent of exceedances. Contingency responses may then include assessment of appropriate corrective measures for the area of recontamination (e.g., increased monitoring or placement of additional residuals cover).

5 Confirmation Monitoring in Phase 2 Site Areas

This section describes the confirmation monitoring activities that are to be performed in the year following completion of construction in Phase 2 Site Areas (estimated 2032) and will be repeated in parallel with planned Phase 1 monitoring events in Year 20 and 30 (2036 and 2046, respectively).

5.1 Cap Integrity Monitoring

Bathymetric surveys will be used to verify the physical integrity of capping surfaces. These surveys will be performed 1 year following completion of Phase 2 cleanup activities (estimated 2032) and in parallel with Phase 1 Year 20 monitoring event (estimated 2036).

5.1.1 Bathymetric and Topographic Surveys

Bathymetric and topographic surveys will be completed in each capping area including the following:

- Unit 1C (BST under-dock areas)
- Unit 2B (ASB entrance channel side slopes)
- Unit 2C (Inner Waterway and GP dock shoreline areas)
- Unit 3A (head of Whatcom Waterway)
- Unit 4 (side slopes between Log Pond and Unit 2C)
- Unit 5C (C-Street Outfall Area)
- Unit 6 (Rail Span Area)
- Unit 8 (ASB side slopes)

Bathymetric and topographic surveying will be conducted using the following methods:

- Bathymetric surveys will be conducted by a licensed surveyor using multi-beam survey equipment and will meet or exceed the accuracy standards for a USACE Navigation and Dredging Support Survey as referenced in the *Engineering and Design – Hydrographic Surveying* manual (USACE 2013).
- In shoreline capping areas, drone-based topographic surveys will be performed at low tide to document cap elevations in above-water areas. These surveys will be performed using either drone-based topographic surveys (most areas) or a LiDAR survey (under-pier areas).

5.1.2 Visual and Structural Surveys

Visual surveys will be conducted in shoreline capping areas, and marine structural surveys will be conducted to document the condition of the CDF retaining structure as follows:

- **Visual surveys of Shoreline Cap Areas:** Visual surveys will be conducted at low tide by a principal engineer to document the ongoing integrity of each of the caps placed in shoreline areas. These surveys will supplement information available from the shoreline topographic surveys. Visual surveys will be completed in the shoreline capping areas in Unit 1C (BST

under-dock areas) Unit 2C (former GP dock areas), Unit 3A (head of the Whatcom Waterway), Unit 4 (the Log Pond), Unit 5C (C-Street Outfall Area), and the capping areas along the Unit 8 interior and exterior shorelines (ASB shoreline). Visual survey findings will be documented with photographs, a map of photograph locations, and a narrative summarizing the findings for each capping area.

- S**tructural Surveys for CDF Retaining Structure:** Structural surveys will be performed to document the ongoing integrity of the CDF retaining structure. These surveys will be performed by a licensed civil or structural engineer. Structural survey findings will be documented with photographs, a map of photograph locations, and a narrative summarizing the integrity of the structure.

5.1.3 Contingency Response Actions

If significant reductions in mudline elevations are observed in engineered cap areas, then contingency response measures will include the collection of additional data to assess whether the elevation changes indicate potential cap erosion. (Elevation changes can also be caused by settling and consolidation, which does not impact cap integrity.) In the event that cap erosion is identified, the extent of the cap erosion will be defined along with potentially applicable control options. Appropriate corrective measures will be discussed with Ecology and implemented as necessary to protect cap integrity. These corrective measures could include implementing changes to institutional controls or operating procedures, placement of additional cap material or armoring, or modifications to cap elevation through placement of new material.

If visual assessments indicate potential erosion of upper bank cap or armor material or potential damage to containment structures, then contingency response measures may include the collection of follow-up information to assess the nature of any potential erosion or damage. Appropriate corrective measures will be discussed with Ecology and implemented as necessary to protect cap and containment structure integrity. These corrective measures could include implementing changes to institutional controls or operating procedures, placement of additional cap material or armoring, modifications to cap elevation through placement of new material or repair, or modification or replacement of the containment structures.

If structural surveys indicate damage or excessive wear of the CDF retaining structure, then a repair and maintenance plan will be developed and submitted to Ecology. Appropriate repair and maintenance activities will then be implemented following review and approval by Ecology.

5.2 Surface Sediment Quality Monitoring

Surface sediment quality will be monitored to document the effectiveness of remediation in maintaining cleanup levels for site contaminants. Surface sediment will be collected from the top

12 cm of sediment at 16 locations within the Phase 2 remediation areas. Locations of the compliance monitoring surface sampling stations are depicted in Figure H-4 and specified in Table H-2.

Compliance monitoring will take place during the first year following completion of Phase 2 construction activities (estimated in 2032) and in parallel with Year 20 (2036) and Year 30 (2046) monitoring in Phase 1 and MNR Site Areas. Sampling will include collection of archived materials for bioassay testing in the event that site contaminants are detected in excess of the SCO.

5.2.1 Sampling and Analysis Approach

Surface sediment from all locations will be analyzed for SMS testing parameters including heavy metals, mercury, D/F, TS, TOC, and semivolatile organic compounds as presented in Table H-2.

Surface sediment (0 to 12 cm) will be collected using a hydraulic Van Veen or similar sampling device. Sufficient volume will be collected for sediment chemical analyses, potential re-analyses, and contingent bioassay tests. Contingent bioassay tests will be performed at stations where the SCO is exceeded for mercury or other compounds.

5.2.2 Contingent Bioassay Testing

If mercury exceeds its respective benthic SCO criteria, contingent bioassay testing will be initiated. Specifically, the following PSEP sediment bioassay tests will be performed if there are SQS criteria exceedances (PSEP 1995):

- 10-Day Acute Toxicity Amphipod Test (*Ampelisca abdita*, *Eohaustorius estuarius*, or *Rhepoxynius abronius*, depending on grain size of sediments to be tested)
- Larval Bivalve Development Test (*Mytilus galloprovincialis* or *Dendraster excentricus*)
- 20-Day Juvenile Polychaete Chronic Toxicity Test (*Neanthes arenaceodentata*)

Bioassay testing will be performed in accordance with PSEP protocols (PSEP 1995) by an Ecology-accredited laboratory and as updated during the Sediment Management Annual Review Meeting process. Methods for bioassay tests will be defined in the SAP. Final sediment test species will be selected in coordination with Ecology and based on grain size, salinity, and collection season prior to test initiation.

5.2.3 Contingency Response Actions

If there are exceedances of the benthic SCO for mercury (as measured with chemical and/or confirmatory bioassay tests) or the BSL, contingency response measures will be evaluated and discussed with Ecology. D/F TEQ concentrations will also be screened against the site-wide cleanup level, taking into account the applicable averaging areas.

Initial contingency response actions for cleanup level exceedances would include sampling to verify results and the extent of exceedances. Contingency responses may then include assessment of appropriate corrective measures for the area of recontamination.

5.3 Confined Disposal Facility Groundwater Monitoring

Groundwater monitoring will be initiated in the year following completion of construction in Phase 2 Site Areas. Two groundwater wells will be installed in the clean backfill placed inside the retaining structure to monitor the quality of groundwater discharge into the aquatic use area of Unit 8 (Figure H-4).

5.3.1 Sample Collection and Analysis

Groundwater samples from monitoring wells will be collected using a peristaltic pump or similar sampling device with dedicated polyethylene tubing at each well location. Sampling will be conducted using low-flow methods to minimize turbidity in the water samples. Field parameters (pH, temperature, specific conductance, dissolved oxygen, oxidation-reduction potential, and turbidity) will be measured at each location at the time of sample collection.

Sufficient volume will be collected for chemical analyses and potential re-analyses. All groundwater samples will be analyzed for total and dissolved mercury and TOC as presented in Table H-2.

Following completion of construction, groundwater monitoring will be performed under the following frequency:

- **Years 1 and 2:** Quarterly (i.e., four times per year)
- **Years 3 and 4:** Semiannually (i.e., twice per year), once during wet weather and once during dry weather
- **Years 5 Through 9:** Annually during wet weather
- **Years 10 Through 30:** Every 5 years (Years 10, 20, and 30 in coordination with Phase 2 confirmation sampling and reporting) during wet weather

Because the groundwater's highest beneficial use is discharge to marine water, protectiveness of that beneficial use is dependent on meeting marine-protection-based groundwater cleanup levels at the points where groundwater discharges to marine sediment (biologically active zone) and then the marine water column of Whatcom Waterway and Bellingham Bay. Therefore, groundwater concentrations will be compared to WAC 173-201A surface water quality standards.

5.3.2 Contingency Response Actions

If mercury exceeds the respective surface water quality standards, contingency response measures will be evaluated and discussed with Ecology. Initial actions would include resampling to verify results and testing of surface water samples in the locations immediately adjacent to the CDF

retaining structure. The presence of elevated mercury concentrations in the surface water samples as well as the groundwater samples would indicate a complete transport pathway.

Methods for evaluating and implementing proposed contingency response measures would be presented in a contingency response evaluation memorandum. In the absence of a complete transport pathway, contingency responses would include review and potential modification of the sampling schedule to provide more frequent groundwater monitoring data to assess contaminant trends, and addition of supplemental geochemical testing parameters to assess contaminant fate and transport processes occurring within the CDF retaining structure backfill. If a complete transport pathway is demonstrated, then appropriate corrective measures may include targeted source control measures as necessary to reduce dissolved mercury concentrations, such as the introduction of treatment reagents within the CDF retaining structure backfill to immobilize dissolved mercury concentrations.

If groundwater compliance monitoring data for the Central Waterfront site indicates the following: 1) groundwater migration pathways through the CDF; and 2) concentrations of Central Waterfront site contaminants that exceed applicable cleanup standards along the northeastern boundary of the CDF, the compliance monitoring wells may be used to monitor concentrations of the indicated contaminants along that migration pathway. This work would be performed using the same methodology described in Section 5.3.1 but with updated analytical parameters as detailed in the applicable monitoring plan for the Central Waterfront site.

5.4 Supplemental Monitoring Following Extreme Events

In addition to the monitoring intervals prescribed in this document, supplemental monitoring may be performed after extreme events (e.g., significant earthquake events or tsunamis) or visible damage to the cap where necessary to verify that the cleanup action has not been adversely affected. The need for and the extent of supplemental monitoring will be identified by the Port in consultation with Ecology; supplemental monitoring activities could include some of the monitoring program elements described in this plan where necessary. For example, if a significant earthquake event caused sediment bed elevation changes within sediment cap areas, supplemental bathymetric surveys, shoreline inspections, and/or surface sediment testing may be appropriate to ensure protectiveness and evaluate the need for additional contingency response measures. If supplemental monitoring activities are required, these will be specified in an addendum to this CMCRP, and the findings will be communicated to Ecology in a supplemental monitoring report.

6 Ongoing Monitoring in MNR and Phase 1 Site Areas

Confirmation monitoring has been ongoing in the Site MNR and Phase 1 Site Areas since 2017, the year following completion of Phase 1 construction activities. For a discussion of completed activities and observations, refer to the *Year 5 Monitoring Report* (Anchor QEA 2022).

As described in the *Year 5 Monitoring Report*, tissue monitoring activities have been previously completed. That monitoring has confirmed that mercury concentrations in juvenile and adult Dungeness crab collected from the Site have decreased to levels not significantly different from the Samish Bay clean reference site, and D/F concentrations in flatfish are not significantly different from those in Samish Bay.

This section describes the ongoing confirmation monitoring activities that will continue in the Site MNR and Phase 1 Site Areas at the locations shown in Figure H-2. The next monitoring events scheduled for these areas include Years 10, 20, and 30 (2026, 2036, and 2046, respectively).

6.1 Phase 1 Cap Integrity Monitoring

Bathymetric surveys will be used to verify the physical integrity of Phase 1 capping surfaces at Year 10 (2026) to supplement previous observations and document that the caps continue to be stable under existing site conditions. The work will include bathymetric and topographic surveys and visual inspections using the same methods presented for Phase 2 Site Areas in Section 5.1.

Phase 1 cap areas to be evaluated include the following:

- Units 2A and 2C (Inner Waterway)
- Unit 3B (Inner Waterway)
- Unit 4 (Log Pond)

Contingency response actions will be the same as described for Phase 2 Site capping areas in Section 5.1.

6.2 Surface Sediment Quality Monitoring

Surface sediment quality will be monitored to document the surface sediment contaminant concentrations in both Phase 1 capping areas and Site MNR areas (Figure H-2). Surface sediment will be collected from the top 12 cm of sediment at each of the monitoring locations shown in Figure H-2. At location WW-P1CM-11, a 0- to 2-cm sample will also be collected to assist in tracking contaminant trends near the C-Street Outfall.

Compliance monitoring will take place during Years 10, 20, and 30 (2026, 2036, and 2046, respectively). Testing locations and parameters are defined in Tables H-4 and H-5. Sampling will include collection of archived materials for bioassay testing in the event that site contaminants are

detected in excess of the SCO. Sampling and analysis methods and contingency response actions are the same as those listed in Section 5.2 for Phase 2 Site Areas.

6.3 Subsurface Mercury Testing in Site Monitored Natural Recovery Areas

Subsurface sediment mercury concentrations will be collected at five locations within Site MNR areas (Figure H-2) to document the accumulation of clean sediments over time. This testing will be performed at Years 10, 20, and 30 (2026, 2036, and 2046, respectively).

Sediment cores will be collected using a vibracore. A new core tube (or liner) will be used for sampling at each station to eliminate the possibility of cross contamination among stations. The vibracore will be deployed from the vessel using the A-frame and hydraulic winch. The vibracore will be energized as it nears the bottom and supported upright with the winch line during penetration into the sediment. The vibracore will penetrate into the sediment to the target core depth of 3 feet below the sediment water interface or refusal, whichever comes first. Upon completing penetration at a station, the vibracore will be shut down, the position recorded, and the sampler recovered. After the core is on deck, the liner containing sediment will be extracted onto a core tray.

Refusal will be defined as less than 5 cm of penetration per minute. If refusal is encountered, the vessel will be slightly moved and a second core attempted, then, if needed, a third attempt will be made. If refusal is encountered after the third attempt, additional cores will not be attempted unless operational problems are suspected. The longest of the three cores will be retained for analysis.

Cores will be processed aboard the sampling vessel. Core tubes will be cut open using electric shears. Each core will be photographed and visually characterized according to the Unified Soils Classification System (ASTM International Method D2488) and visually examined for evidence of deposition/erosion. Subsamples will be collected in 0.5-foot sections using clean stainless-steel spoons, homogenized in stainless-steel bowls, and placed into appropriate sample containers for subsequent analyses of chemical and physical parameters. Sample containers will be appropriately labeled and stored in coolers on ice until delivery to the laboratory.

Subsurface sediment samples will be analyzed for mercury and TS. Results will be evaluated to confirm the rate of clean sediment deposition occurring within each area of the Site.

6.4 Porewater Testing in Log Pond Nearshore Areas

Porewater monitoring has been performed at two locations along the Log Pond nearshore areas (Figure H-2) to demonstrate that mercury in upland groundwater is being sufficiently attenuated to eliminate risks of sediment recontamination in Log Pond sediments. A final round of porewater testing will be completed during Year 10 (2026) consistent with the requirements of the Phase 1 SQAPP (Anchor QEA 2016).

Sediment porewater will be collected at two sampling locations (Figure H-2) using either nylon mesh diffusion samplers (NMDSs; preferred method) or temporary mini-piezometers.

NMDS sampling methodology will follow methods used by the U.S. Geological Survey (USGS) and U.S. Environmental Protection Agency (EPA; [USGS and EPA 2005]). NMDSs are a type of passive sampler that can be used in both course and fine sediments, provide a comparable measure with which to compare clam exposure over the duration of the incubation period, and limit the introduction of confounding factors (such as erroneously drawing surface water or sediment into the sample).

NMDSs consist of 250- milliliter (mL) polypropylene jars and screw-on lids. NMDS are constructed prior to the field effort using the following procedures:

- Remove the center of the lid so that just the rim remains.
- Place all equipment in buckets/tubs with deionized water that has been purged of oxygen via aerating with nitrogen for at least 1 hour. Continue aerating with nitrogen while assembling the NMDS.
- Place a piece of 20-micron nylon screen mesh over the top of the jar and screw on the lid rim.
- Store jars in the assembly buckets with lids firmly sealed and under nitrogen headspace to prevent contamination until deployment.

NMDSs will be deployed at low tide by field technicians with knee-high boots or waders using the following procedures:

- Attach a small buoy to each NMDS using an electrical tie and rope.
- A small shovel-like device made from PVC may be used to create a hole in the sediment in which the samplers will reside (see USGS and EPA [2003] for details).
- Bury jars at a depth of 6 to 12 cm in the sediment placed on their sides to prevent the mesh from being punctured during deployment and retrieval.
- Cover the NMDSs with sediment.
- Record GPS coordinates on field forms.
- NMDSs will be left in situ for a minimum of 4 days to equilibrate.

NMDSs will be retrieved using GPS coordinates and the buoys in the following manner:

- Gently remove the samplers from the sediment using caution to avoid damaging the nylon mesh.
- Once recovered, any sediment remaining on the top of the mesh will be gently removed to minimize the loss of water from the sampler.
- Porewater will be extracted using a 60-mL disposable syringe.
    - For dissolved mercury analysis, a 13-gage, 8.9-cm hypodermic needle and a 25-millimeter, 0.45-micron filter unit mounted between the syringe and needle (see

USGS and EPA [2003] method for a picture of the assembly) will be used to collect the sample.
  - For total mercury analysis, the filter will be removed and the hypodermic needle connected directly to the syringe to collect the sample.
- For each sample (total and dissolved), the syringe assembly will be pushed into the mesh and 100 mL will be drawn into the syringe.
- The filter and hypodermic needle will be removed from the syringe and the sample volume gently pushed into the sample container. The sample container will be tightly sealed.

Porewater samples will be stored in coolers on ice until delivery to the analytical laboratory.

7 Reporting

Compliance monitoring data will be summarized in reports prepared and submitted according to the following schedule:

- **Year 10 Compliance Monitoring Report:** This report will be submitted to Ecology by February 15 of 2027 and will document the confirmation monitoring activities completed during 2026 for Phase 1 Site Areas and Site MNR areas.
- **Performance Monitoring Data for Phase 2 Site Areas:** These data will be summarized in the As-Built Report for Phase 2 Site Areas. This report will be submitted within 120 days of completion of construction activities in the Phase 2 Site Areas (estimated 2031).
- **1-Year Post-Construction Confirmation Monitoring Report for Phase 2 Site Areas:** This report will be submitted to Ecology in the first calendar year following completion of Phase 2 construction activities (estimated 2032).
- **Year 20 Compliance Monitoring Report:** This report will be submitted to Ecology by February 15 of 2037 and will document the confirmation monitoring activities completed during 2036 for Phase 1 Site Areas, Phase 2 Site Areas, and Site MNR areas.
- **Year 30 Compliance Monitoring Report:** This report will be submitted to Ecology by February 15 of 2047 and will document the confirmation monitoring activities completed during 2046 for Phase 1 Site Areas, Phase 2 Site Areas, and Site MNR areas.

Collected monitoring data will be uploaded to Ecology's Electronic Information Management database at the time the reports are submitted to Ecology.

8 References

Anchor QEA, 2016. *Sampling and Quality Assurance Project Plan for Compliance Monitoring*. Whatcom Waterway Cleanup in Phase 1 Site Areas.

Anchor QEA, 2022. *Year 5 Monitoring Report*. Whatcom Waterway Cleanup in Phase 1 Site Areas. Prepared for Port of Bellingham. April 2022.

Ecology (Washington State Department of Ecology), 2007. *Cleanup Action Plan*. Whatcom Waterway Site, Bellingham, Washington. Exhibit B to Consent Decree No. 07-2-022577-7 for the Whatcom Waterway Site. Toxics Cleanup Program, Northwest Regional Office, Bellevue, Washington. Filed September 24, 2007.

Ecology, 2011. First Amendment to the Cleanup Action Plan. Whatcom Waterway Site, Bellingham, Washington. Exhibit B to Consent Decree No. 07-2-022577-7 for the Whatcom Waterway Site. Toxics Cleanup Program, Northwest Regional Office, Bellevue, Washington. Filed August 19, 2011.

Ecology, 2013. *Sediment Management Standards*. Washington Administrative Code 173-204. Revised February 2013.

Ecology, 2015. *Bellingham Bay Regional Background Sediment Characterization Final Data Evaluation and Summary Report*. Publication No. 15-09-044. February 2015.

Ecology, 2021. *Sediment Cleanup Users Manual*. Ecology Publication Number 12-09-057. Revised December 2021.

Ecology, 2024. Second Amendment to the Cleanup Action Plan. Whatcom Waterway Site, Bellingham, Washington. Exhibit B to Consent Decree No. 07-2-022577-7 for the Whatcom Waterway Site. Toxics Cleanup Program, Northwest Regional Office, Bellevue Washington. Filed March 27, 2024.

PSEP (Puget Sound Estuary Program), 1995. *Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments*. Prepared for the U.S. Environmental Protection Agency, Region 10, Seattle, Washington, and Puget Sound Water Quality Authority, Olympia, Washington, by King County Environmental Lab, Seattle, Washington. 1995.

RETEC (The RETEC Group, Inc.), 2006. *Supplemental Remedial Investigation and Feasibility Study. Volume 1: RI Report and Draft Supplemental Remedial Investigation and Feasibility Study. Volume 2: FS Report*. Whatcom Waterway Site, Bellingham, Washington. Prepared for Port of Bellingham. October 10, 2006.

USACE (U.S. Army Corps of Engineers), 2013. *Engineering and Design – Hydrographic Surveying*. Publication No. EM 1110-2-1003. CECW-CE and CECW-OD. November 30, 2013.

USGS and EPA (U.S. Geological Survey and U.S. Environmental Protection Agency), 2005. *Field Tests of Nylon-Screen Diffusion Samplers and Pushpoint Samplers for Detection of Metals in Sediment Pore Water, Ashland and Clinton, Massachusetts, 2003*. U.S. Geological Survey Scientific Investigations Report 2005-5155; p. 51.

Tables

Table H-1
Overview of Phase 2 Performance and Compliance Monitoring Activities

Monitoring Type	Monitoring Objective	Frequency	Parameters
Performance Monitoring in Full Dredge Areas			
Bathymetric Testing	Verify removal to target elevations	Following material removal	Bathymetry
Post-Dredge Performance Monitoring	Verify residuals quality and thickness	Following material removal	Residuals thickness, Hg, D/F, TS, TOC
	Verify lack of missed inventory	Following material removal	Hg, D/F, TS, TOC
Performance Monitoring After Residuals Management	Document final sediment quality following residuals cover placement	Following residuals cover placement	Hg, D/F, TS, TOC, contingent bioassays[1]
Performance Monitoring for Capping and Marine Structures			
Bathymetric Testing	Verify sediment removal to target elevations in dredge areas	Following material removal	Bathymetry
	Verify cap placement to target elevations	Following cap placement	Bathymetry
Visual Surveys and Structural Surveys	Visual surveys to verify integrity of intertidal caps	Following structure installation	Visual inspections of intertidal caps
	Structural inspections to verify integrity of installed marine structures	Following structure installation	Structural inspection of retaining structure and other marine structures
Compliance Monitoring in Full Dredge Areas			
Surface Sediment	Monitor long-term equilibrium concentrations	1 year following completion and in parallel with Year 20 and Year 30 Monitoring	Heavy metals, Hg, SVOC, D/F, TS, TOC, contingent bioassays[1]
Compliance Monitoring in Capping Areas			
Visual Surveys	Visual surveys to verify integrity of intertidal caps and CDF	1 year following completion and in parallel with Year 20 and Year 30 Monitoring	Visual survey of intertidal cap areas and completed CDF
Bathymetric Testing	Document cap integrity and final consolidation behavior	1 year following completion and in parallel with Year 20 and Year 30 Monitoring	Bathymetry in cap areas
Surface Sediment	Document compliance with site cleanup levels; monitor long-term equilibrium concentrations	1 year following completion and in parallel with Year 20 and Year 30 Monitoring	Heavy metals, Hg, D/F, SVOC, TS, TOC, contingent bioassays[1]
Compliance Monitoring of CDF Retaining Structure			
Structural Inspections	Structural inspection to verify condition and integrity of retaining structure	1 year following completion and in parallel with Year 20 and Year 30 Monitoring	Structural inspection of CDF retaining structure
Groundwater Monitoring	Verify compliance with site cleanup levels	Periodic[2]	Field parameters, total and dissolved Hg and TOC

Notes:

1. Contingent bioassays will be performed if mercury concentrations exceed the benthic SCO and will include three standard PSEP tests: 10-day acute amphipod, 20-day juvenile polychaete growth, and larval development.

2. Groundwater monitoring will be performed quarterly for 2 years, semiannually for Years 3 to 5, annually for Years 6 to 10, and every 5 years for Years 15 to 30.

CDF: Confined Disposal Facility
D/F: dioxin/furan
heavy metals: priority pollutant heavy metals
Hg: mercury
SVOC: semivolatile organic compounds
TOC: total organic carbon
TS: total solids

Table H-2
Phase 2 Performance Monitoring Locations and Test Parameters for Full Dredge Areas

Site Unit	Station ID	Proposed Coordinates[1]		Sample Method	Post-Dredge Sampling	Sampling After Placement of Residuals Cover	Sample ID	Analytical Testing	
		Easting	Northing					Chemistry	Archive[2]
1A and 1B	WW-P2PM-01	1237867.1	639484.8	Van Veen grab	1 Sample of apparent residuals layer (typically thickness 0–5 centimeters) Additional sample of undisturbed native sediment (10–20 cm below apparent residuals layer)	Surface sediment (0–12 cm)[2]	WW-P2PM-01-SS	Hg, D/F, TS, TOC	Contingent bioassays[2]
	WW-P2PM-02	1238221.6	639825.6				WW-P2PM-02-SS		
	WW-P2PM-03	1238613.5	640196.1				WW-P2PM-03-SS		
	WW-P2PM-04	1238941.5	640515.8				WW-P2PM-04-SS		
1C	WW-P2PM-05	1239177.4	640755.8				WW-P2PM-05-SS		
	WW-P2PM-06	1239532.7	641081.9				WW-P2PM-06-SS		
1C (Under-Pier)[3]	WW-P2PM-07	1239845.1	641095.7				WW-P2PM-07-SS		
	WW-P2PM-09	1239589.1	641702.5				WW-P2PM-09-SS		
5B	WW-P2PM-08	1240046.0	641285.8				WW-P2PM-08-SS		
2B	WW-P2PM-13	1239724.4	642624.8				WW-P2PM-13-SS		
2C	WW-P2PM-10	1240153.7	641660.7				WW-P2PM-10-SS		
	WW-P2PM-12	1239868.5	642349.7				WW-P2PM-12-SS		
8	WW-P2PM-11	1240114.0	642069.7				WW-P2PM-11-SS		
	WW-P2PM-14	1239566.2	642928.8				WW-P2PM-14-SS		

Notes:

1. NAD83 State Plane Washington North Federal Information Processing System 4601 feet

2. Bioassays will be conducted only on surface sediments collected following residuals cover placement and only if chemical concentrations exceed the benthic sediment cleanup objectives for total Hg.

3. BST under-pier samples will be analyzed only for post-dredge sampling parameters prior to placement of the Type 3 cap.

BST: Bellingham Shipping Terminal
cm: centimeter
D/F: dioxin/furan
Hg: mercury
NAD83: North American Datum of 1983
TOC: total organic carbon
TS: total solids

Table H-3
Phase 2 Confirmation Monitoring Locations and Test Parameters

Site Unit	Station ID	Proposed Coordinates[1]		Sample Media	Sample Method	Monitoring Frequency	Sample ID	Analytical Testing	
		Easting	Northing					Chemistry[2]	Archive
Phase 2 Full Dredge Areas									
1A and 1B	WW-P2CM-01	1238224.4	639813.1	Surface Sediment (0–12 cm)	Van Veen grab	Years 1, 10, 20	WW-P2CM-01-SS	Mercury, D/F, TS, TOC	Contingent Bioassays[2]
1C	WW-P2CM-02	1239065.2	640616.6				WW-P2CM-02-SS		
2C	WW-P2CM-06	1239620.5	642808.4				WW-P2CM-06-SS		
5B	WW-P2CM-03	1239499.7	641765.2				WW-P2CM-03-SS		
8	WW-P2CM-04	1240130.9	641650.8				WW-P2CM-04-SS		
	WW-P2CM-05	1239833.7	642380.3				WW-P2CM-05-SS		
Phase 2 Capping Areas									
2C	WW-P2CM-07	1240361.6	641798.4	Surface Sediment (0–12 cm)	Van Veen grab	Years 1, 5, 10, 20	WW-P2CM-07-SS	Mercury, D/F, TS, TOC	Contingent Bioassays[2]
	WW-P2CM-08	1240628.5	642271.7				WW-P2CM-08-SS		
	WW-P2CM-09	1240753.3	642150.1				WW-P2CM-09-SS		
3A	WW-P2CM-10	1241831.0	643361.6				WW-P2CM-10-SS		
6	WW-P2CM-11	1239914.1	640510.0				WW-P2CM-11-SS		
CDF Groundwater Monitoring									
8	WW-P2GW-01	1239864.1	643056.9	Groundwater	Peristaltic pump	Periodic[3]	WW-P2GW-01-GW	Field parameters, total and dissolved mercury, and TOC	--
	WW-P2GW-02	1240061.2	642599.8				WW-P2GW-02-GW		

Notes:

1. NAD83 State Plane Washington North Federal Information Processing System 4601 feet

2. Confirmational bioassays will be conducted if chemical concentrations exceed the Sediment Management Standards benthic sediment cleanup objective value but are below the site-specific mercury bioaccumulation screening level (archive pending chemistry results).

3. Groundwater monitoring will be performed quarterly for 2 years, semiannually for Years 3 to 5, annually for Years 6 to 10 ,and every 5 years for Years 15 to 30.

CDF: Confined Disposal Facility

cm: centimeter

D/F: dioxin/furan

NAD83: North American Datum of 1983

TOC: total organic carbon

TS: total solids

Table H-4
Overview of Ongoing Phase 1 and MNR Confirmation Monitoring Activities

Monitoring Type	Monitoring Objective	Frequency	Parameters	Schedule		
				Year 10 (2026)	Year 20 (2036)	Year 30 (2046)
Ongoing Phase 1 Cap Monitoring						
Bathymetric Surveys	Confirmation surveys to document Phase 1 cap integrity	Year 10	Bathymetry	X	--	--
Visual Surveys	Visual surveys to verify integrity of intertidal caps and above-water components of containment walls	Year 10	Visual inspections for cap erosion, wall integrity, groundwater seepage	X	--	--
Log Pond Porewater	Assess potential recontamination risks associated with groundwater	Year 10	Total and dissolved Hg	X	--	--
Remaining Monitoring for Phase 1 and MNR Areas						
Surface Sediment	Surface sediment quality	Years 10, 20, and 30	Heavy metals, Hg, SVOC, D/F, TS, TOC, contingent bioassays[1]	X	X	X
Subsurface Sediment	Subsurface sediment quality	Years 10, 20, and 30	Hg, TS	X	X	X

Notes:

1. Contingent bioassays will be performed if metals, PAH, or phenolic compounds exceed their respective benthic sediment cleanup objective values. Bioassay tests will include three standard PSEP tests: 10-day acute amphipod, 20-day juvenile polychaete growth, and larval development.

D/F: dioxin/furan

heavy metals: priority pollutant heavy metals

Hg: mercury

MNR: monitored natural recovery

PAH: polycyclic aromatic hydrocarbon

PSEP: Puget Sound Estuary Program

SVOC: semivolatile organic compound

TOC: total organic carbon

TS: total solids

Table H-5

Phase 1 and MNR Confirmation Monitoring Locations and Test Parameters

Site Unit	Station ID	Coordinates[1]		Sample Media	Sample Method	Sampling Interval	Sample ID	Analytical Testing	Archive
		Easting	Northing					Chemistry	
Phase 1 Construction Areas									
1C	WW-P1CM-01	1239693.5	641212.3	Surface Sediment	Van Veen	0 to 12 cm	WW-P1CM-01-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
	WW-P1CM-02	1239872.1	641378.8	Surface Sediment	Van Veen	0 to 12 cm	WW-P1CM-02-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
2A	WW-P1CM-06	1241514.6	642837.3	Surface Sediment	Van Veen	0 to 12 cm	WW-P1CM-06-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
	WW-P1CM-07	1241343.7	642989.4	Surface Sediment	Van Veen	0 to 12 cm	WW-P1CM-07-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
	WW-P1CM-08	1241146.6	642800.0	Surface Sediment	Van Veen	0 to 12 cm	WW-P1CM-08-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
3B	WW-P1CM-09	1241712.8	643039.0	Surface Sediment	Van Veen	0 to 12 cm	WW-P1CM-09-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
	WW-P1CM-10	1241562.6	643186.2	Surface Sediment	Van Veen	0 to 12 cm	WW-P1CM-10-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
4	WW-P1CM-03	1240532.8	641249.1	Surface Sediment	Van Veen	0 to 12 cm	WW-P1CM-03-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
	WW-P1CM-04	1240693.4	641391.5	Surface Sediment	Van Veen	0 to 12 cm	WW-P1CM-04-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
	WW-P1CM-05	1240815.9	641874.5	Surface Sediment	Van Veen	0 to 12 cm	WW-P1CM-05-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
	WW-P1CM-03	1240532.8	641249.1	Porewater	NMDS samplers	6–12 cm below mudline	WW-P1CM-03-PW	Hg (total and dissolved) [2]	--
	WW-P1CM-04	1240693.4	641391.5	Porewater	NMDS samplers	6–12 cm below mudline	WW-P1CM-04-PW	Hg (total and dissolved) [2]	--
5C	WW-P1CM-11	1240846.6	642752.9	Surface Sediment	Van Veen	0 to 2 cm	WW-P1CM-11-SS-0-2	Heavy metals, Hg, SVOC, D/F, TS, TOC	--
				Surface Sediment	Van Veen	0 to 12 cm	WW-P1CM-11-SS-0-12	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
Monitored Natural Recovery Areas									
5A	WW-MNR-06	1239218.4	642296.7	Surface Sediment	Van Veen	0 to 12 cm	WW-MNR-06-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
	WW-MNR-07	1238791.5	641463.6	Surface Sediment	Van Veen	0 to 12 cm	WW-MNR-07-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
	WW-MNR-07	1238791.5	641463.6	Subsurface Sediment	Vibracore	0–0.5 foot	WW-MNR-07-SC-0-0.5	Hg, TS	--
						0.5–1 foot	WW-MNR-07-SC-0.5-1	Hg, TS	--
						1–1.5 feet	WW-MNR-07-SC-1-1.5	Hg, TS	--
						1.5–2 feet	WW-MNR-07-SC-1.5-2	Hg, TS	--
						2–2.5 feet	WW-MNR-07-SC-2-2.5	Hg, TS	--
						2.5–3 feet	WW-MNR-07-SC-2.5-3	Hg, TS	--
7	WW-MNR-05	1237855.1	638100.7	Surface Sediment	Van Veen	0 to 12 cm	WW-MNR-05-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]

Table H-5
Phase 1 and MNR Confirmation Monitoring Locations and Test Parameters

Site Unit	Station ID	Coordinates[1]		Sample Media	Sample Method	Sampling Interval	Sample ID	Analytical Testing	Archive
		Easting	Northing					Chemistry	
9	WW-MNR-01	1236589.3	641690.4	Surface Sediment	Van Veen	0 to 12 cm	WW-MNR-01-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
	WW-MNR-02	1236335.6	636672.7	Surface Sediment	Van Veen	0 to 12 cm	WW-MNR-02-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
	WW-MNR-03	1237324.4	643041.7	Surface Sediment	Van Veen	0 to 12 cm	WW-MNR-03-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
	WW-MNR-04	1237147.5	639909.2	Surface Sediment	Van Veen	0 to 12 cm	WW-MNR-04-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
	WW-MNR-08	1239014.4	639146.3	Surface Sediment	Van Veen	0 to 12 cm	WW-MNR-08-SS	Heavy metals, Hg, SVOC, D/F, TS, TOC	Contingent Bioassays [3]
	WW-MNR-02	1236335.6	636672.7	Subsurface Sediment	Vibracore	0–0.5 foot	WW-MNR-02-SC-0-0.5	Hg, TS	--
						0.5–1 foot	WW-MNR-02-SC-0.5-1	Hg, TS	--
						1–1.5 feet	WW-MNR-02-SC-1-1.5	Hg, TS	--
						1.5–2 feet	WW-MNR-02-SC-1.5-2	Hg, TS	--
						2–2.5 feet	WW-MNR-02-SC-2-2.5	Hg, TS	--
						2.5–3 feet	WW-MNR-02-SC-2.5-3	Hg, TS	--
	WW-MNR-03	1237324.4	643041.7	Subsurface Sediment	Vibracore	0–0.5 foot	WW-MNR-03-SC-0-0.5	Hg, TS	--
						0.5–1 foot	WW-MNR-03-SC-0.5-1	Hg, TS	--
						1–1.5 feet	WW-MNR-03-SC-1-1.5	Hg, TS	--
						1.5–2 feet	WW-MNR-03-SC-1.5-2	Hg, TS	--
						2–2.5 feet	WW-MNR-03-SC-2-2.5	Hg, TS	--
						2.5–3 feet	WW-MNR-03-SC-2.5-3	Hg, TS	--
	WW-MNR-04	1237147.5	639909.2	Subsurface Sediment	Vibracore	0–0.5 foot	WW-MNR-04-SC-0-0.5	Hg, TS	--
						0.5–1 foot	WW-MNR-04-SC-0.5-1	Hg, TS	--
						1–1.5 feet	WW-MNR-04-SC-1-1.5	Hg, TS	--
						1.5–2 feet	WW-MNR-04-SC-1.5-2	Hg, TS	--
						2–2.5 feet	WW-MNR-04-SC-2-2.5	Hg, TS	--
						2.5–3 feet	WW-MNR-04-SC-2.5-3	Hg, TS	--
	WW-MNR-08	1239014.4	639146.3	Subsurface Sediment	Vibracore	0–0.5 foot	WW-MNR-08-SC-0-0.5	Hg, TS	--
						0.5–1 foot	WW-MNR-08-SC-0.5-1	Hg, TS	--
						1–1.5 feet	WW-MNR-08-SC-1-1.5	Hg, TS	--
						1.5–2 feet	WW-MNR-08-SC-1.5-2	Hg, TS	--
						2–2.5 feet	WW-MNR-08-SC-2-2.5	Hg, TS	--
						2.5–3 feet	WW-MNR-08-SC-2.5-3	Hg, TS	--

Notes:

1. NAD83/98 (Washington State Plane NAD83 Lambert Conformal North Zone Grid, per the 1998 Adjustment)

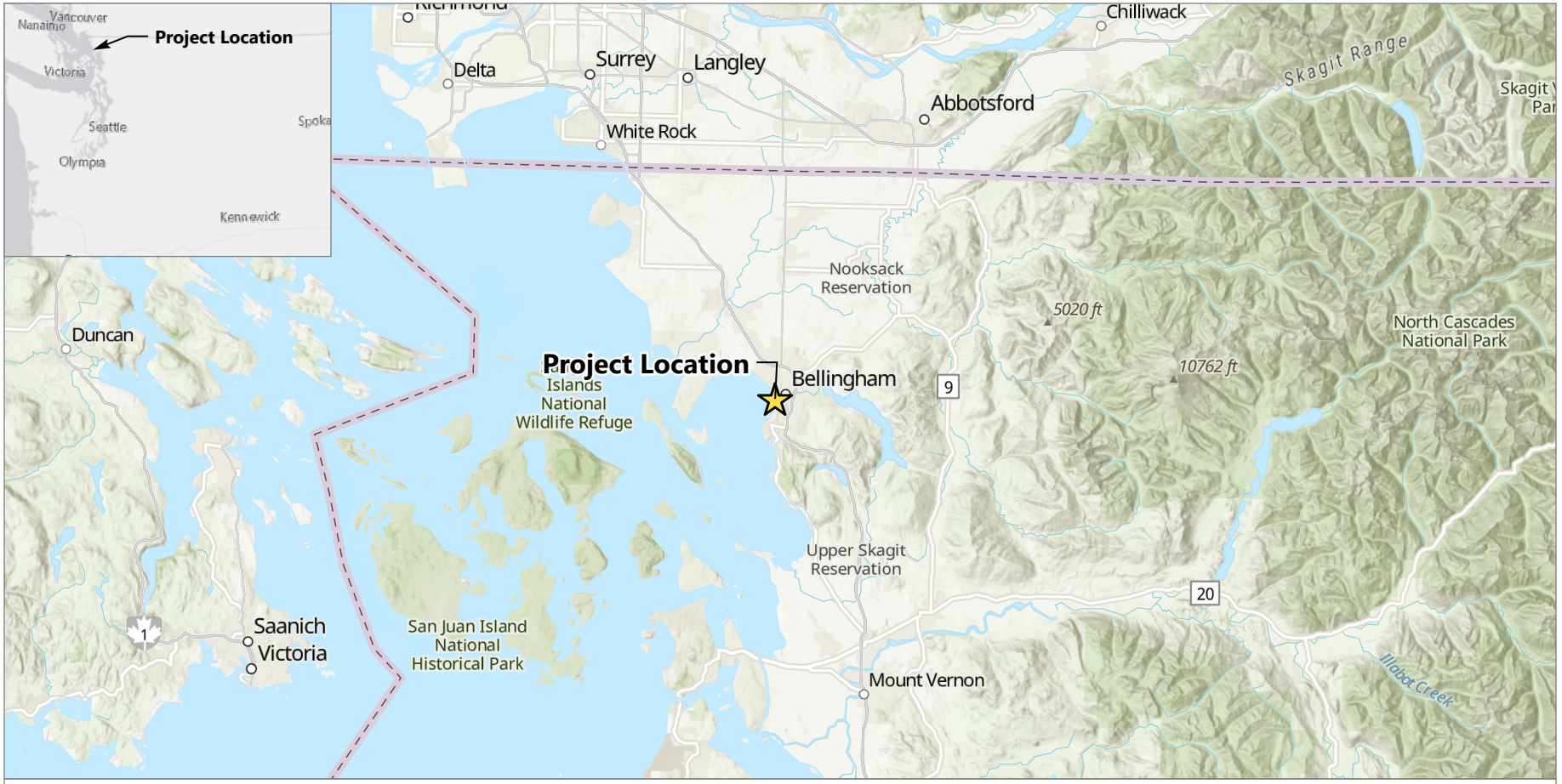
2. Total and dissolved Hg will be analyzed using low-level Hg methods (modified 7470). Results will be compared to the site-specific screening level (0.059 µg/L) determined to be protective of sediment quality at the benthic sediment cleanup objectives (0.41 mg/kg) in the Log Pond area. This screening level is less than the water quality reference values protective of marine aquatic organisms under acute and chronic toxicity thresholds.

3. Contingent bioassays to be performed if the benthic sediment cleanup objective values are exceeded; tests to include three standard PSEP tests: 10-day acute amphipod, 20-day juvenile polychaete growth, and larval development.

µg/L: microgram per liter
cm: centimeter
D/F: dioxin/furan
heavy metals: priority pollutant heavy metals
Hg: mercury
mg/kg: milligram per kilogram
NAD83: North American Datum of 1983
PAH: polycyclic aromatic hydrocarbon
PSEP: Puget Sound Estuary Program
SVOC: semivolatile organic compound
TOC: total organic carbon
TS: total solids
Zn: zinc

Figures

DRAFT



LEGEND:

☆ Project Location

Notes:
1. Imagery source: ESRI, HERE, et. al.

0 15
Miles

Publish Date: 2025/06/11, 2:05 PM | User: emueller
Filepath: \\GSTFile01\GIS\Jobs\PortofBellingham_0007\Whatcom_Waterway_Ph2\Maps\Reports\EDR\EDR_figures.aprx | AQ_EDR_FigH-1_VicinityMap

ANCHOR QEA

Figure H-1
Vicinity Map

Appendix H: Compliance Monitoring and Contingency Response Plan
Whatcom Waterway Phase 2 Cleanup: Engineering Design Report



LEGEND:

- MNR Surface Sediment Station
- MNR Surface Sediment and Subsurface Sediment Station
- Phase 1 Surface Sediment Station
- Phase 1 Surface Sediment and Porewater Station
- Remedial Action Unit Boundaries
- Sediment Site Unit
- Previously Capped Area (Log Pond Interim Remedial Action)
- Phase 1 MNR Area

NOTES:

1. Site units are shown based on those in Figure 2-3 Cleanup Action Plan, Whatcom Waterway Site, September 2007. Unit 9 boundary updated based on Pre-remedial Design Investigation findings.
2. Horizontal datum: Washington State Plane North, North American Datum 1983 (NAD83) Feet.
3. Vertical datum: Mean Lower Low Water (MLLW).
4. Imagery source: USDA NAIP Image Service.

0 2,000

Feet

Publish Date: 2025/06/11, 2:06 PM | User: emueller
Filepath: \\GSTFile01\GIS\Jobs\PortofBellingham_0007\Whatcom_Waterway_Ph2\Maps\Reports\EDR\EDR_figures.aprx | AQ_EDR_FigH-2_Phase1and_MNRcomplianceMonitoringLocs

ANCHOR QEA

Figure H-2
Phase 1 and MNR Compliance Monitoring Locations

Appendix H: Compliance Monitoring and Contingency Response Plan
Whatcom Waterway Phase 2 Cleanup: Engineering Design Report

DRAFT



LEGEND:

- Site Unit
- Federal Navigation Channel
- BST/Log Pond Corner Additional Dredging Footprint
- Confined Disposal Facility (CDF)
- Cap Placement (Including Partial Dredge and Cap)
- Full Dredge to the Extent Practicable
- Approximate Location and Extent of CDF Retaining Structure

Notes:
1. Imagery source: USDA NAIP Image Service
2. Horizontal Datum: NAD83
3. Vertical Datum: MLLW

0 400
Feet

Publish Date: 2025/06/11, 2:06 PM | User: emueller
Filepath: \\GSTFile01\GIS\Jobs\PortofBellingham_0007\Whatcom_Waterway_Ph2\Maps\Reports\EDR\EDR_figures.aprx | AQ_EDR_FigH-3_ProjectArea

ANCHOR QEA

Figure H-3
Construction Elements for Phase 2 Site Areas
Appendix H: Compliance Monitoring and Contingency Response Plan
Whatcom Waterway Phase 2 Cleanup: Engineering Design Report

DRAFT



LEGEND:

- Site Unit
- Federal Navigation Channel
- Performance Monitoring Surface Sediment Sampling Location
- BST/Log Pond Corner Additional Dredging Footprint
- Confined Disposal Facility (CDF)
- Cap Placement (Including Partial Dredge and Cap)
- Full Dredge to the Extent Practicable
- Approximate Location and Extent of CDF Retaining Structure

Notes:
1. Imagery source: USDA NAIP Image Service
2. Horizontal Datum: NAD83
3. Vertical Datum: MLLW

0 400
Feet

Publish Date: 2025/06/11, 2:06 PM | User: emueller
Filepath: \\GSTFile01\GIS\Jobs\PortofBellingham_0007\Whatcom_Waterway_Ph2\Maps\Reports\EDR\EDR_figures.aprx | AQ_EDR_FigH-4_PerformanceMonitoring

ANCHOR QEA

Figure H-4
Phase 2 Post-Dredge Performance Monitoring Locations
Appendix H: Compliance Monitoring and Contingency Response Plan
Whatcom Waterway Phase 2 Cleanup: Engineering Design Report

DRAFT



LEGEND:

- Site Unit
- Federal Navigation Channel
- Surface Sediment Sampling Location
- Groundwater Sampling Location
- BST/Log Pond Corner Additional Dredging Footprint
- Confined Disposal Facility (CDF)
- Cap Placement (Including Partial Dredge and Cap)
- Full Dredge to the Extent Practicable
- Approximate Location and Extent of CDF Retaining Structure

NOTES:

1. Imagery source: USDA NAIP Image Service
2. Horizontal Datum: NAD83
3. Vertical Datum: MLLW
4. The Compliance monitoring location shown here are in addition to the ongoing Phase 1 and MNR area compliance monitoring specified in Figure H-5
5. The testing location within Unit 3A will replace the MNR monitoring locations previously located within in this area.

0 400
Feet

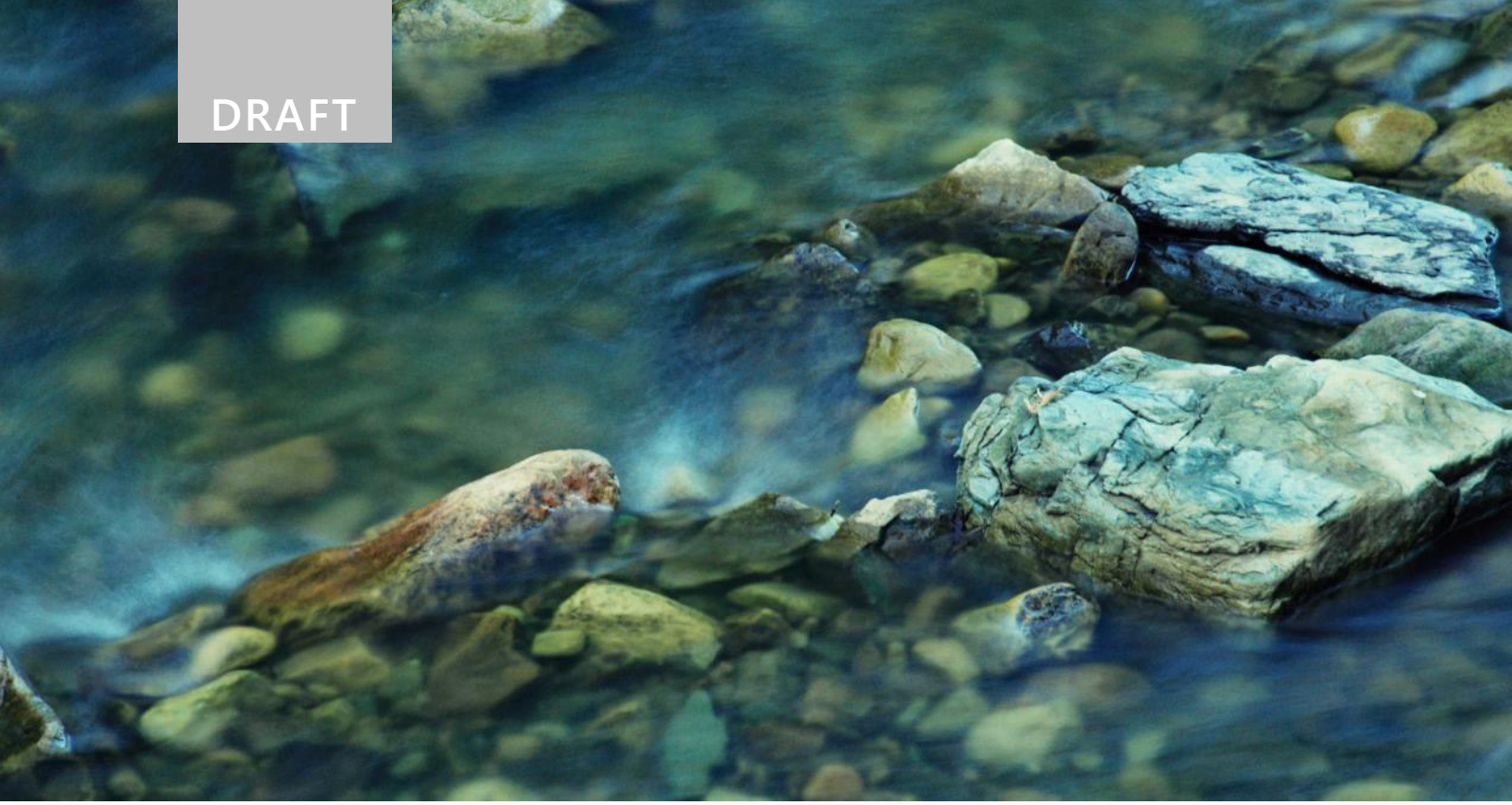
Publish Date: 2025/06/11, 2:06 PM | User: emueller
Filepath: \\GSTFile01\GIS\Jobs\PortofBellingham_0007\Whatcom_Waterway_Ph2\Maps\Reports\EDR\EDR_figures.aprx | AQ_EDR_FigH-5_SedimentGWMonitoringLocs

ANCHOR QEA

Figure H-5
Phase 2 Surface Sediment and Groundwater Compliance Monitoring Locations
Appendix H: Compliance Monitoring and Contingency Response Plan
Whatcom Waterway Phase 2 Cleanup: Engineering Design Report

Appendix I
Fate and Transport Analysis for CDF

DRAFT



June 2025
Whatcom Waterway Cleanup in Phase 2 Site Areas

ANCHOR QEA

Appendix I
Contaminant Mobility Modeling for the CDF

Prepared for Port of Bellingham

June 2025
Whatcom Waterway Cleanup in Phase 2 Site Areas

Appendix I
Contaminant Mobility Modeling for CDF

Prepared for
Port of Bellingham
1801 Roeder Avenue
Bellingham, Washington 98227

Prepared by
Anchor QEA
20 Bellwether Way, Suite 101
Bellingham, Washington 98225

Project Number: 190007-01.01

TABLE OF CONTENTS

1 Introduction 5
1.1 Purpose 5
1.2 Report Organization 5

2 Overview of Mercury Fate and Transport Processes 6

3 Historical Data 8
3.1 Sediment Data 8
3.1.1 Mercury 8
3.1.2 Organic Carbon 9
3.1.3 Sulfide 9
3.1.4 Methylmercury 11
3.2 Porewater Data 11
3.3 Leach Testing 13

4 Mercury Fate and Transport Evaluation 16
4.1 Geochemical Conceptual Site Model 16
4.2 Geochemical Modeling 17
4.2.1 Model Setup 17
4.2.2 Results and Discussion 19
4.3 Mercury Solubility in CDF Sediments 21
4.3.1 Factors Governing Dissolved Sulfide Concentrations 21
4.3.2 Potential for Mercury Sulfide Destabilization 22

5 Conclusions 24

6 References 25

TABLES

Table I-1 Estimated Sediment Placement Volumes and Average Mercury Concentrations for CDF 8
Table I-2 TOC Concentrations in Sediment 9
Table I-3 Sulfide Concentrations in Sediment 10
Table I-4 Methylmercury Concentrations in Sediment 11
Table I-5 Porewater Mercury Concentrations 12
Table I-6 Co-Located Clam Tissue, Porewater, and Sediment Mercury Concentrations 12
Table I-7 TCLT Results 13
Table I-8 Key Reactions Included in the Geochemical Model 17
Table I-9 Porewater Values Used in the Geochemical Model[1] 17
Table I-10 Geochemical Model Scenarios 18

FIGURES

Figure I-1 Overview of Mercury Cycling in the Aquatic Environment 7
Figure I-2 TCLT Results 15
Figure I-3 Sediment Porewater Mercury Concentrations as Controlled by Metacinnabar Solubility, Dissolved Sulfide Concentration, pH, and Dissolved Organic Carbon Concentration 20
Figure I-4 Groundwater Elevation Contours Along the Eastern Border of the Aerated Stabilization Basin Measured During High Tide, November 29, 2023 23

ABBREVIATIONS

µg/kg	microgram per kilogram
µg/L	microgram per liter
ASB	Aerated Stabilization Basin
CAP	Cleanup Action Plan
CDF	Confined Disposal Facility
cm/s	centimeter per second
CSM	conceptual site model
CY	cubic yard
DOC	dissolved organic carbon
DOM	dissolved organic matter
DRET	Dredge Elutriate Test
Ecology	Washington State Department of Ecology
EDR	*Engineering Design Report*
Eh	redox potential
EPA	U.S. Environmental Protection Agency
FeS	iron sulfide
Hg	mercury
HgS	mercury sulfide
L	liter
m	meter
MeHg	methylmercury
MET	Modified Elutriate Test
mg/kg	milligram per kilogram
mg/L	milligram per liter
mol/kg	solvent moles per kilogram
mS	milliSiemen
mV	millivolt
NMDS	nylon mesh diffusion samplers
Pe	electron activity
pH	potential of hydrogen (measure of acidity or basicity)
ppt	parts per thousand
PRDI	Pre-Remedial Design Investigation
RI/FS	Remedial Investigation and Feasibility Study
Site	Whatcom Waterway Site
S.U.	Standard Unit
SOM	sediment organic matter

TCLT	thin-layer column leach test
TOC	total organic carbon
ww	wet weight

1 Introduction

This document, which is an appendix to the *Engineering Design Report* (EDR) for the Whatcom Waterway Site (Site) in Bellingham, Washington. The EDR was prepared in accordance with Consent Decree No. 07-2-02257-7 (Ecology 2007) as amended by the Washington State Department of Ecology with the First Amendment to the Consent Decree (Ecology 2011) and the Second Amendment to the Consent Decree (Ecology 2024).

1.1 Purpose

During cleanup of the Whatcom Waterway Phase 2 Site Areas, mercury-contaminated sediments will be dredged and placed in a Confined Disposal Facility (CDF) located within the Former Aerated Stabilization Basin (ASB). The CDF has been designed to permanently contain the contaminated sediments and associated mercury.

Previous investigations conducted during the Remedial Investigation and Feasibility Study (RI/FS; Anchor Environmental 2000) and Pre-Remedial Design Investigation (PRDI; Anchor Environmental 2010) have documented that the Site-associated mercury is strongly bound to solid phases in the sediment, making it relatively immobile.

The purpose of this appendix is to summarize existing fate and transport data regarding mercury in Site sediments and evaluate the expected behavior of mercury in sediments once they are placed in the CDF. This evaluation includes recommendations to optimize the immobilization of mercury within the CDF.

1.2 Report Organization

The information contained in this report has been organized in the following manner:

- **Section 2 – Overview of Mercury Fate and Transport Processes.** Section 2 provides an overview of mercury fate and transport processes focused on those most relevant in the CDF environment.
- **Section 3 – Historical Data.** Section 3 provides background regarding the data collection and analyses relevant to the present evaluation.
- **Section 4 – Mercury Fate and Transport Evaluation.** Section 4 presents a geochemical conceptual site model (CSM) for mercury fate and transport at the Site supported by geochemical modeling to predict aqueous mercury concentrations within the CDF.
- **Section 5 – Conclusions.** Section 5 summarizes the conclusions of the mercury fate and transport evaluation.

2 Overview of Mercury Fate and Transport Processes

In the aquatic environment, mercury may be present in solid or aqueous phases. A brief description of each is presented in the following paragraphs. A schematic of mercury cycling in aquatic environments is presented as Figure I-1.

Aqueous phase mercury may exist as Hg(II) (mercuric, oxidation state +2) or Hg(0) (elemental, metallic, zero oxidation state). Hg(0) comprises a small fraction of total aqueous Hg; the majority is Hg(II). Hg(II) is relatively insoluble. Dissolved Hg(II) is reactive and is bound predominantly to dissolved organic matter (DOM) or ligands such as sulfide. Hg(0) is volatile and may diffuse out of the water column or be oxidized to Hg(II).

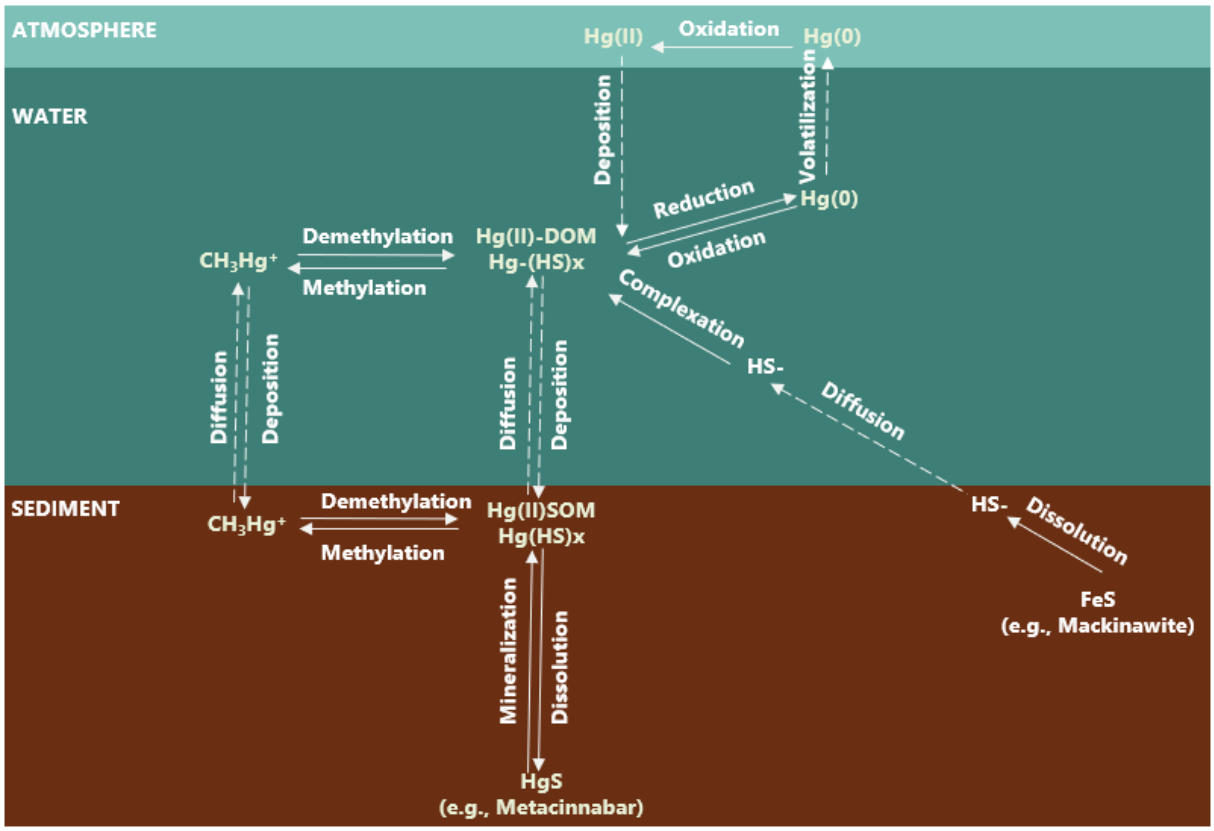
In anoxic (low oxygen) environments, a portion of mercury in natural waters may be transformed by naturally occurring microbes to methylmercury (MeHg), which can bioaccumulate in the food chain. MeHg concentrations depend on rates of Hg(II) methylation and MeHg demethylation, which depend on a variety of environmental factors, including the specific types of organic carbon functional group present (Si 2022; Seelen 2023). Previous investigations conducted at Whatcom Waterway determined that methylmercury makes up a very small portion of the total mercury and is not a risk driver (see discussion of historical data in Section 3.1).

Aqueous Hg(II) reacts with dissolved sulfides and dissolved organic carbon to form mercury sulfide and mercury-DOM complexes, respectively. Mercury sulfide complexes are typically more stable and therefore tend to be the dominant form of dissolved Hg(II) even at very low dissolved sulfide concentrations (Skyllberg et al. 2021).

Solid-phase mercury can also exist as Hg(II) or Hg(0). Hg(0) (elemental mercury) is relatively rare in aquatic environments, except where releases of elemental mercury have occurred, and tends to be transformed to other Hg(II) species. Hg(II) can be sorbed to sediment organic matter (SOM) or surfaces of minerals present in sediment. Hg(II) has a strong affinity for binding to sulfur, such as thiol groups (-SH) in SOM, or sulfur binding sites on sulfide mineral surfaces. Mercury sulfide phases (HgS) such as cinnabar and metacinnabar are very insoluble and can also form under reducing sediment conditions, e.g., where iron sulfide minerals such as mackinawite (FeS) or pyrite (FeS_2) are present. HgS phases are resistant to oxidation and dissolution and can persist under a wide range of conditions.

Key processes governing the fate and transport of mercury at the Site are described in the geochemical CSM presented in Section 4.

Figure I-1
Overview of Mercury Cycling in the Aquatic Environment



Notes:
Dotted arrows represent physical processes; solid arrows represent chemical transformations.
DOM: dissolved organic matter; SOM: sediment organic matter

3 Historical Data

The CDF will contain sediments from the ASB, sediments from other areas of the Site, and sediments from other Port dredging projects, including the Harris Avenue Shipyard cleanup and planned maintenance dredging projects within the Squalicum Marina.

Mercury concentrations in the sediments to be placed in the CDF have been characterized during numerous historical efforts including the RI/FS, pre-design investigations, and compliance monitoring programs. Historical data and analyses relevant to the evaluation of mercury fate and transport in the CDF are summarized in the following subsections.

3.1 Sediment Data

Results of numerous sediment investigations at the Site were compiled to inform this evaluation and provide input constraints for fate and transport modeling. These data are presented in the following subsections.

3.1.1 Mercury

The estimated volume and average mercury concentrations for sediments in the CDF are summarized in Table I-1.

Table I-1
Estimated Sediment Placement Volumes and Average Mercury Concentrations for CDF

Site Unit	Subarea	Estimated Dredge Volume (CY)	Percentage of Total CDF Volume	Estimated Total Mercury (mg/kg)
1A/1B	Open Water	131,500	17.2%	2
1C	Open Water	96,300	12.6%	4
1C	Under Pier	14,000	1.8%	10
2B	Contaminated Portion	31,700	4.2%	4
2C	Open Water	66,400	8.7%	10
2C	GP Dock Area	15,500	2.0%	5
3A	Head of Waterway	7,500	1.0%	4
4	Long Pond Corner	30,100	3.9%	80
5B	ASB Shoulder	14,500	1.9%	8
6C	Rail Span	11,300	1.5%	3
8	ASB Soft Sediment	157,700	20.7%	8
8	ASB Transition Sand	37,300	4.9%	1
Other	Harris Avenue Shipyard	29,700	3.9%	0.5
Other	I&J Waterway	20,000	2.6%	0.5

Site Unit	Subarea	Estimated Dredge Volume (CY)	Percentage of Total CDF Volume	Estimated Total Mercury (mg/kg)
Other	Marinas	100,000	13.1%	0.2
	In CDF:	763,500	100	7.3

Note:
These estimated volumes are subject to change during final design and permitting. Unit 8 volumes exclude the soft sediments and transition sands already located within the CDF footprint.

3.1.2 Organic Carbon

Total organic carbon (TOC) has been measured in samples collected throughout Whatcom Waterway in numerous investigations. Representative concentrations are summarized in Table I-2.

Table I-2
TOC Concentrations in Sediment

Site Unit(s)	Subarea(s)	Media	Number of Samples	Minimum	Maximum	Average TOC (Percent)	Reference(s)
1, 2, 3, 4, 5, 6, and 7	Multiple	Surface Sediment	46	0.8	5.0	3.0	Supplemental RI/FS (Anchor Environmental 2004); PRDI Report (Anchor Environmental 2010)
1, 2, 3, 5, 6, and 8	Multiple	Subsurface Sediment	248	0.11	22	1.5	PRDI Report (Anchor Environmental 2010)
8	ASB	Unit A	5	28	44	33	Supplemental RI/FS (Anchor Environmental 2004)
		Unit B	5	2.0	42	27	
		Unit C	4	2.7	2.7	1.6	
		Unit D	5	0.58	0.58	0.41	

Notes:
Unit A: Upper Soft Sediments
Unit B: Lower Soft Sediments
Unit C: Native Post Glacial Fluvial Deposits (Sands)
Unit D: Native Glacial Outwash Deposits (Silt and Clay)

3.1.3 Sulfide

Historical sediment sulfide concentrations are summarized in Table I-3. The average sulfide concentration is 2,000 mg/kg.

Table I-3
Sulfide Concentrations in Sediment

Site Unit	Subarea	Location(s)	Sulfide Concentration (mg/kg)	Depth Interval	Reference
8	ASB	GPA-01S	1100	0 to 6 feet	Supplemental RI/FS (Anchor Environmental 2004)
		GPA-02S	950	0 to 2.1 feet	
		GPA-03S	750	0 to 2.6 feet	
		GPA-04S	9700	0 to 4 feet	
		GPA-05S	5200	0 to 6.5 feet	
1B	Outer Waterway	1B-01-SS	904	0 to 12 cm	PRDI Report (Anchor Environmental 2010)
1C		1C-01-SS	4040 J		
2C	Inner Waterway	2C-01-SS	2560 J		
		2C-02-SS	2550		
		2C-03-SS	2120		
3A		3A-01-SS	4130 J		
		3A-02-SS	786		
		3A-03-SS	2720		
		3A-04-SS	2590		
5B	Offshore Areas	5B-01-SS	1310 J		
		5B-02-SS	758 J		
		5B-03-SS	783		
		5B-04-SS	2220		
		5B-05-SS	631		
		5B-06-SS	512		
		5B-07-SS	323		
5C		5C-01-SS	121		
		5C-02-SS	623 J		
6B	Barge Dock Area	6B-01-SS	2950		
		6B-02-SS	2540		
		6B-03-SS	1960		
		6B-04-SS	2680		
		6B-05-SS	2530 J		
6C		6C-01-SS	1160		
		6C-02-SS	990		

Notes:
J: estimated value

3.1.4 Methylmercury

As part of the 2008 PRDI effort (Anchor Environmental 2010), mercury speciation data were collected in Site surface sediments to assess the site-specific ranges and patterns of mercury speciation/methylation.

Methylmercury concentrations ranged from 0.386 to 5.51 micrograms per kilogram (µg/kg), with an average of 2.74 µg/kg. No elevated solid-phase methylmercury concentrations were detected across the six sampled locations, and methylmercury concentrations were less than 2% of total mercury concentrations. These observed values, presented in Table I-4, are consistent with literature documenting that methylmercury typically makes up less than 2% of total mercury in shallow surface sediments in U.S. bays and harbors (Benoit et al. 2005; Hollweg et al. 2009).

Table I-4
Methylmercury Concentrations in Sediment

Site Unit	Location(s)	Methylmercury Concentration (µg/kg)	Percentage of Total Mercury	Total Mercury Concentration (mg/kg)	Reference
1B	1B-01-SS	2.66	1.3	0.2	PRDI Report (Anchor Environmental 2010)
1C	1C-01-SS	5.51	1.8	0.3	
2C	2C-01-SS	2.26	0.75	0.3	
2C	2C-02-SS	2.95	0.74	0.4	
5C	5C-01-SS	0.386	0.32	0.12	
6B	6B-05-SS	2.69	0.90	0.3	

3.2 Porewater Data

Available porewater mercury data are summarized in Table I-5, and the collocated tissue, porewater, and sediment data are provided in Table I-6.

During the 2008 PRDI, sediment porewater data were collected from Units 2C, 5B, and 6C/6D using mini-piezometers. Mercury concentrations in all six samples were below detection limits (0.1 microgram per liter (µg/L) (Anchor Environmental 2010). In 2016, porewater samples were collected co-located with clam tissue and surface sediment samples.

During cleanup construction activities in the Phase 1 Site Areas, sediment samples were collected from construction areas and reference areas. Total mercury concentrations in porewater ranged from 0.0055 to 0.0085 µg/L. No significant difference was noted between the samples collected from the construction areas and the reference areas. Detected concentrations of dissolved mercury in porewater did not correlate with concentrations of total mercury in sediment (Anchor QEA 2018).

Compliance monitoring was conducted by the Port of Bellingham in Years 1, 3, and 5 following Phase 1 Cleanup to ensure the continued effectiveness of the Phase 1 remediation. During the Year 1 and 3 sampling, porewater samples were collected at two sampling stations with nylon mesh diffusion samplers (NMDS) for total and dissolved mercury. Dissolved mercury in all samples was below the reported detection limit (0.02 µg/L; Anchor QEA 2019).

Table I-5
Porewater Mercury Concentrations

Site Unit	Type of Sampler	No. of Samples	Mercury Concentration (µg/L)	Reference
2C, 5B, 6B/6C	Mini-piezometers	6	<0.1 U	PRDI Report (Anchor Environmental 2010)
1C, 2A, 2B, 5, 9	Peepers	10	0.0020 to 0.0053 (dissolved) 0.0055 to 0.0085 (total)	As-Built Report (Anchor QEA 2018)
4	NMDS	3	<0.02 (dissolved)	Year 1 Compliance Monitoring Report (Anchor QEA 2019)
4	NMDS	2	<0.012 J to 0.019 J (dissolved)	Year 3 Compliance Monitoring Report (Anchor QEA 2020)

Notes:
Total concentrations from NMDSs were qualified due to turbidity.
J: estimated value

Table I-6
Co-Located Clam Tissue, Porewater, and Sediment Mercury Concentrations

ID	Clam Tissue	Porewater		Sediment	Reference
	(mg/kg ww)	Total Hg (µg/L)	Dissolved Hg (µg/L)	Total Hg (mg/kg ww)	
Construction Areas					As-Built Report (Anchor QEA 2018)
PSCM-01	0.02	0.00850 J	0.00560 J	0.18	
PSCM-07	0.02 U	0.00600 J	0.00300 J	--	
MNR Areas					
MNR-03	0.02 U	0.00550 J	0.00200 U	0.26	
MNR-04	0.02 U	0.00560 J	0.00510 J	0.19	
MNR-07	0.02 U	0.00700 J	0.00280 J	0.64	

3.3 Leach Testing

As part of the 2003 Pre-Remedial Design Evaluation (Anchor Environmental 2003), potential water quality impacts from dredging and discharging water from the ASB were evaluated using the Dredge Elutriate Test (DRET) and Modified Elutriate Test (MET) on two samples. No metals were detected above acute or chronic toxicity criteria, indicating that short-term water quality impacts during dredging or disposal are unlikely. Dissolved mercury concentrations were below 0.01 and 0.05 µg/L for the DRET and MET, respectively.

In 2010, additional DRET and MET evaluations were performed to supplement the data collected in the 2003 Pre-Remedial Design Evaluation. Mercury for all DRET and MET samples were below the detection limit (0.1 µg/L), reaffirming previous conclusions.

To support future remedial design evaluations for long-term water quality protection in the planned CDF, a thin-layer column leach test (TCLT) was conducted in 2003 (Anchor Environmental 2003). Six bulk sediment samples and a composite sample were analyzed for mercury and other contaminants of potential concern. The TCLT was conducted using deionized, deoxygenated water, and sediments were maintained in low oxygen (see Table I-7) conditions to simulate conditions in the CDF (Anchor Environmental 2002). Total (unfiltered) mercury was detected in the effluent samples from the column test with higher effluent mercury concentrations coinciding with lower salinity, suggesting mobilization of colloidal mercury forms from the sediment. TCLT leachate total mercury concentrations ranged from 0.029 to 1.16 µg/L (see Table I-7). Peak total mercury concentrations marginally exceeded the marine surface water chronic toxicity criterion of 0.94 µg/L (which is a dissolved criteria). Dissolved mercury concentrations were not quantified and were likely less than the criteria.

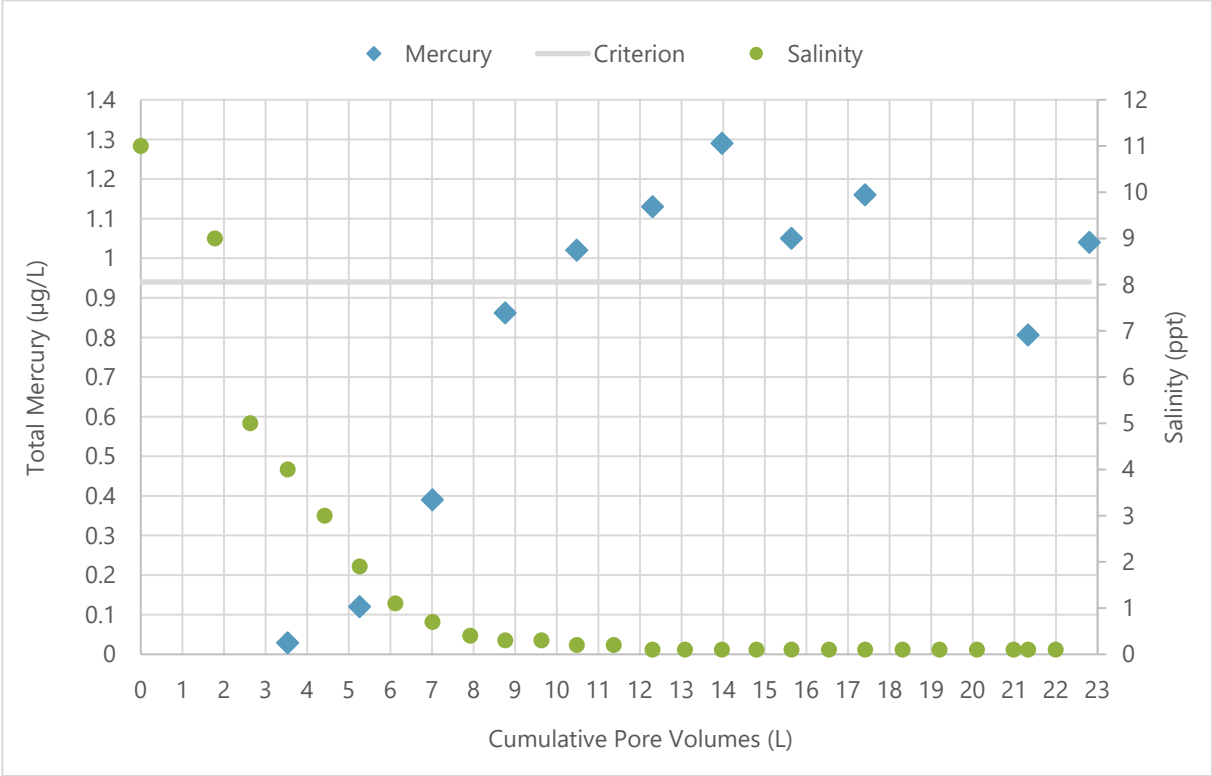
Table I-7
TCLT Results

ID	Cumulative Volume (L)	Pore Volumes	pH	Eh (mV)	Conductivity (mS)	Salinity (ppt)	DO (mg/L)	Ferrous Iron (mg/L)	Total Mercury (µg/L)
C3-01	0	0.81	7.53	-27.3	22	11	2.6	0.1	--
C3-02	1.78	1.62	7.53	37.2	17.9	9	1.6	0.1	--
C3-03	2.63	2.39	7.65	170.5	10.5	5	1.1	0.1	--
C3-04	3.53	3.21	7.69	138.2	8	4	1.3	0.1	0.029
C3-05	4.42	4.02	7.63	173.2	6.1	3	1.5	0.3	--
C3-06	5.26	4.78	7.64	148.2	3.6	1.9	1.9	0.3	0.12
C3-07	6.12	5.56	7.81	142.4	2.2	1.1	0.7	0.1	--
C3-08	7.01	6.37	7.9	153.8	1.3	0.7	2.0	1.1	0.39
C3-09	7.92	7.20	8.15	124.7	0.9	0.4	1.2	2.0	--

ID	Cumulative Volume (L)	Pore Volumes	pH	Eh (mV)	Conductivity (mS)	Salinity (ppt)	DO (mg/L)	Ferrous Iron (mg/L)	Total Mercury (µg/L)
C3-10	8.76	7.96	8.47	124.2	0.64	0.3	1.1	2.1	0.862
C3-11	9.63	8.75	8.4	138.7	0.54	0.3	0.6	2.8	--
C3-12	10.48	9.53	8.72	145.3	0.41	0.2	0.6	3.3	1.02
C3-13	11.37	10.34	8.79	127.6	0.41	0.2	0.8	5	--
C3-14	12.3	11.15	9.13	22.3	0.3	0.1	0.9	6.1	1.13
C3-15	13.08	11.89	9.03	-245.4	0.25	0.1	1.0	6.5	--
C3-16	13.97	12.70	8.83	-49.1	0.22	0.1	1.1	3.3	1.29
C3-17	14.8	13.45	8.61	70	0.24	0.1	1.2	3.2	--
C3-18	15.64	14.22	8.62	-11.6	0.25	0.1	0.5	3.7	1.05
C3-19	16.54	15.04	8.21	-196.6	0.24	0.1	1.0	6.1	--
C3-20	17.41	15.83	8.77	-207.4	0.23	0.1	0.8	5.6	1.16
C3-21	18.31	16.65	8.72	-211.2	0.22	0.1	0.5	6.4	--
C3-22	19.2	17.45	8.27	-120.6	0.21	0.1	1.2	7.0	--
C3-23	20.1	18.27	8.61	8.2	0.21	0.1	1.4	4.0	--
C3-24	20.98	19.07	8.22	68.8	0.19	0.1	1.5	4.2	--
C3-25a	21.33	19.39	8.13	119.6	0.25	0.1	3.6	2.8	0.806
C3-25b	21.99	19.99	8.76	-182.1	0.2	0.1	0.8	6.0	--
C3-26	22.8	20.76	8.28	-4.2	0.22	0.1	1.0	2.9	1.04

Note:
--: not tested

Figure I-2
TCLT Results



4 Mercury Fate and Transport Evaluation

Transport evaluations presented in this section were performed to confirm that mercury will remain immobilized within sediments placed in the CDF through natural processes. A geochemical CSM is presented in Section 4.1. The results of geochemical modeling are discussed in Section 4.2. Potential changes in mercury solubility for worst-case scenarios using site geochemical and hydrologic data are evaluated and discussed in Section 4.3.

4.1 Geochemical Conceptual Site Model

As discussed in Section 2, the mobility of mercury in sediment is governed by the partitioning of mercury between the solid and aqueous phases. In coastal marine sediments, key minerals controlling the solubility of mercury include iron sulfides, such as mackinawite, and mercury sulfides, such as metacinnabar (Gagnon et al. 1997; Drott et al. 2013). The solubility of sulfide minerals is affected by porewater chemistry (e.g., dissolved organic carbon and sulfide concentrations, and pH) and redox potential. Iron and mercury sulfides are stable under reducing conditions (i.e., where dissolved oxygen concentrations are low) (Paquette and Helz 1995; Schippers and Jorgensen 2002).

The CDF is to be constructed adjacent to the former Roeder Avenue Landfill. Geochemical conditions within the landfill are reducing. In the CDF, reducing conditions will be maintained, in part, by the organic carbon content of the sediment, which averages approximately 3% by mass (see Section 3.1.2). Organic carbon decomposition by microorganisms consumes oxygen and forms sulfide minerals (e.g., mackinawite) through activity of sulfate-reducing bacteria (Schippers and Jorgensen 2002). Iron sulfide minerals will also consume oxygen and ensure that reducing conditions are maintained. The ASB sediments have an average total (solid-phase) sulfide concentration of 2,000 mg/kg (see Section 3.1.3). In these sulfidic and organic carbon-containing sediments, mercury is expected to exist predominantly as metacinnabar (Drott et al. 2013). As long as metacinnabar is stable in the CDF, porewater mercury concentrations will remain low.

Therefore, the key geochemical processes controlling mercury solubility in the CDF are dissolution/ precipitation of mercury sulfide minerals and aqueous complexation of mercury with dissolved sulfide and dissolved organic carbon to form dissolved mercury complexes (Table I-8). Under these conditions in the CDF, variables that could impact porewater mercury concentrations are concentrations of dissolved sulfide and dissolved organic carbon, and pH. A geochemical model was developed to assess the impact of these variables on porewater mercury concentrations in the CDF (Section 4.2).

Table I-8
Key Reactions Included in the Geochemical Model

Species	Reaction	Log K[1]
Solubility		
Metacinnabar (HgS)	$HgS(s) + H^+ = Hg^{2+} + HS^-$	-36.9
Mackinawite (FeS)	$FeS(s) + H^+ = Fe^{2+} + HS^-$	-5
Aqueous Complexation		
Mercury sulfide complexes	$2HS^- + Hg^{2+} = Hg(SH)_2$	39.1
	$2HS^- + Hg^{2+} = HgS_2H^- + H^+$	32.5
	$2HS^- + Hg^{2+} = HgS_2^{2-} + 2H^+$	23.2
Mercury-dissolved organic matter (thiols)	$Hg^{2+} + 2RSH = Hg(RS)_2 + 2H^+$	20.0

Notes:
1. Equilibrium constants are from Drott et al. 2013 or Skyllberg 2008.

The geochemical model focuses on mercury in the form of mercury sulfide (i.e., metacinnabar) It does not include other mercury attenuation mechanisms that are expected to occur within the CDF and that will contribute to mercury immobilization, such as sorption by organic carbon and iron sulfides. Thus, the porewater mercury concentrations calculated in the model are conservatively high.

4.2 Geochemical Modeling

A geochemical model was developed to predict mercury concentrations in porewater of sediments that will be placed in the CDF using the U.S. Geological Survey geochemical modeling software PHREEQC (Parkhurst and Appelo 2021). Details of the model setup, simulations, and a discussion of model results are provided in the following sections.

4.2.1 Model Setup

Model inputs included the initial porewater chemistry, which is represented by the major ion composition of seawater based on Nordstrom et al. 1979 and shown in Table I-9. In the model, dissolved mercury concentrations are controlled by the solubility of metacinnabar, which depends on pH, DOM, and sulfide concentrations. Equilibrium constants for key reactions are from the thermodynamic database used by Bessinger et al. (2012) with updated thermodynamic data for mercury sulfide species from Drott et al. (2013).

Table I-9
Porewater Values Used in the Geochemical Model[1]

Variable	Value	Unit
Temperature	25	°C
pH[2]	6.6 to 8.2	S.U.

Variable	Value	Unit
Pe	8	S.U.
Alkalinity, as HCO_3^-	141.682	mg/L
Calcium	412.3	mg/L
Chloride	19353	mg/L
Iron(II)	0.002	mg/L
Potassium	399.1	mg/L
Magnesium	1291.8	mg/L
Sodium	10768	mg/L
Dissolved Organic Carbon[3]	10 to 200	mg/L
Dissolved Sulfide[4]	1×10^{-12}	mg/L
Sulfate	2712	mg/L

Notes:

1. Based on Nordstrum et al. (1979) unless otherwise noted.
2. The range is bounded by the lowest upgradient groundwater pH within the Central Waterfront site and the pH of seawater.
3. Typical range in sediment porewater. Conversion from DOC concentration (mg/L) to equivalent thiol concentration (mol/kg) in model based on Skyllberg 2008). Corresponds to thiol concentration range of 5×10^{-7} to 9.34×10^{-6} mol/kg.
4. Set to a low concentration initially to evaluate the impact on increasing sulfide concentrations on porewater mercury concentrations.

To evaluate the potential range of mercury concentrations in sediment porewater, key variables including pH, DOM concentration (represented as dissolved organic carbon or DOC), and dissolved sulfide concentration were varied. The dissolved mercury concentration in equilibrium with metacinnabar was calculated for each set of porewater conditions modeled.

Porewater pH was set to either 6.6 or 8.2, corresponding to the lowest upgradient groundwater pH and standard seawater, respectively. Likewise, the DOC concentration was set to either 10 mg/L or 200 mg/L, representing a typical DOC concentration and an extreme value. These inputs resulted in a set of four model scenarios, which span the plausible range of pH and DOC in the CDF sediments (Table I-10).

Table I-10
Geochemical Model Scenarios

Scenario	pH	DOC (mg/L)
1	6.6	10
2	6.6	200
3	8.2	10
4	8.2	200

To assess the effect of dissolved sulfide, the model system, including porewater and metacinnabar-containing sediment, was titrated with dissolved sulfide over a concentration range of several orders of magnitude (0.0003 to 30 mg/L). For each scenario, the dissolved concentration of mercury was calculated as a function of dissolved sulfide. In the model, metacinnabar is present in excess such that its complete dissolution did not occur. Due to its low solubility, this only required assigning a very small initial mass of metacinnabar in the models (well within the range of measured mercury concentrations of sediments that will be placed in the CDF).

4.2.2 Results and Discussion

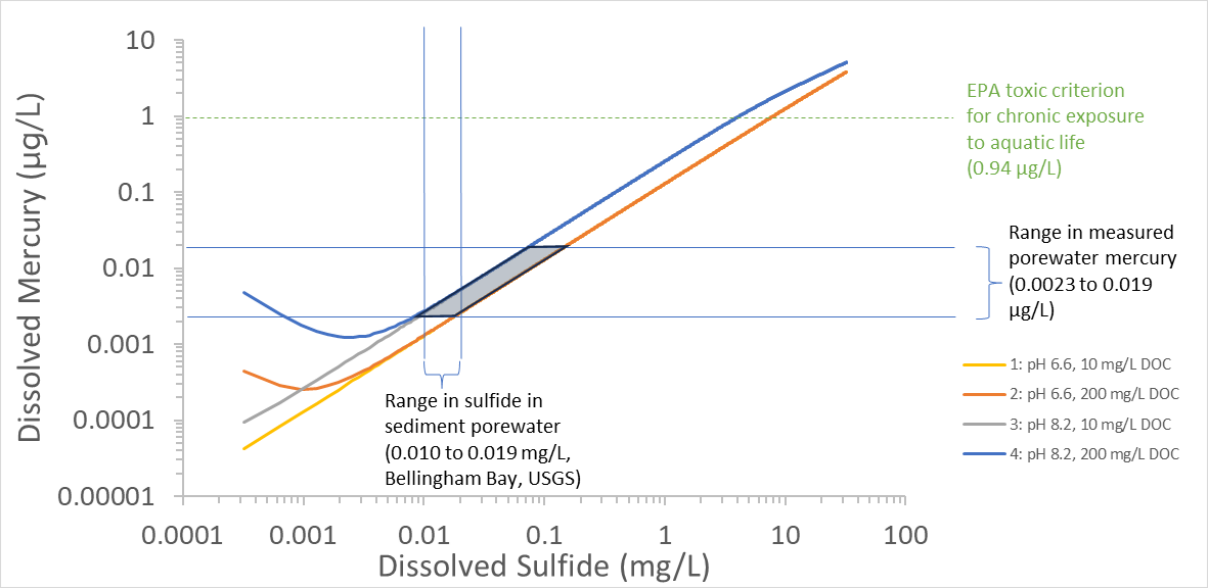
The geochemical modeling results predict the potential range of porewater mercury concentrations that may occur in the CDF over the ranges of pH, DOC, and sulfide concentrations considered (Figure I-3). Limited available data indicate that sulfide concentrations in Bellingham Bay sediment porewaters are relatively low (10 to 19 µg/L; USGS 2010). At these sulfide levels (and the ranges of pH and DOC considered in the models), the predicted range of porewater mercury concentrations match the lower end of measured porewater mercury concentrations (Figure I-3).

Mercury solubility is predicted to increase with increasing dissolved sulfide concentrations due to the formation of dissolved mercury sulfide species (Table I-8). The upper range of measured porewater mercury concentrations can be explained by the model as resulting from somewhat higher sulfide concentrations as shown in the gray box (Figure I-3). The highest measured porewater mercury concentration (0.019 µg/L) requires slightly less than 0.1 mg/L dissolved sulfide to be in equilibrium with metacinnabar. Therefore, the available porewater mercury concentration data for Whatcom Waterway are consistent with mercury being controlled by solubility equilibrium with a mercury sulfide phase at relatively low dissolved sulfide concentrations.

The U.S. Environmental Protection Agency (EPA) water quality criterion for chronic exposure to aquatic life is a mercury concentration of 0.94 µg/L. Recall this is approximately two orders of magnitude higher than the highest measured porewater concentration in Whatcom Water sediments (range in of 0.0023 to 0.019 µg/L; see Section 3.2).

According to the geochemical model, a porewater mercury concentration exceeding 0.94 µg/L would require a dissolved sulfide concentration greater than 3.5 mg/L. This is true for all four scenarios. The potential for dissolved sulfide concentrations to exceed 3.5 mg/L is evaluated in Section 4.3.

Figure I-3
Sediment Porewater Mercury Concentrations as Controlled by Metacinnabar Solubility, Dissolved Sulfide Concentration, pH, and Dissolved Organic Carbon Concentration



When mercury sulfide dissolution controls mercury solubility, increasing dissolved sulfide concentrations results in increased dissolved mercury concentrations (Figure I-3). The mercury sulfide dissolution reaction (Reaction 1) is impacted by Reaction 2, in which dissolved sulfide reacts with Hg^{2+} to form mercury sulfide complexes (e.g., HgS_2H^-).

(1) $HgS(s) + H^+(aq) = Hg^{2+}(aq) + HS^-(aq)$
(2) $HS^-(aq) + Hg^{2+}(aq) = HgS_2H^-(aq) + H^+(aq)$

As dissolved sulfide (HS^-) increases, mercury sulfide solubility increases due to formation of soluble mercury sulfide complexes:

(3) $HgS(s) + HS^-(aq) = HgS_2H^-(aq)$

However, as seen in Scenarios 2 and 4, under conditions of high dissolved organic carbon concentrations (200 mg/L) and low dissolved sulfide concentrations (<2 µg/L), the reaction controlling mercury sulfide solubility is the aqueous complexation of dissolved mercury with DOM thiol groups, $RS^-(aq)$:

(4) $Hg(RS)_2(aq) + H_2S(aq) = HgS(s) + 2RSH(aq)$

In these high DOC, low dissolved sulfide conditions, mercury sulfide solubility increases with decreasing dissolved sulfide (H_2S) (Figure I-3). Comparing Scenario 1 to Scenario 3 and Scenario 2 to

Scenario 4 reveals the impact of pH on porewater mercury concentrations (Table I-10; Figure I-3). Increasing pH from 6.6 to 8.2 slightly increases the dissolved mercury concentration in the system at equilibrium (Figure I-3). As the pH increases, H^+, a product in Reactions 2 and 3, is removed, thereby shifting equilibrium further to where RS^-(aq) is the thiol group on DOM, forming more dissolved mercury complexes.

The results of the geochemical modeling support the conceptual model, specifically that the low dissolved mercury concentrations measured in Whatcom Waterway sediment porewater are controlled by the solubility of a mercury sulfide solid phase (e.g., metacinnabar). Future porewater mercury concentrations in the CDF are expected to remain very low provided that 1) conditions in the CDF continue to favor mercury sulfide stability; and 2) dissolved sulfide concentrations remain similar to their present values. The geochemical conditions impacting mercury sulfide stability and dissolved sulfide concentrations in the CDF system in response to potential future changes to site conditions are examined in the next section.

4.3 Mercury Solubility in CDF Sediments

This section discusses why the favorable geochemical properties of the site sediments are unlikely to be negatively affected in the CDF, either through 1) significant increases in dissolved sulfide concentrations; or 2) the establishment of oxidizing geochemical conditions within the CDF that destabilize mercury sulfide phases in the sediments.

4.3.1 Factors Governing Dissolved Sulfide Concentrations

Dissolved sulfide in sediments is produced by microbial sulfate reduction coupled to organic matter mineralization. Iron sulfide minerals are the dominant sink for sulfide in marine sediments. As described in Section 4.2.2, dissolved sulfide concentrations would need to reach approximately 350 µg/L for porewater mercury concentrations to approach the EPA chronic toxicity criterion of 0.94 µg/L. This scenario is improbable, as dissolved sulfide concentrations are limited by the iron sulfides present. The average total solid-phase concentration of sulfides in sediment is 2,000 mg/kg.

PHREEQC was used to calculate the range of dissolved sulfide concentrations in equilibrium with mackinawite ($FeS_{(s)}$), a common iron sulfide phase in marine sediments. The solubility of mackinawite is written as:

$$FeS_{(s)} + H^+ = Fe^{2+} + HS^-$$

The equilibrium sulfide concentration is determined by dissolved ferrous iron (Fe^{2+}) concentration and pH (Table I-8). Using data for ferrous iron and pH from the Bellingham Bay TCLT leachate test (Table I-7) and assuming that mackinawite is present in the TCLT sediment, dissolved sulfide

concentrations of 2.0 to 9.3 µg/L were calculated. These values are similar to the dissolved sulfide concentrations previously measured in Bellingham Bay sediments (10 to 19 µg/L; USGS 2010).

Dissolved sulfide concentrations are expected to remain relatively low, because they are regulated by iron sulfide equilibria in the CDF sediments.

4.3.2 Potential for Mercury Sulfide Destabilization

The current concentrations of dissolved mercury (≤0.019 µg/L) will remain low under reducing conditions. Reducing conditions in the ASB and sediments placed in the CDF are expected to be maintained due to both 1) the reducing conditions present in adjacent Central Waterfront site groundwater; and 2) the organic matter and sulfide phases (i.e., predominantly iron sulfides such as mackinawite and pyrite) present in the sediments to be confined within the CDF.

The reducing conditions in groundwater at the adjacent Central Waterfront site are controlled by the presence of the former Roeder Avenue Landfill materials. These landfill materials are present in large quantities both above and below the water table and are expected to maintain reducing conditions in the adjacent Central Waterfront site groundwater indefinitely.

Microbial decomposition of organic matter occurs naturally in sediments and depletes dissolved oxygen that may diffuse into the porewater from overlying water. This natural process creates and maintains reducing conditions. The high organic carbon content of the ASB soft sediments and the other contaminated sediments to be placed in the CDF provides a large reservoir of organic matter to maintain these reducing conditions over the long term.

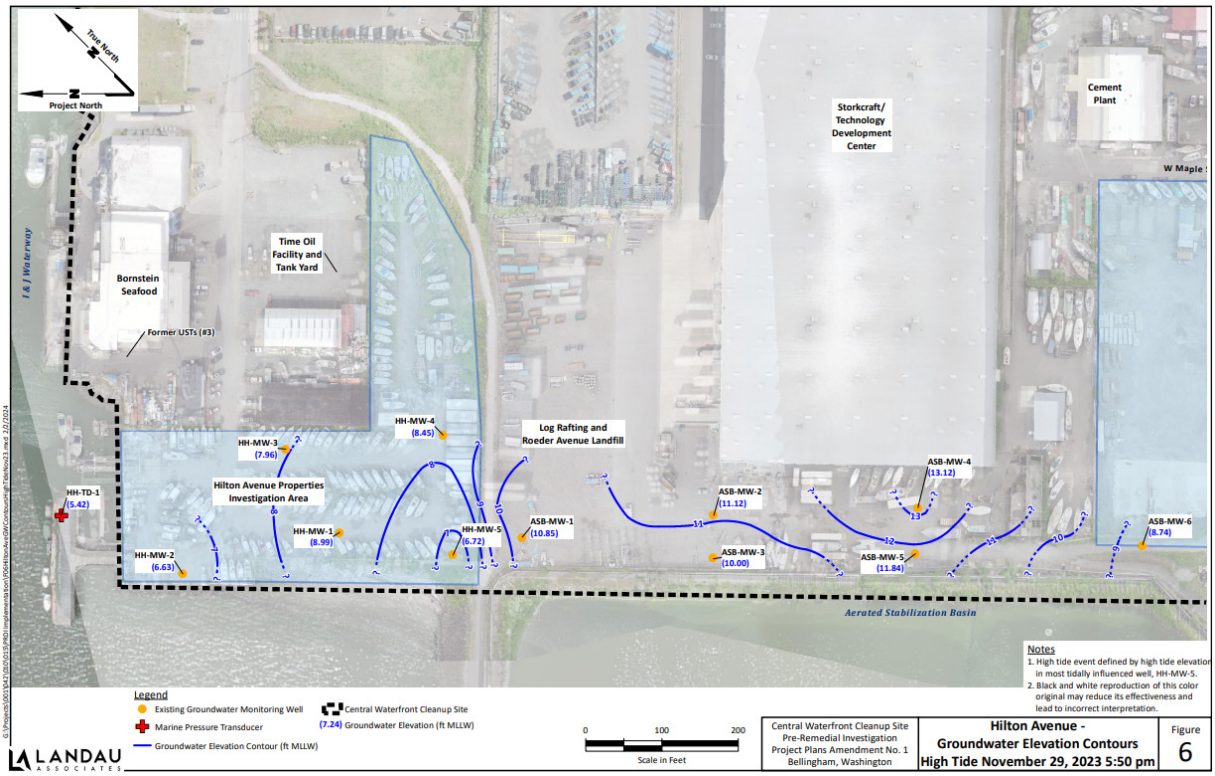
Iron sulfides are also reactive towards dissolved oxygen through oxidation of sulfide to sulfate and ferrous iron(II) to iron(III) oxides.

These two components (microbial and iron-mediated processes) both contribute to the reducing capacity of the sediments to be placed in the CDF. Reducing conditions can be expected to persist as long as the reservoirs of SOM and sulfides exceed the oxidative demand, which is predominantly due to oxygen ingress into the sediments. The timescale required to deplete these reductive reservoirs by the flux of dissolved oxygen to the sediment porewater depends on the concentrations of organic carbon and sulfide reservoirs relative to the flux of dissolved oxygen. Dissolved oxygen is not expected to enter the CDF via groundwater transport given the reducing conditions present in the Central Waterfront site.

The entry of oxygen into the CDF is expected to be primarily through the infiltration of precipitation through the CDF capping soils. Under anticipated marine trades uses, this infiltration is likely to be equal to between 10% and 40% of total precipitation with the balance accounted for by evapotranspiration and stormwater runoff. However, substantial reservoirs of sulfide and organic

carbon in the CDF contents will maintain reducing conditions over the very long term (i.e., tens of thousands of years). This is because the mass of oxygen contained in infiltrating water is very small in relation to the mass of organic carbon and sulfide present in the CDF contents. The geochemical conditions are therefore expected to remain stable and reducing unless chemical oxidizing agents are intentionally introduced into the subsurface. There is no reasonable scenario under which such introduction is expected to occur.

Figure I-4
Groundwater Elevation Contours Along the Eastern Border of the Aerated Stabilization Basin Measured During High Tide, November 29, 2023



5 Conclusions

The mercury fate and transport evaluations conducted in this document supplement the available empirical data on mercury fate and transport collected during previous RI/FS, pre-design, and monitoring studies. Both lines of evidence indicate that dissolved mercury concentrations within the CDF porewater/groundwater are expected to remain similar to the range measured in Site sediments (between 0.0023 and 0.019 ug/L). Mercury concentrations in groundwater and porewater located outside of the CDF fill prism are expected to be even lower.

The low porewater mercury concentrations in the Site sediments are maintained by the presence of organic carbon, natural microbial activity, iron, and sulfide present in the materials. Under the conditions planned for the CDF, the mercury will continue to be present predominantly as insoluble forms. Under the proposed design, these geochemical conditions are expected to remain consistent over the very long term (i.e., thousands of years).

Limiting infiltration of rainwater into the CDF is not required to maintain site geochemical conditions. However, active measures that have the potential to substantially increase soil and groundwater pH (e.g., spills or injection of caustic chemicals into the CDF) or that have the potential to actively oxidize the sediments and groundwater (e.g., injection of oxidizing agents) should be precluded because these types of active interventions could shift the equilibrium concentrations in favor of higher mercury solubilities.

The CDF retaining structure will include clean backfill approximately 40 to 60 feet thick, which will act as a filter layer to prevent potential transport of particulate or colloidal sediments. Monitoring of groundwater quality within this backfill layer can be used to verify groundwater quality remains consistent with expectations during CDF monitoring.

6 References

Anchor Environmental, 2000. *Remedial Investigation / Feasibility Study*. Whatcom Waterway Site Bellingham, WA. Prepared by Anchor Environmental, L.L.C., Seattle, Washington. Prepared for Port of Bellingham. July 2000.

Anchor Environmental, 2002. *Work Plan/Sampling and Analysis Plan*. Pre-Remedial Design Evaluation, Whatcom Waterway Site, Bellingham Washington. Prepared for Port of Bellingham. May 2002.

Anchor Environmental, 2003. *Whatcom Waterway Pre-Remedial Design Evaluation Data Report*. Prepared by Anchor Environmental, L.L.C., Seattle, Washington. Prepared for Port of Bellingham. January 2003.

Anchor Environmental, 2004. *Supplemental Remedial Investigation / Feasibility Study and Environmental Impact Statement Addendum*. Whatcom Waterway Site, Including Georgia Pacific Aerated Stabilization Basin Area Bellingham, Washington. Prepared for Port of Bellingham. March 2004.

Anchor Environmental, 2010. *Pre-Remedial Design Investigation Report*. Whatcom Waterway Site Cleanup. Prepared for Port of Bellingham. August 2010.

Anchor QEA, 2018. *Final As-Built Report, Whatcom Waterways Cleanup in Phase 1 Site Areas*. Prepared for Port of Bellingham. September 2018.

Anchor QEA, 2019. *Year 1 Compliance Monitoring Report, Whatcom Waterway Cleanup in Phase 1 Site Areas*. Prepared for Port of Bellingham. April 2019.

Anchor QEA, 2020. *Year 3* Compliance M*onitoring Report, Whatcom Waterway Cleanup in Phase 1 Site Areas*. Prepared for Port of Bellingham. June 2020.

Benoit, J.M, D.H. Shull, P. Robinson, and L.R. Ucran, 2005. Infaunal burrow densities and sediment monomethyl mercury distributions in Boston Harbor, Massachusetts. Marine Chemistry 102: 124-133. Elsevier Press. September 2005.

Bessinger, B.A., D. Vlassopoulos, S. Serrano, and P.A. O'Day, 2012. "Reactive Transport Modeling of Subaqueous Sediment Caps and Implications for the Long-Term Fate of Arsenic, Mercury, and Methylmercury." *Aquatic Geochemistry* 18:297–326.

Drott, A., E. Björn, and U. Skyllberg, 2013. "Refining Thermodynamic Constants for Mercury(II)-Sulfides in Equilibrium with Metacinnabar at Sub-Micromolar Aqueous Sulfide Concentrations." *Environmental Science and Technology* 47(9): 4197–4203.

Ecology (Washington State Department of Ecology), 2007. Consent Decree No. 07-2-02257-7 for the Whatcom Waterway Site (with Exhibits). Filed September 24, 2007.

Ecology, 2011. First Amendment to the Consent Decree 07-2-02257-7 for the Whatcom Waterway Site (with Exhibits). Filed August 19, 2011.

Ecology, 2024. Second Amendment to the Consent Decree 07-2-02257-7 for the Whatcom Waterway Site. Filed March 27, 2024.

Gagnon, C., É. Pelletier, and A. Mucci, 1997. "Behavior of anthropogenic mercury in coastal marine sediments." *Marine Chemistry* 59:159–176.

Hollweg, T.A., C.C. Gilmour, and R.P. Mason, 2009. Methylmercury production in sediments of Chesapeake Bay and the mid-Atlantic continental margin. *Marine Chemistry* 114:86–101. Elsevier Press. April 2009.

Nordstrom, D.K., L.N. Plummer, T.M.L. Wigley, T.J. Wolery, J.W. Ball, E.A. Jenne, R.L. Bassett, et al., 1979. "A comparison of computerized chemical models for equilibrium calculation in aqueous systems." *Chemical Modeling in Aqueous Systems* 38:857–892.

Parkhurst, D.L., and C.A.J. Appelo, 2013. Description of input and examples for PHREEQC version 3 – a computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations. Reston, Virginia: U.S. Department of the Interior, U.S. Geological Survey. https://www.usgs.gov/software/phreeqc-version-3.

Paquette, K., and G. Helz,. "Solubility of cinnabar (red HgS) and implications for mercury speciation in sulfidic waters." *Water Air Soil Pollution* 80:1053–1056. https://doi.org/10.1007/BF01189765.

Schippers, A., and B.B. Jørgensen, 2002. "Biogeochemistry of pyrite and iron sulfide oxidation in marine sediments." *Geochimica et Cosmochimica* 66(1):85–92. PII: S0016-7037(01)00745-1 (geologyscience.ru)

Seelen, E., V. Liem-Nguyen, U. Wünsch, et al., 2023. "Dissolved organic matter thiol concentrations determine methylmercury bioavailability across the terrestrial-marine aquatic continuum." *Nature Communications* 14:6728. https://doi.org/10.1038/s41467-023-42463-4

Si, L., B.A. Branfireun, and J. Fierro, 2022. "Chemical Oxidation and Reduction Pathways of Mercury Relevant to Natural Waters: A Review." *Water* 14(12):1891. https://doi.org/10.3390/w14121891

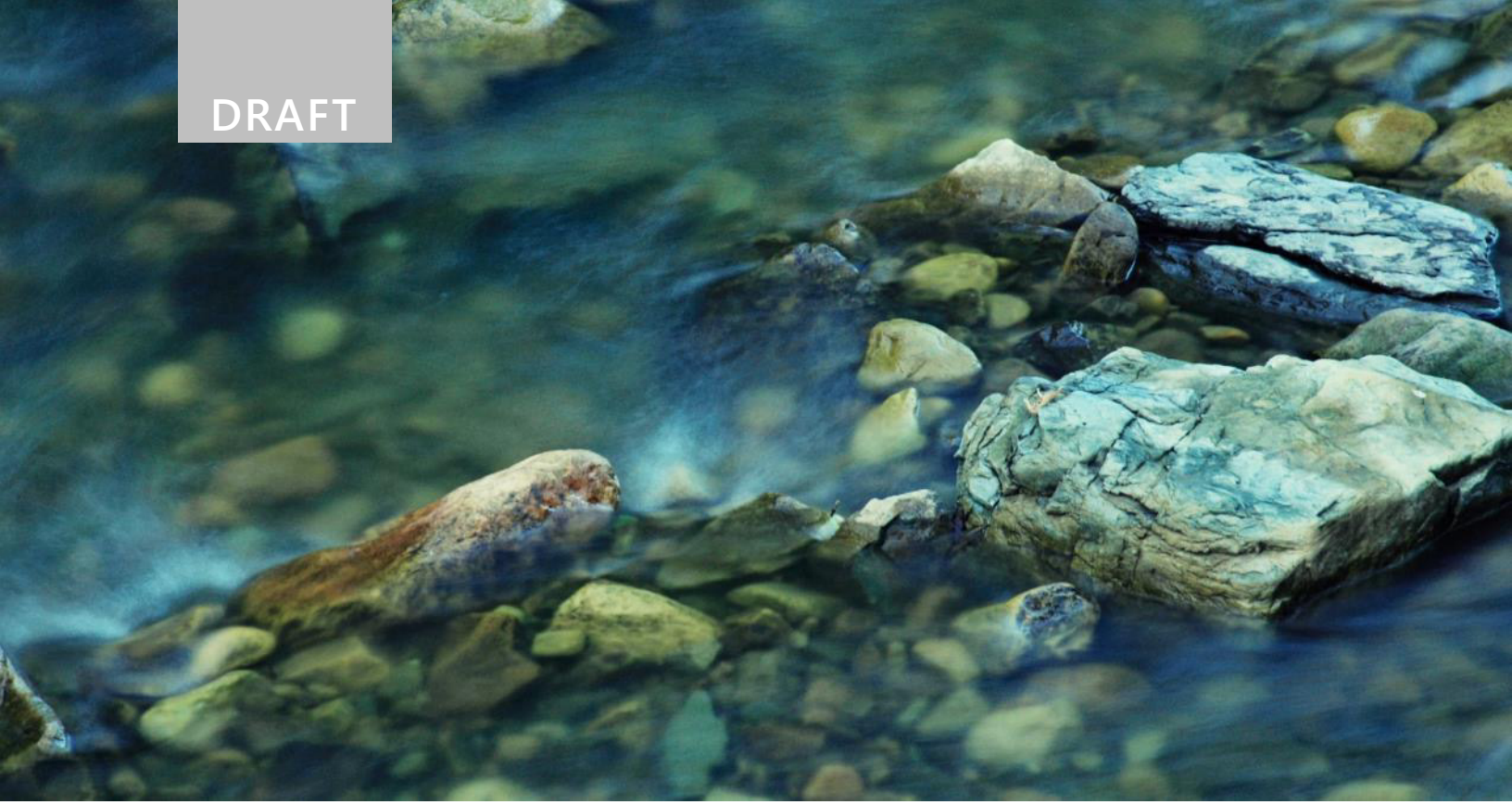
Skyllberg, U, 2008. "Competition Among Thiols and Inorganic Sulfides and Polysulfides for Hg and MeHg in Wetland Soils and sediments Under Suboxic Conditions: Illumination of Controversies and Implications for MeHg Net Production." *Journal of Geophysical Research* 113 (G2):G00C03. https://doi.org/10.1029/2008JG000745.

Skyllberg, U., A. Persson, I. Tjerngren, R.M. Kronberg, A. Drott, M. Meili, and E. Bjørn, 2021. "Chemical Speciation of Mercury, Sulfur and Iron in a Dystrophic Boreal Lake Sediment, as Controlled by the Formation of Mackinawite and Framboidal Pyrite." *Geochimica et Cosmochimica* 294:106–125.

USGS (U.S. Geological Survey), 2010. Sediment toxicity test results for the Urban Waters Study 2010, Bellingham Bay, Washington. *Data Series 591*. 65.

Appendix J
Preliminary Sediment Cap Chemical Isolation Layer Design

DRAFT



June 2025
Whatcom Waterway Cleanup in Phase 2 Site Areas

ANCHOR QEA

Appendix J
Preliminary Sediment Cap Chemical Isolation Layer Design

Prepared for Port of Bellingham

June 2025
Whatcom Waterway Cleanup in Phase 2 Site Areas

Appendix J
Preliminary Sediment Cap Chemical Isolation Layer Design

Prepared for
Port of Bellingham
1801 Roeder Avenue
Bellingham, Washington 98227

Prepared by
Anchor QEA
20 Bellwether Way, Suite 101
Bellingham, Washington 98225

Project Number: 190007-01.01

TABLE OF CONTENTS

1 Introduction 1

2 Evaluation Approach 4

2.1 Model Framework 4
2.2 Cap Areas Evaluated 4
2.3 Model Domain and Layers 4
2.4 Target Concentrations and Compliance Depth 6

3 Cap Model Inputs 7

3.1 Partitioning Coefficients 11
3.2 Porewater Concentrations in Sediment Beneath the Cap 12
3.3 Groundwater Seepage Rates and Dispersion 15

4 Cap Modeling Results 17

5 Summary 18

6 References 19

TABLES

Table J-1 Input Parameter Values for the Chemical Isolation Cap Model 8
Table J-2 Partition Coefficients Used in the Model 11
Table J-3 Maximum Estimated Existing Porewater Concentrations for each Cap Area 13
Table J-4 Model-Predicted Concentrations in the Top 12 cm of the Cap at 100 Years 17

FIGURES

Figure J-1a Locations of Type 1 and Type 2 Caps in Phase 2 Site Areas 2
Figure J-1b Locations of Type 1 and Type 2 Caps in Phase 2 Site Areas 3
Figure J-2 Cap Configuration and Simulated Fate and Transport Processes 5
Figure J-3 Estimates of Darcy Flux from Upland Groundwater 16

ABBREVIATIONS

µg/L	microgram per liter
ASB	Aerated Stabilization Basin
BSL	bioaccumulation screening level
CAP	Cleanup Action Plan
Cleanup	Whatcom Waterway Cleanup in Phase 2 Site Areas
COC	contaminant of concern
cm	centimeter
cm/hr	centimeter per hour
cm/yr	centimeter per year
cm^2/s	centimeter squared per second
cm^2/yr	centimeter squared per year
CSL	cleanup screening level
D/F	dioxin/furan
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
f_{OC}	fraction organic carbon
GP West	Georgia-Pacific West, Inc., mill site
g/cm^3	gram per cubic centimeter
K_d	equilibrium partition coefficient
K_{OC}	organic carbon partition coefficient
K_{OW}	octanol-water partition coefficient
L/kg	liter per kilogram
mg/kg	milligram per kilogram
ng/kg	nanogram per kilogram
SCO	Sediment Cleanup Objective
Site	Whatcom Waterway Site
SMS	Sediment Management Standards
TEQ	toxic equivalency quotient
yr^{-1}	per year

1 Introduction

This appendix to the *Engineering Design Report* (EDR) was prepared in accordance with Consent Decree No. 07-2-02257-7 (Ecology 2007) as amended by the Washington State Department of Ecology (Ecology) with the First Amendment to the Consent Decree (Ecology 2011) and the Second Amendment to the Consent Decree (Ecology 2024).

This appendix describes evaluations of the chemical isolation component of engineered Type 1 and Type 2 caps to be constructed during the Whatcom Waterway Cleanup in Phase 2 Site Areas (Cleanup). These Type 1 and Type 2 capping areas are identified in Figures J-1a and J-1b.

This appendix focuses on mercury and dioxin/furan (D/F) compounds, which have been identified as the contaminants of concern (COCs) for the Cleanup:

- Whatcom Waterway Site sediments have been impacted by mercury discharges from the former Georgia-Pacific West, Inc. chlor-alkali plant, which was located on a portion of the adjacent Georgia-Pacific West, Inc., mill site (GP West) and discharged mercury-containing wastewater into Whatcom Waterway primarily during the late 1960s and 1970s.
- D/F compounds are also known to be present in surface and subsurface sediments at the Site, and throughout most of Bellingham Bay, as well as other urban bays within Puget Sound. The full range of historical and contemporary sources of D/F compounds in Bellingham Bay have not yet been fully determined and may include contributions from multiple sources throughout the bay, including former combustion sources, former GP West pulp and paper mill operations, former wood-treating facilities, historical and ongoing stormwater and wastewater discharges, and atmospheric deposition.

The analyses described herein were performed in accordance with guidance on cap design set forth by the U.S. Environmental Protection Agency and U.S. Army Corps of Engineers (Palermo et al. 1998), and the Interstate Technology and Regulatory Council (ITRC 2014, 2023). The primary goal of these analyses was to design the chemical isolation component (i.e., layer) of engineered sediment caps. This goal was accomplished by performing numerical model simulations of the transport of dissolved-phase mercury and D/F compounds within an engineered cap to identify a chemical isolation layer configuration (i.e., thickness and composition) that would provide long-term effectiveness by limiting concentrations at the cap surface to which benthic and aquatic organisms can be exposed.

Figure J-1a
Locations of Type 1 and Type 2 Caps in Phase 2 Site Areas

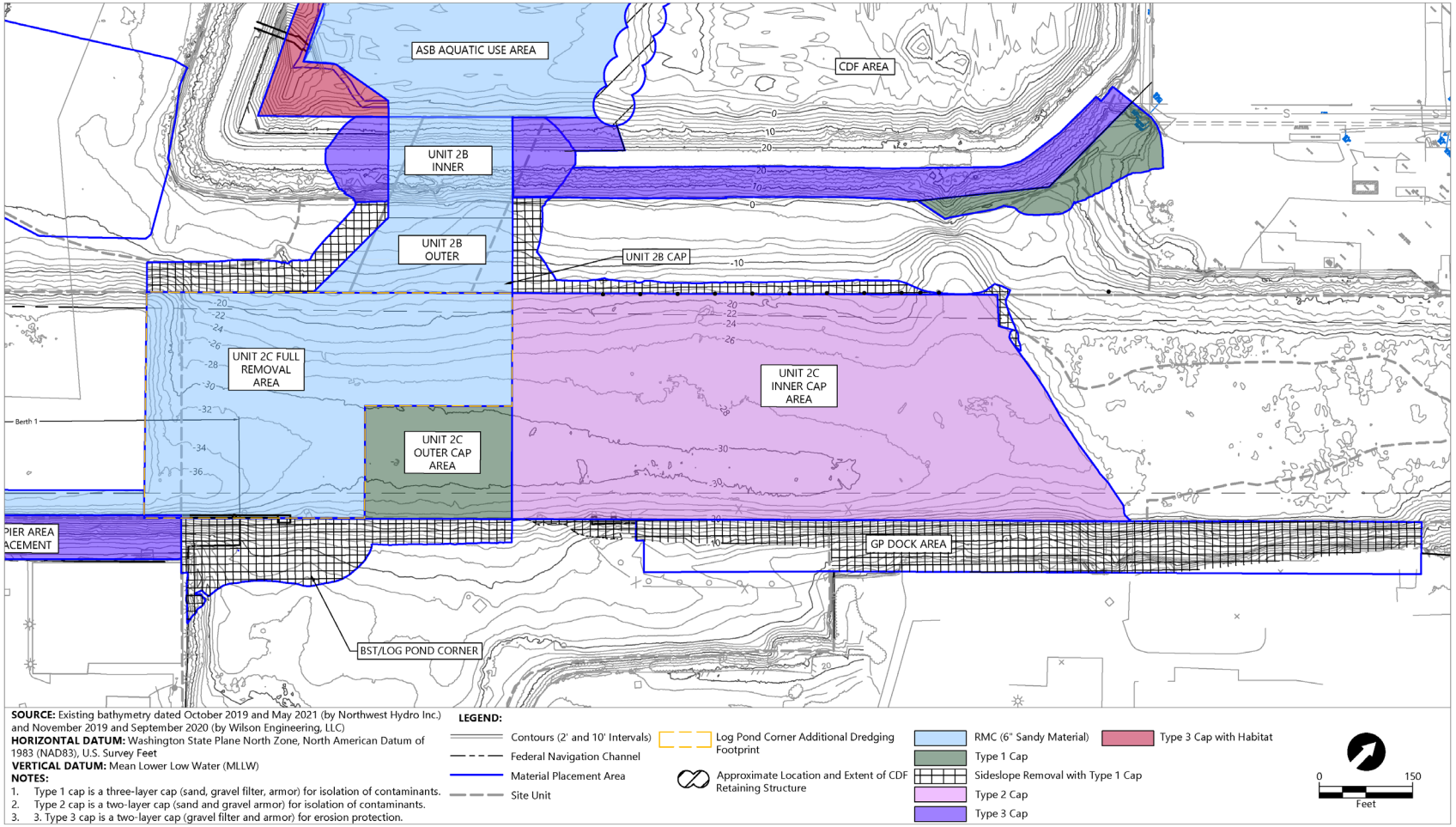
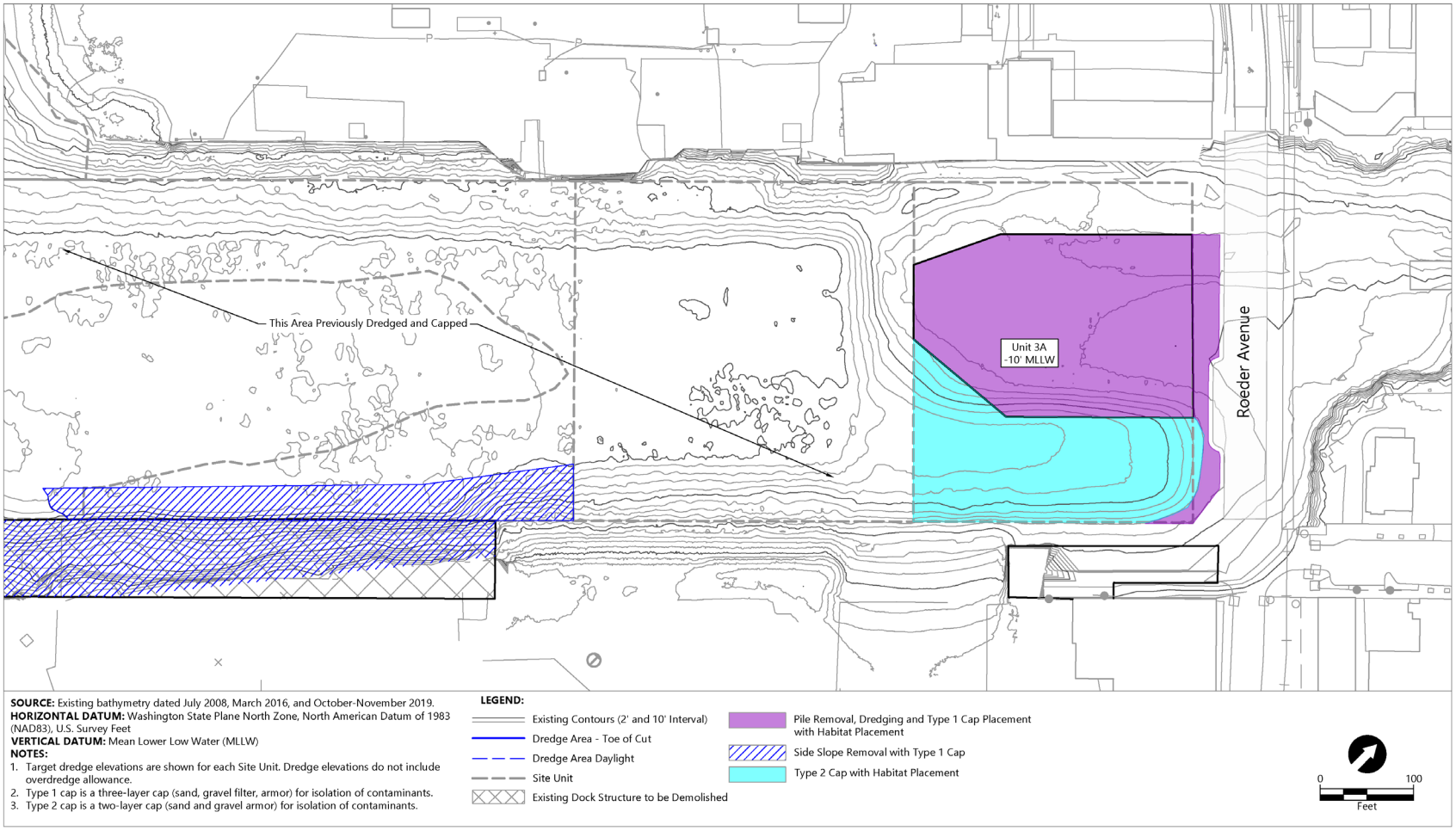


Figure J-1b
Locations of Type 1 and Type 2 Caps in Phase 2 Site Areas



2 Evaluation Approach

2.1 Model Framework

The widely used model of chemical transport within sediment caps, CapSim (version 4.2; Reible 2023), was used for this evaluation. This model simulates the time variable fate and transport of chemicals (both dissolved and sorbed phases, including partitioning between these phases) under the processes of advection, diffusion/dispersion, biodegradation, bioturbation/bioirrigation, and exchange with the overlying surface water within a sediment cap.

The model is one dimensional and simulates vertical differences in concentration within the various layers of a sediment cap as well as in the underlying sediment. Details on the model structure and underlying theory and equations are provided in Lampert and Reible (2009), Go et al. (2009), and Shen et al. (2018). CapSim and its predecessors have been used to support the evaluation and design of sediment caps at numerous domestic and international sites.

2.2 Cap Areas Evaluated

This appendix focuses on the design of chemical isolation layers for Site Areas where Type 1 and Type 2 engineered caps are to be placed over contaminated sediments. These Type 1 and Type 2 capping areas include the following:

- Portions of Unit 2C (Inner Waterway), including the Unit 2C sideslopes along the GP Dock Area, Long Pond, and Aerated Stabilization Basin (ASB)
- Portions of Unit 3A (Head of Waterway)
- Portions of Unit 6 (Railspan Area)

Type 3 cap areas were not evaluated because Type 3 caps are not used to directly contain contaminated sediments and do not require a chemical isolation layer. Type 3 caps are used to make sure the Cleanup is resilient by controlling potential future shoreline erosion in remediated areas.

2.3 Model Domain and Layers

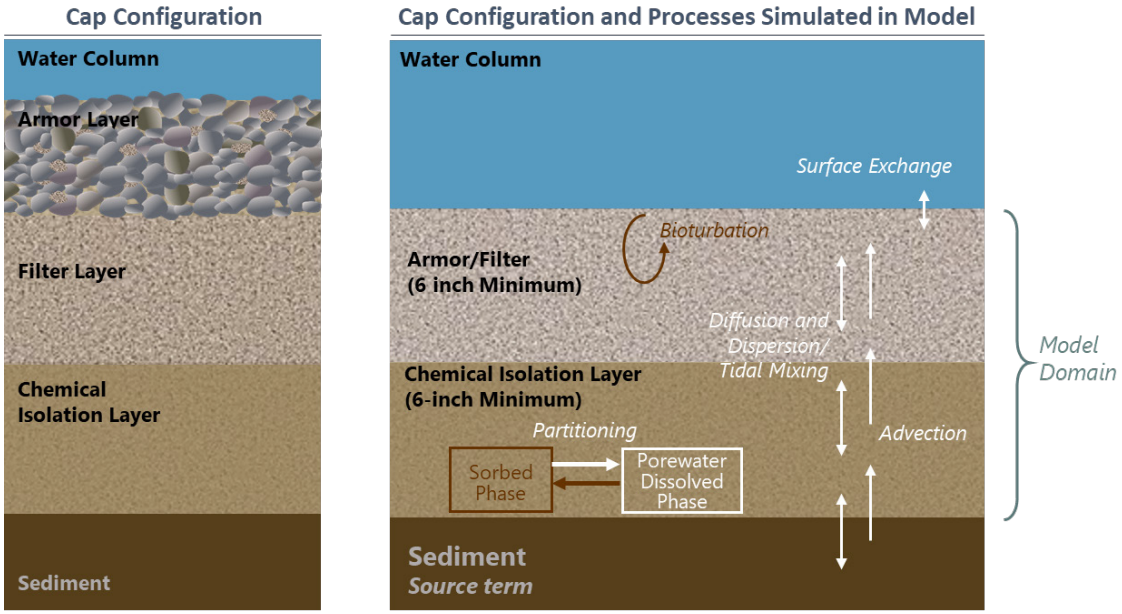
The model was configured to represent the presence of a multilayer cap placed atop the sediments. The cap design consisted of three basic layers, listed from top to bottom as follows:

- **Armor and Filter Layers:** Type 1 and Type 2 caps contain an armor layer to resist erosive forces. Type 1 caps also include a filter layer to prevent intermixing of the armor and chemical isolation layer materials. The design evaluations for the armor and filter layers are presented in Appendix D (Coastal and Propwash Evaluation) of the EDR, although propwash was the driver of the armor layer design.

- **Chemical Isolation Layer:** A chemical isolation layer is included in both Type 1 and Type 2 caps to limit and attenuate dissolved-phase contaminant transport. The chemical isolation layer is the focus of this document.

Figure J-2 compares the typical profile of a Type 1 cap (with armor and filter layers) and a Type 2 cap (with armor layer) with the simplified cap design as modeled (only 15 centimeters [cm] of the bottom portion of the filter/armor layer). Typical Type 1 armor and filter layers will be at least 2.5 feet (76 cm), with 24 inches (61 cm) of armor and at least 6 inches (15 cm) of filter material. A typical Type 2 armor layer will be 3.0 feet (91.5 cm) thick. In comparison, the modeling only simulates the bottom 6 inches of this 2.5-foot armor and filter layer profile. The upper portion of the armor, if not well graded, is not expected to provide sorptive capacity and possibly no attenuation due to dispersive exchange with surface water. That said, deposition has been observed at the Site, so it is likely that if a poorly graded armor layer were to be constructed, the large interstitial spaces of the armor stone would fill in with depositing sediment over time. It would be in this graded armor material or deposited sediment that fills the interstitial spaces of the armor stone that benthic organisms would inhabit and mix the material through bioturbation at the cap surface. Therefore, a simplified representation consisting of a 15-cm (6-inch) layer of porous media with bioturbation and a somewhat greater fraction organic carbon (f_{OC}) than quarry material was simulated in the model.

Figure J-2
Cap Configuration and Simulated Fate and Transport Processes



Note: Not to scale

Fine-grained sediment will tend to deposit on the armor layer and fill in the pore spaces and enhance contaminant attenuation. This long-term beneficial effect was disregarded in the modeling evaluations.

2.4 Target Concentrations and Compliance Depth

Compliance with the sediment cleanup levels applies over the thickness of the biologically active zone. In Bellingham Bay, this thickness is the upper 12 cm of the sediment bed (RETEC 2006; Ecology 2007). Target concentrations for mercury and D/F toxic equivalency quotient (TEQ) were compared to the model-predicted concentrations at the cap surface (top 12 cm) over time to evaluate protectiveness of caps at this Site.

Sediment cleanup levels for mercury were defined in the Whatcom Waterway Cleanup Action Plan (CAP) (Ecology 2007):

- The total mercury cleanup level for benthic protection was established at 0.41 milligram per kilogram (mg/kg), consistent with the current Sediment Cleanup Objective (SCO) established in the Sediment Management Standards (SMS) regulations. Compliance with the mercury SCO is measured on a point-by-point basis. If the mercury SCO is exceeded, benthic protection must be verified using toxicity bioassays. For this evaluation, model outputs were compared directly to the 0.41 mg/kg numeric SCO without consideration of potential bioassay testing.
- Cleanup standards for sediment mercury concentrations also include consideration of bioaccumulation effects. These effects are considered potentially significant at concentrations exceeding 1.2 mg/kg, which is the bioaccumulation screening level (BSL) established in the Consent Decree (Ecology 2007). Compliance with the BSL is measured on a point-by-point basis. Because the BSL is higher than the mercury SCO, the BSL was not used for evaluation of model outputs.
- Sediment cleanup levels for D/F compounds were defined in the Second Amendment to the Consent Decree (Ecology 2024). The D/F cleanup level was established at the cleanup screening level (CSL) at a concentration of 9.8 nanograms per kilogram (ng/kg) TEQ. Compliance with the D/F CSL is measured on an area-wide basis throughout the Site. For the current evaluation, the individual D/F compounds were simulated with the model; the sum of the individual D/F model-predicted sorbed phase concentrations multiplied by its respective toxic equivalence factor were used for comparison to the D/F TEQ target criteria. For this evaluation, model outputs were compared directly to the 9.8 ng/kg TEQ cleanup level without further consideration of area-wide averaging.

3 Cap Model Inputs

The CapSim model uses several input parameters that describe chemical-specific properties, cap material properties, and chemical mass transfer rates. These parameters are based on Site-specific data, information from the literature, and experience with cap design at other similar sites.

The model input parameters, the values used for this modeling assessment, and the source(s) from which they were derived are provided in Table J-1. More details describing certain key model inputs are provided in Sections 3.1 through 3.3.

Table J-1
Input Parameter Values for the Chemical Isolation Cap Model

Model Input Parameter	Value	Data Source
Chemical-Specific Properties		
Partitioning onto cap materials (L/kg)	See Table J-2	For D/F compounds, literature-based log K_{OC} values were used. For mercury, a Site-specific K_d value was used. See Section 3.1 for more details.
Porewater COC concentrations (µg/L)	See Table J-3	Site-specific sediment data converted to porewater concentrations based on equilibrium partitioning formulations. See Section 3.2 for more details.
Molecular diffusivity (cm^2/s)	D/F: 3.5×10^{-6} to 4.6×10^{-6} Mercury: 2.8×10^{-5}	For D/F compounds, calculated based on the molecular weight of the chemical compound using the correlation identified from Schwarzenbach et al. (1993). For mercury, molecular diffusivity was based on molar volume using the correlation derived by Hayduk and Laudie (1974). The model calculates an effective diffusion coefficient using the chemical-specific input value for the molecular diffusivity multiplied by a tortuosity factor that is a function of the material porosity (Lampert and Reible 2009).
Chemical biodegradation rate (yr^{-1})	0	Assumed no degradation.
Chemical Isolation Layer Properties		
Thickness (cm)	Variable	Design parameter; started with a chemical isolation layer thickness of 15 cm and increased as necessary to maintain COC concentrations in the top 12 cm of the cap to values less than the target concentrations.
Dry bulk density (g/cm^3)	1.6	Calculated based on typical particle density of 2.6 g/cm^3 and porosity of 0.4 for sand (see next row).
Total porosity	0.4	Based on typical value of 0.4 for sand (e.g., Domenico and Schwartz 1990).
Fraction organic carbon of sand (f_{OC}; %)	0.1	A lower-bound estimate typically used to represent quarry sand in which sorption to mineral fractions can also occur (Karickhoff 1984; USEPA 2000).
Armor/Filter Layer		
Thickness (cm)	15	Conservatively simulated only 15 cm of granular material above the chemical isolation layer, representing a portion of the armor layer, filter layer, and future deposited sediment that will infill the interstices.
Dry bulk density (g/cm^3)	1.6	Calculated based on typical particle density of 2.6 g/cm^3 and porosity of 0.4 representing a simplified representation of material within the armor stone interstitial spaces at the cap surface (either well-graded armor material or filled in from deposited sediment; see next row).

Model Input Parameter	Value	Data Source
Total porosity	0.4	Typical value for sand or gravels gravel consistent with armor layer that is well graded or infilled by deposition (e.g., Domenico and Schwartz 1990).
f_{OC} (%)	0.5 in top 12 cm 0.1 in bottom 3 cm	A value of 0.5% in the bioturbation zone was selected based on experience and monitoring data from other sites and the assumption that, over time, the f_{OC} at the cap surface will increase toward background levels in the sediment outside of the Phase 2 Site Units, which range from 1% to 3%, but not as high due to mixing with the low f_{OC} cap material. In the armor/filter layer below the bioturbation zone, a nominal f_{OC} of 0.1% was assumed.
Mass Transport Properties		
Boundary layer mass transfer coefficient (cm/hr)	0.3	Midpoint of range of values compiled from laboratory and field measurements reported in the literature (e.g., Thibodeaux et al. 2001) and values calibrated as part of models of sediment/water exchange at other sites (e.g., LBG et al. 2014).
Groundwater seepage rate (cm/yr)	1,000	Based on estimates from Site groundwater modeling (ThermoRetec 2001). See Section 3.3 for more details.
Tortuosity factor for molecular diffusion	Millington and Quirk	Model uses an empirical relationship with porosity to calculate a tortuosity factor that is multiplied by the chemical-specific molecular diffusion coefficient to result in an effective diffusion coefficient associated with porous media flow. The Millington and Quirk (1961) relationship was used because it is applicable to granular (sand and gravel) materials.
Net sedimentation rate (cm/yr)	0	Deposition rates in the Site area of 1.3 cm/yr have been reported (Anchor Environmental and Hart Crowser 2000; RETEC 2006). Conservatively no future net sedimentation was assumed in the model. That is, the model domain thickness was held constant.
Dispersion length (cm)	9	Dispersion length was assumed to be 20% of the domain length. An assumed domain length of 45 cm (1.5 feet) was used in this calculation. See Section 3.3 for more detail.
Bioturbation depth (cm)	12	Detailed core analyses performed in Bellingham Bay suggest that the sediment bioactive zone is approximately 12 cm (5 inches) in thickness, and that bioturbation is minimal below a depth of approximately 0.5 foot (15 cm) (Officer and Lynch 1989; Anchor Environmental and Hart Crowser 2000).
Porewater biodiffusion coefficient (cm^2/yr)	600	Parameter represents bioturbation rate applied to dissolved phase; typical value for estuarine systems (e.g., Thibodeaux and Mackay 2011).
Particle biodiffusion coefficient (cm^2/yr)	6	Parameter represents bioturbation rate applied to particulate phase; typical value for estuarine systems (e.g., Thibodeaux and Mackay 2011).

Model Input Parameter	Value	Data Source
Consolidation thickness (cm) and time (years) to reach 90% consolidation for underlying sediment	30 cm 1 and 1.5 years	Consolidation can result in an additional temporary upward flux of porewater over the time that consolidation occurs. A range in consolidation was identified of 15 to 30 cm over 1 to 1.5 years. Conservatively, the greater consolidation was used in the modeling and two scenarios were simulated—consolidation occurring over 1 year and consolidation occurring over 1.5 years.

3.1 Partitioning Coefficients

The partitioning of chemicals between the dissolved and sorbed phases (i.e., between porewater and cap material) is described in the model by the chemical-specific equilibrium partition coefficient (K_d). For mercury, Site data have previously been used to develop a Site-specific mercury K_d value (Aspect and Anchor QEA 2011).

For organic chemicals, such as D/F compounds, the partition coefficient is calculated in the model based on the customary $K_d = f_{OC}*K_{OC}$ approach (e.g., Karickhoff 1984), where K_{OC} is the compound's organic carbon partition coefficient and f_{OC} is the organic carbon fraction of the solid phase (e.g., cap material). Literature-based K_{OW} values were obtained from Aberg et al. (2008) for the individual D/F compounds simulated in the model. Log K_{OC} values were then calculated from the widely used Di Toro (1985) empirical relationship (log K_{OC}=0.00028+(0.983*log K_{OW}). The partition coefficients for mercury and D/F compounds are listed in Table J-2.

Table J-2
Partition Coefficients Used in the Model

Chemical Name	Log K_{OC} (log L/kg)	Log K_d (log L/kg)
Mercury	--	3.8
1,2,3,4,6,7,8-HpCDD	7.8	--
1,2,3,4,6,7,8-HpCDF	7.3	--
1,2,3,4,7,8,9-HpCDF	7.3	--
1,2,3,4,7,8-HxCDD	7.3	--
1,2,3,4,7,8-HxCDF	6.9	--
1,2,3,6,7,8-HxCDD	7.3	--
1,2,3,6,7,8-HxCDF	6.9	--
1,2,3,7,8,9-HxCDD	7.3	--
1,2,3,7,8,9-HxCDF	6.9	--
1,2,3,7,8-PeCDD	6.9	--
1,2,3,7,8-PeCDF	6.5	--
2,3,4,6,7,8-HxCDF	6.9	--
2,3,4,7,8-PeCDF	6.5	--
2,3,7,8-TCDD	6.4	--
2,3,7,8-TCDF	6.1	--
OCDD	8.2	--
OCDF	7.7	--

Note:
--: not applicable

3.2 Porewater Concentrations in Sediment Beneath the Cap

Contaminant concentrations of porewater in the sediment beneath the cap define the source term in the model. Porewater concentrations were calculated from bulk sediment contaminant concentrations using equilibrium partitioning:

- For mercury, the Site-specific K_d and sediment sample concentrations were used to calculate the porewater concentration.
- For the individual D/F compounds, literature-derived K_{OC} values (from Table J-2), sample-specific f_{OC} values, and sediment sample D/F concentrations were used to calculate the porewater concentrations.
- For sediment samples not analyzed for f_{OC}, an assumed f_{OC} was assigned based on the Site median f_{OC} by depth interval as follows:
  - 0 to 5 feet below the mudline: 2.0%
  - 5 to 10 feet below the mudline: 1.4%
  - Greater than 10 feet below the mudline: 0.40%

Because some dredging will be performed within each of the Type 1 and Type 2 capping areas, the evaluation of contaminant source concentrations was not limited to the existing surface sediment data. Rather, the highest contaminant concentration present at any depth within each Site Unit was considered and used as the basis for modeling. These maximum estimated porewater concentrations are shown in Table J-3.

Table J-3
Maximum Estimated Existing Porewater Concentrations for each Cap Area

Chemical	Unit 2C (Including Sideslopes)			Unit 3A			Unit 6		
	Sample Having Maximum Porewater	Calculated Porewater Concentration (µg/L)	Sediment Concentration (µg/kg)	Sample Having Maximum Porewater	Calculated Porewater Concentration (µg/L)	Sediment Concentration (µg/kg)	Sample Having Maximum Porewater	Calculated Porewater Concentration (µg/L)	Sediment Concentration (µg/kg)
Mercury	2C-03-VC-1-2-200826	3.2	20,100	3A-03-VC-7-9	1.0	6,300	1C-16-VC-4-5-200825	2.0	12,600
1,2,3,4,6,7,8-HpCDD	2C-05-VC-3-4-200831	6.9E-06	8.7	WW-MNR-11-SS-190827	7.1E-07	1.9	1C-16-VC-5-5.8-200825	4.0E-06	7.2
1,2,3,4,6,7,8-HpCDF	2C-05-VC-3-4-200831	1.7E-06	0.67	WW-MNR-11-SS-170713	3.4E-07	0.28	6C-05-VC-11-12-200826	1.8E-06	0.77
1,2,3,4,7,8,9-HpCDF	2C-05-VC-3-4-200831	9.9E-08	0.040	WW-MNR-11-SS-170713	1.7E-08	0.014	6C-04-VC-4-4.8-200903	7.5E-08	0.052
1,2,3,4,7,8-HxCDD	2C-08-DC-0-1.1-200828	1.4E-07	0.057	WW-MNR-10-SS-190827	2.0E-08	0.0051	6C-03-VC-0-1-200903	3.1E-08	0.012
1,2,3,4,7,8-HxCDF	2C-05-VC-3-4-200831	3.4E-07	0.054	WW-MNR-11-SS-170713	4.3E-08	0.015	6C-04-VC-4-4.8-200903	8.4E-07	0.23
1,2,3,6,7,8-HxCDD	2C-05-VC-3-4-200831	1.3E-06	0.52	WW-MNR-11-SS-170713	9.0E-08	0.076	6C-04-VC-4-4.8-200903	3.3E-07	0.23
1,2,3,6,7,8-HxCDF	2C-05-VC-3-4-200831	1.4E-07	0.023	WW-MNR-10-SS-190827	2.3E-08	0.0024	6C-04-VC-4-4.8-200903	1.7E-07	0.046
1,2,3,7,8,9-HxCDD	2C-08-DC-0-1.1-200828	2.2E-07	0.086	WW-MNR-11-SS-170713	5.1E-08	0.043	6C-04-VC-4-4.8-200903	8.9E-08	0.061
1,2,3,7,8,9-HxCDF	2C-05-VC-3-4-200831	2.3E-07	0.037	WW-MNR-11-SS-170713	1.4E-08	0.0049	6C-04-VC-4-4.8-200903	1.6E-07	0.043
1,2,3,7,8-PeCDD	2C-08-DC-0-1.1-200828	1.3E-07	0.021	WW-MNR-10-SS-190827	8.5E-08	0.0085	6C-05-VC-11-12-200826	4.2E-08	0.0073
1,2,3,7,8-PeCDF	2C-05-VC-3-4-200831	2.3E-07	0.014	WW-MNR-11-SS-170713	3.2E-08	0.0043	6C-02-VC-6-7-200831	2.2E-07	0.027
2,3,4,6,7,8-HxCDF	2C-05-VC-3-4-200831	4.0E-07	0.064	WW-MNR-10-SS-190827	3.7E-08	0.0037	6C-04-VC-4-4.8-200903	2.3E-07	0.063

Chemical	Unit 2C (Including Sideslopes)			Unit 3A			Unit 6		
	Sample Having Maximum Porewater	Calculated Porewater Concentration (µg/L)	Sediment Concentration (µg/kg)	Sample Having Maximum Porewater	Calculated Porewater Concentration (µg/L)	Sediment Concentration (µg/kg)	Sample Having Maximum Porewater	Calculated Porewater Concentration (µg/L)	Sediment Concentration (µg/kg)
2,3,4,7,8-PeCDF	2C-08-DC-0-1.1-200828	2.2E-07	0.014	WW-MNR-10-SS-190827	3.4E-08	0.0014	6C-04-VC-4-4.8-200903	3.4E-07	0.037
2,3,7,8-TCDD	2C-08-DC-0-1.1-200828	4.4E-08	0.0022	WW-MNR-10-SS-190827	2.9E-08	0.00093	1C-16-VC-5-5.8-200825	4.7E-08	0.0034
2,3,7,8-TCDF	2C-08-DC-0-1.1-200828	1.1E-06	0.027	WW-MNR-10-SS-190827	1.7E-07	0.0028	1C-16-VC-5-5.8-200825	2.4E-06	0.088
OCDD	2C-05-VC-3-4-200831	1.7E-05	55	WW-MNR-11-SS-190827	2.6E-06	17	1C-16-VC-5-5.8-200825	1.7E-05	76
OCDF	2C-107-VC-3-4.7-200831	8.8E-07	0.88	WW-MNR-11-SS-190827	3.5E-07	0.74	6C-05-VC-11-12-200826	2.7E-06	3.0
D/F TEQ[1]	--	7.3E-07	0.23	--	1.8E-07	0.052	--	6.9E-07	0.20

Note:

1. The porewater and sediment concentrations for D/F TEQ is provided for reference only. The sediment D/F TEQ concentration is calculated using the maximum porewater concentration for each individual D/F. The individual D/F compounds were simulated with the model; the sum of the individual D/F model-predicted sorbed phase concentrations multiplied by its respective toxic equivalence factor were used for comparison to the D/F TEQ target criteria.

3.3 Groundwater Seepage Rates and Dispersion

Estimates of groundwater seepage rates were obtained from groundwater modeling that was performed as part of the Remedial Investigation and Feasibility Study for the Central Waterfront Site (ThermoRetec 2001). That 3-dimensional modeling effort was performed using MODFLOW with the USGS SEAWAT code to address variability of groundwater density in shoreline areas with saline waters. The model incorporated the geologic stratigraphy and characteristics of the Central Waterfront Site's existing site development conditions and was calibrated to quarterly groundwater gradients. The model accurately simulated 3-dimenstional groundwater trends in total chromium, a tracer for groundwater from the Roeder Avenue Landfill. One set of scenarios modeled included simulation of aquatic reuse of the ASB (i.e., as a marina).

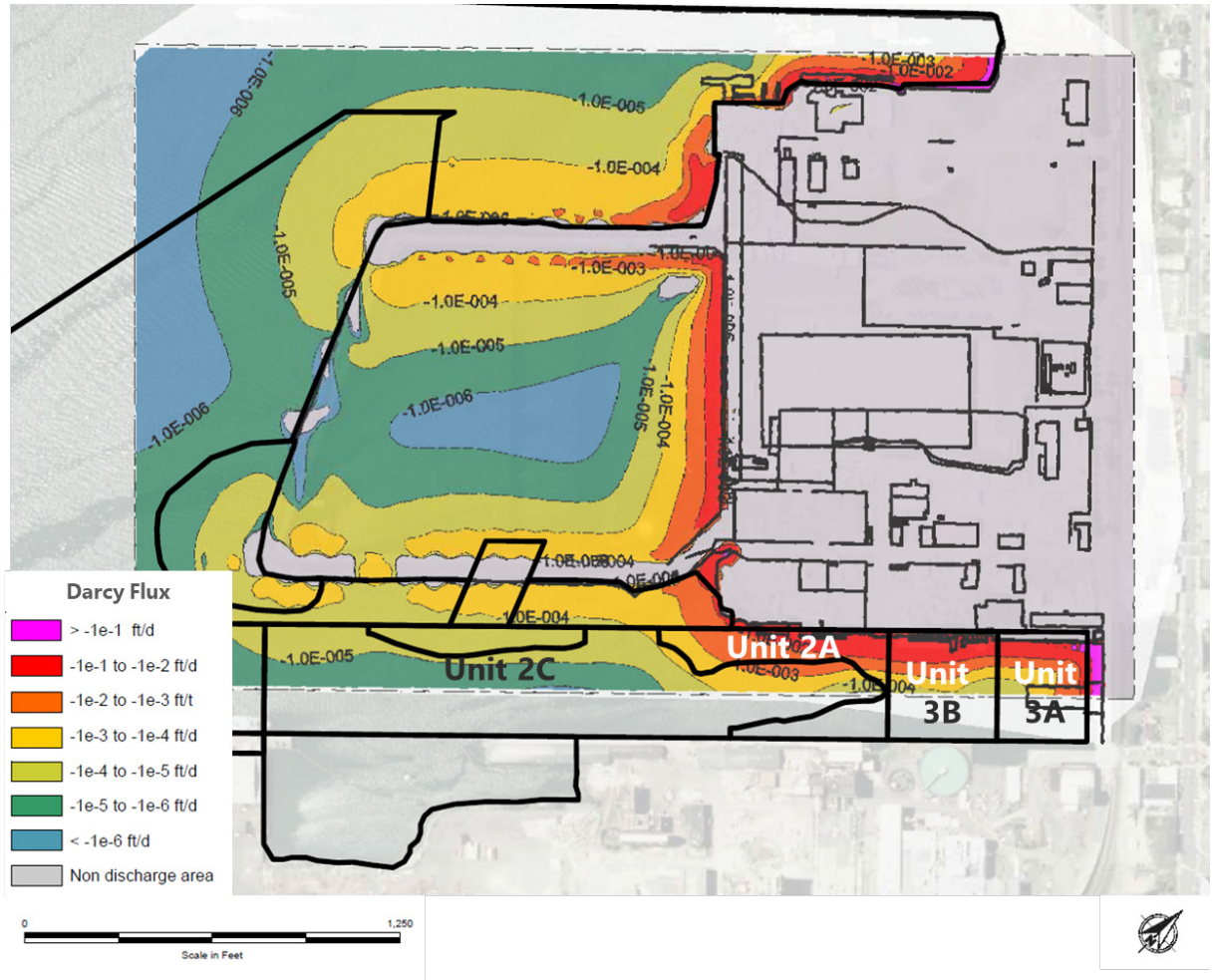
Figure J-3 summarizes the range of groundwater seepage rates estimated by the Central Waterfront Site groundwater model. Within a majority of the area to be capped, the model-predicted seepage rates range from 1E-06 feet/day (0.011 cm/year) to 1E-01 feet/day (1,000 cm/year). Groundwater seepage rates were highest in shoreline areas and lower in offshore areas.

Estimated groundwater seepage rate at the highest end of those estimated in the Central Waterfront Site groundwater modeling outputs were used in the cap model evaluations. Outside of nearshore areas, this seepage rate (1,000 cm/year) likely overestimates actual site conditions by several orders of magnitude.

Bellingham Bay is tidally influenced, so dissolved phase transport within a cap may also be influenced by the tidal dynamics of groundwater-surface water exchange, which include hydraulic gradient and seepage rate oscillations, including potential reversals in groundwater flow direction. Representing tidal oscillations in porous media flow velocity as a dispersion process is a common approach in modeling of long-term contaminant transport in groundwater systems (e.g., La Licata et al. 2011) because high-frequency variations in pore velocity have been shown to behave as a dispersive process over the long term (e.g., de Dreuzy et al. 2012).

Dispersivity, or dispersion length, values used for modeling flow and transport in porous media over relatively short distances (such as those of a sediment cap) are typically in the range of 1% of the model domain length (consistent with typical values used in cap modeling [Reible 2012]), whereas those associated with large-scale groundwater plumes are on the order of 10% (Gelhar et al. 1992; Neuman 1990). To represent the seepage variations and reversals from tidal fluctuations as an additional dispersion process, an upper-end hydrodynamic dispersivity value of 20% of the model domain length was assumed for these model evaluations. This dispersivity value (i.e., 20% of domain length) is consistent with values used in the final cap designs conducted at other tidally influenced sites, Gloucester Harbor, Massachusetts, where dispersivity was derived from model calibrations to vertical profiles of salinity in porewater (Anchor QEA and GZA 2015; Reidy et al. 2015).

Figure J-3
Estimates of Darcy Flux from Upland Groundwater



Note: Model output from groundwater modeling described in ThermoRetec (2001)

4 Cap Modeling Results

Cap modeling evaluations were used to simulate the transport of both D/F compounds and mercury within Type 1 and Type 2 caps to be placed in Phase 2 Site Areas during the Cleanup. The model evaluations were conducted conservatively to provide reasonable worst-case estimates of cap performance over very long time periods (i.e., 100 years). Potentially conservative model assumptions include the following:

- Excluding future sedimentation
- Excluding a portion of the armor layer thickness
- Use of maximum contaminant concentrations identified within each Site Unit (particularly D/F compounds, which are assessed on an area-wide average)
- Use of upper-bound estimates of groundwater seepage rates
- Comparison of model outputs to numeric cleanup standards without consideration of the beneficial effects of area-wide averaging (D/F compounds) or bioassay testing, which could result in a different criteria (mercury)

Cap modeling results are summarized in Table J-4 for each consolidation scenario. Model results indicated that a 12-inch sand chemical isolation layer was needed to meet the target concentrations for more than 100 years in Unit 3A. In Unit 6 and Unit 2C, an 18-inch sand chemical isolation layer was predicted to be needed. Effects of consolidation were minimal.

Table J-4
Model-Predicted Concentrations in the Top 12 cm of the Cap at 100 Years

Consolidation Scenario	Chemical Isolation Layer Thickness	Site Unit	Model-Predicted D/F TEQ in the Top 12 cm at Year 100 (ng/kg)	Model-Predicted Mercury Concentration in the Top 12 cm at Year 100 (mg/kg)
			Target: 9.8 ng/kg TEQ	*Target: 0.41 mg/kg*
12 inches over 1 year	12 inches	3A	0.10	0.23
	18 inches	2C	0.17	0.038
		6	0.35	0.024
12 inches over 1.5 years	12 inches	3A	0.10	0.23
	18 inches	2C	0.17	0.038
		6	0.35	0.024

5 Summary

Numerical modeling was conducted to evaluate the chemical isolation layer design for engineered Type 1 and Type 2 caps to contain sediments contaminated with D/F compounds and mercury. The modeling was performed with conservative input parameters intended to yield reasonable worst-case estimates of cap performance over the very long term.

Results demonstrated that for capping of Unit 3A, a minimum 12-inch sand chemical isolation layer will comply with Site cleanup levels. For Units 6 and Unit 2C, use of a minimum 18-inch sand chemical isolation layer is recommended.

The above-described values do not consider cap over-placement thicknesses, the beneficial effects of upper amor layers, additional habitat substrate, or future sedimentation. Each of these factors would tend to increase the protectiveness of the caps.

6 References

Aberg, A., M. MacLeod, and K. Wiberg, 2008. "Physical-Chemical Property Data for Dibenzo-p-dioxin (DD), Dibenzofuran (DF), and Chlorinated DD/Fs: A Critical Review and Recommended Values." *Journal of Physical and Chemical Reference Data* 37(4). Available at: https://doi.org/10.1063/1.3005673.

Anchor Environmental and Hart Crowser, 2000. *Remedial Investigation and Feasibility Study for the Whatcom Waterway Site*. Prepared for GP West. July 25, 2000.

Anchor QEA and GZA (Anchor QEA, LLC; GZA GeoEnvironmental, Inc.), 2015. *Phase IV Remedy Implementation Plan*. Former Gloucester Manufactured Gas Plant. August 26, 2015.

Aspect (Aspect Consulting, LLC) and Anchor QEA, 2011. *Site-Specific Nearshore Mercury Partition Coefficient for Use in Modeling Groundwater Screening Levels Protective of Sediment and Surface Water*. Prepared for the Port of Bellingham. June 2011.

Di Toro, D.M., 1985. "A Particle Interaction Model of Reversible Organic Chemical Sorption." *Chemosphere* 14(10):1503–1538. Available at: https://doi.org/10.1016/0045-6535(85)90008-6.

Domenico, P.A., and F.W. Schwartz, 1990. *Physical and Chemical Hydrogeology*. New York: John Wiley & Sons, Inc.

de Dreuzy et al. (de Dreuzy, J.-R., J. Carrera, M. Dentz, and T. Le Borgne), 2012. "Asymptotic Dispersion for Two-Dimensional Highly Heterogeneous Permeability Fields Under Temporally Fluctuating Flow." *Water Resources Research* 48:W01532. Available at: https://doi:10.1029/2011WR011129.

Ecology (Washington State Department of Ecology), 2007. Consent Decree No. 07-2-022577-7 for the Whatcom Waterway Site (with Exhibits). Filed September 24, 2007.

Ecology, 2011. First Amendment to the Consent Decree 07-2-02257-7 for the Whatcom Waterway Site (with Exhibits). Filed August 19, 2011.

Ecology, 2024. Second Amendment to the Consent Decree 07-2-02257-7 for the Whatcom Waterway Site. Filed March 27, 2024.

Gelhar, L.W., C. Welty, and K.R. Rehfeldt, 1992. "A Critical Review of Data on Field-Scale Dispersion in Aquifers." *Water Resources Research* 28(7):1955–1974. Available at: https://doi.org/10.1029/92WR00607.

Go, J., D.J. Lampert, J.A. Stegemann, and D.D. Reible, 2009. "Predicting Contaminant Fate and Transport in Sediment Caps: Mathematical Modeling Approaches." *Applied Geochemistry* 24(2009):1347–1353.

Hayduk, W., and H. Laudie, 1974. "Prediction of Diffusion Coefficients for Nonelectrolytes in Dilute Aqueous Solutions." *AIChE Journal* 20(3):611–615.

ITRC (Interstate Technology and Regulatory Council), 2014. *Contaminated Sediments Remediation: Remedy Selection for Contaminated Sediments (CS-2)*. Washington, D.C.: Interstate Technology and Regulatory Council, Contaminated Sediments Team. Available at: https://clu-in.org/download/contaminantfocus/sediments/Sediment-ITRC-CS-2.pdf.

ITRC (Interstate Technology & Regulatory Council), 2023. Sediment Cap Chemical Isolation Guidance (SD-1). Washington, D.C.: Interstate Technology & Regulatory Council. www.itrcweb.org.

Karickhoff, S.W., 1984. "Organic Pollutant Sorption in Aquatic System." *Journal of Hydraulic Engineering* 110(6):707–735.

La Licata, I., C.D. Langevin, A.M. Dausman, and L. Alberti, 2011. "Effect of Tidal Fluctuations on Transient Dispersion of Simulated Contaminant Concentrations in Coastal Aquifers." *Hydrogeology Journal* 19:1313–1322. Available at: https://link.springer.com/article/10.1007%2Fs10040-011-0763-9.

Lampert, D.J., and D. Reible, 2009. "An Analytical Modeling Approach for Evaluation of Capping of Contaminated Sediments." *Soil and Sediment Contamination: An International Journal* 18(4):470–488.

LBG (The Louis Berger Group), Battelle, and HDR|Hydroqual, 2014. *Lower Eight Miles of the Lower Passaic River: Remedial Investigation Report for the Focused Feasibility Study*. *Prepared for U.S. Environmental Protection Agency, Region 2, and U.S. Army Corps of Engineers, Kansas City District*. Appendix Biii. *Lower Passaic River Contaminant Fate and Transport Model*. Accessed November 3, 2021. Available at: https://sharepoint.ourpassaic.org/Public%20Documents/2014_02_10_App_BIIICarbon_Contaminants_HDR.pdf.

Millington, R.J., and J.P. Quirk, 1961. "Permeability of Porous Solids." *Transactions of the Faraday Society* 57:1200–1207.

Neuman, S.P., 1990. "Universal Scaling of Hydraulic Conductivities and Dispersivities in Geologic Media." *Water Resources Research* 26(8):1749–1758.

Officer, C.B., and D.L. Lynch, 1989. Bioturbation, Sedimentation, and Sediment-Water Exchanges. *Estuarine Coastal and Shelf Science* 28:1–12.

Palermo, M., S. Maynord, J. Miller, and D. Reible, 1998. *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments*. USEPA 905-B96-004. Great Lakes National Program Office, Chicago, Illinois.

Reidy, D., K. Russell, J. Harrison Rice, M. Mahoney, and K.E. Lento, 2015. *Achieving Higher Confidence in Cap Design Modeling through Calibration*. Eighth (8th) International Conference on the Remediation of Contaminated Sediments (New Orleans, Louisiana); February 2015.

Reible, D., 2012. *Model of 2 Layer Sediment Cap, Description and Parameters*. Version - 2 Layer Analytical Model v.1.18 and Active Cap Layer Model v 4.1. Available at: https://www.depts.ttu.edu/ceweb/groups/reiblesgroup/downloads/2%20layer%20analytical%20model%20description.doc.

Reible, 2023. *CapSim 4.2 Basic Users Manual*. Accessed November 11, 2023. Available at: https://www.depts.ttu.edu/ceweb/research/reiblesgroup/CapSim_4.2_Basic_User_Manual.pdf

RETEC, 2006. *Supplemental Remedial Investigation & Feasibility Study*. Prepared for the Port of Bellingham. October 10, 2006.

Schwarzenbach, R.P., P.M. Gschwend, and D.M. Imboden, 1993. *Environmental Organic Chemistry*. New York: John Wiley & Sons, Inc.

Shen, X., D. Lampert, S. Ogle, and D. Reible, 2018. "A Software Tool for Simulating Contaminant Transport and Remedial Effectiveness in Sediment Environments." *Environmental Modelling and Software* 109(2018):104-113.

ThermoRetec (ThermoRetec Consulting Corporation), 2001. *Remedial Investigation and Feasibility Study, Roeder Avenue Landfill, Bellingham, Washington*. Prepared for Port of Bellingham. October 1, 2001.

Thibodeaux, L.J., and D. Mackay, 2011. *Handbook of Chemical Mass Transport in the Environment*. Boca Raton, Florida: CRC Press.

Thibodeaux, L.J., K.T. Valsaraj, and D.D. Reible, 2001. "Bioturbation-Driven Transport of Hydrophobic Organic Contaminants from Bed Sediment." *Environmental Engineering Science* 18(4):215–223.

USEPA (U.S. Environmental Protection Agency), 2000. *Technical Basis for the Derivation of Equilibrium Partitioning Sediment Quality Guidelines (ESGs) for the Protection of Benthic Organisms: Nonionic Organics*. EPA-822-R-00-001. June 2000.