APPENDIX G – MONITORING
EAST WATERWAY OPERABLE UNIT FEASIBILITY STUDY

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June 2019

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1 INTRODUCTION

This appendix presents the rationale and conceptual structure for a multi-component East Waterway (EW) Operable Unit (OU) monitoring program. The conceptual monitoring program serves solely as the basis for estimating the costs of monitoring associated with each remedial alternative in Appendix E of the Feasibility Study (FS). Because it is solely for the limited purpose of costing, the conceptual monitoring program uses several simplifying assumptions and is not intended to represent the specific scope, timing, and duration of monitoring that will eventually occur in the EW. The final cleanup will include a monitoring program with a statistical basis for demonstrating compliance with applicable criteria and standards and the success of remedial alternatives, as well as provisions for adjusting the monitoring program to support adaptive management decisions. These details will be determined in the Record of Decision and during remedial design.

The monitoring program described herein is sufficiently broad, detailed, and consistent with guidance to fulfill FS-level scope and cost estimation objectives. The elements of the monitoring program described in this appendix include the following:

- Pre-construction baseline monitoring
- Construction monitoring and confirmational sampling
- Operations and maintenance monitoring
- Long-term monitoring

This appendix sets forth assumptions regarding quantities and frequencies of sampling and reporting that form the basis for cost estimation. Table 1 presents a summary of monitoring assumptions by monitoring category and matrix. Table 2 presents additional detail on assumptions for long-term monitoring for each remedial alternative. The sampling scope in Table 2 is used as the basis for estimating monitoring costs in Appendix E of the FS.

2 MONITORING OBJECTIVES

The general goals of monitoring are to support effective remedial design, verify that design goals have been met, and measure effectiveness following construction. The monitoring objectives specific to the monitoring elements are provided in the following bullets:

- **Pre-construction baseline monitoring:** Establish baseline conditions for comparison to post-construction performance monitoring results.
- **Construction monitoring and confirmational sampling:** Protect human health and the environment during construction activities, comply with regulatory requirements, verify that construction is performed to specifications, and assess the need for construction contingencies, such as the placement of residuals management cover following dredging.
- **Operations and maintenance monitoring:** Measure the post-construction and long-term performance of remedial technologies. This type of monitoring targets the performance of specific remedial technologies (e.g., cap stability).
- **Long-term monitoring:** Measure the post-construction and long-term performance of remediation toward achievement of remedial action objectives (RAOs) that ensure protection of human health and the environment. This type of monitoring targets parameters that indicate performance relative to the RAOs (e.g., site-wide average concentrations).

3 PRE-CONSTRUCTION BASELINE MONITORING

The objective of baseline monitoring is to establish a site-wide basis for comparing pre- and post-construction conditions. Baseline monitoring occurs before construction commences and has some overlap with remedial design sampling and data collection (Section 8.1.3 of the FS). Data for baseline monitoring is described in this section and summarized in Tables 1 and 2. Costs for pre-construction baseline monitoring presented in Appendix E of the FS are based on the approximate costs associated with the sampling program described herein. Baseline sampling is assumed to have similar scope as long-term monitoring in years 5, 10, 15, and 20 for the alternatives (Table 2). Baseline monitoring also includes a site-wide bathymetric survey; however, this is included as a separate line item in the cost estimate.

One aspect of pre-construction baseline monitoring is to measure seafood tissue concentrations. For this evaluation, additional tissue data are assumed to be collected to establish a site-wide composite seafood tissue concentration, represented by various species and tissue types for site-wide consumption scenarios (e.g., English sole [*Parophrys vetulus*], shiner surfperch [*Cymatogaster aggregate*], crab [*Cancer magister* or *Cancer productus*], and clams such as butter clams [*Saxidomus gigantean*]).

Another aspect of pre-construction baseline monitoring is sediment chemistry, including surface sediment concentrations for the key exposure areas of the site: site-wide (RAOs 1, 2, and 4) and in potential clamming areas (RAO 2) and on a point-by-point basis (RAO 3). Sampling media and densities are assumed to be consistent with Long-term Monitoring, described in Sections 5 and 6 of this appendix, respectively, and include surface sediment chemistry (site-wide), surface sediment porewater (only in situ treatment and enhanced natural recovery [ENR] areas), surface water, and subsurface sediment chemistry (only in situ treatment areas).

4 CONSTRUCTION MONITORING AND CONFIRMATIONAL SAMPLING

Construction monitoring during remediation is used to protect human health and the environment during construction activities, and to evaluate whether the project is being constructed in accordance with plans, specifications, and permit requirements. Construction monitoring will be determined during remedial design and permitting, and is assumed to include the following:

- Daily contractor progress bathymetric surveys in removal and placement areas.
- Daily field-based water quality monitoring in the immediate vicinity of the remediation activities to demonstrate compliance with water quality certification requirements (e.g., physical measures such as turbidity) to determine whether the resuspension of contaminated sediments and their downgradient movement are being adequately controlled.
- Intermittent collection of downcurrent water column samples for chemical analyses (e.g., polychlorinated biphenyls [PCBs]). The need for chemical analyses will be based on the screening results from the daily field-based water quality monitoring during dredging and sand placement activities. A portion of these samples will be submitted for chemical analyses regardless of field-based monitoring results.
- Bathymetric surveys, assumed to be site-wide events, one before and one after each construction season.

Costs for construction monitoring are based on daily and annual contractor costs for surveys and daily costs for water quality monitoring (see Appendix E of the FS).

The objective of confirmational sampling is to demonstrate whether, after construction, the cleanup complies with project requirements and design specifications (e.g., surface sediment contaminant concentrations are below the remedial action levels [RALs]; minimum ENR thickness meets requirements in specifications), and to assess the need for construction contingencies such as residuals management cover. Confirmational sampling is assumed to occur prior to contractor demobilization as phases of work are completed. Costs for confirmational sampling are assumed to be the same as those for year 1 Operations and Maintenance Monitoring and Long-term Monitoring for the remedial alternatives (Appendix E).

5 OPERATIONS AND MAINTENANCE MONITORING

The purpose of operations and maintenance monitoring is to assess the effectiveness of the remedial technologies (e.g., the stability of a sediment cap, or the rate of natural recovery in monitored natural recovery [MNR] areas). Operations and maintenance monitoring is summarized in Tables 1 and 2 and includes monitoring shortly after construction (i.e., year 1 post-construction) and monitoring in the long term (i.e., for 20 years following construction). Costs for operations and maintenance monitoring presented in Appendix E of the FS are based on the approximate costs associated with the sampling program described herein. This includes technology-specific sampling for performance of specific locations. Sampling media and densities in years 1, 5, 10, 15, and 20 post-construction are assumed to include surface sediment chemistry (all technology areas), surface sediment porewater (only in situ treatment and ENR areas), and subsurface sediment chemistry (only in situ treatment areas) (Table 1). Analysis will occur for the analytes listed in Table 1. Bathymetric survey and physical inspections (e.g., diver inspections) will also occur in capping, ENR, and in situ treatment areas in years 1, 5, 10, 15, and 20 post-construction. In year 3 post-construction, operations and maintenance monitoring is assumed to be performed only within in situ treatment, ENR, and MNR areas, where additional time-trend data (i.e., in addition to years 1 and 5) will be valuable for understanding contaminant trends.

6 LONG-TERM MONITORING

Long-term monitoring for tissue is assumed to be similar in scope to baseline sampling (described in Section 3), so that monitoring results can be compared. Tissue concentrations are anticipated to be measured as five composite samples for English sole, perch, crab, and intertidal clams in years 1, 3, 5, 10, 15, and 20 following construction (20 composite samples). As discussed in Section 7.2.6, dredging residuals could result in elevated fish and shellfish tissue concentrations due to impacts to the water column; therefore, tissue samples measured within 2 years of construction are more likely to be influenced by construction related releases than post-construction sediment conditions. Surface water sampling is also assumed to be similar in scope to baseline sampling and measured in years 1, 5, 10, 15, and 20 following construction. The final monitoring framework will be developed in remedial design.

Sediment chemistry will include surface sediment samples for the key exposure areas of the site: site-wide (RAOs 1, 2, 3 and 4) and in clamming areas (RAO 2). Achievement of RAO 3 is measured by site-wide sampling on a point-by-point basis, whereas other RAOs are based on 95% upper confidence limit on the mean (UCL95) based on site-wide or clamming area-wide sampling. Sampling will occur at the appropriate points of compliance (top 10 centimeters [cm] site-wide for all RAOs, and top 25 cm in intertidal areas for the RAO 2 portion for tribal clamming). For the purpose of defining the monitoring scope, long-term monitoring has been combined with operations and maintenance monitoring in Tables 1 and 2.

TABLES

Table 1
Long-term Monitoring Assumptions for Remedial Alternatives

Monitoring Category	Surface Sediment[a]	Porewater[b]	Subsurface Sediment[c]	Tissue[d]	Surface Water[e]	Bathymetric Survey and Physical Inspections
Pre-construction Baseline Sampling	Baseline sampling includes surface sediment, subsurface sediment, tissue, and bathymetric surveys for the purpose of establishing site-wide conditions. Assumed to have similar scope as years 5, 10, 15, and 20 Operations and Maintenance Monitoring and Long-term Monitoring for the alternatives.					
Construction Monitoring and Confirmational Sampling	Determined during remedial design, assumed to include water quality monitoring during removal and placement activities, surface sediment, and physical inspection. Confirmation sampling assumed to have similar scope as year 1 Operations and Maintenance Monitoring and Long-term Monitoring for the alternatives.					
Operations and Maintenance Monitoring and Long-term Monitoring						
Year 1						
Site-wide	Sampling in technology areas provides site-wide coverage	n/a	n/a	5 composites for 3 species (sole, crab, and perch)	2 locations, 2 depths, 2 measurements (8 total samples)	--
Clamming areas	Sampling in technology areas provides coverage	n/a	n/a	5 composites of clams	n/a	n/a
Open-water						
Dredging	1 sample/4 acres	--	--	n/a	n/a	n/a
Capping	1 sample/2 acres			n/a	n/a	Bathymetric survey and physical inspections
ENR		1 sample/acre		n/a	n/a	
No action	1 sample/4 acres	--		n/a	n/a	n/a
Underpier and Under Low Bridges						
Dredging	1 sample/2 acres	--	--	n/a	n/a	n/a
In situ treatment	1 sample/acre	1 sample/acre	1 core/acre	n/a	n/a	Bathymetric survey and physical inspections
ENR		--	--	n/a	n/a	
MNR				n/a	n/a	n/a
No action	1 sample/2 acres			n/a	n/a	n/a
Year 3						
Site-wide	--	n/a	n/a	5 composites for 3 species (sole, crab, and perch)	--	--
Clamming areas	--	n/a	n/a	5 composites of clams	n/a	n/a
Open-water						
Dredging	--	--	--	n/a		
Capping						
ENR	2 samples/2 acres	1 sample/acre				
No action	--	--				
Underpier and Under Low Bridges						
Dredging	--	--	--	n/a		
In situ treatment	1 sample/acre	1 sample/acre	1 core/acre			
ENR		--	--			
MNR						
No action	--					
Years 5, 10, 15, and 20						
Site-wide	Sampling in technology areas provides site-wide coverage	n/a	n/a	5 composites for 3 species (sole, crab, and perch)	2 locations, 2 depths, 2 measurements (8 total samples)	--
Clamming areas	Sampling in technology areas provides coverage	n/a	n/a	5 composites of clams	n/a	n/a
Open-water						
Dredging	1 sample/4 acres	--	--	n/a	n/a	n/a
Capping	1 sample/2 acres			n/a	n/a	Bathymetric survey and physical inspections
ENR		1 sample/acre		n/a	n/a	
No action	1 sample/4 acres	--		n/a	n/a	n/a
Underpier and Under Low Bridges						
Dredging	1 sample/2 acres	--	--	n/a	n/a	n/a
In situ treatment	1 sample/acre	1 sample/acre	1 cores/acre	n/a	n/a	Bathymetric survey and physical inspections
ENR		--	--	n/a	n/a	
MNR				n/a	n/a	n/a
No action	1 sample/2 acres			n/a	n/a	n/a

Notes:
-- = no monitoring
n/a = not applicable
1. Monitoring assumptions are for Feasibility Study cost purposes; monitoring framework will be developed in design.
a. Assume all samples are analyzed for total PCBs (as Aroclors), arsenic, cPAHs, and the 29 benthic risk-driver COCs, and associated conventional parameters (e.g., TOC, grain size, and percent solids), and 25% of samples are analyzed for dioxins/furans, PCB congeners, and other COCs. Sediment toxicity would be performed as necessary (assume 25% of samples).
b. Assume all porewater samples are analyzed for PCB congeners and dioxins/furans.
c. Assume cores consist of 4 samples each, analyzed for total PCBs (as Aroclors), arsenic, cPAHs, all SMS contaminants, and associated conventional parameters (e.g., TOC, grain size, and percent solids), and 25% of samples are analyzed for dioxins/furans, PCB congeners, and other COCs.
d. Assume all composite tissue samples are analyzed for arsenic, cPAHs, and PCBs (as Aroclors) and 25% of samples are analyzed for dioxins/furans, PCB congeners, and other COCs.
e. Assume surface water is analyzed only for TBT (only surface water COC).
COC - contaminant of concern
ENR - enhanced natural recovery
MNR - monitored natural recovery
SMS - Sediment Management Standards
TBT - tributyltin
TOC - total organic carbon

Table 2
Long-term Monitoring for Remedial Alternatives

Alternative (PCB RAL in mg/kg OC)	Surface Sediment Samples (All Areas)	Porewater Samples (ENR and In Situ Treatment Areas)	Cores (In Situ Treatment Areas)	Tissue Composite Samples (5 Composites for Each of Sole, Crab, Perch, and Clam)	Surface Water Samples (2 Locations, 2 Depths, 2 Measurements)	Bathymetric Survey and Physical Inspection Events
Pre-construction Baseline Sampling. Baseline sampling includes surface sediment, subsurface sediment, tissue, and bathymetric surveys for the purpose of establishing site-wide conditions. Assumed to have similar scope as years 5, 10, 15, and 20 Operations and Maintenance Monitoring and Long-term Monitoring for the alternatives.						
Construction Monitoring and Confirmational Sampling. Determined during remedial design, assumed to include water quality monitoring during removal and placement activities, surface sediment, and physical inspection. Confirmation sampling assumed to have similar scope as year 1 Operations and Maintenance Monitoring and Long-term Monitoring for the alternatives.						
Operations and Maintenance Monitoring and Long-term Monitoring						
Year 1						
No Action	39	0	0	0	0	0
1A(12)	62	0	0	20	8	1
1B(12)	62	13	13	20	8	1
1C+(12)	62	13	13	20	8	1
2A(12)	58	0	0	20	8	1
2B(12)	58	13	13	20	8	1
2C(12)	57	11	11	20	8	1
2C+(12)	58	13	13	20	8	1
3B(12)	56	13	13	20	8	1
3C+(12)	56	13	13	20	8	1
3D(12)	50	0	0	20	8	1
2C+(7.5)	56	13	13	20	8	1
3C+(7.5)	54	13	13	20	8	1
3E(7.5)	55	13	13	20	8	1
2C+(5.0)	58	14	14	20	8	1
3D(5.0)	49	0	0	20	8	1
3E(5.0)	56	14	14	20	8	1
Year 3						
No Action	0	0	0	0	0	0
1A(12)	31	0	0	20	0	0
1B(12)	31	13	13	20	0	0
1C+(12)	31	13	13	20	0	0
2A(12)	23	0	0	20	0	0
2B(12)	23	13	13	20	0	0
2C(12)	21	11	11	20	0	0
2C+(12)	23	13	13	20	0	0
3B(12)	19	13	13	20	0	0
3C+(12)	19	13	13	20	0	0
3D(12)	6	0	0	20	0	0
2C+(7.5)	23	13	13	20	0	0
3C+(7.5)	19	13	13	20	0	0
3E(7.5)	20	13	13	20	0	0
2C+(5.0)	24	14	14	20	0	0
3D(5.0)	6	0	0	20	0	0
3E(5.0)	20	14	14	20	0	0
Years 5, 10, 15, and 20						
No Action	39	0	0	0	0	0
1A(12)	62	0	0	20	8	1
1B(12)	62	13	13	20	8	1
1C+(12)	62	13	13	20	8	1
2A(12)	58	0	0	20	8	1
2B(12)	58	13	13	20	8	1
2C(12)	57	11	11	20	8	1
2C+(12)	58	13	13	20	8	1
3B(12)	56	13	13	20	8	1
3C+(12)	56	13	13	20	8	1
3D(12)	50	0	0	20	8	1
2C+(7.5)	56	13	13	20	8	1
3C+(7.5)	54	13	13	20	8	1
3E(7.5)	55	13	13	20	8	1
2C+(5.0)	58	14	14	20	8	1
3D(5.0)	49	0	0	20	8	1
3E(5.0)	56	14	14	20	8	1

Notes:

1. Monitoring assumptions are for Feasibility Study cost purposes; monitoring framework will be developed in design.
2. For the action alternatives, sampling scope is based on the sampling densities in Table 1. For the No Action Alternative, sampling is based on one surface sediment sample every 4 acres of sediment approximately every 5 years.

ENR - enhanced natural recovery
mg/kg - milligram per kilogram
OC - organic carbon
PCB - polychlorinated biphenyl
RAL - remedial action level