THEA FOSS AND WHEELER-OSGOOD WATERWAYS REMEDIATION PROJECT

OPERATIONS, MAINTENANCE, AND MONITORING PLAN

SEPTEMBER 2006





Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY

Prepared by:

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1.0 INTRODUCTION

This document presents the Operations, Maintenance, and Monitoring Plan (OMMP) for the Thea Foss and Wheeler-Osgood Waterways Remediation Project located in Tacoma, Washington. A project location map is presented in Figure 1-1. Remediation construction was completed in 2006 by the City of Tacoma (City) under a Consent Decree (CD) issued by the Environmental Protection Agency (EPA). This OMMP is the formal document that specifies the post-construction operations, maintenance and monitoring, and corrective action procedures planned for this site. This OMMP fulfills the City's requirement to prepare a long-term monitoring plan for the project and will be subject to EPA's 5-year review process for the Commencement Bay Nearshore Tideflats (CB/NT) Superfund Site.

This OMMP describes long-term qualitative, physical, and chemical monitoring to be completed at the site and sets forth specific performance standards for planned monitoring activities to demonstrate that the long-term objectives for the project are met. The OMMP also details the process for contingency planning and presents possible response actions in the event that performance standards are not achieved. This OMMP may be revised and updated as necessary, as agreed upon by EPA and the City, to improve and better describe work processes, and to adapt to new information and technological updates.

This OMMP was prepared in compliance with the Record of Decision (ROD) (EPA 1989), Administrative Order on Consent (AOC) / Statement of Work (SOW) (EPA 1994) for pre-remedial design investigation and remedial design, Explanation of Significant Difference (ESD) (EPA 1997), 2000 ESD, 2004 ESD, and the CD/SOW (EPA 2003) for remediation construction. This OMMP also considered long-term monitoring approaches currently being implemented at other EPA Region 10 Superfund sites located in Commencement Bay and Puget Sound. The work specified under this plan will be conducted under the Consent Decree and associated SOW dated May 9, 2003 (EPA 2003). The OMMP is an integrated program designed to evaluate and ensure the effectiveness of the remedial action relative to the project Remedial Action Objectives (RAO).

Details on the investigation, design, and construction activities completed as part of the site cleanup are detailed in the following documents:

- Remedial Design Work Plan (City of Tacoma 1995)
- Round 1 Data Evaluation Report (City of Tacoma 1995)
- Screening of Remedial Options Report (SROR) (City of Tacoma 1996)
- Round 2 Data Evaluation Report (City of Tacoma 1997)
- Round 3 Pre-Remedial Design Sampling and Analysis Plan (SAP) and Sampling and Analysis Plan, Sediment Management Area 7 (City of Tacoma 1997)
- Remedial Action Alternative Technical Memorandum (City of Tacoma 1997)
- Round 3 Data Evaluation and Pre-Remedial Design Evaluation Report (City of Tacoma 1999)
- Final Design, Design Analysis Report (City of Tacoma 2003)
- Remedial Action Construction Report (RACR) (City of Tacoma 2006)

The City's pre-remedial design work and the 2000 ESD identified seven Superfund Sediment Management Areas (SSMA), and many sub-areas, within the Thea Foss and Wheeler-Osgood Waterways. To facilitate the remedial design for the project, the City converted the seven SSMAs to Remedial Areas (RAs) where remediation activities were needed. In some cases several SSMAs and sub-areas were combined to form a single RA. The correlation between the RAs and the SSMAs is presented in Table 1-1. The completed remedial actions for the project and descriptions of these actions are documented in the Remedial Action Construction Report (RACR) prepared by the City (RACR 2006) and are summarized in Table 1-2 and illustrated on Figure 1-2.

Also shown on Figure 1-2 is the Utilities work area. In this area, monitoring will be performed by the Utilities in accordance with their Operations, Maintenance and Monitoring Plan (PacifiCorp 2003). The City will work cooperatively with the Utilities work group to respond to any incidences of recontamination in this area.

1.1 Demonstration of Meeting Remedial Action Objectives

Demonstration of meeting the RAOs during construction was provided by inspections and agency oversight that determined the remedial actions were successfully implemented relative to the EPA-approved remedial design plans and specifications. Construction inspections included physical and chemical verification of the remedial actions both during and after the construction activities were completed. Remedial actions included dredging certain areas of the site to remove sediments with chemical concentrations greater than Sediment Quality Objectives (SQO), placement of cap materials on sediments exceeding SQOs, as well as identifying and implementing enhanced monitored natural recovery (henceforth referred to as enhanced natural recovery) and monitored natural recovery (MNR; henceforth referred to as natural recovery) in areas where sediment concentrations marginally exceeded SQOs. Within the enhanced natural recovery and natural recovery areas, sediment concentrations are expected to recover to levels below SQOs within a 10-year period following the completion of construction. The habitat mitigation and enhancement sites are subject to monitoring to confirm their functions relative to site specific performance standards.

1.1.1 In-Situ Capping

The remedial action for capped areas, which includes channel sand caps, slope caps, and grout mat caps, specified that the caps must have a minimum thickness of three feet and will address adverse impacts by physically isolating contaminated sediments from ecological receptors, stabilize contaminated sediments to prevent re-suspension and transport to other locations in the waterway, reduce contaminant transport through groundwater pathways, and provide a surface that promotes colonization by aquatic organisms. In some RAs, sediments were dredged prior to placement of the cap to allow for installation of the cap without any reduction of existing water depth or infringement on Federally-authorized navigation requirements. In many cases, navigational depths were significantly improved and brought into compliance with the Federally-authorized channel depth requirements through this initial dredging.

The requirement that the cap consist of a minimum thickness was satisfied by a combination of calculating the volume of material placed over a given area as determined by placement rates and by bathymetric surveys.

1.1.2 Dredge and Confined Disposal

The remedial action for dredged areas specified that sediments exceeding the SQO criteria were to be dredged and disposed of in the St. Paul Confined Disposal Facility (CDF). The depth of dredging was determined by the use of pre-construction core sediment samples and progress surface sediment samples and analyses for SQOs. Within the dredge areas, sediments were dredged to a clean surface or dredged and capped after the quality of the sediments exposed by the dredging was documented. Verification sampling and analysis demonstrated that the areas that were dredged to clean met the SQOs and that the areas that were capped following dredging met both the cap thickness requirements and the SQO at the cap's surface. Dredged materials were disposed of within the CDF located in the St. Paul Waterway.

1.1.3 Natural Recovery and Enhanced Natural Recovery

The ROD and ESD allow for natural recovery and enhanced natural recovery in areas that are expected to recover to below the SQO through natural sedimentation, mixing, and other processes within 10 years of completion of the remedial action. Verification sampling for adjacent RAs performed during construction confirmed that the sediment concentrations within the natural recovery and enhanced natural recovery areas of the site are at levels that are expected to attenuate to below the SQOs within the 10-year compliance period. In some cases, verification sampling showed that parts of the natural recovery areas are currently below the SQOs. During design, enhanced natural recovery was determined to be appropriate in an area of RA 7 where minor exceedances of the SQOs were identified by pre-design sampling.

Long-term monitoring will be performed in sediment areas designated for natural recovery or enhanced natural recovery to ensure that the contaminant concentrations are decreasing over time and will be at levels below SQO criteria within the 10-year compliance period.

1.1.4 Habitat Mitigation

To mitigate for habitat impacts resulting from the remedial actions completed in the Thea Foss and Wheeler-Osgood Waterways and partially filling the St. Paul Waterway, multiple shoreline habitat enhancements and habitat mitigation sites were constructed. These habitat enhancements and mitigation areas are located within the Thea Foss and Wheeler-Osgood Waterways, the adjacent Middle and St. Paul Waterways, and along the Puyallup River and Hylebos Creek (Figure 1-1). The designations for the habitat enhancements and mitigation sites are summarized in Table 1-3. Table 1-3 correlates the current habitat designation with previous designations for the habitat areas. Maintaining the integrity of the habitat mitigation areas and the viability of the plantings are included in this OMMP.

1.2 Objective and Scope of the OMMP

This OMMP has been prepared to ensure that the completed remedial actions performed at the site achieve the performance objectives as specified in the ROD and subsequent ESDs as related to the protection of surface sediment, surface water, and biological and physical habitat quality.

The RAO for the cleanup is stated in the ROD as:

- The objective of the selected remedy is to achieve acceptable sediment quality in a reasonable timeframe.

Additional language in the ROD states that the remedy was designed to incorporate the following:

- Natural recovery considerations are used to identify sediment remedial action levels that delineate sediments that are allowed to recover naturally from those that require active sediment cleanup;
- The sediment quality objective also applies to source controls requirements. Monitoring sources and sediments will be used to determine the effectiveness of source controls; and
- Habitat function and enhancement of fisheries resources will also be incorporated as part of the overall project cleanup objectives.

Specific details of the project RAOs and requirements for the design and implementation of the remedy are presented in Table 1-4.

Specific details of the project RAOs and objectives for monitoring of the remedy and the subsequent OMMP activities that meet those requirements are presented in Table 1-5.

To meet the monitoring objectives (Table 1-5), the following monitoring will be performed:

- Performance monitoring of capped, enhanced natural recovery, and natural recovery areas located within the Thea Foss and Wheeler-Osgood Waterways to evaluate the long-term effectiveness of the remedial actions and progress toward natural recovery;
- Cap integrity monitoring through low tide inspections and hydrographic surveys to ensure that the sediment caps remain intact;
- Early warning monitoring of remediated areas within the Thea Foss and Wheeler-Osgood Waterways to evaluate the potential for recontamination;
- Benthic recolonization monitoring to evaluate the post-construction recovery of benthic organism communities within the Thea Foss and Wheeler-Osgood Waterways;
- Monitoring of groundwater quality in the vicinity of the St. Paul CDF, to ensure the contaminated dredged sediments are effectively contained in the disposal facility; and
- Habitat area monitoring to evaluate habitat conditions established within the project area and to confirm that mitigation sites are making progress toward providing habitat function necessary to meet site specific objectives.

1.3 Chemicals of Concern

Chemicals of Concern (COC) to be evaluated for sediment performance monitoring and early warning monitoring include those sediment chemical constituents with established SQOs used to verify completion of remedial actions. The CB/NT SQOs were derived from the long-term sediment quality goal for Puget Sound, defined by PSWQA (1988) as the absence of acute or chronic adverse effects on biological resources or significant human health risk as described in the ROD (1989). Conventional parameters such as total organic carbon (TOC) and Total Solids will also be evaluated.

1.4 Schedule of Monitoring and Reporting Activities

A target milestone schedule for monitoring and reporting activities is presented in Figure 1-3. A summary of the schedule is provided in Table 1-6. Figure 1-3 provides the general schedule relationships to ensure that monitoring activities are completed in a consistent manner over time. This schedule shows the target time frames for sampling, analyses, and reporting. Actual monitoring dates are, however, to be determined by EPA and the City prior to implementation of the monitoring activities. The actual monitoring activity schedule is subject to change from year to year due to availability of subcontractors, site access constraints beyond the control of the City, and supplemental sampling requirements (if necessary). The goal is to sample consistently in the same timeframes each time sampling is required.

For each monitoring event a Preliminary Findings Memorandum will be issued to EPA after the monitoring data validation has been completed. The purpose of the memorandum is to inform EPA of new monitoring results and to facilitate any decisions and/or contingency actions, if necessary. Given the purpose of the Preliminary Findings Memorandum, EPA approval of the document will not be required. For each monitoring year, an Annual Monitoring Report will be prepared presenting the final comprehensive information and data for the monitoring activities completed. The Annual Monitoring Report will also document any decisions and/or contingency actions, if implemented.

In general, the following topics will be addressed in the Annual Monitoring Reports:

- Sediment Remediation Area Performance Monitoring;
- Early Warning Monitoring for Recontamination;
- Benthic Recolonization Monitoring;
- Confined Disposal Facility Monitoring; and
- Habitat Mitigation Area Monitoring.

In addition, the City will provide a summary of the status of other related items, including but not limited to:

- Ecology's handling of material from the Puyallup River Side Channel site that is being temporarily stored in a temporary containment unit (TCU) at the Tacoma Metals property;
- Ongoing stormwater source control activities being performed under the Stormwater Workplan Addendum;

- Simpson's monitoring for the accumulation and redistribution of wood waste potentially resulting form their log storage and haul out operations; and
- Status of any response actions underway to address recontamination issues in the Utilities work area (see Figure 1-2).

The details of the report contents are described in the following relevant sections. The required Annual Monitoring Report will be submitted to EPA within 45 days of receipt of the final validated data for the last monitoring activity of a given year.

Additional monitoring of capped areas and the CDF may be conducted if a storm event that has led to shoreline failure, such as erosion or a landslide, a marine accident, such as a vessel grounding or spill, or a seismic event where structural damages have been realized within the City is determined to have potentially adversely impacted the integrity of the remedy or disposal site. Performance of supplemental monitoring will be coordinated with EPA.

1.5 Organization of the OMMP

This OMMP provides the requirements and specifications for sediment, groundwater, and habitat monitoring activities. Operational manuals for the completion of OMMP activities are provided in the appendices to this document and include information on the following:

- Data Quality Objectives (DQO) for sampling, analysis, inspection, and surveying activities;
- Requirements for sampling activities, including sample type, number, location, accuracy, and frequency of sampling;
- Requirements for surveying and visual inspection activities, including survey type, number, location, accuracy, and frequency of surveying;
- Physical, chemical, and biological analyses to be performed;
- Sampling, inspection and surveying methods and equipment; and
- Schedules for monitoring and reporting.

The sediment sampling locations within each RA for the various monitoring activities are presented in Table 1-7; CDF monitoring locations are presented in Table 1-8; and habitat mitigation monitoring locations are presented in Table 1-9.

Additionally, the OMMP provides decision matrices to facilitate the data evaluation process and provide guidance regarding evaluation of potential response actions and notifications to EPA that may be necessary in the event that the monitoring goals are not met.

The OMMP is organized into the following sections:

- Section 1.0 – Introduction
- Section 2.0 – Sediment Remediation Area Performance Monitoring
- Section 3.0 – Early Warning Monitoring for Recontamination

- Section 4.0 – Benthic Recolonization Monitoring
- Section 5.0 – Confined Disposal Facility Monitoring
- Section 6.0 – Habitat Mitigation Area Monitoring

Each section of the OMMP is divided into subsections defining the purpose and objectives, scope of work, monitoring approach, performance standards, schedule overview, and specific activities associated with each required monitoring category. The relationship between the monitoring activities to be performed and the sections and appendices of the OMMP is shown in Figure 1-4. The monitoring activities to be performed in each individual RA are shown in Figure 1-5. The sections of the OMMP are supported by appendices that specify the field methodologies, and quality assurance/quality control measures that will be utilized during the implementation of the monitoring program.

The OMMP appendices include the following:

- Appendix A – Physical Cap Integrity Operations Manual
- Appendix B – Sediment Sampling Operations Manual
- Appendix C – Benthic Recolonization Monitoring Operations Manual
- Appendix D – Confined Disposal Facility Monitoring Operations Manual
- Appendix E – Habitat Mitigation Area Monitoring Operations Manual
- Appendix F – Health and Safety Plan
- Appendix G – Institutional Controls Plan

The Institutional Controls Plan (Appendix G) is being developed through a separate process with EPA. Upon finalization, a copy of the document will be provided to planholders for inclusion in this report.

REFERENCES

City of Tacoma. 1995a. Remedial Design Work Plan, Thea Foss and Wheeler-Osgood Waterways, Tacoma, Washington. March 31, 1995.

City of Tacoma. 1995b. Round 1 Data Evaluation Report, Thea Foss and Wheeler-Osgood Waterways, Tacoma, Washington. May 30, 1995.

City of Tacoma. 1996. Screening of Remedial Options Report, Thea Foss and Wheeler-Osgood Waterways, Tacoma, Washington. November 15, 1996.

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City of Tacoma. 1997b. Round 3 Pre-Remedial Design Sampling and Analysis Plan and Sampling and Analysis Plan, Sediment Management Area 7, Thea Foss and Wheeler-Osgood Waterways, Tacoma, Washington. June 13, 1997.

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PacifiCorp. 2003. Head of the Thea Foss Waterway Remediation Project, Tacoma, Washington, Operations, Maintenance and Monitoring Plan. August 27, 2003.

U.S. Environmental Protection Agency (EPA). 1989. Commencement Bay Nearshore/Tideflats Record of Decision (ROD). Region 10. September 1989.

U.S. Environmental Protection Agency (EPA). 1994. Administrative Order on Consent (AOC) for Remedial Design Study. March 23, 1994.

U.S. Environmental Protection Agency (EPA). 1997. Explanation of Significant Difference-PCB, Commencement Bay Nearshore/Tideflats Superfund Site, Tacoma, Washington. July 1997.

U.S. Environmental Protection Agency (EPA). 2000. Explanation of Significant Differences – Commencement Bay Nearshore/Tideflats Superfund Site. Region 10. August 3, 2000.

U.S. Environmental Protection Agency (EPA). 2003. Consent Decree and Statement of Work for RD/RA of the Thea Foss and Wheeler Osgood Waterways Problem Areas, Commencement Bay Nearshore/Tideflats Superfund Site. Region 10. May 9, 2003.

U.S. Environmental Protection Agency (EPA). 2004. Explanation of Significant Differences – Commencement Bay Nearshore/Tideflats Superfund Site. Region 10. September 2004.

TABLES

FIGURES

Table 1-1
Correlation Between RAs and SSMAs

Remedial Areas (RA)	Superfund Sediment Management Areas (SSMA)
RA 1A & RA 1B	1e1 and 1e2
RA 2	2b5
RA 3	2a2
RA 4	2b4
RA 5	3b1, 3b2, 3b4, and 5b1
RA 6	3b3, 3b5a, 3b5b, 5b2a, 5b2b, 5b3a, 5b3b, and 5b4
RA 7 & RA 7A	3c1 and 3c2 (partial)
RA 8	3c2 (partial), 3d, and 5c
RA 9	4c
RA 10 & RA 11	4d2
RA 12	4a
RA 13	4d1
RA 14	5a2
RA 15	6a2a
RA 16	6a2b and 6b3
RA 17	6b1
RA 18	6b2
RA 19A	6b4, 6b5, 7c (partial), and 7d1 (partial)
RA 19B	7c (partial), 7d1 (partial), and 7d2
RA 20	7a and 7b1
RA 21	7b2
RA 22	7b3a

Table 1-2
Project Actions and Descriptions

Action	Action Description	Remedial Areas (RA)
Slope Rehabilitation[1]	Removal of anthropogenic debris (i.e., concrete, piling, etc.) and/or placement of import material (i.e., armoring, habitat mix, etc.) to stabilize, flatten, and/or provide more suitable habitat.	RA 10, RA 11, RA 13, and RA 15
Natural Recovery	Areas that are not designated for active remedial action because the area is expected to recover naturally (i.e., surface sediment concentrations will meet the SQOs) within 10 years of completion of sediment remedial action.	Northern portions of RA 5, RA 6, and RA 7
Enhanced Natural Recovery	Placement of a thin layer (i.e., six inches) of clean material (i.e., channel sand cap material) to facilitate natural recovery within 10 years of completion of the remedial action.	RA 7
Habitat Enhancement[1]	Modification to an existing shoreline area to enhance habitat development that may include constructing a benched area at a specific elevation, modifying the substrate, and/or installing large woody debris and/or plants.	RA 8 and RA 20
Backfill[1]	Placement of channel sand cap material to meet the surrounding grade (i.e., surrounding sediment surface elevation) in an area where dredging has removed sediment with chemical concentrations greater than the SQOs.	RA 2, RA 4, RA 6, and RA 12
Channel Sand Cap	Placement of a minimum of three feet of channel sand cap material comprised of imported sand (i.e., 100 percent passing 3/8-inch sieve size, 85-100 percent passing the No. 4 sieve size, and 25-45 percent passing the No. 10 sieve size) from an upland quarry to confine underlying sediment with chemical concentrations greater than the SQOs.	RA 1A, RA 6, RA 7A, RA 9, RA 16, RA 17, RA 18, RA 19A, RA 19B, RA 20, RA 21, RA 22, and the sheen source removal area
Slope Cap	Placement of a minimum of 18 inches of slope cap filter material comprised of imported sand and gravel (i.e., 100 percent passing the 6-inch sieve size, 35-65 percent passing the No. 4 sieve size, and 15-45 percent passing the No. 10 sieve size) from an upland quarry as a confining layer, followed by placement of a minimum of 18 inches of armoring (i.e., riprap or quarry spalls), followed by placement of habitat mix on the surface of the armoring layer. Habitat mix is comprised of an imported sand and gravel (i.e., 100 percent passing the 2-inch sieve size, 40-60 percent passing the No. 4 sieve size, and 30-50 percent passing the No. 10 sieve size) supplied by an upland quarry.	RA 1B, RA 3, RA 5, RA 8, RA14, RA 19A, RA 19B, and RA 20

Action	Action Description	Remedial Areas (RA)
Dredge to Clean	Removal of sediment with chemical concentrations that are greater than the SQOs at the final dredge surface.	RA 5, RA 6, RA 16, and RA 17
Grout Mat Cap	A mat placed to confine sediment with chemical concentrations greater than the sediment quality objectives, that is comprised of one or two six-inch thick layers of concrete, established by injecting grout into a fabric sheath that has been placed over a remedial area.	RA 3, RA 19A, and RA 19B

Note:
1) Completed action was not constructed for chemical containment and is not included in OMMP cap integrity monitoring requirements.

Table 1-3
Summary of Habitat Area Designations

<table>
<tr><th>Current Designation</th><th>Construction Report Designation</th><th>Design Documents / Biological Opinion</th></tr>
<tr><td rowspan="3">North Beach Habitat</td><td>Peninsula Habitat</td><td rowspan="2">North Beach Habitat</td></tr>
<tr><td>St. Paul Beach Habitat</td></tr>
<tr><td>Middle Waterway Corridor Habitat</td><td>Middle Waterway Corridor Habitat</td></tr>
<tr><td>Middle Waterway Tideflat Habitat</td><td>Middle Waterway Tideflat Habitat</td><td>Middle Waterway Brackish Marsh</td></tr>
<tr><td>Puyallup River Side Channel</td><td>Puyallup River Side Channel</td><td>Puyallup River Side Channel</td></tr>
<tr><td>Hylebos Creek Mitigation Site</td><td>Hylebos Creek Mitigation Site/Bunker Property Site</td><td>Remaining Habitat Deficit</td></tr>
<tr><td>Log Step Habitat Enhancement</td><td>Steam Plant Log Step Habitat</td><td>Foss Waterway Marina Habitat</td></tr>
<tr><td>Johnny's Dock Habitat Enhancement</td><td>Johnny's Dock Saltmarsh Habitat</td><td>Pick's Cove Marina Habitat</td></tr>
<tr><td>SR 509 Esplanade Riparian Habitat</td><td>Esplanade Area Habitat</td><td>--</td></tr>
<tr><td>Head of the Thea Foss Shoreline Habitat</td><td>Berg Scaffolding Habitat</td><td>Head of Thea Foss Waterway</td></tr>
</table>

Note: (--) indicates that a designation was not provided in the associated document.

Table 1-4
RAOs and Design Requirements

DESIGN REQUIREMENTS FOR *IN SITU* CAPS	REMEDIAL DESIGN ELEMENTS THAT SATISFY REQUIREMENTS	APPLICATION TO OMMP ACTIVITIES
Commencement Bay Nearshore/Tideflats Record of Decision (ROD) – September 1989		
Relationship to Sediment Quality Objectives (see Sec 7.2.4, p.51) "As part of the remedial investigation/feasibility study, sediment quality objectives were required that could be used to: a) Identify problem chemicals in sediments b) Identify sources associated with problem chemicals c) Establish spatial designations of problem areas, especially in areas where site-specific biological testing results were not available."	Sediment Quality Objectives (SQOs) were developed as part of the Commencement Bay Nearshore / Tideflats Remedial Investigation / Feasibility Study. The SQOs were used to identify problem chemicals, identify sources of problem chemicals, and define problem areas during the remedial design. The SQOs are the compliance criteria for remedial action surfaces including final dredge and capping surfaces per the Construction Quality Assurance Project Plan (CQAP) and project plans and specifications.	The SQOs will continue to be used to identify problem chemicals, identify sources, and define problem areas as part of OMMP activities.
Sediment Cleanup Objectives and Extent of Contamination (see Sec 8.1, p.62) "The long-term sediment quality goal for Puget Sound, defined by PSWQA (1988) as the absence of acute or chronic adverse effects on biological resources or significant human health risk, was translated into a set of sediment quality objectives for the CB/NT site… As such, sediment quality objectives form the basis for both source control and sediment remedial actions."	The SQOs are the compliance criteria for remedial action surfaces including final dredge and capping surfaces per the Construction Quality Assurance Project Plan (CQAP) and project plans and specifications. The final dredge and cap surfaces met the SQOs upon completion of remedial actions.	The SQOs will continue to be used as the criteria for evaluating sediment chemical concentrations during monitoring performed as part of OMMP activities.
In Situ Capping (see Sec 8.3.3, p.68) "Capping material may be clean, dredged material or fill (e.g. sand). In addition, it may be feasible to include additives (e.g. bentonite) to reduce the hydraulic permeability of the cap or sorbents to inhibit contaminant migration."	The project plans specified that capping material from aquatic (i.e., dredged) or upland sources could be used for the remedial actions. Additionally, the project plans specified requirements for cap material characterization prior to use. The cap material characterization reports were provided to EPA for review and approval.	No further action is required under the OMMP.
In Situ Capping (see Sec 8.3.3, p.68) "Both mechanical and hydraulic dredging equipment may be used for in-situ capping operations. Cohesive, mechanically dredged material would be placed by using a split-hulled barge. Hydraulically dredged material would be placed by using a downpipe and diffuser." For the ROD cost estimate, it was assumed that capping material would be dredged using a clamshell and deposited hydraulically to create a cap with a minimum thickness of 3 feet.	Selection of the methods to be used for placing capping material was generally left to the contractor in the plans, and specifications. The project specifications required the contractor to prepare a Work Plan that specified methods and equipment for construction activities. The contractor's Work Plan was submitted to EPA for review and approval. Cap material was placed using multiple mechanical methods including clamshell buckets, excavators, and conveyor equipment.	No further action is required under the OMMP.
In-Place Capping (see Sec 10.2.4, p.102) "In-place capping is inappropriate for environments with a high potential for ship scour, current action, or wave action because these disturbances can lead to cap erosion. Currents in the CB/NT problem areas are primarily tidal in origin and result in generally quiescent flow conditions. Maintenance dredging precludes the use of capping in areas maintained for shipping navigation."	Channel and slope areas in the Thea Foss and Wheeler-Osgood Waterways where boating traffic is anticipated were analyzed for the potential of erosion. Appendix G of the Round 3 Report presents results of cap scour due to typical vessels operating in the Thea Foss Waterway. Appendix J of the Design Analysis Report present results of cap scour at the Martinac facility. Results of the analysis assisted in the selection of capping materials to prevent scour of the caps and maintain cap thickness. The project specifications identified cap material types based on the design analyses. The cap material specified in the project plans were used and placed 2 feet below the authorized navigation depth to allow for maintenance dredging for navigation in capped areas.	No further action is required under the OMMP.
In-Place Capping (see Sec 10.2.4, p.102) "The primary environmental impacts associated with implementation of this alternative [i.e., capping] is loss of existing benthic and intertidal habitat at the site. Because of the high value placed on intertidal habitat, any loss of intertidal habitat would require corresponding habitat mitigation."	The approved project design included mitigation for impacts related to project construction including any impacts to the existing benthic and intertidal habitat.	Habitat mitigation area monitoring will be performed as described in Section 6.0 of the OMMP to ensure the long-term function of the constructed mitigation sites.

Explanation of Significant Differences (ESD 1997) – July 1997		
Modification to PCB Cleanup Standard (see Sec 1, p.2) "Based on EPA's reevaluation of the human health risks associated with PCBs, and through our evaluation using EPA's nine Superfund remedy selection criteria, EPA has determined that it is appropriate to modify the PCB cleanup level to 450 µg/kg, to be achieved during cleanup, and 300 µg/kg, to be achieved within 10 years after cleanup through natural recovery processes."	The SQOs were used to identify problem chemicals, identify sources of problem chemicals, and define problem areas during the remedial design. These revised SQOs are the compliance criteria for Total PCBs in remedial action surfaces including final dredge and capping surfaces per the Construction Quality Assurance Project Plan (CQAP) and project plans and specifications.	The revised PCB cleanup levels will be used with other SQOs and will continue to be used to identify problem chemicals, identify sources, and define problem areas as part of OMMP activities.
Requirements for *In Situ* Caps - Explanation of Significant Differences (ESD 2000) – August 2000		
Performance Requirements for Remedial Actions - Cap Requirements (see Sec IV A, p.11) "Caps will have a minimum thickness of three feet and will be constructed to address adverse impacts through four primary functions: 1. Physical isolation of the contaminated sediments for the ecological receptors; 2. Stabilization of the contaminated sediments, preventing resuspension and transport to other locations within the waterway 3. Reduction of contaminants transported through the groundwater pathway to levels that will that will not recontaminate surface sediments above the SQOs or adverse biological effect levels, or contaminate surface water at levels exceeding background concentrations or marine chronic water quality criteria; 4. Provide a cap surface that promotes colonization by aquatic organisms."	Caps consisting of approved materials were placed to a minimum thickness of 3 feet as part of remedial actions (except for enhanced natural recovery areas; i.e., thin capping). Section 3 of the Design Analysis Report presents an analysis of the cap thickness requirements based on the Corps of Engineers' Cap Guidance Document. Appendix G of the Round 3 Data Report and Appendix J of the Design Analysis Report present results of cap scour studies for use in the cap thickness analysis.	OMMP Performance and Early Warning monitoring will be conducted to ensure that the caps are providing physical isolation, stabilizing contaminated sediment, and to monitor for recontamination of surface sediment. Sediment Performance and Early Warning Monitoring will be performed in OMMP Monitoring Years 2, 4, 7, and 10. Benthic recolonization monitoring will be performed to monitor the colonization of the benthos in waterway sediments including capped surfaces. Benthic Recolonization Monitoring will be performed in OMMP Monitoring Years 2, 4, 7, and 10.
Cap Requirements (see Sec IV A, p.11) "Long term monitoring of the cap will include, as appropriate, visual inspection, bathymetric survey, sediment deposition monitoring, chemical monitoring, and biological monitoring."	Long-term monitoring and maintenance for the cap is specified in the OMMP.	The following tasks will be performed as part of the long-term monitoring of capped areas: ▪ Sediment performance monitoring that includes sediment compliance sampling and analysis as described in Section 2.0 of the OMMP; ▪ Cap integrity monitoring; low tide slope cap inspections and subtidal hydrographic surveys as described in Section 2.0 of the OMMP ▪ Early warning monitoring sediment sampling and analysis as described in Section 3.0 of the OMMP; and ▪ Benthic recolonization monitoring as described in Section 4.0 of the OMMP.
Performance Requirements for Remedial Actions – Subsurface Contamination (see Sec IV D, p.12) "In order to meet SQOs in the long term, subsurface sediments must either meet SQOs or be isolated from the surface. Exposure of contaminated subsurface sediments may occur during the cleanup by dredging adjacent areas, through physical processes, such as storms or ship scour, or through future dredging or excavation. In order for subsurface contamination to remain in place, it must either be present at such low levels that it would not present a risk if it were exposed, or it must have a very low potential for exposure. These criteria have been applied in selecting the cleanup construction phases of the remediation."	The requirements for subsurface contamination were applied during development of the remedial design and identification of dredge to clean and cap areas. Subsurface contamination was either removed so that the remaining sediment surface was less than the SQOs, in the case of dredge to clean remediation areas, or subsurface sediment with contaminant concentrations that exceed the SQOs was confined (i.e., isolated) by three feet of cap material, in the case of capped remediation areas. Potential for erosion and scour were taken into account in selecting capping materials. Additionally, the design thickness accounts for the physical processes of erosion due to waves, current, and propeller scour. Section 3 of the Design Analysis Report presents an analysis of the cap thickness requirement based on the Corps of Engineers' Cap Guidance Document.	Physical cap integrity monitoring will be performed as part of OMMP activities to ensure that remaining subsurface sediments with chemical concentrations that are greater than the SQOs (i.e. capped sediments) remain isolated from the surface. The physical integrity of capped areas will be monitored by intertidal slope cap inspections in Years 0, 2, 4, 7, and 10 and by subtidal hydrographic surveys in Years 2, 4, 7, and 10.

Final Design - Design Analysis Report (DAR) – November 2002		
Cap Design Objectives - General Considerations and Capping Requirements (see Sec 3.1, p.3-1) "The cap design is required to fulfill typical EPA requirements regarding the following primary functions: a) Physically isolate the contaminated sediment from ecological receptors; b) Physically stabilize contaminated sediments, preventing resuspension and transport to other locations in the waterway; c) Reduce contaminant transport via groundwater to levels that will not recontaminate surface sediments, cause adverse biological effects, or exceed background concentrations or marine chronic water quality criteria; and d) Promote colonization by aquatic organisms.	Caps consisting of approved materials were placed to a minimum thickness of 3 feet as part of remedial actions (except for enhanced natural recovery areas; i.e., thin capping). Section 3 of the Design Analysis Report presents an analysis of the cap thickness requirements based on the Corps of Engineers' Cap Guidance Document. Appendix G of the Round 3 Data Report and Appendix J of the Design Analysis Report present results of cap scour studies for use in the cap thickness analysis.	OMMP Performance and Early Warning monitoring will be conducted to ensure that the caps are providing physical isolation, stabilizing contaminated sediment, and to monitor for recontamination of surface sediment. Sediment Performance and Early Warning Monitoring will be performed in OMMP Monitoring Years 2, 4, 7, and 10. Benthic recolonization monitoring will be performed to monitor the colonization of the benthos in waterway sediments including capped surfaces. Benthic Recolonization Monitoring will be performed in OMMP Monitoring Years 2, 4, 7, and 10.
Cap Design Objectives - Design Considerations (see Sec 3.1, p.3-1) "Based on guidance from the Corps (1998), cap components and thicknesses for the channel areas and slopes of the Thea Foss Waterway are designed to account for erosion (scour), bioturbation, consolidation, chemical isolation, and operational considerations."	The Corps guidance was the basis for the design of slope and channel caps and selection of capping materials. Section 3 of the Design Analysis Report presents an analysis of the cap thickness requirements based on the Corps of Engineers' Cap Guidance Document. Appendix G of the Round 3 Data Report and Appendix J of the Design Analysis Report present results of cap scour studies for use in the cap thickness analysis.	OMMP Performance and Early Warning monitoring will be conducted to ensure that the caps are providing physical isolation, stabilizing contaminated sediment, and to monitor for recontamination of surface sediment. Sediment Performance and Early Warning Monitoring will be performed in OMMP Monitoring Years 2, 4, 7, and 10. Benthic recolonization monitoring will be performed to monitor the colonization of the benthos in waterway sediments including capped surfaces. Benthic Recolonization Monitoring will be performed in OMMP Monitoring Years 2, 4, 7, and 10.
DESIGN REQUIREMENTS FOR DREDGING AND DISPOSAL	**REMEDIAL DESIGN ELEMENTS THAT SATISFY REQUIREMENTS**	**APPLICATION TO OMMP ACTIVITIES**
Commencement Bay Nearshore/Tideflats Record of Decision (ROD) – September 1989		
Removal / Nearshore Disposal (see Sec 8.3.5, p.70) "Dredging followed by confined disposal in the nearshore environment is another alternative for sediment remediation at the CB/NT site. Generally, nearshore sites must be diked before they can receive dredged material. There are essentially no limitations in the selection of dredging and transport equipment, although hydraulic dredging followed by pipeline transport to the disposal facility is considered optimal….Other assumed design features include fill depth of 30 feet and a minimum cap thickness of 3 feet."	The design of the St. Paul CDF included consideration of ROD performance requirements. Selection of the methods and equipment to be used for dredging and dredge material disposal were generally left to the contractor in the project plans and specifications. The project specifications required the contractor to prepare a Work Plan that specified methods and equipment for construction activities. The contractor's Work Plan was submitted to EPA for review and approval. Disposal of sediment within the CDF was performed in accordance with requirements of specified in the Water Quality Certifications issued by EPA for the remedial action.	No further action is required under the OMMP.
Dredging Operations with Upland Disposal (see Sec 8.3.5, p.70) "Dredging followed by upland disposal would involve the transfer of dredged material to a land-based confinement facility and would be implemented following source control. Sediment could be dredged either mechanically or hydraulically and transferred to the disposal site by truck, rail, or pipeline…the alternative can be implemented using standard dredging and transport equipment that is generally used for similar operations. Provisions would be required for the management of dredge water and leachate generated during the dewatering process. Disposal site design features would include a liner and cap."	Dredging and upland disposal of dredged material was not performed as part remedial actions for contaminated sediment in the Thea Foss and Wheeler-Osgood Waterways. Sediment dredged from the Thea Foss and Wheeler-Osgood Waterways was disposed of in the St. Paul CDF.	No further action is required under the OMMP.

Explanation of Significant Differences (ESD 2000) – August 2000		
Dredging		
Performance Requirements for Remedial Actions - Dredging and Confined Disposal (see Sec IV B, p.11) "Performance standards for dredging and confined disposal will be consistent with Clean Water Act and Rivers and harbors Act requirements….Both the remediation waterways and the disposal sites will be subject to long-term monitoring to ensure that the selected remedy remains protective, including monitoring to ensure that surface sediments do not become re-contaminated in the remediation waterways, and that marine chronic water quality standards or background concentrations are not exceeded in the surface water outside of the confined disposal sites."	The long-term monitoring of the Thea Foss and Wheeler-Osgood Waterways and St. Paul CDF will be performed as part of OMMP activities.	OMMP Performance and Early Warning monitoring will be conducted to ensure that the caps are providing physical isolation, stabilizing contaminated sediment, and to monitor for recontamination of surface sediment. Sediment Performance and Early Warning Monitoring will be performed in OMMP Monitoring Years 2, 4, 7, and 10. Performance and early warning monitoring are described in Sections 2.0 and 3.0, respectively. The objective of the OMMP CDF monitoring program is to protect water quality in adjacent surface water bodies from contaminants that could potentially migrate in groundwater from the CDF. CDF monitoring is described in Section 5.0 of the OMMP.
Final Design- Design Analysis Report (DAR) – November 2002		
Dredging Design Objectives (see Sec 2.1.1, p..2-1) 1) "Additional design objectives included preventing sheen on the water surface and reducing the polycyclic aromatic hydrocarbon (PAH) load to eliminate recontamination of the waterway following the remedial action." 2) "Within SSMAs 2, 3, 4, and 5, a majority of the SSMAs will be dredged to a depth that corresponds to the maximum depth of SQO exceedance." 3) "Within SSMAs 6 and 7, the dredge depth has been determined based on the navigational requirements. The selected dredge depths are sufficient to partially remove sediments containing concentrations above the SQOs."	The project specifications required the contractor to prepare an Environmental Projection Plan and Water Quality Monitoring Field Sampling Plan that described BMPs for construction activities and procedures for water quality monitoring, respectively. BMPs were identified in the project Environmental Protection Plan and employed during remedial actions to minimize sheen on surface water during construction. Water quality monitoring was performed to control and monitor impacts to water quality. Additionally, the dredge depths required to remove sediment with chemical concentrations greater than the SQOs in dredge to clean areas or partially removing sediment with chemical concentrations greater than the SQOs followed by capping, and meet navigational requirements, were specified in the project plans.	No further action is required under the OMMP.
Dredging on Slopes Requirements (see Sec 2.1.1, p. 2-2) "in some localized areas, the design of sediment dredging and/or placement of capping material within the waterway has been tailored to reduce the risk of impacts on adjacent slopes and structures…..Alternative 1-Extend Existing Slope Outward to Dredged Depth….Under this option, a wedge of potentially impacted sediment is left behind. The wedge of impacted sediment would be capped."	The remedial design for slope areas consisted of dredging a 2-foot horizontal / 1-foot vertical slope followed by construction of a 3-foot thick slope cap to reduce the risk of impacts on adjacent slopes and structures and provide confinement of contaminated sediment.	Physical cap integrity monitoring will be performed as part of OMMP activities to ensure that contaminated sediment present beneath slope caps remain isolated from the surface. The physical integrity of slope caps will be monitored by intertidal slope cap inspections in Years 0, 2, 4, 7, and 10 and by subtidal hydrographic surveys in Years 2, 4, 7, and 10. Physical integrity monitoring is described in Section 2.0 of the OMMP.
Navigational Depths Requirements (see Sec 2.2.1.2, p.2-9) "Where dredging and/or capping is proposed in the Thea Foss Waterway, the post-construction elevations are set at a minimum of 2 feet below the authorized channel depth."	The remedial design elevations for dredging and/or capping were specified at two feet below the authorized channel depth except in several locations where the channel had not met the authorized channel depth prior to remediation and significant obstructions were present or dredging to the authorized channel depth would have affected adjacent shoreline structures. The areas were the post-construction channel elevations encroach on the authorized channel depth are identified in the Memorandum of Agreement between the City of Tacoma and the U.S. Army Corps of Engineers presented in Appendix F of the Remedial Action Construction Report.	Any future action concerning areas of encroachment on the channel navigation depth will be performed in accordance with the Memorandum of Agreement between the City of Tacoma and the U.S. Army Corps of Engineers presented in Appendix F of the Remedial Action Construction Report.
Areas Requiring Slope Stability Considerations (see Sec 2.2.2, p.2-10) "Figure 2-3 shows areas that have been identified as having slope- or geotechnical-related constraints due to one or more of the slope stability factors discussed in Section 2.1.2. The areas of interest are as follows..: Petrich Marine Dock, Colonial Fruit and Produce Warehouse, Martinac Shipbuilding, and Johnny's Seafood."	The remedial design and project plans identified remedial actions that were developed in consideration of slope stability factors. The remedial actions in these areas were constructed in accordance with the project plans.	No further action is required under the OMMP.
Areas Occupied by Existing Marinas (see Sec 2.2.3, p.2-13) "Dredging and capping activities in these areas either need to be designed to accommodate and maintain the current marina layouts and draft depths, or the marinas need to be revised or reduced."	The remedial design incorporated marina use. Marina layouts and designs were reviewed and approved by the Corps prior to construction.	No further action is required under the OMMP.

Tie-in to Upland Construction Projects Requirements (see Sec 2.2.4, p.2-16) "The in-water remedial action will tie-in with the uplands work in a number of specific locations where the two projects meet…..Esplanade Parcel 3, Floatplane Dock at Johnny's Seafood, and Albers Mill Dock."	The remedial design and project plans were developed in consideration of adjacent projects including the previously completed Esplanade work at Parcel 3, seaplane float, at Johnny's Seafood, and Alber's Mill Dock. The remedial actions in these areas were constructed in accordance with the approved project plans.	No further action is required under the OMMP.
Dredging Equipment and Method Requirements (see Sec 2.4, p. 2-23) "The Contractor's equipment and methods will be required to meet both operational and regulatory performance requirements, including water quality criteria and draft limitations with the St. Paul CDF."	Selection of the construction equipment and methods to be used were generally left to the contractor in the plans, and specifications. The project specifications required the contractor to prepare a Work Plan that specified equipment and methods for construction activities. The contractor's Work Plan was submitted to EPA for review and approval. Additionally, water quality monitoring was performed in accordance with the project plans and Water Quality Certifications during construction to monitor and control water quality impacts. Finally, equipment draft considerations were evaluated by the contractor and used to select equipment for specific remedial activities.	No further action is required under the OMMP.
CDF Design Considerations (see Sec 5.1.2, p. 5-1) "The following presents the relevant design considerations for design and construction of a CDF. They include: a) Effective long-term containment of contaminants. Groundwater and tidal flux are the mechanisms for contaminant mobility; b) Berm construction technology, aggregate selection, and determination of the berm's static and seismic stability; c) Expected amounts and time rates of consolidation of disposed of sediment and underlying foundation soils; d) Design of a containment cap for the CDF; e) Impact of CDF filing on adjacent structures; f) Volumetric capacity of the constructed CDF basin; and g) Habitat mitigation requirements.	The design specified in the project plans for the CDF was developed based on the considerations identified in the DAR. The project plans included habitat mitigation projects to mitigate for losses in aquatic habitat as a result of for use of the St. Paul Waterway as the CDF. The habitat mitigation sites and CDF were constructed in accordance with the approved project plans.	Monitoring of the CDF will be performed to ensure long-term containment of contaminated sediments. CDF monitoring is described in Section 5.0 of the OMMP. Habitat mitigation area monitoring will be performed as described in Section 6.0 of the OMMP to ensure the long-term function of the constructed mitigation sites.
DESIGN REQUIREMENTS FOR NATURAL RECOVERY	**REMEDIAL DESIGN ELEMENTS THAT SATISFY REQUIREMENTS**	**APPLICATION TO OMMP ACTIVITIES**
Commencement Bay Nearshore/Tideflats Record of Decision (ROD) – September 1989		
Sediment Cleanup Objectives and Extent of Contamination (see Sec 8.1, p.62) "Sediment Quality objectives were also translated into sediment remedial action levels and source control levels. Sediment remedial action levels incorporate technical feasibility and cost considerations by incorporating mitigating factors such as natural recovery. The sediment remedial action level differentiates areas that exceed the sediment quality objective, but are predicted to recover naturally, from those that are more significantly contaminated and therefore require active remediation to achieve the sediment quality objectives. If natural recovery is predicted to be effective in achieving the cleanup objectives in a reasonable timeframe (10 years), then no sediment remediation would be required."	Sediment Remedial Action Levels (SRALs) were used to identify areas for active remediation and natural recovery during remedial design. Natural recovery modeling was performed during the design to identify natural recovery areas and the results of modeling are presented in Section 9 of the Round 3 Data Report. Model results predict that the natural recovery areas within the Thea Foss and Wheeler-Osgood Waterways will recover within the 10-year time frame required by EPA. Long-term monitoring of the natural recovery (and enhanced natural recovery) areas will be performed as part of OMMP activities.	Long-term natural recovery monitoring will be conducted in Years 2, 4, 7, and 10 or until two consecutive rounds of sampling indicate that the area meets the performance standards. Natural recovery monitoring will be performed as described in Section 2.0 of the OMMP.
Natural Recovery (see Sec 10.2.3, p.99) "Areas that are expected to recover naturally within 10 years of sediment remedial action (based on modeling results confirmed by monitoring data) are initially exempt from sediment remedial action (i.e., confined disposal). However, monitoring to confirm the long-tem effectiveness of the recovery will be required as part of the overall CB/NT selected remedy. Should subsequent monitoring data indicate that natural recovery is not viable in a reasonable timeframe, the need for active sediment remediation may be reconsidered."	Natural recovery modeling was performed during the pre-design activities and results are presented in Section 9 of the Round 3 Data Report. Model results predict natural recovery areas will recover within the 10-year time frame required by EPA. Long-term monitoring of the natural recovery (and enhanced natural recovery) areas is described in the OMMP.	The objective of the natural recovery and enhanced natural recovery performance monitoring program is to evaluate detected chemical concentration trends and whether natural recovery areas will recover to concentrations below SQOs within the allowable 10-year natural recovery time period. Supplemental baseline data will be collected within designated natural recovery areas during Year 0 activities to complete the characterization of baseline concentrations. Long-term natural recovery monitoring will be conducted in Years 2, 4, 7, and 10. Natural recovery monitoring will be performed as described in Section 2.0 of the OMMP.

Explanation of Significant Differences (ESD 1997) – July 1997		
Modification to PCB Cleanup Standard (see Sec 1, p.2) “Based on EPA’s reevaluation of the human health risks associated with PCBs, and through our evaluation using EPA’s nine Superfund remedy selection criteria, EPA has determined that it is appropriate to modify the PCB cleanup level to 450 µg/kg, to be achieved during cleanup, and 300 µg/kg, to be achieved within 10 years after cleanup through natural recovery processes.”	The SQOs were used to identify problem chemicals, identify sources of problem chemicals, and define problem areas during the remedial design. These revised SQOs are the compliance criteria for Total PCBs in remedial action surfaces including final dredge and capping surfaces per the Construction Quality Assurance Project Plan (CQAP) and project plans and specifications.	The revised PCB cleanup levels will be used with other SQOs and will continue to be used to identify problem chemicals, identify sources, and define problem areas as part of OMMP activities.
Explanation of Significant Differences (ESD 2000) – August 2000		
Performance Requirements for Remedial Actions - Natural Recovery and Enhanced Natural Recovery (see Sec IV C, p.11) “Natural recovery or enhanced natural recovery is an acceptable remediation approach at locations where sediment are marginally contaminated and are likely to recover to cleanup levels within the 10 year time frame specified in the ROD. At the CB/NT site, EPA considers marginally contaminated sediments as those with chemical concentrations less than the second lowest Apparent Effects Threshold (AET) value (the SQO is set at the lowest AET) or biological test results that do not exceed the minimum cleanup level (MCUL) value under Washington State Sediment Management Standards…Areas selected for natural recovery (including enhanced natural recovery) will require: (1) monitoring plans, (2) triggers for initiating contingent actions if the monitoring indicates natural recovery will not succeed in the 10 year time frame, and (3) contingent plans for active remediation if monitoring in interim years indicates natural recovery will not occur by year 10.”	Areas were identified for natural recovery and enhanced natural recovery as part of design. Monitoring and contingency actions for natural recovery areas will be performed as part of the OMMP activities.	Monitoring of the natural recovery (and enhanced natural recovery) areas is described in Section 2.0 of the OMMP. Surface sediment (0 to 10 cm) quality in natural recovery areas will be compared to SQO criteria and will be used to evaluate chemical concentration trends to identify whether natural recovery will occur within 10 year time frame. The OMMP includes trigger and contingency measures if natural recovery does not (or will not) occur by Year 10.
DESIGN REQUIREMENTS FOR MITIGATION	**REMEDIAL DESIGN ELEMENTS THAT SATISFY REQUIREMENTS**	**APPLICATION TO OMMP ACTIVITIES**
Commencement Bay Nearshore/Tideflats Record of Decision (ROD) – September 1989		
Cleanup Objectives (see Sec 10.1, p.97) “Habitat function and enhancement of fisheries resources will also be incorporated as part of the overall project cleanup objectives. For example, the physical characteristics and placement of material used for capping contaminated sediment in the marine environment will be required to provide a suitable substrate and habitat for aquatic organisms that may utilize that environment.”	The remedial design included identification of capping materials to be used to construct caps in the Thea Foss and Wheeler-Osgood Waterways. Caps consisting of approved materials were placed to a minimum thickness of 3 feet as part of remedial actions.	Benthic recolonization monitoring will be performed to monitor the colonization of the benthos in waterway sediments including capped surfaces. Benthic Recolonization Monitoring will be performed in OMMP Monitoring Years 2, 4, 7, and 10 as described in Section 4.0 of the OMMP.
Explanation of Significant Differences (ESD 2000) – August 2000		
Performance Requirements for Remedial Actions - Mitigation (see IV F, p.13) “All appropriate measures will be taken during remedial design, construction, and site maintenance to continue to avoid and minimize adverse impacts. Such measures that will be required by EPA include, but are not limited to, avoidance of fish-critical activity periods for in-water work, incorporation of “best-design” features and/or materials into remedial and compensatory mitigation plans that protect or enhance ESA-listed species, and creation or restoration of critical salmonid habitat. Additionally EPA will require compensatory mitigation plans to off-set loss and other impacts to aquatic habitat and meet ESA responsibilities.”	The design and project plans included measures to avoid and minimize adverse impacts including 1) appropriate measures to be taken during construction to avoid and minimize adverse impacts including avoidance of fish-critical activity periods for in-water work, 2) incorporation of “best-design” features and/or materials into remedial and compensatory mitigation plans that protect or enhance ESA-listed species, and 3) creation or restoration of critical salmonid habitat. The appropriate measures were implemented during construction and included water quality monitoring to monitor and control impacts from in-water construction activities, use of Best Management Practices (BMPs) (control of dredging and material placement speed, containment of debris with debris booms, use of oil absorbent booms, etc.) during construction, avoidance of construction during fish critical activities periods or use of BMPs and fish monitoring during construction when a work was performed during the fish window. Additionally, all planned habitat mitigation and enhancement areas were constructed in accordance with the approved project plans.	Habitat mitigation area monitoring will be performed as described in Section 6.0 of the OMMP to ensure the long-term function of the constructed mitigation sites.

Final Design- Design Analysis Report (DAR) – November 2002		
Overall Project Habitat Objectives (see Sec 6-1, p.6-3) "The overall habitat objectives of the Thea Foss and Wheeler-Osgood Waterways Remediation Project and the possible use of the St. Paul CDF are to: a) Actively remediate nearly 60 acres of contaminated benthic sediments in Thea Foss and Wheeler-Osgood Waterways; b) Increase and enhance littoral habitat conditions in Thea Foss and Wheeler-Osgood Waterways resulting in improved shallow nearshore conditions for migration of juvenile salmonids; c) Fully mitigate for losses of all shallow subtidal and intertidal (littoral) habitat acreage resulting from remediation and from the possible use of St. Paul Waterway as a CDF; this will be accomplished by restoring or enhancing critical intertidal and other estuarine habitats adjacent to the neodelta; d) Fully mitigate for temporal loss of ecological functions that result from project implementation; e) Establish a monitoring and adaptive management program to help ensure that the waterways and mitigation/restoration actions are managed to optimize habitat functions provided; and f) Meet performance criteria in the ESD including actions that contribute to the recovery of federally listed threatened species from a Commencement Bay ecosystem perspective."	The design of habitat mitigation and enhancement areas specified in the project plans were developed based on the considerations identified in the DAR. Habitat Mitigation and enhancement areas were constructed in accordance with the approved project plans.	Habitat mitigation area monitoring will be performed as described in Section 6.0 of the OMMP to ensure the long-term function of the constructed mitigation sites.
Specific Salmonid Habitat Goals (see Sec 6-1, p. 6-2) "The specific salmonid habitat goals of the mitigation/restoration plan under the CDF Disposal Option are to: a) Expand critical habitat adjacent to the neodelta, including the reintroduction of side channel habitat, and achieve a near continuous corridor of enhanced, restored, reconstructed, and expanded littoral habitat from the rebuilding delta, across the outer St. Paul Waterway, around the St. Paul/Middle Waterway peninsula, and along most of the eastern shoreline of the Middle Waterway; b) Protect and enhance the integrity of the relatively large, relict original mudflat in Middle Waterway by enlarging a part of its eastern shoreline with more complex and vegetated habitats; c) Increase both the quality and the quantity of critical intertidal and shallow subtidal habitats and associated riparian areas in the waterway west of the Puyallup River mouth, including reintroduction of estuarine marsh habitats; d) Improve shallow water connectivity between these important estuarine habitat areas, leading to improved function of each; e) Compensate for the temporal loss of function resulting from Thea Foss and Wheeler-Osgood Waterways remediation to more than replace existing habitat values lost to construction of the CDF in St. Paul Waterway. The post-remediation the Thea Foss Waterway and the constructed mitigation/restoration habitats will provide both higher quality habitat than currently exists and a more contiguous corridor from the Puyallup River delta to the Ruston Way tideflats; f) Provide Puyallup River off-channel brackish marsh, intertidal and shallow subtidal mudflat, and shallow open water habitat."	The design of habitat mitigation and enhancement areas specified in the project plans were developed based on the considerations identified in the DAR. Habitat Mitigation and enhancement areas were constructed in accordance with the approved project plans.	Habitat mitigation area monitoring will be performed as described in Section 6.0 of the OMMP to ensure the long-term function of the constructed mitigation sites.

DESIGN REQUIREMENTS FOR SOURCE CONTROL	REMEDIAL DESIGN ELEMENTS THAT SATISFY REQUIREMENTS	APPLICATION TO OMMP ACTIVITIES
Explanation of Significant Differences (ESD 2000) – August 2000		
Source Control in the Thea Foss Waterway (see Sec IV E, p.13) "In the design phase or prior to remedial action, however, the following specific performance criteria for source control and the remedy for the head of the waterway must be met to eliminate or reduce the potential for recontamination from storm drains as well as from the NAPL beneath the sediments and in adjacent uplands. An approved stormwater action plan which includes, at a minimum, the following: a) an Ecology-approved stormwater sampling and analysis plan which will complete the Stormwater Management Plan for Thea Foss as required under the general NPDES permit, b) a phthalate study for determining possible phthalate sources to the waterway, c) pilot testing to determine the contribution of dissolved versus particulate contamination loading to the waterway, d) an evaluation of stormwater structural controls, and e) an implementation schedule for the above stormwater studies, plans, and controls.	A stormwater action plan was developed in the design phase and prior to remedial actions. The *Thea Foss Basin Stormwater Control Remedial Design Work Plan* (January 2002) was prepared and submitted to Ecology for review and approval and is included as Attachment 1 to the Consent Decree Statement of Work.	Implementation of elements of the Stormwater Work Plan Addendum will Continue through the monitoring period.

Table 1-5
RAOs and Long-Term Monitoring Requirements

GENERAL LONG-TERM MONITORING REQUIREMENTS	OMMP ACTIVITIES THAT SATISFY LONG-TERM MONITORING REQUIREMENTS
Commencement Bay Nearshore/Tideflats Record of Decision (ROD) – September 1989	
General Long-Term Monitoring Requirements (see Sec 10.2.5, p. 104) "Monitoring within problem areas, at disposal sites, and at habitat mitigation/restoration areas developed as part of the sediment remedial action within the CB/NT problem areas will be conducted to evaluate the effectiveness of the remedy in achieving the sediment quality objectives and in relation to habitat function, especially relative to fisheries resources."	Long-term performance sediment monitoring will be conducted within capped, dredged, natural recovery, and enhanced natural recovery areas of the waterways. Sediment monitoring activities include surface sampling (0 to 10 cm), early warning (0 to 2 cm) sampling, and benthic recolonization monitoring. The CDF monitoring program includes the identification of baseline groundwater and surface water conditions (8 quarters) followed by performance monitoring that includes comparison of the results of baseline monitoring to the results of subsequent groundwater monitoring. The constructed habitat mitigation areas will be monitored to ensure that they are effective in the development of necessary biological and physical features to provide adequate habitat function.
General Sediment Monitoring Requirements (see Sec 10.2.5, p. 104) "Sediment monitoring will be used to develop data for priority problem chemicals within each problem area as described in the feasibility study and other chemicals that may become of concern to EPA through source monitoring or other related studies."	Sediment monitoring (0 to 10 cm and 0 to 2 cm) will be conducted in Years 2, 4, 7, and 10.
Consent Decree and Scope of Work (CD and SOW) – August 2000	
General Long-Term Monitoring Requirements (see Sec IV.E., p. 14) "Under this Statement of Work, the Performing Defendant shall implement the approved Final OMMP which covers both long-term maintenance and monitoring of the remedial action, including mitigation areas."	The OMMP monitoring activities include the monitoring of the remedial actions performed, natural recovery areas and enhanced natural recovery areas, the confined disposal facility, and the constructed habitat mitigation areas.
General Long-Term Monitoring Requirements (see Sec IV.E., p. 14) "Performing Defendant shall submit laboratory records, records for long-term monitoring costs, documentation to comply with the CERCLA 5-Year Review Reporting requirements and reports to State or Federal agencies."	OMMP reporting to EPA includes preliminary findings technical memoranda upon the completion of monitoring activities, and annual monitoring year reports in support of EPA's preparation of 5-Year Review Reports.
LONG-TERM MONITORING REQUIREMENTS FOR IN SITU CAPS	
Explanation of Significant Differences (ESD) – August 2000	
Cap Maintenance (see Sec IV A, p.11) "Long term monitoring of the cap will include, as appropriate, visual inspection, bathymetric survey, sediment deposition monitoring, chemical monitoring, and biological monitoring."	To meet the objective of the long-term monitoring of the cap, the following monitoring activities will be performed: ▪ Sediment performance monitoring and early warning monitoring ▪ Cap integrity monitoring; low tide slope cap inspections and subtidal hydrographic surveys ▪ Benthic recolonization monitoring
Consent Decree and Scope of Work (CD and SOW) – August 2000	
Cap Requirements (see Sec III.A., p. 6) "Long-term monitoring of the cap will include visual inspection, bathymetric survey, sediment deposition monitoring, chemical monitoring, and biological monitoring."	To meet the objective of the long-term monitoring of the cap, the following monitoring activities will be performed: ▪ Sediment performance monitoring and early warning monitoring ▪ Cap integrity monitoring; low tide slope cap inspections and subtidal hydrographic surveys ▪ Benthic recolonization monitoring

LONG-TERM MONITORING REQUIREMENTS FOR DREDGING AND DISPOSAL	
Consent Decree and Scope of Work (CD and SOW) – August 2000	
Dredging and Confined Disposal Requirements (see Sec III.B, p. 6) a) "Problem areas and the St. Paul disposal site, or any other disposal option identified in the ESD, will be subject to long-term chemical and biological monitoring to ensure that surface sediments do not become recontaminated in the Thea Foss and Wheeler-Osgood Waterways, and that marine chronic water quality standards or background concentrations, whichever are higher, are not exceeded in surface water during in-water activities (e.g., capping or dredging) and outside of the St. Paul confined disposal site during and after construction." b) "Verification that performance standards, including SQOs, have been achieved shall be documented in the pre- final construction reports, and in documentation required by the OMMP, as appropriate."	Early warning (0 to 2 cm) sediment sampling will be conducted in dredged areas in Years 2, 4, 7, and 10 to evaluate the potential for recontamination of the constructed remedial actions. To evaluate the effectiveness of the CDF to contain contaminated sediment and protect the adjacent surface water quality, groundwater and surface water monitoring will be performed during a 2 year (8 quarter) baseline monitoring program that will be followed by a long-term performance monitoring program. The frequency, analytes, and well locations to be sampled during the performance monitoring program will be based on the results of the baseline monitoring program as well as the results of a 72-hour tidal study and slug tests. Potential response actions are identified in Section 2.4 in the event that monitoring data indicate that performance standards will not be achieved.
LONG-TERM MONITORING REQUIREMENTS FOR NATURAL RECOVERY	
Commencement Bay Nearshore/Tideflats Record of Decision (ROD) – September 1989	
Cleanup Objective (see Sec. 10.1, p. 97) "Because the objective of the selected remedy is to achieve the sediment quality goal in a reasonable timeframe, natural recovery is integrated into the overall remedy. Natural recovery considerations are used to identify sediment remedial action levels that delineate sediments that are allowed to recover naturally from those that require active sediment cleanup."	Long-term monitoring in natural recovery and enhanced natural recovery areas is presented in Section 2.4 and Appendix B of the OMMP.
Consent Decree and Scope of Work (CD and SOW) – August 2000	
Natural Recovery Requirements (see Sec III.C, p. 7) a) "For those areas selected for natural recovery, performing defendant has (1) prepared monitoring plans, (2) identified triggers for initiating additional response actions if the monitoring indicates natural recovery will not succeed in the ten year time frame, and (3) specified additional response actions for active remediation if monitoring in interim years indicates natural recovery will not occur by year ten." b) "Natural Recovery monitoring will be performed until cleanup objectives are achieved."	The objective of the natural recovery and enhanced natural recovery performance monitoring program is to evaluate detected chemical concentration trends and if they will recover to concentrations below SQOs within the allowable 10-year natural recovery time period. Long-term natural recovery monitoring will be conducted in Years 2, 4, 7, and 10. Potential response actions are identified in Section 2.4 in the event that monitoring data indicate that performance standards will not be achieved.
LONG-TERM MONITORING REQUIREMENTS FOR MITIGATION	
Commencement Bay Nearshore/Tideflats Record of Decision (ROD) – September 1989	
Evaluation Protocols (see Sec 10.2.5, p.104) "Habitat evaluation will be conducted in accordance with habitat restoration protocols that are currently being developed by EPA's Region 10 Wetlands Program and Puget Sound Estuary Program. These protocols will be incorporated into habitat evaluation in the CB/NT problem areas before and after sediment remedial action at both dredging and disposal sites. These protocols are being designed to quantitatively assess the characteristics of an area that contribute to habitat function (i.e., feeding, refuge, and reproduction)."	The procedures and protocols to be used during the monitoring of habitat mitigation areas are presented in Section 6.0 and Appendix E of the OMMP.
Consent Decree and Scope of Work (CD and SOW) – August 2000	
Mitigation Requirements (see Sec III.E., p.8) "Under this SOW, the Performing Defendant shall implement the final compensatory mitigation plan included in the Final Design as well as a long-term monitoring plan for the habitat mitigation. Performance criteria for the mitigation areas are outlined in the Final OMMP for the site."	The procedures and protocols to be used during the monitoring of habitat mitigation areas are presented in Section 6.0 and Appendix E of the OMMP.

Explanation of Significant Differences (ESD) – August 2000	
Compensatory Mitigation Performance Criteria (see Sec IV.F., p. 14) "Drawing from the Simenstad report, EPA has identified the following "performance criteria" that must, at minimum, be addressed in any acceptable compensatory mitigation plan: 1) All compensatory mitigation must be consistent with the criteria and finding of the Simenstad report. 2) Preference will be given to compensatory mitigation plans that are consistent with habitat function prioritization criteria (to be determined). 3) All compensatory mitigation plans will include an assessment of how they contribute toward recovery. 4) Mitigation plans must include consideration for connectivity (i.e., habitat that is linked or capable of being linked to other habitat and is intended to avoid mitigative actions that are geographically isolated and underutilized by the target species and/or do not reach full function). 5) Compensatory mitigation sites will be located within or will provide connections to or between one or more of the critical areas of "salmon landscape" (e.g., osmoregulatory transition) described by the Simenstad report within the Commencement Bay and lower Puyallup River watershed. 6) The aspect of *risk* of mitigation success/failure must be specifically factored into habitat plans and provided for up-front rather than solely as a post-construction contingency (i.e., in most cases this will mean additional habitat acreage). 7) All compensatory mitigation plans will include measurable performance objectives, management, monitoring and reporting requirements, responsibilities, and schedule. 8) Native species only will be utilized in any plantings to the maximum extent practicable. 9) Mitigation plans should include facility design and site plans for any development/redevelopment that occurs as a result of a fill. The facility and site plans must ensure that the facility and the site characteristics and functions do not create adverse impacts to water, sediment, and habitat quality during construction and operation. For example, the site plan for the expanded Simpson facility should include on- and off-site stormwater treatment; beneficial use of relatively clean stormwater (e.g. rooftop runoff, treated stormwater etc.); lighting and noise impacts minimization, including buffering; and other site-specific best management practices."	The compensatory mitigation plan was completed and approved by EPA during the design phase of the project. Potential response procedures are identified in Sections 6.4 and 6.5 in the event that monitoring data indicate that performance standards will not be achieved.
Biological Opinion and Essential Fish Habitat Consultation (BO) – March 2004	
Reasonable and Prudent Measure Implementation (see Sec 2.6.3, Part 4f) "See that, as a minimum, the habitats constructed to offset the impacts of this action are maintained at their functional design for as long as the St. Paul Waterway remains filled with contaminated sediment. Should circumstances require modification of any of the habitats, functional replacement must be at a factor of 1.5 the acreage and any replacement habitats must be constructed and functioning 12 months prior to disturbance of the original habitat."	Habitat monitoring of the mitigation areas performed as described in Section 6.0 and Appendix E of the OMMP will verify that the areas are functioning in accordance with the approved design and also set forth response actions in the event this is not occurring.
LONG-TERM MONITORING REQUIREMENTS FOR SOURCE CONTROL	
Commencement Bay Nearshore/Tideflats Record of Decision (ROD) – September 1989	
Cleanup Objective (see Sec 10.1, p. 97) "The sediment quality objective also applies to source control requirements. Monitoring of sources and sediments will be used to determine the effectiveness of source controls."	Early warning monitoring (0 to 2 cm) for recontamination will be performed to evaluate the potential for recontamination and to identify potential sources of recontamination before the remediated sediments become out of compliance with the remedial action and long-term objectives.

Table 1-6
Monitoring Schedule

Activity	Monitoring Year (Calendar Year)										
	Year 0 (2006)	Year 1 (2007)	Year 2 (2008)	Year 3 (2009)	Year 4 (2010)	Year 5 (2011)	Year 6 (2012)	Year 7 (2013)	Year 8 (2014)	Year 9 (2015)	Year 10 (2016)
1) Sediment Remediation Area Performance Monitoring											
Supplemental Data Collection for Natural Recovery Area Sediment Quality	X										
Sediment Quality (0 to 10 cm) Performance Monitoring of Cap and Natural Recovery Areas			X		X			X			X
Low Tide Slope Cap Inspection for Cap Integrity	X		X		X			X			X
Subtidal Cap Hydrographic Survey for Cap Integrity			X		X			X			X
2) Early Warning Monitoring for Recontamination											
Sediment Quality (0 to 2 cm) Monitoring			X		X			X			X
3) Benthic Recolonization Monitoring											
Sediment Profile Imaging and Archive Sediment Sample (0 to 10 cm) Collection			X		X			X			X
4) Confined Disposal Facility Monitoring											
72-Hour Tidal Study and Slug Tests	X										
Baseline Monitoring		4 Q	4 Q								
Performance Monitoring				TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

Activity	Monitoring Year (Calendar Year)										
	Year 0 (2006)	Year 1 (2007)	Year 2 (2008)	Year 3 (2009)	Year 4 (2010)	Year 5 (2011)	Year 6 (2012)	Year 7 (2013)	Year 8 (2014)	Year 9 (2015)	Year 10 (2016)
5) Habitat Mitigation Area Monitoring											
Qualitative Ground Surveys	X	X	X	X	X	X	X	X	X	X	X
Quantitative Vegetation Surveys		X	X		X			X			X
Photo Documentation	X	X	X		X			X			X
Elevation Monitoring[1,2]	X	X	X	X		X		X			X
Brackish Marsh Salinity Monitoring	X	X									
Juvenile Salmonid Monitoring		X		X							
Invertebrate Monitoring		X		X							
Water Surface Elevation Monitoring	X			X		X		X			X

Notes:
- 4 Q Four quarters.
- TBD To be determined.
- 1 The vertical datum used during the construction phase of the project was MLLW. Due to the length of the OMMP monitoring period and the fact that MLLW changes over time, the vertical datum to be used during this phase has been designated as NGVD 29.
- 2 Note that survey transects of the channels at Hylebos Creek will be performed annually while monitoring of elevation stakes at the other locations will be performed on the schedule shown.

Table 1-7
Summary of Sediment Monitoring Activities and Sample Locations

Remedial Areas (RA)	Completed Remedial Action	Sample Location/Survey Designations: Cap Performance	Early Warning	Natural Recovery	Benthic Recolonization	Slope Cap	Hydrographic	Low Tide
RA 1A	Channel Sand Cap	CC-01	EW-01	--	--	--	X	--
RA 1B	Slope Cap	--	--	--	--	SC-01	X	X
RA 2	Dredge and Backfill	NA	NA	NA	NA	NA	NA	NA
RA 3	Slope and Grout Mat Caps	--	--	--	--	SC-03	X	X
RA 4	Dredge and Backfill	NA	NA	NA	NA	NA	NA	NA
RA 5	Dredge to Clean, Slope Cap between Stations 37+10 and 39+80 (Petrich) and Natural Recovery; Quarry Spall Backfill between Station 37+10 and the south side of the 11th Street Bridge, along northern boundary of RA	--	EW-22, EW-13	NR-13	BR-22	--	--	--
RA 6	Dredge to Clean, Slope Cap between Stations 43+50 and 52+30 on the western side of RA6, and Natural Recovery along northern boundary of RA	--	EW-24, EW-21, EW-15	NR-14	BR-23, BR-21, BR-15	--	X	--
RA 7	Enhanced Natural Recovery (placed six inches of channel sand cap material)	--	EW-16, EW-12	NR-16, NR-12	BR-16	--	X	--
RA 7A	Dredge and Channel Sand Cap	--	--	--	--	--	X	--
RA 8	Slope Cap and Habitat Enhancement	--	--	--	--	SC-08A, SC-08B	X	X
RA 9	Dredge and Channel Sand Cap	CC-18	--	--	BR-18	--	X	
RA 10	Slope Rehabilitation	NA	NA	NA	NA	NA	NA	NA
RA 11	Slope Rehabilitation between Stations 9+00 and 13+50 and No Action from Stations 4+00 to 9+00	NA	NA	NA	NA	NA	NA	NA
RA 12	Dredge and Backfill and Channel Sand Cap in adjacent sheen source area[1]	NA	NA	NA	NA	NA	NA	NA
RA 13	Slope Rehabilitation	NA	NA	NA	NA	NA	NA	NA
RA 14	Slope Cap	--	--			SC-14	X	X
RA 15	Slope Rehabilitation and Dredge to Clean	NA	NA	NA	NA	NA	X[2]	NA
RA 16	Dredge to Clean and Channel Sand Cap between the northern RA boundary and Station 55+30 and from Stations 57+00 to 58+90	--	EW-28	--	BR-28	--	X	--
RA 17	Dredge to Clean and Channel Sand Cap between Station 54+70 and southern boundary of the RA	CC-27, CC-26	EW-27, EW-26	--	BR-26	--	X	--
RA 18	Dredge and Channel Sand Cap			--	--	--	X	--
RA 19A	Channel Sand, Grout Mat, and Slope Caps	CC-32, CC-29	EW-32, EW-29	--	BR-32, BR-29	SC-19A	X	X
RA 19B	Channel Sand, Grout Mat, and Slope Caps	--	--	--	--	SC-19B	X	X
RA 20	Dredge, Channel Sand and Slope Caps, and Habitat Enhancement	CC-31	EW-31	--	BR-31	SC-20	X	X
RA 21	Dredge and Channel Sand Cap	CC-30	EW-30	--	--	--	X	--
RA 22	Dredge and Channel Sand Cap	CC-33	EW-33	--	BR-33	--	X	--
Natural Recovery Area North of the 11th Street Bridge		--	EW-11, EW-10, EW-09, EW-08, EW-07, EW-06	NR-11, NR-10, NR-09, NR-08, NR-07, NR-06	BR-11, BR-10, BR-09, BR-07, BR-06	--	--	--
Natural Recovery Area adjacent to RA 12[1]		--	EW-19, EW-20	NR-19, NR-20	--	--	--	--
Natural Recovery Area at the mouth of the Wheeler-Osgood Waterway		--	EW-17	NR-17	--	--	--	--
Natural Recovery Area adjacent to RA 15 and RA 16		--	EW-25	NR-25	--	--	--	--

Notes:
1) Early Warning sediment sampling will be performed at sampling location EW-19, adjacent to the channel sand cap placed in the sheen source area.
2) Hydrographic survey performed to the 0 feet MLLW elevation, which extends partially into RA 15.
(--) Sample type not collected.
RA - Remedial Area
NA - Not applicable. Completed action was not constructed for chemical containment and is not included in OMMP monitoring requirements.
The CDF Monitoring Activities and Habitat Mitigation Monitoring Activities are shown separately in Tables 1-8 and 1-9.

Table 1-8
Summary of CDF Monitoring Activities and Sample Locations

OMMP Monitoring Activities	Sampling Location
Well Installation and Development	MW-01 through MW-15
72-Hour Tidal Study	MW-01 through MW-15, Middle Waterway and Surface Water Swale
Slug Tests	MW-01 through MW-15
Baseline Monitoring	
Well Sampling	TBD[1]
Surface Water Sampling	SMW-01
Performance Monitoring	TBD[2]

Notes:
1) Well locations selected for Baseline Monitoring will be based on the results of the 72-hour tidal study.
2) Frequency, well locations, and analyte list selected for Performance Monitoring will be based on the results of the Baseline Monitoring and results of the 72-hour tidal study.
CDF - Confined Disposal Facility
TBD - To be determined

Table 1-9
Summary of Habitat Mitigation Area Monitoring Activities and Locations

OMMP Monitoring Activities	Monitoring/Survey Locations				
	North Beach	Middle Waterway Tideflat	Puyallup River Side Channel	Hylebos Creek	Thea Foss Enhancement Area
Qualitative Ground Surveys	X	X	X	X	X
Quantitative Vegetation Surveys	X	X	X	X	
Photo Documentation	X	X	X	X	X
Elevation Monitoring[1]	X	X	X	X	
Brackish Marsh Salinity Monitoring		X			
Juvenile Salmonid Monitoring	X	X	X	X	
Invertebrate Monitoring			X	X	
Water Surface Elevation Monitoring				X	

Notes:
1) The vertical datum used during the construction phase of the project was MLLW. Due to the length of the OMMP monitoring period and the fact that MLLW changes over time, the vertical datum to be used during this phase has been designated as NGVD 29.

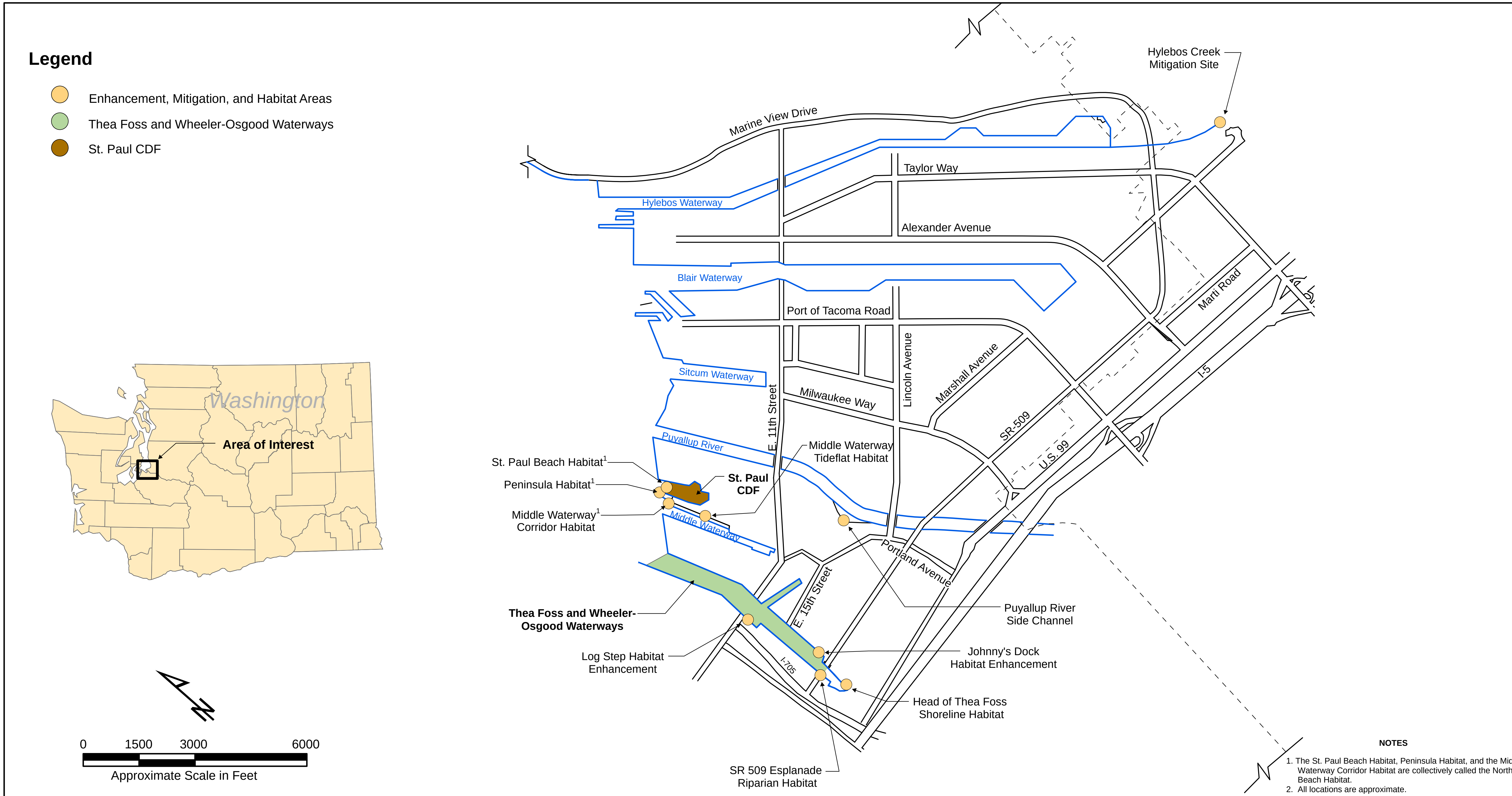

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Figure 1-1
Project Location Map

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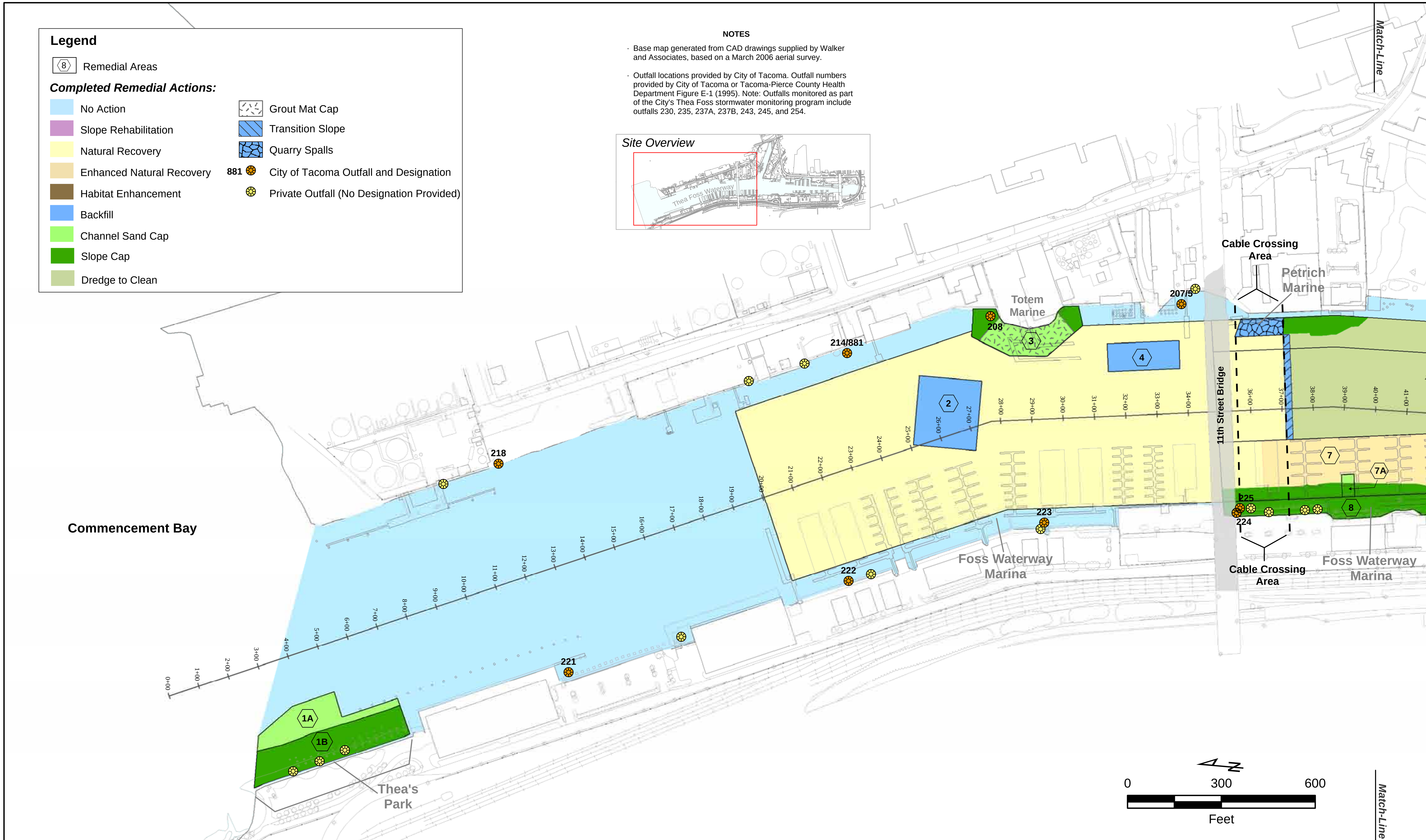

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Figure 1-2 (Page 1 of 2)
Completed Remedial Actions

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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure 1-2 (Page 2 of 2)
Completed Remedial Actions

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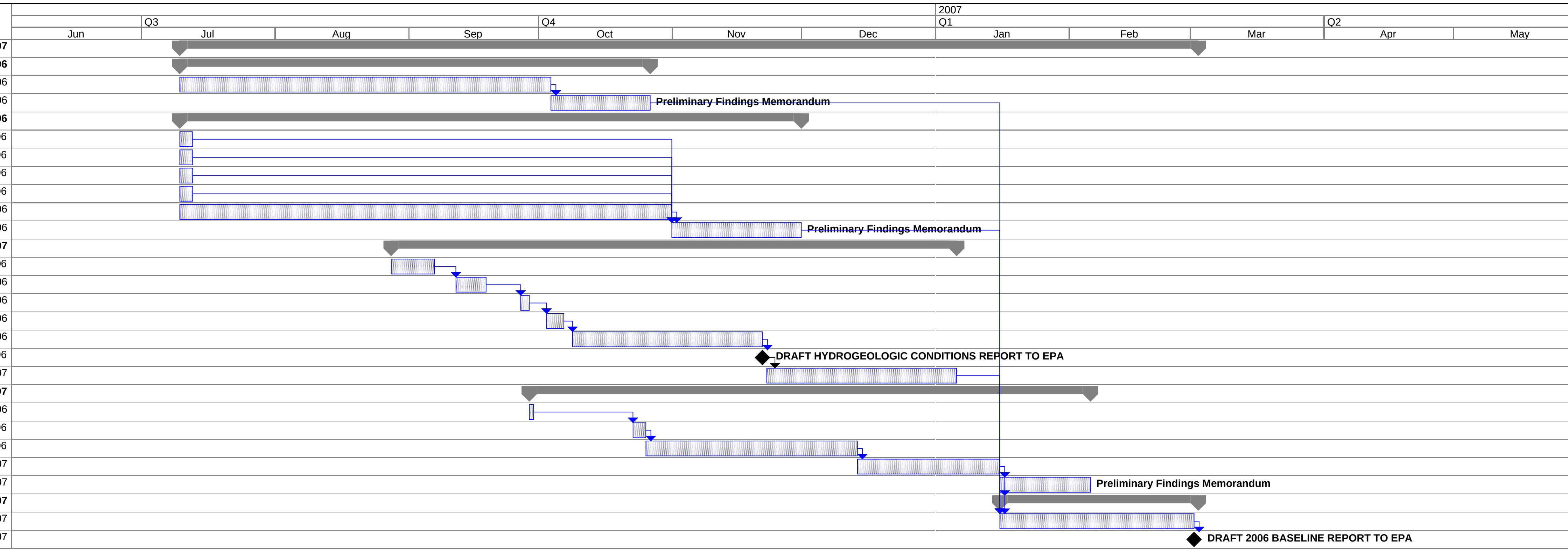
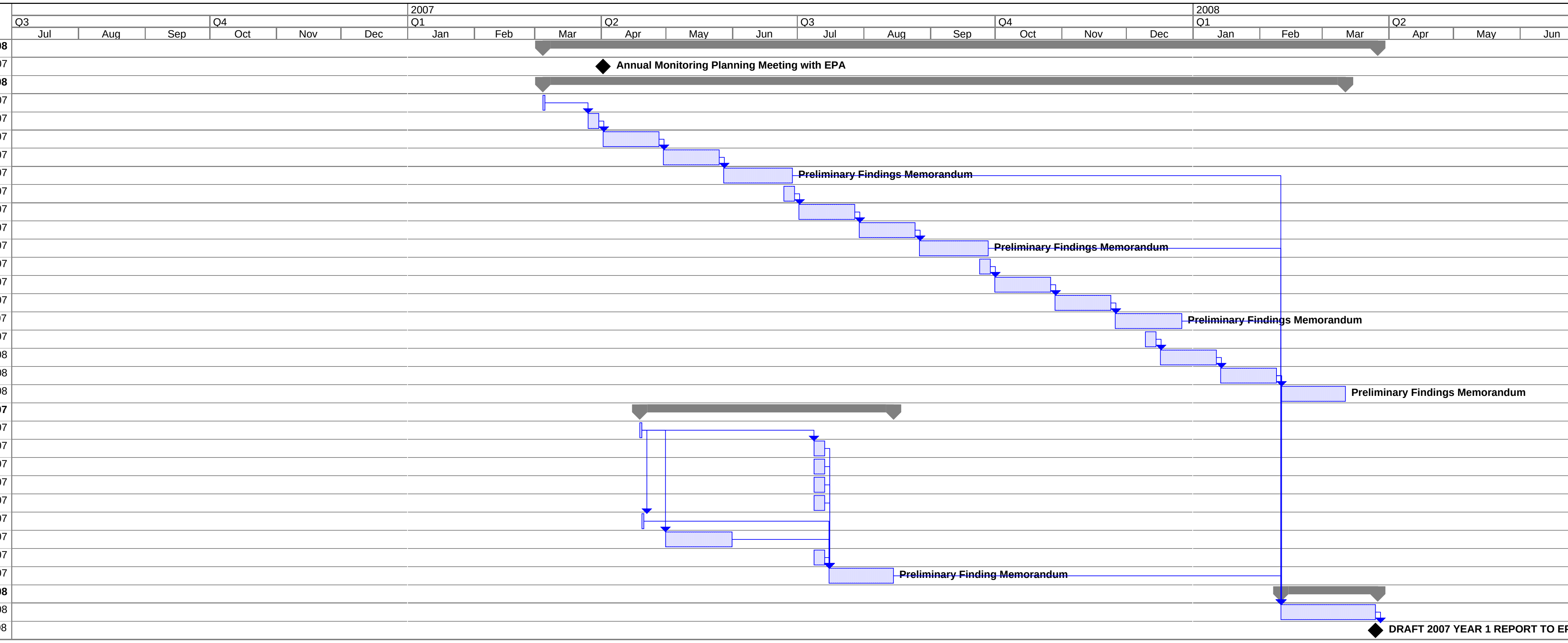
ID	Task Name	Start	Finish
1	**Baseline 2006 (Year 0)**	**Mon 7/10/06**	**Fri 3/2/07**
2	**Physical Cap Integrity Monitoring**	**Mon 7/10/06**	**Thu 10/26/06**
3	Low Tide Slope Cap Inspections	Mon 7/10/06	Tue 10/3/06
4	Preparation of Preliminary Findings Memo	Wed 10/4/06	Thu 10/26/06
5	**Habitat Mitigation Monitoring**	**Mon 7/10/06**	**Thu 11/30/06**
6	Qualitative Ground Survey	Mon 7/10/06	Wed 7/12/06
7	Photo Documentation	Mon 7/10/06	Wed 7/12/06
8	Elevation Monitoring	Mon 7/10/06	Wed 7/12/06
9	Brackish Marsh Salinity Monitoring	Mon 7/10/06	Wed 7/12/06
10	Water Surface Elevation Monitoring - Hylebos Creek	Mon 7/10/06	Tue 10/31/06
11	Preparation of Preliminary Findings Memo	Wed 11/1/06	Thu 11/30/06
12	**CDF Monitoring**	**Mon 8/28/06**	**Fri 1/5/07**
13	Well Installation	Mon 8/28/06	Wed 9/6/06
14	Well Development	Tue 9/12/06	Mon 9/18/06
15	Slug Tests	Wed 9/27/06	Thu 9/28/06
16	Tidal Study	Tue 10/3/06	Fri 10/6/06
17	Preparation of Hydrogeologic Conditions Report	Mon 10/9/06	Tue 11/21/06
18	Draft Hydrogeologic Conditions Report to EPA	Wed 11/22/06	Wed 11/22/06
19	Finalization of Report and Baseline Monitoring Program	Thu 11/23/06	Fri 1/5/07
20	**Sediment Remediation Area Performance Monitoring**	**Fri 9/29/06**	**Mon 2/5/07**
21	Notification of Field Activitites to EPA	Fri 9/29/06	Fri 9/29/06
22	Supplemental Baseline Natural Recovery Sampling	Mon 10/23/06	Wed 10/25/06
23	Analyses of Sediment Samples	Thu 10/26/06	Wed 12/13/06
24	Data Validation of Sediment Sampling Results	Thu 12/14/06	Mon 1/15/07
25	Preparation of Preliminary Findings Memo	Tue 1/16/07	Mon 2/5/07
26	**Annual Monitoring Report / Planning**	**Tue 1/16/07**	**Fri 3/2/07**
27	Prepare Baseline 2006 (Year 0) Report	Tue 1/16/07	Thu 3/1/07
28	Draft Baseline 2006 (Year 0) Report to EPA	Fri 3/2/07	Fri 3/2/07



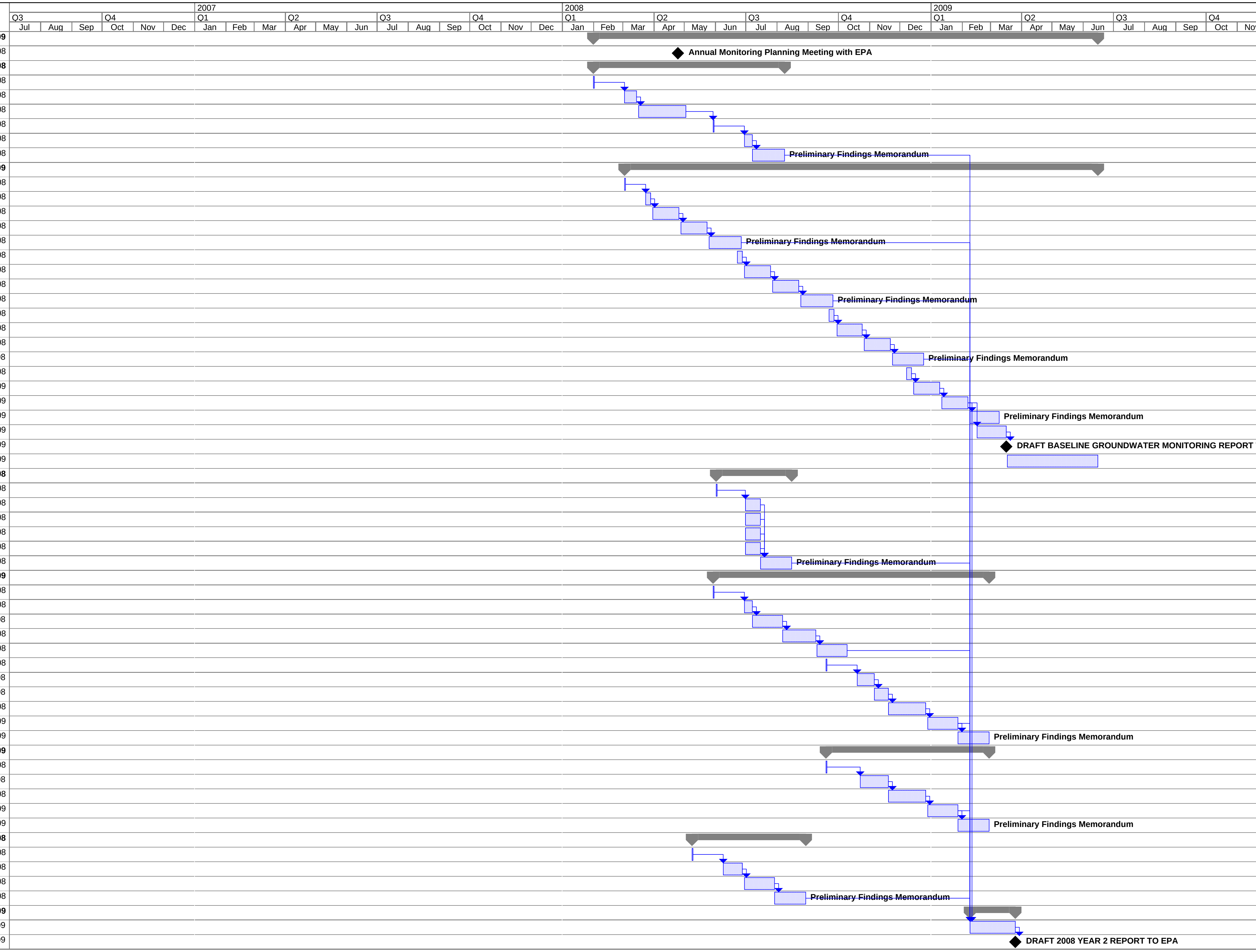
Notes:
All monitoring dates are subject to change due to available subcontractors, site/area access, and sampling. Exact dates of the schedule will be established with EPA.

ID	Task Name	Start	Finish
1	**2007 (Year 1)**	**Mon 3/5/07**	**Wed 3/26/08**
2	Annual Monitoring Planning Meeting with EPA	Mon 4/2/07	Mon 4/2/07
3	**CDF Monitoring**	**Mon 3/5/07**	**Tue 3/11/08**
4	Notification of Field Activities to EPA	Mon 3/5/07	Mon 3/5/07
5	Baseline Monitoring (First Quarter 2007)	Mon 3/26/07	Fri 3/30/07
6	Analyses of Water Samples	Mon 4/2/07	Fri 4/27/07
7	Data Validaiton of Monitoring Results	Mon 4/30/07	Fri 5/25/07
8	Preparataion of Preliminary Findings Memo	Mon 5/28/07	Thu 6/28/07
9	Baseline Monitoring (Second Quarter 2007)	Mon 6/25/07	Fri 6/29/07
10	Analyses of Water Samples	Mon 7/2/07	Fri 7/27/07
11	Data Validaiton of Monitoring Results	Mon 7/30/07	Fri 8/24/07
12	Preparation of Preliminary Findings Memo	Mon 8/27/07	Thu 9/27/07
13	Baseline Monitoring (Third Quarter 2007)	Mon 9/24/07	Fri 9/28/07
14	Analyses of Water Samples	Mon 10/1/07	Fri 10/26/07
15	Data Validaiton of Monitoring Results	Mon 10/29/07	Fri 11/23/07
16	Preparation of Preliminary Findings Memo	Mon 11/26/07	Wed 12/26/07
17	Baseline Monitoring (Fourth Quarter 2007)	Mon 12/10/07	Fri 12/14/07
18	Analyses of Water Samples	Mon 12/17/07	Fri 1/11/08
19	Data Validaiton of Monitoring Results	Mon 1/14/08	Fri 2/8/08
20	Preparation of Preliminary Findings Memo	Mon 2/11/08	Tue 3/11/08
21	**Habitat Mitigation Monitoring**	**Thu 4/19/07**	**Tue 8/14/07**
22	Notification of Field Activities to EPA	Thu 4/19/07	Thu 4/19/07
23	Qualitative Ground Survey	Mon 7/9/07	Fri 7/13/07
24	Quantitative Vegetation Surveys	Mon 7/9/07	Fri 7/13/07
25	Photo Documentation	Mon 7/9/07	Fri 7/13/07
26	Elevation Monitoring	Mon 7/9/07	Fri 7/13/07
27	Brackish Marsh Salinity Monitoring	Fri 4/20/07	Fri 4/20/07
28	Juvenile Salmonid Monitoring	Tue 5/1/07	Thu 5/31/07
29	Invertebrate Monitoring	Mon 7/9/07	Fri 7/13/07
30	Preparation of Preliminary Findings Memo	Mon 7/16/07	Tue 8/14/07
31	**Annual Monitoring Report**	**Mon 2/11/08**	**Wed 3/26/08**
32	Prepare 2007 Year 1 Report	Mon 2/11/08	Tue 3/25/08
33	Draft 2007 Year 1 Report to EPA	Wed 3/26/08	Wed 3/26/08



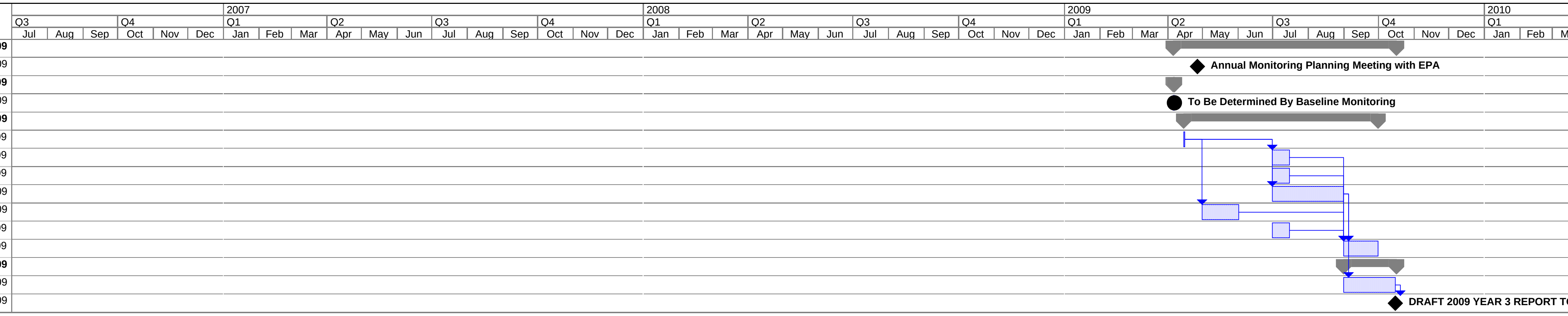
Notes:
All monitoring dates are subject to change due to available subcontractors, site/area access, and sampling. Exact dates of the schedule will be established with EPA.

ID	Task Name	Start	Finish
1	**2008 (Year 2)**	**Fri 2/1/08**	**Mon 6/15/09**
2	Annual Monitoring Planning Meeting with EPA	Fri 4/25/08	Fri 4/25/08
3	**Physical Cap Integrity Monitoring**	**Fri 2/1/08**	**Fri 8/8/08**
4	Notification of Field Activities to EPA	Fri 2/1/08	Fri 2/1/08
5	Subtidal Cap Hydrographic Surveys	Mon 3/3/08	Fri 3/14/08
6	Survey Data Processing and Analysis	Mon 3/17/08	Fri 5/2/08
7	Notification of Field Activities to EPA	Fri 5/30/08	Fri 5/30/08
8	Low Tide Slope Cap Inspections	Mon 6/30/08	Mon 7/7/08
9	Preparation of Preliminary Findings Memo	Tue 7/8/08	Fri 8/8/08
10	**CDF Monitoring**	**Mon 3/3/08**	**Mon 6/15/09**
11	Notification of Field Activities to EPA	Mon 3/3/08	Mon 3/3/08
12	Baseline Monitoring (First Quarter 2008)	Mon 3/24/08	Fri 3/28/08
13	Analyses of Water Samples	Mon 3/31/08	Fri 4/25/08
14	Data Validaiton of Monitoring Results	Mon 4/28/08	Fri 5/23/08
15	Preparation of Preliminary Findings Memo	Mon 5/26/08	Thu 6/26/08
16	Baseline Monitoring (Second Quarter 2008)	Mon 6/23/08	Fri 6/27/08
17	Analyses of Water Samples	Mon 6/30/08	Fri 7/25/08
18	Data Validaiton of Monitoring Results	Mon 7/28/08	Fri 8/22/08
19	Preparation of Preliminary Findings Memo	Mon 8/25/08	Thu 9/25/08
20	Baseline Monitoring (Third Quarter 2008)	Mon 9/22/08	Fri 9/26/08
21	Analyses of Water Samples	Tue 9/30/08	Fri 10/24/08
22	Data Validaiton of Monitoring Results	Mon 10/27/08	Fri 11/21/08
23	Preparation of Preliminary Findings Memo	Mon 11/24/08	Wed 12/24/08
24	Baseline Monitoring (Fourth Quarter 2008)	Mon 12/8/08	Fri 12/12/08
25	Analyses of Water Samples	Mon 12/15/08	Fri 1/9/09
26	Data Validaiton of Monitoring Results	Mon 1/12/09	Fri 2/6/09
27	Preparation of Preliminary Findings Memo	Mon 2/9/09	Mon 3/9/09
28	Preparation of Baseline Groundwater Monitoring Report	Mon 2/16/09	Mon 3/16/09
29	Draft Baseline Groundwater Monitoring Report to EPA	Tue 3/17/09	Tue 3/17/09
30	Finalization of Report and Performance Monitoring Program	Wed 3/18/09	Mon 6/15/09
31	**Habitat Mitigation Monitoring**	**Mon 6/2/08**	**Fri 8/15/08**
32	Notification of Field Activities to EPA	Mon 6/2/08	Mon 6/2/08
33	Qualitative Ground Survey	Tue 7/1/08	Tue 7/15/08
34	Quantitative Vegetation Surveys	Tue 7/1/08	Tue 7/15/08
35	Photo Documentation	Tue 7/1/08	Tue 7/15/08
36	Elevation Monitoring	Tue 7/1/08	Tue 7/15/08
37	Preparation of Preliminary Findings Memo	Wed 7/16/08	Fri 8/15/08
38	**Sediment Remediation Area Performance Monitoring**	**Fri 5/30/08**	**Fri 2/27/09**
39	Notification of Field Activities to EPA	Fri 5/30/08	Fri 5/30/08
40	Slope Cap Performance Monitoring (0 to 10 cm)	Mon 6/30/08	Mon 7/7/08
41	Analyses of Sediment Samples	Tue 7/8/08	Wed 8/6/08
42	Data Validation of Sediment Sampling Results	Thu 8/7/08	Mon 9/8/08
43	Preparation of Preliminary Findings Memo	Wed 9/10/08	Thu 10/9/08
44	Notification of Field Activities to EPA	Fri 9/19/08	Fri 9/19/08
45	Channel Sand Cap Performance Monitoring (0 to 10 cm)	Mon 10/20/08	Wed 11/5/08
46	Natural Recovery Performance Monitoring (0 to 10 cm)	Thu 11/6/08	Wed 11/19/08
47	Analyses of Sediment Samples	Thu 11/20/08	Fri 12/26/08
48	Data Validation of Sediment Sampling Results	Mon 12/29/08	Tue 1/27/09
49	Preparation of Preliminary Findings Memo	Wed 1/28/09	Fri 2/27/09
50	**Early Warning Monitoring for Recontamination**	**Fri 9/19/08**	**Fri 2/27/09**
51	Notification of Field Activities to EPA	Fri 9/19/08	Fri 9/19/08
52	Sediment Quality (0 to 2 cm) Monitoring	Thu 10/23/08	Wed 11/19/08
53	Analyses of Sediment Samples	Thu 11/20/08	Fri 12/26/08
54	Data Validation of Sediment Sampling Results	Mon 12/29/08	Tue 1/27/09
55	Preparation of Preliminary Findings Memo	Wed 1/28/09	Fri 2/27/09
56	**Benthic Recolonization Monitoring**	**Fri 5/9/08**	**Fri 8/29/08**
57	Notification of Field Activities to EPA	Fri 5/9/08	Fri 5/9/08
58	Sediment Profile Imaging and Archive Sediment Sample (0 to 10 c	Mon 6/9/08	Fri 6/27/08
59	Data Analysis	Mon 6/30/08	Tue 7/29/08
60	Preparation of Preliminary Findings Memo	Wed 7/30/08	Fri 8/29/08
61	**Annual Monitoring Report**	**Mon 2/9/09**	**Wed 3/25/09**
62	Prepare 2008 Year 2 Report	Mon 2/9/09	Wed 3/25/09
63	Draft 2008 Year 2 Report to EPA	Wed 3/25/09	Wed 3/25/09



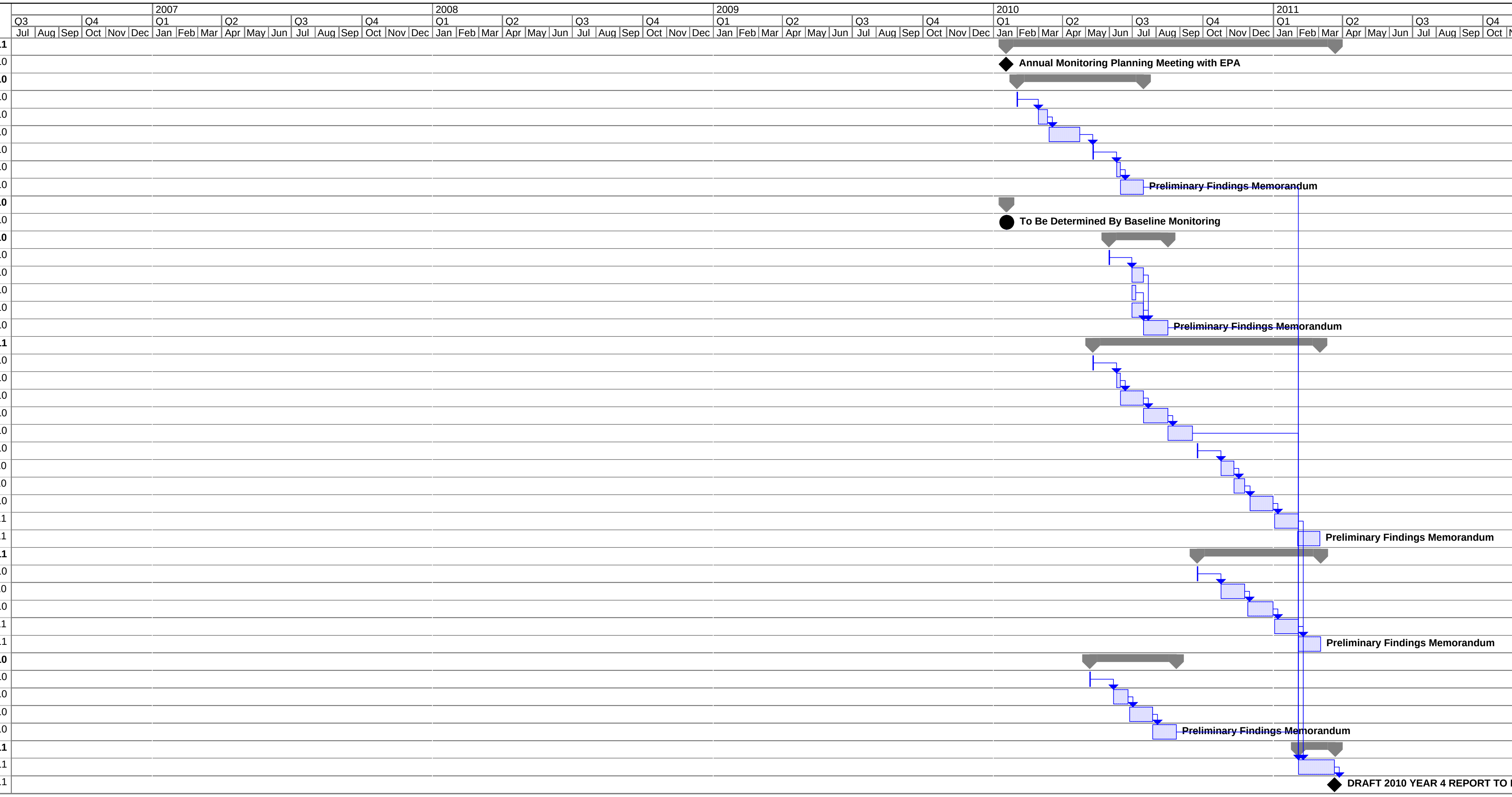
Notes:
All monitoring dates are subject to change due to available subcontractors, site/area access, and sampling. Exact dates of the schedule will be established with EPA.

ID	Task Name	Start	Finish
1	**2009 (Year 3)**	**Mon 4/6/09**	**Fri 10/16/09**
2	Annual Monitoring Planning Meeting with EPA	Mon 4/27/09	Mon 4/27/09
3	**CDF Monitoring**	**Mon 4/6/09**	**Mon 4/6/09**
4	Performance Monitoring (To Be Determined)	Mon 4/6/09	Mon 4/6/09
5	**Habitat Mitigation Monitoring**	**Wed 4/15/09**	**Wed 9/30/09**
6	Notification of Field Activities to EPA	Wed 4/15/09	Wed 4/15/09
7	Qualitative Ground Survey	Wed 7/1/09	Wed 7/15/09
8	Elevation Monitoring	Wed 7/1/09	Wed 7/15/09
9	Water Surface Elevation Monitoring - Hylebos Creek	Wed 7/1/09	Mon 8/31/09
10	Juvenile Salmonid Monitoring	Fri 5/1/09	Mon 6/1/09
11	Invertebrate Monitoring	Wed 7/1/09	Wed 7/15/09
12	Preparation of Preliminary Findings Memo	Tue 9/1/09	Wed 9/30/09
13	**Annual Monitoring Report**	**Tue 9/1/09**	**Fri 10/16/09**
14	Prepare 2009 Year 3 Report	Tue 9/1/09	Thu 10/15/09
15	Draft 2009 Year 3 Report to EPA	Fri 10/16/09	Fri 10/16/09



Notes:
All monitoring dates are subject to change due to available subcontractors, site/area access, and sampling. Exact dates of the schedule will be established with EPA.

ID	Task Name	Start	Finish
1	**2010 (Year 4)**	**Mon 1/18/10**	**Tue 3/22/11**
2	Annual Monitoring Planning Meeting with EPA	Mon 1/18/10	Mon 1/18/10
3	**Physical Cap Integrity Monitoring**	**Mon 2/1/10**	**Thu 7/15/10**
4	Notification of Field Activities to EPA	Mon 2/1/10	Mon 2/1/10
5	Subtidal Cap Hydrographic Surveys	Mon 3/1/10	Fri 3/12/10
6	Survey Data Processing and Analysis	Mon 3/15/10	Fri 4/23/10
7	Notification of Field Activities to EPA	Tue 5/11/10	Tue 5/11/10
8	Low Tide Slope Cap Inspections	Fri 6/11/10	Tue 6/15/10
9	Preparation of Preliminary Findings Memo	Wed 6/16/10	Thu 7/15/10
10	**CDF Monitoring**	**Mon 1/18/10**	**Mon 1/18/10**
11	Performance Monitoring (To Be Determined)	Mon 1/18/10	Mon 1/18/10
12	**Habitat Mitigation Monitoring**	**Tue 6/1/10**	**Mon 8/16/10**
13	Notification of Field Activities to EPA	Tue 6/1/10	Tue 6/1/10
14	Qualitative Ground Survey	Thu 7/1/10	Thu 7/15/10
15	Quantitative Vegetation Surveys	Thu 7/1/10	Mon 7/5/10
16	Photo Documentation	Thu 7/1/10	Thu 7/15/10
17	Preparation of Preliminary Findings Memo	Fri 7/16/10	Mon 8/16/10
18	**Sediment Remediation Area Performance Monitoring**	**Tue 5/11/10**	**Wed 3/2/11**
19	Notification of Field Activities to EPA	Tue 5/11/10	Tue 5/11/10
20	Slope Cap Performance Monitoring (0 to 10 cm)	Fri 6/11/10	Tue 6/15/10
21	Analyses of Sediment Samples	Wed 6/16/10	Thu 7/15/10
22	Data Validation of Sediment Sampling Results	Fri 7/16/10	Mon 8/16/10
23	Preparation of Preliminary Findings Memo	Tue 8/17/10	Fri 9/17/10
24	Notification of Field Activities to EPA	Fri 9/24/10	Fri 9/24/10
25	Channel Sand Cap Performance Monitoring (0 to 10 cm)	Mon 10/25/10	Wed 11/10/10
26	Natural Recovery Performance Monitoring (0 to 10 cm)	Thu 11/11/10	Wed 11/24/10
27	Analyses of Sediment Samples	Thu 12/2/10	Fri 12/31/10
28	Data Validation of Sediment Sampling Results	Mon 1/3/11	Wed 2/2/11
29	Preparation of Preliminary Findings Memo	Wed 2/2/11	Wed 3/2/11
30	**Early Warning Monitoring for Recontamination**	**Fri 9/24/10**	**Thu 3/3/11**
31	Notification of Field Activities to EPA	Fri 9/24/10	Fri 9/24/10
32	Sediment Quality (0 to 2 cm) Monitoring	Mon 10/25/10	Wed 11/24/10
33	Analyses of Sediment Samples	Mon 11/29/10	Fri 12/31/10
34	Data Validation of Sediment Sampling Results	Mon 1/3/11	Wed 2/2/11
35	Preparation of Preliminary Findings Memo	Thu 2/3/11	Thu 3/3/11
36	**Benthic Recolonization Monitoring**	**Fri 5/7/10**	**Fri 8/27/10**
37	Notification of Field Activities to EPA	Fri 5/7/10	Fri 5/7/10
38	Sediment Profile Imaging and Archive Sediment Sample (0 to 10 c	Mon 6/7/10	Fri 6/25/10
39	Data Analysis	Mon 6/28/10	Tue 7/27/10
40	Preparation of Preliminary Findings Memo	Wed 7/28/10	Fri 8/27/10
41	**Annual Monitoring Report**	**Thu 2/3/11**	**Tue 3/22/11**
42	Prepare 2010 Year 4 Report	Thu 2/3/11	Mon 3/21/11
43	Draft 2010 Year 4 Report to EPA	Tue 3/22/11	Tue 3/22/11

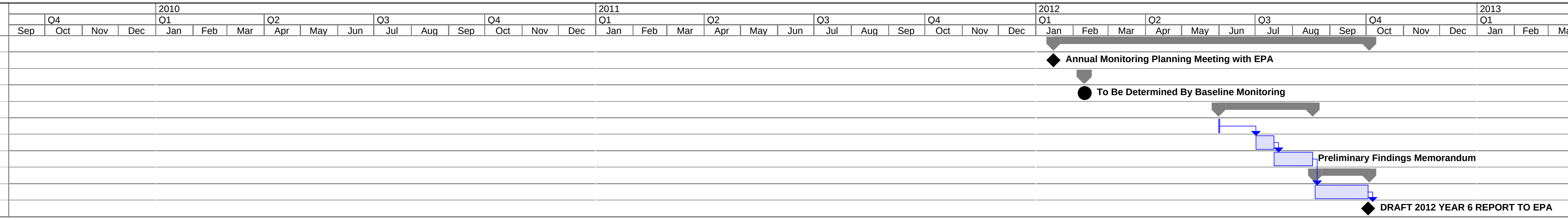


Notes:
All monitoring dates are subject to change due to available subcontractors, site/area access, and sampling. Exact dates of the schedule will be established with EPA.

ID	Task Name
1	**2011 (Year 5)**
2	Annual Monitoring Planning Meeting with EPA
3	**CDF Monitoring**
4	Performance Monitoring (To Be Determined)
5	**Habitat Mitigation Monitoring**
6	Notification of Field Activities to EPA
7	Qualitative Ground Survey
8	Elevation Monitoring
9	Water Surface Elevation Monitoring - Hylebos Creek
10	Preparation of Preliminary Findings Memo
11	**Annual Monitoring Report**
12	Prepare 2011 Year 5 Report
13	Draft 2011 Year 5 Report to EPA

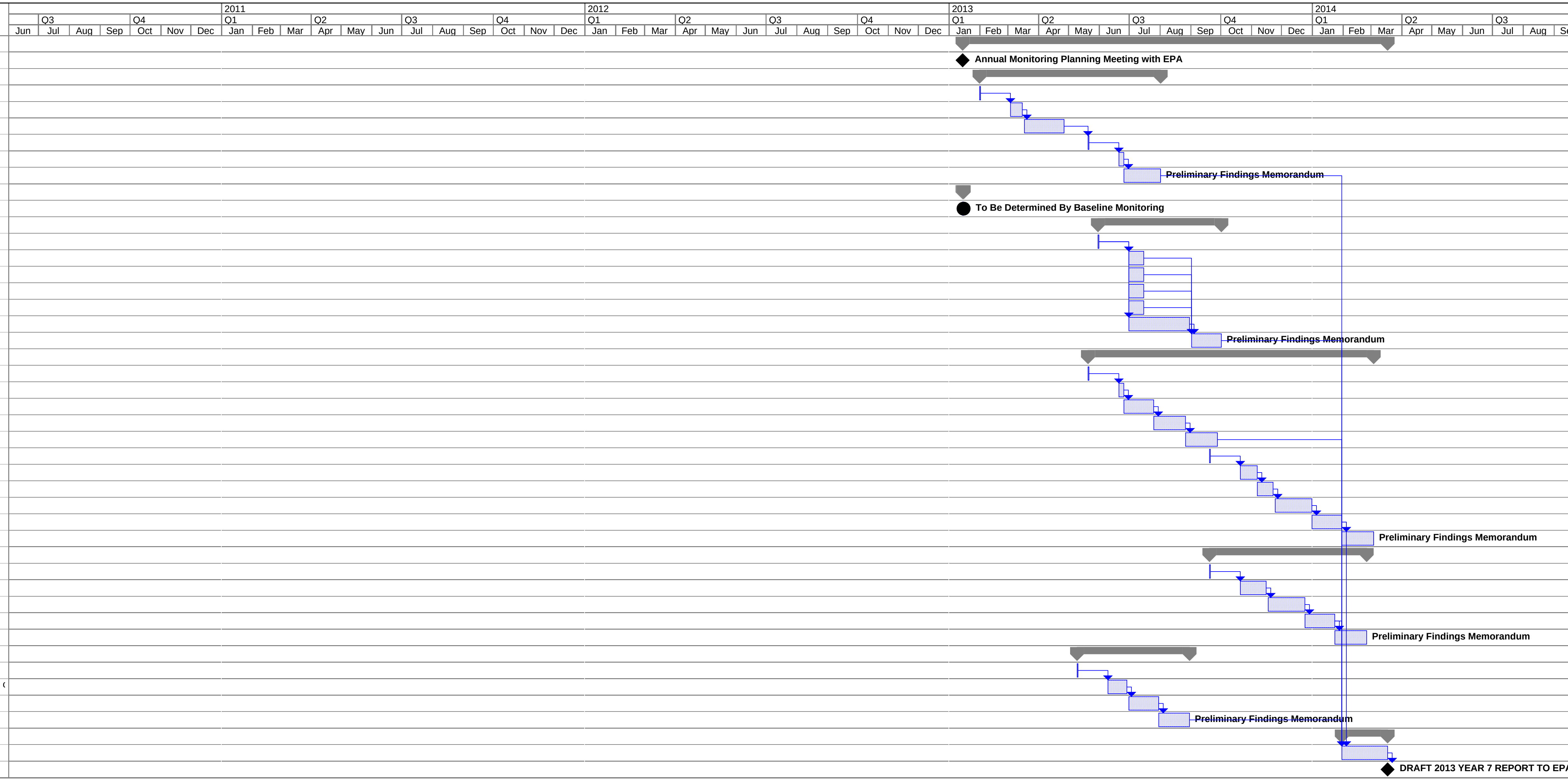
Notes:
All monitoring dates are subject to change due to available subcontractors, site/area access, and sampling. Exact dates of the schedule will be established with EPA.

ID	Task Name
1	**2012 (Year 6)**
2	Annual Monitoring Planning Meeting with EPA
3	**CDF Monitoring**
4	Performance Monitoring (To Be Determined)
5	**Habitat Mitigation Monitoring**
6	Notification of Field Activities to EPA
7	Qualitative Ground Survey
8	Preparation of Preliminary Findings Memo
9	**Annual Monitoring Report**
10	Prepare 2012 Year 6 Report
11	Draft 2012 Year 6 Report to EPA



Notes:
All monitoring dates are subject to change due to available subcontractors, site/area access, and sampling. Exact dates of the schedule will be established with EPA.

ID	Task Name
1	**2013 (Year 7)**
2	Annual Monitoring Planning Meeting with EPA
3	**Physical Cap Integrity Monitoring**
4	Notification of Field Activities to EPA
5	Subtidal Cap Hydrographic Surveys
6	Survey Data Processing and Analysis
7	Notification of Field Activities to EPA
8	Low Tide Slope Cap Inspections
9	Preparation of Preliminary Findings Memo
10	**CDF Monitoring**
11	Performance Monitoring (TBD)
12	**Habitat Mitigation Monitoring**
13	Notification of Field Activities to EPA
14	Qualitative Ground Survey
15	Quantitative Vegetation Surveys
16	Photo Documentation
17	Elevation Monitoring
18	Water Surface Elevation Monitoring - Hylebos Creek
19	Preparation of Preliminary Findings Memo
20	**Sediment Remediation Area Performance Monitoring**
21	Notification of Field Activities to EPA
22	Slope Cap Performance Monitoring (0 to 10 cm)
23	Analyses of Sediment Samples
24	Data Validation of Sediment Sampling Results
25	Preparation of Preliminary Findings Memo
26	Notification of Field Activities to EPA
27	Channel Sand Cap Performance Monitoring (0 to 10 cm)
28	Natural Recovery Performance Monitoring (0 to 10 cm)
29	Analyses of Sediment Samples
30	Data Validation of Sediment Sampling Results
31	Preparation of Preliminary Findings Memo
32	**Early Warning Monitoring for Recontamination**
33	Notification of Field Activities to EPA
34	Sediment Quality (0 to 2 cm) Monitoring
35	Analyses of Sediment Samples
36	Data Validation of Sediment Sampling Results
37	Preparation of Preliminary Findings Memo
38	**Benthic Recolonization Monitoring**
39	Notification of Field Activities to EPA
40	Sediment Profile Imaging and Archive Sediment Sample (0 to 10 c
41	Data Analysis
42	Preparation of Preliminary Findings Memo
43	**Annual Monitoring Report**
44	Prepare 2013 Year 7 Report
45	Draft 2013 Year 7 Report to EPA

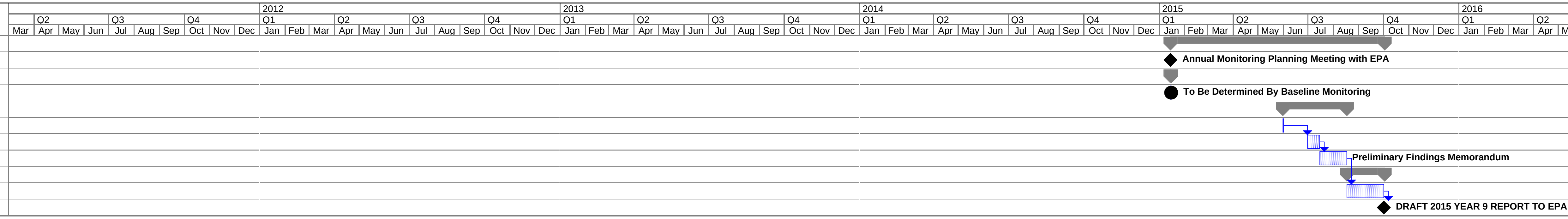


Notes:
All monitoring dates are subject to change due to available subcontractors, site/area access, and sampling. Exact dates of the schedule will be established with EPA.

ID	Task Name
1	**2014 (Year 8)**
2	Annual Monitoring Planning Meeting with EPA
3	**CDF Monitoring**
4	Performance Monitoring (To Be Determined)
5	**Habitat Mitigation Monitoring**
6	Notification of Field Activities to EPA
7	Qualitative Ground Survey
8	Preparation of Preliminary Findings Memo
9	**Annual Monitoring Report**
10	2014 Year 8 Reporting
11	Draft 2014 Year 8 Report to EPA

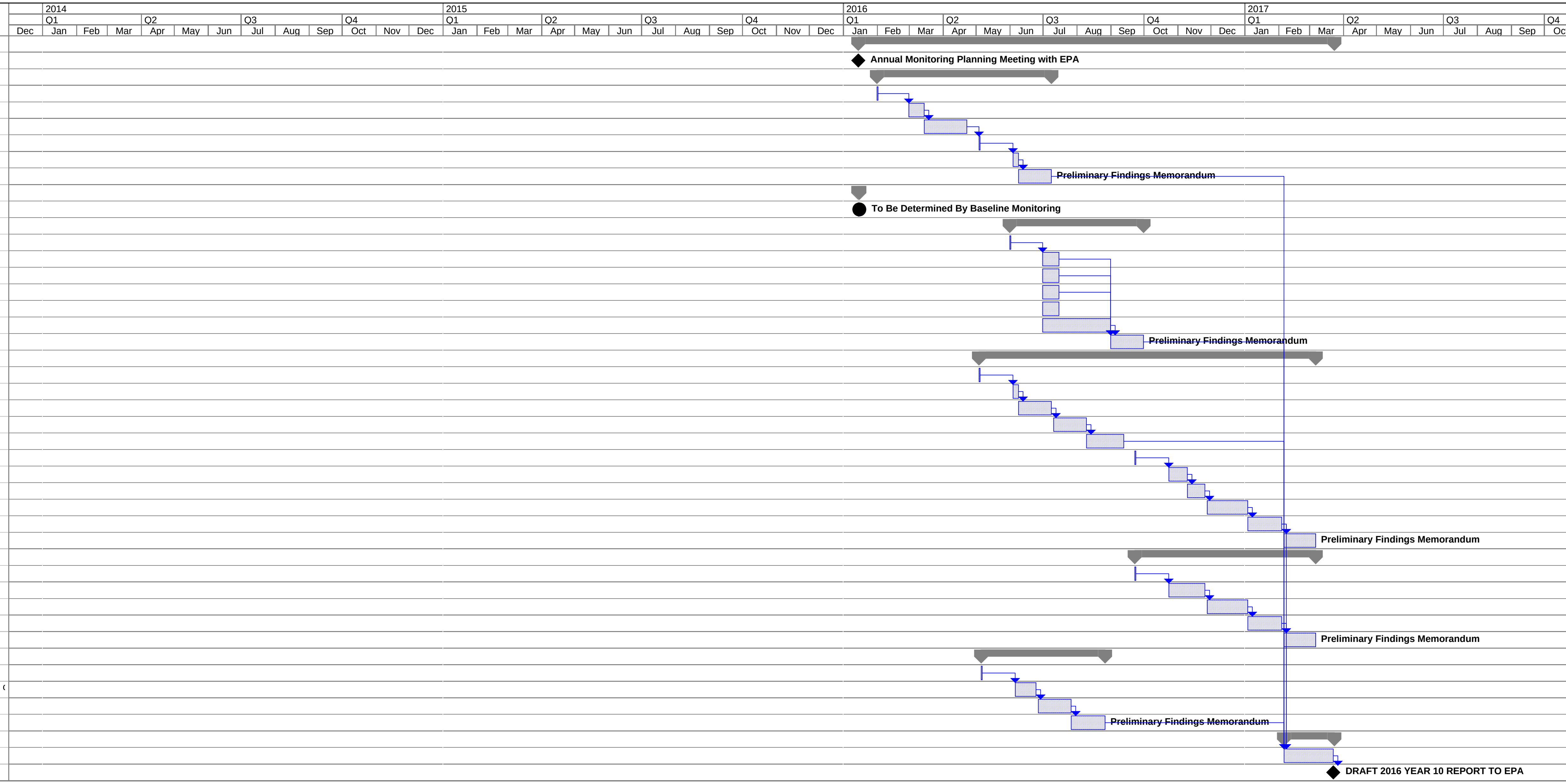
Notes:
All monitoring dates are subject to change due to available subcontractors, site/area access, and sampling. Exact dates of the schedule will be established with EPA.

ID	Task Name
1	**2015 (Year 9)**
2	Annual Monitoring Planning Meeting with EPA
3	**CDF Monitoring**
4	Performance Monitoring (To Be Determined)
5	**Habitat Mitigation Monitoring**
6	Notification of Field Activities to EPA
7	Qualitative Ground Survey
8	Preparation of Preliminary Findings Memo
9	**Annual Monitoring Report**
10	Prepare 2015 Year 9 Report
11	Draft 2015 Year 9 Report to EPA



Notes:
All monitoring dates are subject to change due to available subcontractors, site/area access, and sampling. Exact dates of the schedule will be established with EPA.

ID	Task Name
1	**2016 (Year 10)**
2	Annual Monitoring Planning Meeting with EPA
3	**Physical Cap Integrity Monitoring**
4	Notification of Field Activities to EPA
5	Subtidal Cap Hydrographic Surveys
6	Survey Data Processing and Analysis
7	Notification of Field Activities to EPA
8	Low Tide Slope Cap Inspections
9	Preparation of Preliminary Findings Memo
10	**CDF Monitoring**
11	Performance Monitoring (To Be Determined)
12	**Habitat Mitigation Monitoring**
13	Notification of Field Activities to EPA
14	Qualitative Ground Survey
15	Quantitative Vegetation Surveys
16	Photo Documentation
17	Elevation Monitoring
18	Water Surface Elevation Monitoring - Hylebos Creek
19	Preparation of Preliminary Findings Memo
20	**Sediment Remediation Area Performance Monitoring**
21	Notification of Field Activities to EPA
22	Slope Cap Performance Monitoring (0 to 10 cm)
23	Analyses of Sediment Samples
24	Data Validation of Sediment Sampling Results
25	Preparation of Preliminary Findings Memo
26	Notification of Field Activities to EPA
27	Channel Sand Cap Performance Monitoring (0 to 10 cm)
28	Natural Recovery Performance Monitoring (0 to 10 cm)
29	Analyses of Sediment Samples
30	Data Validation of Sediment Sampling Results
31	Preparation of Preliminary Findings Memo
32	**Early Warning Monitoring for Recontamination**
33	Notification of Field Activities to EPA
34	Sediment Quality (0 to 2 cm) Monitoring
35	Analyses of Sediment Samples
36	Data Validation of Sediment Sampling Results
37	Preparation of Preliminary Findings Memo
38	**Benthic Recolonization Monitoring**
39	Notification of Field Activities to EPA
40	Sediment Profile Imaging and Archive Sediment Sample (0 to 10 c
41	Data Analysis
42	Preliminary Findings Memo to EPA
43	**Annual Monitoring Report**
44	Prepare 2016 Year 10 Report
45	Draft 2016 Year 10 Report to EPA



Notes:
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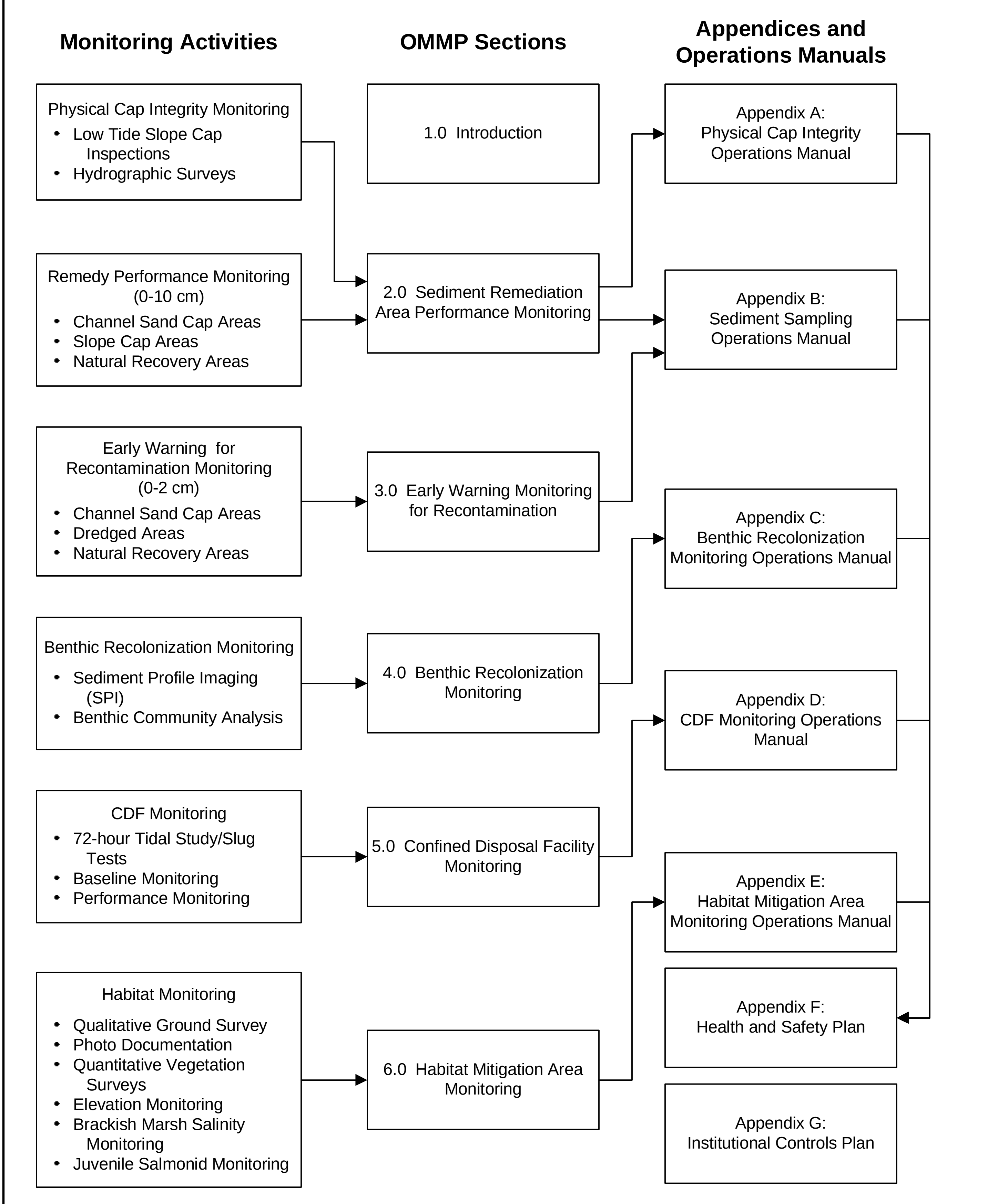

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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure 1-4
Monitoring Activities and OMMP Organization

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Monitoring Activities	Monitoring Activity Types	Remedial Areas (RA) and Other Monitoring Areas
Physical Cap Integrity Monitoring	Low Tide Slope Cap Inspections	RA 1B, RA 3, RA 8, RA 14, RA 19A, RA 19B, RA 20
	Hydrographic Surveys	RA 1A, RA 1B, RA 3, RA 6, RA 7A, RA 8, RA 9, sheen source area, RA 14, RA 16, RA 17, RA 18, RA 19, RA 20, RA 21, RA 22
Remedy Performance Monitoring (0-10 cm)	Channel Sand Cap Areas	RA 1A, RA 6, RA 9, RA 17, RA 19A, RA 20, RA 21, RA 22
	Slope Cap Areas	RA 1B, RA 3, RA 8, RA 14, RA 19A, RA 19B, RA 20
	Natural Recovery/ ENR Areas	RA 5, RA 6, RA 7, NR area north of the 11th St. Bridge, NR area adjacent to RA 12, NR area at the mouth of the Wheeler-Osgood Waterway, NR area adjacent to RA 15 and RA 16
Early Warning for Recontamination Monitoring (0-2 cm)	Channel Sand Cap Areas; Dredged Areas	RA 1A, RA 5, RA 6, RA 16, RA 17, RA 19A, RA 20, RA 21, RA 22
	Natural Recovery Areas	NR area north of the 11th St. Bridge, northern portions of RA 5 and &, NR area adjacent to RA 12, NR area at the mouth of the Wheeler-Osgood Waterway, NR area adjacent to RA 15 and RA 16
Benthic Recolonization Monitoring	Sediment Profile Imaging (SPI); Benthic Community Analysis	RA 5, RA 6, RA 7, RA 9, RA 16, RA 17, RA 19A, RA 20, RA 22, NR area north of the 11th St. Bridge
CDF Monitoring	72-hour Tidal Study/Slug Tests	MW-01 through MW-15
	Baseline Monitoring	Monitoring wells to be determined and SWM-01
	Performance Monitoring	Monitoring wells to be determined
Habitat Mitigation Monitoring	Qualitative Ground Survey; Photo Documentation	North Beach, Middle Waterway Tideflat, Puyallup River Side Channel, Hylebos Creek, Thea Foss Enhancement Area
	Quantitative Vegetation Surveys; Elevation Monitoring; Juvenile Salmonid Monitoring	North Beach, Middle Waterway Tideflat, Puyallup River Side Channel, Hylebos Creek
	Brackish Marsh Salinity Monitoring	Middle Waterway Tideflat

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Figure 1-5
Monitoring Activities and Remedial Areas

2.0 SEDIMENT REMEDIATION AREA PERFORMANCE MONITORING

The sediment remediation area performance monitoring program is designed to evaluate the long-term effectiveness of sediment caps, enhanced natural recovery, and natural recovery remedies implemented by the City of Tacoma (City) as part of the Thea Foss and Wheeler-Osgood Waterways Remediation Project. Performance monitoring activities include physical inspection of capped areas to ensure that the engineered caps remain intact; chemical monitoring of cap surface (0 to 10 cm) sediments to confirm that the underlying contaminants are contained, and chemical monitoring of surface (0 to 10 cm) sediments within natural recovery and enhanced natural recovery areas to confirm that natural recovery is occurring within the compliance period. Areas of the Thea Foss and Wheeler-Osgood Waterways that were dredged to clean or dredged to clean and backfilled are not subject to long-term performance monitoring. Post-dredge verification sampling completed as part of the construction activities demonstrated that contamination was removed and that the removal actions met the dredging remedy performance goals. The monitoring objectives described below are consistent with the Record of Decision (ROD) (EPA 1989), Administrative Order on Consent (AOC) (EPA 1994), Explanation of Significant Differences (ESD) (EPA 2000, EPA 2004), and the Consent Decree (CD) (EPA 2003) for the project. The project Remedial Action Objectives (RAO) and objectives for monitoring of the remedy and the subsequent Operations, Maintenance, and Monitoring Plan (OMMP) activities that meet those requirements are presented in Table 1-5.

This sediment remediation area monitoring plan establishes the performance monitoring purpose, objectives, approach, and criteria. The monitoring plan also presents the methods and procedures for field sampling and quality control/quality assurance protocols (Appendix A – Physical Cap Integrity Operations Manual and Appendix B – Sediment Sampling Operations Manual). Health and Safety protocols regarding performance monitoring activities are presented in Appendix F.

2.1 Sediment Remediation Area Performance Monitoring Objectives and Rationale

The sediment remediation area performance monitoring program is designed to achieve the following objectives:

- Ensure sediment caps provide effective containment, both physically and chemically, of contaminated underlying sediments, and provide a substrate that promotes colonization by aquatic organisms (ROD, ESD); and
- Confirm that within natural recovery areas chemical concentrations will attenuate to below Sediment Quality Objectives (SQO) within the 0 to 10 cm compliance interval within 10 years of completion of remediation construction (i.e., by 2016) (ROD).

The monitoring program includes the collection, analysis, and interpretation of sediment physical and chemical quality data from intertidal sampling locations, channel cap sampling locations, and at natural recovery sampling locations, and conducting hydrographic surveys and low tide slope cap inspections.

2.2 Performance Monitoring Approach

2.2.1 Performance Monitoring Activities

The Scope of Work for the performance monitoring program is separated into Baseline (Year 0) and Long-Term (Years 2, 4, 7, and 10) Performance Monitoring.

Baseline (Year 0) includes the following activities:

- Compiling existing construction verification surface (0 to 10 cm) sediment data collected from final cap surfaces and within natural recovery areas to serve as the baseline condition;
- Conducting supplemental surface (0 to 10 cm) sediment sampling within natural recovery and enhanced natural recovery areas (Figure 2-1). Supplemental sampling data will be combined with existing data to establish a comprehensive natural recovery baseline;
- Perform a low tide slope cap inspection to establish baseline conditions for the intertidal portions of the slope cap; and
- Compile the post-construction hydrographic survey data to serve as the baseline for the subtidal cap integrity conditions.

Table 2-1 presents the existing natural recovery samples locations and identifies locations where supplemental natural recovery baseline data will be collected as part of the Year 0 sampling activities to establish final baseline conditions. Supplemental baseline surface samples will be collected in Year 0 to adequately characterize chemical concentrations in natural recovery areas.

Figure 2-1 presents the proposed additional natural recovery area baseline sampling locations. Figure 2-2 shows the areas where low tide slope cap inspections will be performed during baseline and long-term monitoring activities.

Long-Term (Years 2, 4, 7 and 10) Performance Monitoring includes the following activities:

- Conducting surface (0 to 10 cm) sediment sampling of capped areas to evaluate cap performance. Composite surface (0 to 10 cm) sediment samples will be collected from intertidal areas of the slope cap, whereas discreet samples will be collected from areas of the channel sand cap;
- Conducting surface (0 to 10 cm) sediment sampling within natural recovery and enhanced natural recovery areas to evaluate chemical concentration trends over time;
- Performing low tide inspections of intertidal slope cap areas to evaluate slope cap integrity; and
- Performing hydrographic surveys of subtidal slope cap and channel sand cap areas to evaluate cap integrity.

Monitoring data will be collected throughout several monitoring events and compared to previous monitoring data to evaluate the overall success of the remediation. The areas where low tide slope cap inspections will be performed are shown on Figure 2-2. The areas where the hydrographic surveys will be conducted are shown on Figure 2-3. Figure 2-4 presents the sediment remediation area performance monitoring sampling locations (Years 2, 4, 7, and 10) for the project area. The rationale for the placement of Channel Sand Cap and Natural Recovery Chemical Performance Monitoring locations is presented in Table 2-2.

2.2.2 Performance Criteria and Decision Matrices

Performance Criteria. The long-term compliance of the sediment cap and natural recovery areas in the Thea Foss and Wheeler-Osgood Waterways will be evaluated using the following performance criteria:

- **Natural Recovery Time Frame.** The Commencement Bay SQOs must be achieved within 10 years from the completion of construction (2016), as per the ROD;
- **Capped Areas Sediment Quality Point of Compliance.** The SQOs must be maintained in the upper 10 centimeters of the sediment caps which correspond to the biological mixing zone for benthic organisms, as per the ROD;
- **Minimum Cap Thickness.** A minimum cap thickness of three feet was achieved during placement for capped areas, as per the ROD. A loss of six inches or more of cap thickness will trigger evaluation of potential response actions as determined from the cap integrity hydrographic surveys; and
- **Cap Design Life.** The current minimum design life for the sediment caps is 50 years, however, calculations completed as part of the remedial design show that the caps are expected to remain in compliance for a longer time period.

Parameters to be evaluated for performance monitoring include the Chemicals of Concern (COC) used to evaluate and confirm completion of remedial actions. The COCs and associated SQOs are presented in Table 2-3. Conventional parameter analyses such as total organic carbon (TOC) and Total Solids will also be performed in all sediment samples.

Decision Matrices. Decision matrices have been developed for guidance during the sediment remediation area performance monitoring. The decision matrices are designed to facilitate the data evaluation process and provide guidance regarding evaluation of response actions, notifications to EPA, establishing future monitoring requirements and completion of performance monitoring activities. Decision matrices are presented in Figure 2-5 (Cap Integrity Monitoring), Figure 2-6 (Cap Performance Monitoring) and Figure 2-7 (Natural Recovery Monitoring). The discussion of data analysis procedures (summarized in the decision matrices) is provided in Sections 2.3 and 2.4.

If performance monitoring data indicate the capped and natural recovery areas are not meeting their respective performance criteria, or evidence is provided to indicate that the performance criteria are not likely to be met in the future, potential response actions will be evaluated and discussed with EPA as described in Sections 2.3 and 2.4.

2.2.3 Schedule and Reporting Overview

The schedule for performance monitoring activities is presented in Table 2-4 and includes the following:

Performance Monitoring

All sediment remediation area performance monitoring activities and associated reporting will be completed to provide consistent data and for use in monitoring evaluations throughout the OMMP time frame.

Baseline monitoring activities will be completed during Year 0 (2006), as described in Section 2.2.1. Additionally, the post-construction hydrographic survey, completed in 2006, will be used as the baseline for subtidal cap integrity.

Following establishment of baseline conditions in Year 0, long-term performance monitoring will be completed during Years 2, 4, 7, and 10. Low tide inspections and hydrographic surveys will be performed, and sediment samples will be collected at the same locations, to the extent practicable, during each monitoring event. Protocols for low tide inspections and hydrographic surveys of channel sand cap and subtidal slope cap surfaces are presented in the Physical Cap Integrity Operations Manual (Appendix A). Sampling protocols, location control, analytical methods, and data validation procedures for performance sampling and analysis are presented in the Sediment Sampling Operations Manual (Appendix B).

Reporting

Notification of field activities will be provided to EPA 30 days prior to the beginning of monitoring activities. Following the completion of monitoring activities, data validation, and data analysis, a Preliminary Findings Memorandum will be submitted to EPA to facilitate the next steps in the monitoring process or the implementation of response actions if necessary. The Preliminary Findings Memoranda will be incorporated into annual OMMP monitoring reports. Annual reports will be prepared following each sediment remediation area performance monitoring event, which includes Years 0 (baseline), 2, 4, 7, and 10. Each annual monitoring event report will be submitted to EPA within 45 days from receipt of final data validation or as otherwise approved by EPA. Reports will include a summary of field activities, calculations, field and laboratory data, and results of analyses completed for the monitoring event.

The Baseline (Year 0) Sediment Remediation Area Monitoring Report will include the following information:

- A summary of field activities;
- The post-construction hydrographic survey (used as the baseline subtidal hydrographic survey as part of cap integrity monitoring);
- Results of the Year 0 low tide slope cap inspection, completed to establish the baseline for the low tide cap inspection part of cap integrity monitoring;
- A summary of existing data, collected during remediation construction, within cap areas to establish the baseline for cap areas; and

- A summary of the data collected during remediation construction that partially establishes the sediment quality baseline for natural recovery and enhanced natural recovery areas and the results of supplemental samples collected to complete the baseline for natural recovery and enhanced natural recovery areas.

The Baseline Sediment Remediation Area Monitoring Report will be included in the overall OMMP Year 0 Report which will be submitted for review and approval by EPA.

The Sediment Remediation Area Monitoring Reports for Years 2, 4, 7, and 10 will include the following information:

- A summary of field activities;
- Hydrographic survey data and comparisons to prior survey events for use in cap integrity monitoring;
- Low tide inspection data and comparisons to previous inspection events for use in cap integrity monitoring;
- Sediment quality data, supporting documentation, and data evaluation to support performance monitoring for cap areas;
- Sediment quality data, supporting documentation, and data evaluation to support performance monitoring for natural recovery and enhanced natural recovery areas; and
- Analyses and recommendations for potential response actions, if necessary.

The Sediment Remediation Area Monitoring Reports will be included in the overall OMMP Year 0 Report which will be submitted for review and approval by EPA. Additionally, the Year 10 performance monitoring report will include recommendations for any further monitoring deemed to be necessary to achieve the performance standards.

Table 2-4 provides a relational schedule describing the proposed performance monitoring schedule and corresponding reporting to EPA.

2.3 Cap Area Performance Monitoring

Monitoring will be performed to verify cap integrity and performance (through effective containment of the underlying contaminated sediments). The cap performance monitoring program is designed to detect and evaluate long-term changes in cap thickness, and surface sediment quality to ensure compliance with performance criteria. Cap performance monitoring field activities include the following:

- **Low Tide Slope Cap Inspections.** Low tide slope cap inspections will be performed to verify the physical integrity of the slope and grout mat caps. Monitoring activities and objectives will include visual inspection of slope and grout mat cap conditions to ensure that the caps are intact and coverage has been maintained (i.e., underlying contaminated sediment is not exposed);
- **Subtidal Cap Hydrographic Surveys.** Hydrographic surveys will be performed in subtidal slope, grout mat, and channel sand cap areas to evaluate changes (scour /

erosion or deposition) in cap thickness as indicated by changes in elevation over time; and

- **Sediment Quality Sampling.** Surface (0 to 10 cm) samples will be collected for chemical testing in slope cap and channel sand cap areas to verify compliance with SQOs.

The approach to assessment of cap integrity and the respective inspection requirements are described in Section 2.3.1. Low tide slope cap inspections and hydrographic survey protocols, including location control procedures, are presented in the Physical Cap Integrity Operations Manual (Appendix A).

The assessment of sediment chemical performance monitoring data is described in Section 2.3.2. Sampling protocols, location control, analytical methods, and data validation procedures are presented in the Sediment Sampling Operations Manual (Appendix B).

2.3.1 Cap Integrity Monitoring

The physical integrity of intertidal portions of cap areas will be monitored through low tide inspections of the slope caps (including grout mat caps). The physical integrity of subtidal cap areas will be monitored through hydrographic surveys of subtidal slope and channel sand cap areas.

Low Tide Slope Cap Inspections

The integrity of slope cap material will be monitored by direct observation during periods of low tide (elevation 0 feet Mean Lower Low Water [MLLW] or lower if exposed during low tide) at the locations shown on Figure 2-2.

Monitoring Frequency. Low tide slope cap inspections will be conducted in Years 0 (baseline), 2, 4, 7, and 10, according to the monitoring schedule presented in Section 2.2.3 and Table 2-4. Additional low tide inspections may also be completed after one of the following occurrences is thought to have potentially adversely impacted the integrity of the remedy: a storm event that has led to shoreline failure, such as erosion or a landslide; a marine accident, such as a vessel grounding or spill; and a seismic event where structural damages have been realized within the City. Determination of the need for these additional monitoring events will be made in consultation with EPA.

Cap integrity monitoring activities will be conducted prior to sediment cap performance monitoring to provide additional data on the physical status of capped areas and to facilitate identification of additional sampling locations, or to re-locate sample locations, if necessary.

Field Activities. The shoreline areas that will be monitored during low tide inspections are shown on Figure 2-2. Observations of the slope cap will be documented using approximate 100-foot monitoring intervals along designated shoreline areas. The inspections will document the following observations;

- Slope cap surface characteristics (i.e., rip rap, quarry spalls, habitat mix, etc.);
- Area of slope cap coverage;

- Presence/absence of habitat mix;
- Any areas of exposed sediment due to washout of the slope cap;
- Any areas of sediment accretion;
- Evidence of groundwater seepage;
- Any apparent loss of slope cap material;
- Any apparent down-slope movement of cap materials;
- Presence of debris on the cap surface; and
- Indicators of potential contamination (i.e., sheen or staining) within the surface sediment.

Low tide slope cap inspections of grout mat slope cap areas will also be performed in RAs 19A, 19B, and 3 as shown on Figure 2-2. As part of the low tide inspections, grout mat areas will be inspected to verify that the grout mat cap is effectively containing the underlying contaminated sediments in addition to the observations identified above. Low tide slope cap inspections will also be performed in the capped sheen source area adjacent to RA 12 in the Wheeler-Osgood Waterway.

Data Analysis. Low tide slope cap inspection observations will be recorded on field monitoring forms and evaluated to determine the status of cap integrity. Notes recorded on the field monitoring forms and comparisons to previous monitoring event data will be used to evaluate if the cap is physically intact. This procedure is outlined in the Cap Integrity Monitoring Decision Matrix (Figure 2-5).

If results of low tide slope cap inspections (and hydrographic survey comparisons) indicate cap integrity criteria are achieved after Year 10 monitoring activities have been completed, the need for any future cap integrity monitoring will be evaluated and proposed to EPA in conjunction with the request for Certification of Completion in accordance with the Consent Decree.

Potential Response Actions for Low Tide Slope Cap Integrity Monitoring. If the results of the low tide slope cap inspections and data comparisons to previous survey monitoring events indicate that significant areas of the slope caps are not intact, determination of appropriate response actions will be coordinated with EPA. Potential response actions may include, but are not limited to, the following:

- Conducting supplemental field inspections to delineate areas of cap disturbance and to collect additional information to determine potential causes of the cap disturbance, if needed;
- Performing a diver survey to delineate the extent of cap disturbance that may extend below elevations that would be exposed during low tide conditions;
- Performing repairs and/or modifications to failed areas of the cap to prevent contaminant loss and limit future disturbance of the cap; and
- Implementing administrative controls to limit further cap disturbance, such as potentially modifying vessel traffic in areas that are subject to substantial propeller scour.

Implementation of potential response actions will be based on the evaluation of existing data as well as evaluating if response actions are needed.

Subtidal Cap Hydrographic Surveys

Cap integrity within subtidal slope cap and channel sand cap areas will be monitored by comparison of hydrographic surveys. Surveys will be performed in the areas shown on Figure 2-3. In the event that access to the capped areas is prohibited due to boat moorage, facility activities, etc., the City will coordinate data collection sampling activities with property owners and developers to gain access to areas necessary to provide a complete hydrographic survey of capped areas.

Monitoring Frequency. A hydrographic survey was completed in 2006 upon completion of remediation construction. The post-construction hydrographic survey completed in 2006 will be used as the baseline (Year 0) bathymetric conditions for the cap areas.

As part of performance monitoring, hydrographic surveys will be completed in Years 2, 4, 7, and 10, as described in Section 2.2.3 and Table 2-4. The objective for OMMP multibeam hydrographic surveys of capped areas is to gather data with sufficient density of spot elevations and overlapping beam width to provide complete and comprehensive coverage. Data from these surveys will be compared to previous surveys to assess potential long-term changes in cap thickness.

Field Activities and Quality Control. To ensure comparability between survey events, each hydrographic survey should be completed using compatible methodology in accordance with the methods as described in USACE Engineering Manual 1110-2-1003, and subsequent manual revisions. Transect locations will follow, to the extent possible, those used in the baseline (Year 0) survey to ensure comparative data are collected.

Attachment A-1 of the Physical Cap Integrity Operations Manual (Appendix A) provides details on data collection and quality control for hydrographic surveys.

Data Analysis. Hydrographic survey results will be compared to previous monitoring surveys to evaluate potential changes in the cap elevation over time and to identify possible erosional features. Consolidation of underlying sediments should also be considered in the evaluation of apparent changes in cap thickness, especially during the early years of monitoring. Hydrographic survey data will be evaluated to identify whether a contiguous region of the cap exhibits greater than six inches of net erosion relative to previous surveys.

The decision matrix for the evaluation of hydrographic survey data, including comparison of survey data to previous monitoring events is presented in the Cap Integrity Monitoring Decision Matrix (Figure 2-5).

If results of hydrographic surveys indicate cap integrity criteria are achieved after Year 10 monitoring activities have been completed, the City will evaluate the need for any future cap integrity monitoring and will make a proposal to EPA in conjunction with the request for Certification of Completion in accordance with the Consent Decree.

Potential Response Actions for Subtidal Cap Integrity Monitoring. If analyses of the hydrographic survey data indicate that unacceptable elevation changes have occurred (i.e., a net reduction in cap thickness greater than six inches) or that the cap's physical integrity has been compromised, determination of appropriate response actions will be coordinated with EPA. Potential response actions include, but are not limited to, the following:

- Conducting surveys or supplemental field inspections to delineate areas with a loss of more than one foot of cap material and to collect additional information to determine potential causes of the cap material loss, if needed;
- Collecting subsurface sediment samples to confirm the in-situ cap thickness;
- Completing repairs, which includes filling of the areas where cap erosion has occurred and/or modifications to areas with a loss of cap material to prevent contaminant loss and limit future disturbance of the cap; and
- Implementing administrative controls to limit further cap disturbance.

If monitoring demonstrates a loss in cap thickness over the course of two monitoring years (e.g., Year 2 and Year 4) and that the loss of cap material may be impacting the ability of the cap to prevent contaminant migration, a modification to the remedy, which may involve the above mentioned response actions, will be implemented as soon as reasonably possible. Similar to the results of the low tide slope cap inspections, the implementation of potential response actions will be based on the evaluation of existing data as well as evaluating if response actions are needed.

2.3.2 Slope Cap and Channel Sand Cap Chemical Performance Monitoring

Cap performance will also be monitored through the collection and chemical analysis of surface (0 to 10 cm) sediment samples. Slope cap areas will be monitored using composite surface sediment samples (0 to 10 cm) collected from the intertidal portion of the cap. Channel sand caps will be monitored using discrete surface sediment samples (0 to 10 cm) collected from the cap surface. Slope cap composite samples and channel sand cap samples will be collected beginning in OMMP monitoring Year 2.

Monitoring Frequency. The baseline conditions for capped areas have been established as part of the final cap surface sampling and analyses completed during remediation construction. These results showed that the surface of capped areas do not exceed the SQOs. No additional baseline sampling and analyses will be conducted in these areas.

Sediment cap performance monitoring samples will be collected in Years 2, 4, 7, and 10, as described in the monitoring schedule presented in Section 2.2.3 and outlined in Figure 1-3. Sediment cap performance monitoring will be conducted following the completion of cap integrity monitoring activities to evaluate whether additional sampling locations or relocation of existing sample locations is warranted.

Field Activities. Slope cap composite samples and (discrete) channel sand cap samples will be collected from the cap surface (0 to 10 cm). Sampling locations for slope cap composite and channel sand cap samples are shown on Figure 2-4. Slope cap performance monitoring will consist of a composite sample comprised of evenly spaced aliquots of slope cap material, but will target sediment accumulations on the slope cap. Sampling protocols and location control procedures are presented in the Sediment Sampling Operations Manual (Appendix B).

Slope cap composite samples will be collected by hand from intertidal areas during low tide periods. The multiple-point composite samples will be comprised of material collected from the interstices of the armor layer at the surface of the cap. Channel sand cap samples will be collected during a separate sampling effort using a vessel deployed grab sampler.

If it is determined to be necessary (i.e., chemical concentrations exceed SQO criteria), based on the results of chemical testing, surface (0 to 10 cm) sediment samples will be submitted for biological testing and will be collected using the same methods as described for channel sand cap samples or slope cap samples. These samples may also be collected during the initial sampling effort for chemical testing or during a second sampling effort. When sediment samples are collected for biological testing, synoptic chemical analyses will also be performed (see Appendix B).

Subsurface sediment samples will be collected (if deemed necessary as a response action) using an appropriate method for site conditions. Methods for subsurface sediment sampling are presented in Appendix B. Subsurface samples will not be collected in grout mat cap areas to prevent potential damage to the grout mat cap.

Additional sampling may be required based on the results of chemical and/or biological testing as described in the following section. A sample will not be collected from the slope cap in RA 5 as the surface of the cap in this area is comprised of quarry spalls. The elevation of the slope cap in RA 5 is below -10 feet MLLW and, therefore, habitat mix was not specified for placement in this area.

Data Analysis. The rationale for additional sampling, interpretation of monitoring results, and the evaluation of chemical or biological exceedances is presented in the Cap Performance Monitoring Decision Matrix (Figure 2-6) and is also summarized below.

Sediment quality monitoring data will be compared to post-construction confirmation sampling results. Results of the post-construction sampling events are presented in the 2006 Remedial Action Construction Report (RACR). Chemical testing results for sediment samples will be compiled with quality assurance review qualifiers into summary tables. Any exceedances of the SQOs will be highlighted in the summary tables.

Slope Cap Sampling

- If chemical concentrations in the slope cap composite sample(s) exceed SQO criteria (Table 2-3), additional sampling and chemical analyses may be conducted at the discrete locations that comprised the composite sample to isolate the extent of SQO exceedance;
- If chemical concentrations in the slope cap discrete samples, described above, exceed SQO criteria, confirmational samples may be collected and analyzed at the same discrete locations to confirm SQO exceedances;
- Alternatively, if chemical exceedances are identified in slope cap composite or discreet samples, sediment samples may be collected from a slope cap area(s) for

biological testing to evaluate the severity of the chemical exceedances and potential for adverse biological effects; and

- If chemical or biological criteria are exceeded, the need for additional samples will be evaluated or corrective actions will be identified with EPA as specified in Figure 2-6.

Channel Sand Cap Sampling

- If chemical concentrations in channel sand cap samples exceed SQO criteria, confirmational samples may be collected at the same locations and analyzed to confirm the SQO exceedances;
- Alternatively, if chemical concentrations in channel sand cap sample locations exceed the SQOs, sediment samples may be collected for biological testing to evaluate the severity of the chemical exceedances and potential for adverse biological effects; and
- If chemical or biological criteria are exceeded, the need for additional samples will be evaluated or corrective actions will be identified with EPA as specified in Figure 2-6.

If test results indicate chemical or biological testing criteria are satisfied during the data analysis process described above, the sample location will be considered to be in compliance with performance criteria and the next round of monitoring will be performed according to the schedule presented on Table 2-3. However, if biological testing criteria are not satisfied at any point during the data analysis process, the sample location will be evaluated for evidence of recontamination. Biological test criteria are summarized in Table 2-5. Mechanisms of recontamination include top-down (i.e., non-cap) and bottom-up (i.e., through-cap) transport of contaminants.

Potential Top-Down Sources of Recontamination. The potential for recontamination caused by sources other than transport of chemicals through caps placed in the City's remediation area (i.e., bottom-up transport) will be evaluated to determine if the sediment cap surface is being recontaminated by other sources (i.e., top-down sources).

The following procedures and lines of evidence will be used to evaluate the potential for top-down sources of recontamination:

- Identify potential top-down sources (i.e., marinas, outfalls, industrial operations, etc.) and compare the unique chemical signatures of the potential recontamination sources to exceedances observed in cap surface (0 to 10 cm and/or 0 to 2 cm) early warning monitoring samples. If the chemical signature of a potential top-down source of recontamination is similar to chemical exceedances in surface samples, the top-down source may be causing recontamination of the cap surface. Table 3-4 summarizes locations of potential top-down sources of recontamination within each Remedial Area and chemicals associated with the potential sources;
- Compare the results for 0 to 2 cm early warning monitoring samples (described in Section 3.0) to the results for surface samples (0 to 10 cm) samples. If the concentrations of COCs are generally greater in the 0 to 2 cm samples than those in the 0 to 10 cm samples, top-down sources may be the source of cap recontamination. Note, however, that Dense Non Aqueous Phase Liquid (DNAPL)

seepage through the cap in adjacent areas may not necessarily be ruled out where this contaminant source is present; and

- Evaluate the spatial distribution of chemical exceedances in surface samples to the location of potential top-down sources of recontamination. If a contiguous area with a potential top-down source and the chemical signature of the potential top-down source is similar to the chemical signature in surface samples and chemical concentrations in the 0 to 2 cm interval are greater than in the 0 to 10 cm interval, top-down (i.e., non-cap) recontamination may be occurring.

If evidence of a top-down source of recontamination is confirmed and a potential source is identified, appropriate potential response actions will be evaluated and discussed with EPA. Potential response actions for top-down recontamination are described in Section 3.0, Early Warning Monitoring for Recontamination.

Bottom-Up (Through-Cap) Recontamination. The potential for bottom-up recontamination will be evaluated if top-down sources of recontamination are not identified as the source of SQO exceedances at the cap surface.

The following procedures and lines of evidence will be used to evaluate the potential for bottom-up recontamination:

- Evaluate whether the chemical signature of the surface sample(s) (0 to 10 cm) with criteria exceedances are consistent with the chemical signature of contaminants in sediment beneath the cap. If COCs exceeding criteria at the cap surface are similar to COCs exceeding criteria in the underlying sediment, bottom-up recontamination may be occurring and may be the source of cap recontamination (see Table 3-4);
- Compare the results for 0 to 2 cm early warning samples (described in Section 3.0 of this OMMP) to the results for surface samples (0 to 10 cm) samples. If chemical concentrations for COCs are generally comparable to or greater in the 0 to 10 cm samples than those in the 0 to 2 cm samples, bottom-up recontamination may be occurring and may be the source of cap recontamination;
- Evaluate cap integrity. If deficiencies are observed in the cap (i.e., loss of cap material, downslope movement, etc.), the cap may not be fully containing underlying sediment and recontamination from the underlying sediments may be occurring; and
- Collect and chemically analyze subsurface sediment samples. Analysis of subsurface samples collected at discrete intervals through the cap will be used to identify the presence or absence of a chemical gradient within the cap. Detection of underlying contaminants continuously exceeding the SQO in samples collected through the cap may provide evidence for bottom-up transport. Note that in select cap areas, thin layers of construction residuals exceeding the SQO were entrained between layers of cap material. Identification of these layers may not indicate bottom-up transport. Table 3-4 identifies the location and chemical nature of the entrained construction residuals.

The decision matrix for evaluation of slope cap composite sample data and channel sand cap sample data (including evaluation of top-down and bottom-up recontamination) is presented in Figure 2-6.

If the results of sediment sampling indicate cap performance criteria are achieved after Year 10 monitoring activities have been completed, the need for any future monitoring will be evaluated and proposed to EPA in conjunction with the request for Certification of Completion,

Potential Response Actions for Cap Performance Monitoring. If cap performance monitoring data indicate that bottom-up recontamination is occurring, appropriate response actions will be evaluated and proposed to EPA. Potential response actions for bottom-up recontamination may include, but are not limited to the following:

- Perform biological toxicity testing to evaluate potential for adverse toxicity effects;
- Additional data collection to delineate the spatial extent of cap recontamination;
- Additional data collection to evaluate the potential for adverse environmental impacts and need for response actions; and
- Placement of additional cap materials to supplement the existing cap.

Implementation of potential response actions will be based on the evaluation of existing data as well as evaluating if response actions are needed.

2.4 Natural Recovery and Enhanced Natural Recovery Performance Monitoring

Natural recovery and enhanced natural recovery performance will be monitored through the collection and chemical analysis of surface (0 to 10 cm) sediment samples and the evaluation of detected chemical concentration trends in the allowable 10-year natural recovery time period. Results of chemical testing will be compared to SQO criteria, predicted chemical concentrations, and natural recovery performance criteria (i.e., Sediment Remedial Action Levels [SRAL]) to determine whether natural recovery is likely to be achieved within the compliance period.

Designated natural recovery and enhanced natural recovery areas include the northern portions of RA 5 and RA 6, RA 7, most of the area north of the 11th Street Bridge to Station 20+00, the eastern portion of the Wheeler-Osgood Waterway located between RA 12 and RA 13, the area east of RA 16 and north of RA 15, and an area located east of RA 5 near the mouth of the Wheeler-Osgood Waterway extending from Station 41+50 to 46+50 as shown on Figures 2-1 and 2-4.

In addition, slopes in the Wheeler-Osgood Waterway (RA 10, RA 11, and RA 13) were designated for natural recovery during the Remedial Design phase of the project. Subsequently, these slopes were rehabilitated through debris removal and material placement to provide enhanced habitat.

2.4.1 Monitoring Frequency

Baseline Conditions. Select post-construction confirmation surface (0 to 10 cm) samples collected within the designated natural recovery areas adjacent to RA 2 and RA 4 and within RA 5, RA 6, and RA 7, will be used to characterize natural recovery baseline conditions. Supplemental baseline data will be collected within the designated natural recovery areas during Year 0 monitoring activities in areas where there is insufficient existing post-construction data to complete the baseline characterization. Table 2-1 presents a list of the supplemental natural recovery baseline sample locations and Figure 2-1 identifies the supplemental sampling locations.

Long-Term Natural Recovery Performance Monitoring. Long-term natural recovery performance monitoring will be completed during Years 2, 4, 7, and 10 (as necessary) according to the monitoring schedule presented in Section 2.2.3 and Table 2-3. Long-term monitoring will be completed to verify natural recovery area surface sediments satisfy performance criteria within the allowed 10-year natural recovery monitoring time frame. Long-term monitoring will be performed at the selected post-construction confirmation sample locations as shown in Figure 2-1 and supplemental sampling locations identified in Table 2-1.

2.4.2 Field Activities

Natural recovery surface (0 to 10 cm) samples will be collected at the locations shown in Figure 2-1 during the Year 0, supplemental baseline sampling event and at the locations shown on Figure 2-4 for the Years 2, 4, 7 and 10 performance monitoring events. Natural recovery supplemental surface samples will be collected in Year 0 to adequately characterize chemical concentrations in natural recovery areas.

Natural recovery samples will be collected using a vessel deployed grab sampler except in RA 10, RA 11, and RA 13 (i.e., SR-10, SR-11, and SR-13, respectively) where samples will be collected using procedures consistent with slope cap performance monitoring. Sampling protocols and location control procedures are presented in the Sediment Sampling Operations Manual (Appendix B).

2.4.3 Data Analysis

A summary of the data analysis procedure for the evaluation of natural recovery performance monitoring data is presented in the Natural Recovery Monitoring Decision Matrix (Figure 2-7). Natural recovery will be considered successful if at least one of the following performance criteria is met:

- A minimum of two consecutive rounds of surface sediment (0 to 10 cm) quality monitoring show that detected chemical concentrations are below SQO criteria and that the trend for the detected chemical concentrations is not increasing over time; and or
- A minimum of two consecutive rounds of monitoring show that surface sediment biological Sediment Quality Standards (SQS) criteria (Table B-2-5) are satisfied (if detected chemical concentrations exceed the SQO) and that the trend for the detected chemical concentrations is not increasing over time.

Increasing chemical concentration trends may indicate that ongoing sources of contamination or other conditions are disrupting the natural recovery process. In the event that two or more sampling rounds show that detected chemical concentrations are increasing over time and exceed the SQOs then potential recontamination sources will be evaluated using the methods described in Section 3.0, Early Warning Monitoring for Recontamination. If evidence of ongoing contamination sources is confirmed potential response actions will be evaluated and discussed with EPA as described in Section 3.3.

Additional monitoring may be required to confirm the completeness of natural recovery for areas containing only one sampling location if monitoring results indicate that concentrations are below the SQO, not increasing over time, but are within the range of analytical error. Additional monitoring requirements would be determined under consultation with EPA.

If natural recovery performance criteria are not satisfied within the 10-year allowable time frame or chemical concentration trends predict SQO criteria will be exceeded, potential response actions, described below, will be evaluated and discussed with EPA and implemented as appropriate.

2.4.4 Potential Response Actions for Natural Recovery Performance Monitoring

If natural recovery performance monitoring data indicate that natural recovery will not be achieved within the allowable 10-year time period, for example, if at Year 4, based on three data points the chemical concentration trend is predicted to exceed SQOs by Year 10, appropriate response actions will be evaluated and proposed to EPA. Potential response actions to address a disturbance to the natural recovery process may include, but are not limited to the following:

- Additional or increased frequency of data collection to evaluate chemical concentration trends over time or to delineate the extent of the potentially impacted area;
- Biological toxicity testing to evaluate the potential for adverse toxicity effects;
- Placement of suitably designed cap material layers to accelerate the recovery process;
- Evaluation of potential ongoing sources of recontamination that may be adversely affecting the natural recovery process. This process is described in Section 3.0; and
- Initiation of contaminant source tracing and source identification studies, and implementation of additional source controls, as appropriate.

Implementation of potential response actions will be based on the evaluation of existing data as well as evaluating if response actions are needed. Response actions may be determined not to be necessary if it can be shown that sediments remain environmentally protective.

REFERENCES

U.S. Environmental Protection Agency (EPA). 1989. Commencement Bay Nearshore/Tideflats Record of Decision (ROD). Region 10. September.

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U.S. Environmental Protection Agency (EPA). 2000. Explanation of Significant Differences – Commencement Bay Nearshore/Tideflats Superfund Site. Region 10. August.

U.S. Environmental Protection Agency (EPA). 2003. Consent Decree and Statement of Work for RD/RA of the Thea Foss and Wheeler Osgood Waterways Problem Areas, Commencement Bay Nearshore/Tideflats Superfund Site. Region 10. May 9, 2003.

TABLES

FIGURES

Table 2-1
Rationale for Existing and Supplemental Baseline Natural Recovery Sample Locations

Area	Post-Construction Sampling Event Type	Sample Station	Does Surface Sample Meet SQO Criteria?	Remedial Action	Additional Year 0 Baseline Sampling	Rationale
11th Street Bridge North	Dredge Boundary Verification	RA-02-006	Yes	Natural Recovery	NR-06	Provide spatial distribution within natural recovery area north of the 11th Street Bridge.
		RA-02-007	Yes			
		RA-02-008	Yes		NR-07	
		RA-02-009	Yes			
	Dredge Boundary Verification	RA-04-005	Yes		NR-11	
		RA-04-006	Yes			
		RA-04-007	Yes			
		RA-04-008	Yes			
	Dredge Boundary Verification, Offset Confirmation	RA-04-009	Yes			
		RA-04-010	Yes			
		RA-04-011	Yes			
RA 7	Remedial Action Modification	RA-07-001	Yes	Enhanced Natural Recovery	NR-16	Establish baseline natural recovery conditions for RA 7.
Wheeler-Osgood Waterway Mouth	NA	None	NA	Natural Recovery	NR-17	Establish baseline natural recovery conditions.
Wheeler-Osgood Waterway Head	NA	None	NA	Slope Rehabilitation	SR-10	Establish baseline natural recovery conditions for slope rehabilitation areas in the Wheeler-Osgood Waterway
					SR-11	
					SR-13	
Wheeler-Osgood Waterway Head	NA	None	NA	Natural Recovery	NR-19	Establish baseline natural recovery conditions in the NR area adjacent to RA 12 and outfall 254.
					NR-20	
Shoreline and harbor area adjacent to RA 15 and RA 16	NA	None	NA	Natural Recovery	NR-25	Establish baseline natural recovery conditions.

Table 2-2
Proposed Performance Sediment Sampling Rationale and Data Quality Objectives

Sample Location	Rationale
Channel Sand Cap Performance Samples (0 to 10 cm)	
CC-01	Located to evaluate cap compliance in mouth of Thea Foss Waterway.
CC-18	Located to evaluate cap compliance in Wheeler-Osgood Waterway.
CC-23	Located to evaluate cap compliance in western portion of Thea Foss Waterway and adjacent Outfall 230.
CC-26	Located to evaluate cap compliance in eastern portion of the capped area in Thea Foss Waterway.
CC-27	Located to evaluate cap compliance in northern portion of the capped area in Thea Foss Waterway channel.
CC-29	Located to evaluate cap compliance in western portion of Thea Foss Waterway harbor area.
CC-30	Located to evaluate cap compliance in the central portion of the capped area of the Thea Foss Waterway.
CC-31	Located to evaluate cap compliance in southeastern portion of Thea Foss Waterway and adjacent to Outfall 245.
CC-32	Located to evaluate cap compliance in southwest portion of Thea Foss Waterway harbor area.
CC-33	Located to evaluate cap compliance in southern portion of the capped area in the Thea Foss Waterway.
Natural Recovery Performance Samples (0 to 10 cm)	
NR-06	Located to monitor concentration trends in natural recovery area north of 11th Street Bridge.
NR-07	Located to monitor concentration trends in natural recovery area north of 11th Street Bridge.
NR-08	Located to monitor concentration trends in natural recovery area north of 11th Street Bridge.
NR-09	Located to monitor concentration trends in natural recovery area north of 11th Street Bridge.
NR-10	Located to monitor concentration trends in natural recovery area north of 11th Street Bridge.
NR-11	Located to monitor concentration trends in natural recovery area north of 11th Street Bridge.
NR-12	Located to monitor concentration trends in the natural recovery area in the northern portion of RA 7.

Sample Location	Rationale
Natural Recovery Performance Samples (0 to 10 cm), cont'd	
NR-13	Located to monitor concentration trends in the natural recovery area in northern portion of RA 5.
NR-14	Located to monitor concentration trends in the natural recovery area in northern portion of RA 6.
NR-16	Located to monitor concentration trends in the enhanced natural recovery area of RA 7.
NR-17	Located to monitor concentration trends in the natural recovery in the mouth of the Wheeler-Osgood Waterway.
NR-19	Located to monitor concentration trends in the natural recovery area adjacent to RA 12 and capped sheen source area.
NR-20	Located to monitor concentration trends in the natural recovery area east of RA 12 and adjacent to Outfall 254.
NR-25	Located to monitor concentration trends in the natural recovery area adjacent to RA 15 and 16.

Notes:

CC Channel Sand Cap
NR Natural Recovery

Table 2-3
Sediment Quality Objectives (SQOs)

Analyte	SQO	Analytical Method
Conventionals		
Total Organic Carbon in %	NA	EPA Method 9060
Total Solids in %	NA	PSEP 1997
Metals in mg/kg		
Antimony	150	EPA Method 6010B
Arsenic	57	EPA Method 6010B
Cadmium	5.1	EPA Method 6010B
Copper	390	EPA Method 6010B
Lead	450	EPA Method 6010B
Mercury	0.59	EPA Method 7471A
Nickel	140	EPA Method 6010B
Silver	6.1	EPA Method 6010B
Zinc	410	EPA Method 6010B
LPAHs in µg/kg		EPA Method 8270C
2-Methylnaphthalene	670	
Acenaphthene	500	
Acenaphthylene	1,300	
Anthracene	960	
Fluorene	540	
Naphthalene	2,100	
Phenanthrene	1,500	
Total LPAHs	5,200	
HPAHs in µg/kg		EPA Method 8270C
Benzo(a)Anthracene	1,600	
Benzo(a)Pyrene	1,600	
Benzo(b)Fluoranthene	NA	
Benzo(k)Fluoranthene	NA	
Total Benzofluoranthenes	3,600	
Benzo(g,h,i)Perylene	720	
Chrysene	2,800	
Dibenz(a,h)Anthracene	230	
Fluoranthene	2,500	
Indeno(1,2,3-c,d)Pyrene	690	
Pyrene	3,300	
Total HPAHs	17,000	

Analyte	SQO	Analytical Method
Phthalates in µg/kg		EPA Method 8270C
Dimethylphthalate	160	
Diethylphthalate	200	
Di-n-butylphthalate	1,400	
Butylbenzylphthalate	900	
Bis(2-Ethylhexyl)Phthalate	1,300	
Di-n-octylphthalate	6,200	
Acid Compounds in µg/kg		EPA Method 8270C
Phenol	420	
2-Methylphenol	63	
4-Methylphenol	670	
2,4-Dimethylphenol	29	
Pentachlorophenol	360	
Benzyl alcohol	73	
Benzoic acid	650	
Miscellaneous Compounds in µg/kg		EPA Method 8270C
1,2-Dichlorobenzene	50	
1,3-Dichlorobenzene	170	
1,4-Dichlorobenzene	110	
1,2,4-Trichlorobenzene	51	
Hexachlorobenzene	22	
Dibenzofuran	540	
Hexachlorobutadiene	11	
N-Nitrosodiphenylamine	28	
Pesticide/PCBs in µg/kg		
4,4'-DDD	16	EPA Method 8081
4,4'-DDE	9	Or EPA Method 8270C
4,4'-DDT	34	
PCB-1016	NA	EPA Method 8082
PCB-1221	NA	Or EPA Method 8270C
PCB-1232	NA	
PCB-1242	NA	
PCB-1248	NA	
PCB-1254	NA	
PCB-1260	NA	
Total PCBs	300	

NA: No SQO is defined for chemical analyte/parameter.
Method detection limits for sediment quality analyses must be at or below the SQOs.

Table 2-4
Sediment Remedial Area Performance Monitoring and Reporting Schedule

Task		Task Type	Timeline and Description
1	Perform Baseline Low Tide Slope Cap Inspection	Field Activities	Inspection completed in July 2006
2	Perform Supplemental Baseline Surface (0-10 cm) Sediment Sampling Within Natural Recovery and Enhanced Natural Recovery Areas	Field Activities	Within six months of completion of the remedial actions or within 90 days of the approval of the final OMMP, whichever is later
3	Prepare and Submit the Baseline (Year 0) Sediment Remedial Area Monitoring Report to EPA	Reporting	Within 45 days of completion of all baseline performance data validation activities or as otherwise approved by EPA
4	Conduct Year 2 Monitoring, Including: Sampling Surface (0-10 cm) Sediment in Channel Cap and Natural Recovery Areas, Sampling Surface (0-10 cm) Sediment in Slope Cap Areas, Performing Low Tide Slope Cap Inspections and Performing Subtidal Hydrographic Surveys	Field Activities	Two years after completion of the Baseline field activities
5	Prepare and Submit the Year 2 Sediment Remedial Area Monitoring Report to EPA	Reporting	Within 45 days of completion of all Year 2 performance data validation activities or as otherwise approved by EPA
6	Conduct Year 4 Monitoring, Including: Sampling Surface (0-10 cm) Sediment in Channel Cap and Natural Recovery Areas, Sampling Surface (0-10 cm) Sediment in Slope Cap Areas, Performing Low Tide Slope Cap Inspections and Performing Subtidal Hydrographic Surveys	Field Activities	Two years after completion of the Year 2 field activities
7	Prepare and Submit the Year 4 Sediment Remedial Area Monitoring Report to EPA	Field Activities	Within 45 days of completion of all Year 4 performance data validation activities or as otherwise approved by EPA

Task		Task Type	Timeline and Description
8	Conduct Year 7 Monitoring, Including: Sampling Surface (0-10 cm) Sediment in Channel Cap and Natural Recovery Areas, Sampling Surface (0-10 cm) Sediment in Slope Cap Areas, Performing Low Tide Slope Cap Inspections and Performing Subtidal Hydrographic Surveys	Field Activities	Three years after completion of the Year 4 field activities
9	Prepare and Submit the Year 7 Sediment Remedial Area Monitoring Report to EPA	Reporting	Within 45 days of completion of all Year 7 performance data validation activities or as otherwise approved by EPA
10	Conduct Year 10 Monitoring, Including: Sampling Surface (0-10 cm) Sediment in Channel Cap and Natural Recovery Areas, Sampling Surface (0-10 cm) Sediment in Slope Cap Areas, Performing Low Tide Slope Cap Inspections and Performing Subtidal Hydrographic Surveys	Field Activities	Three years after completion of the Year 7 field activities
11	Prepare and Submit the Final Year 10 Sediment Remedial Area Monitoring Report to EPA	Reporting	Within 45 days of completion of all Year 10 data validation activities or as otherwise approved by EPA

Table 2-5
Biological Testing Criteria

<table>
<tr><th rowspan="2">Biological Test</th><th rowspan="2">Control Performance Standard</th><th rowspan="2">Reference Performance Standard</th><th>SQS</th><th>CSL</th></tr>
<tr><th colspan="2">Test sediment has higher (statistically significant, t-test, p [0.05) mean mortality than the reference sediment[1]</th></tr>
<tr><td colspan="5">Amphipod (acute)</td></tr>
<tr><td>Survival</td><td>M_C <10%</td><td>M_R < 25%</td><td>M_T > 25 %</td><td>$M_T – M_R$ > 30%</td></tr>
<tr><td colspan="5">Larval (acute)</td></tr>
<tr><td>Survival</td><td>$N_C \div I \geq 0.7$ [2]</td><td>$N_C \div N_R \geq 0.65$ (per QA/QC guidance)</td><td>$N_T / N_C \div N_R / N_C < 0.85$</td><td>$N_T / N_C \div N_R / N_C < 0.70$</td></tr>
<tr><td colspan="5">Juvenile polychaete (chronic)</td></tr>
<tr><td>Survival</td><td>M_C < 10%</td><td rowspan="2">$MIG_R \div MIG_C \geq 0.80$</td><td rowspan="2">$MIG_T \div MIG_R < 0.70$</td><td rowspan="2">$MIG_T \div MIG_R < 0.50$</td></tr>
<tr><td>Growth</td><td>$MIG_C \geq 0.72$ mg/ind/day (dry)</td></tr>
</table>

Notes:

Any two exceedances of the SQS criteria also constitute a CSL exceedance

1 The SQS and CSL criteria for the acute larval test require results that are statistically significant, t-test, p[0.1

2 Control performance standard for larval is equal to a 30 percent combined abnormality and mortality

I Initial count of larvae used to inoculate the test containers

M_C Control sediment

M_R Reference sediment

M_T Test sediment

MIG_C Mean individual growth rate – control

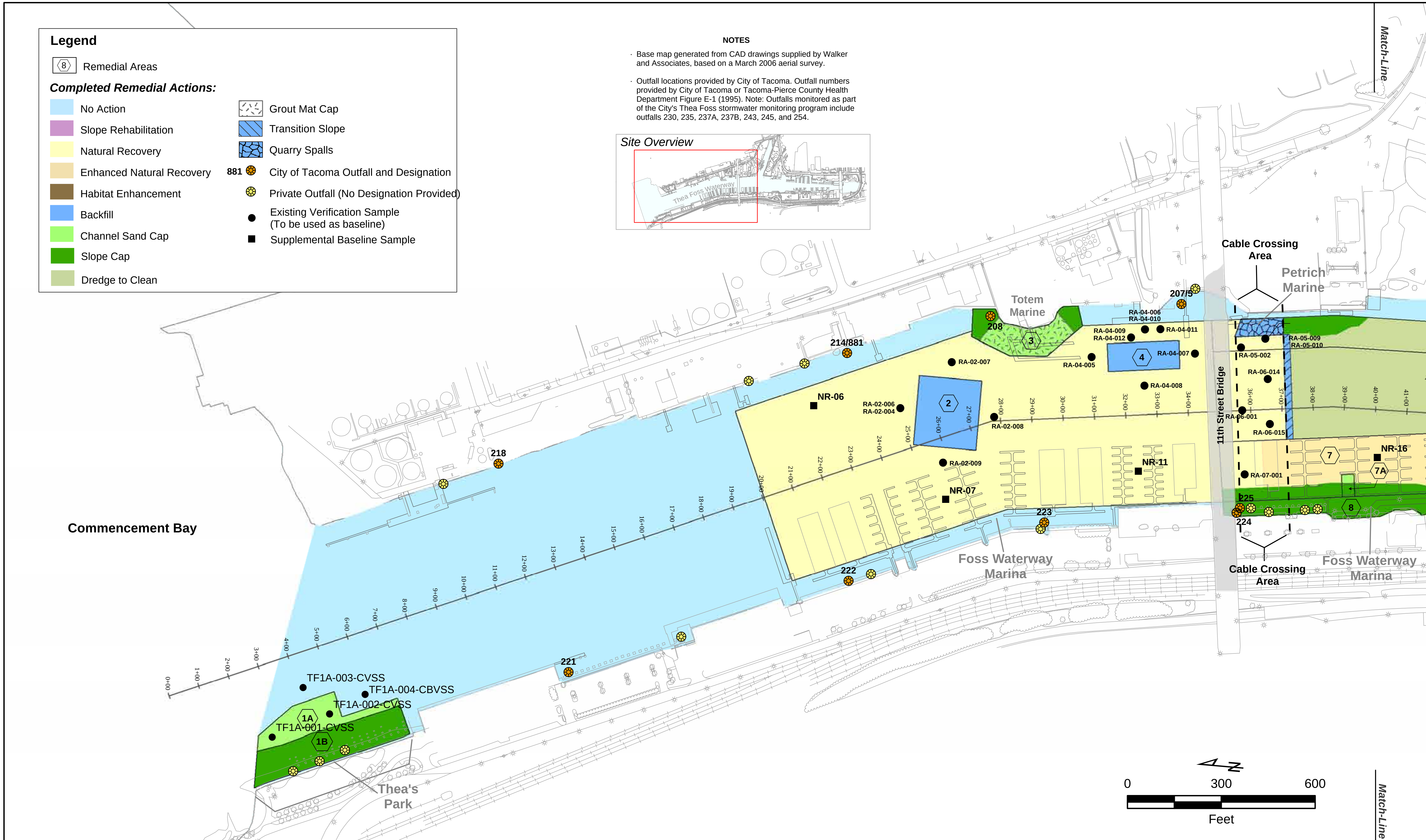
MIG_R Mean individual growth rate – reference

MIG_T Mean individual growth rate – test

N_C Normal survivorship of the control sediment

N_R Normal survivorship of the reference sediment

N_T Normal survivorship of the test sediment



FLOYD | SNIDER strategy • science • engineering	Thea Foss and Wheeler-Osgood Waterways OMMP	Figure 2-1 (Page 1 of 2) Existing and Supplemental Sampling Locations

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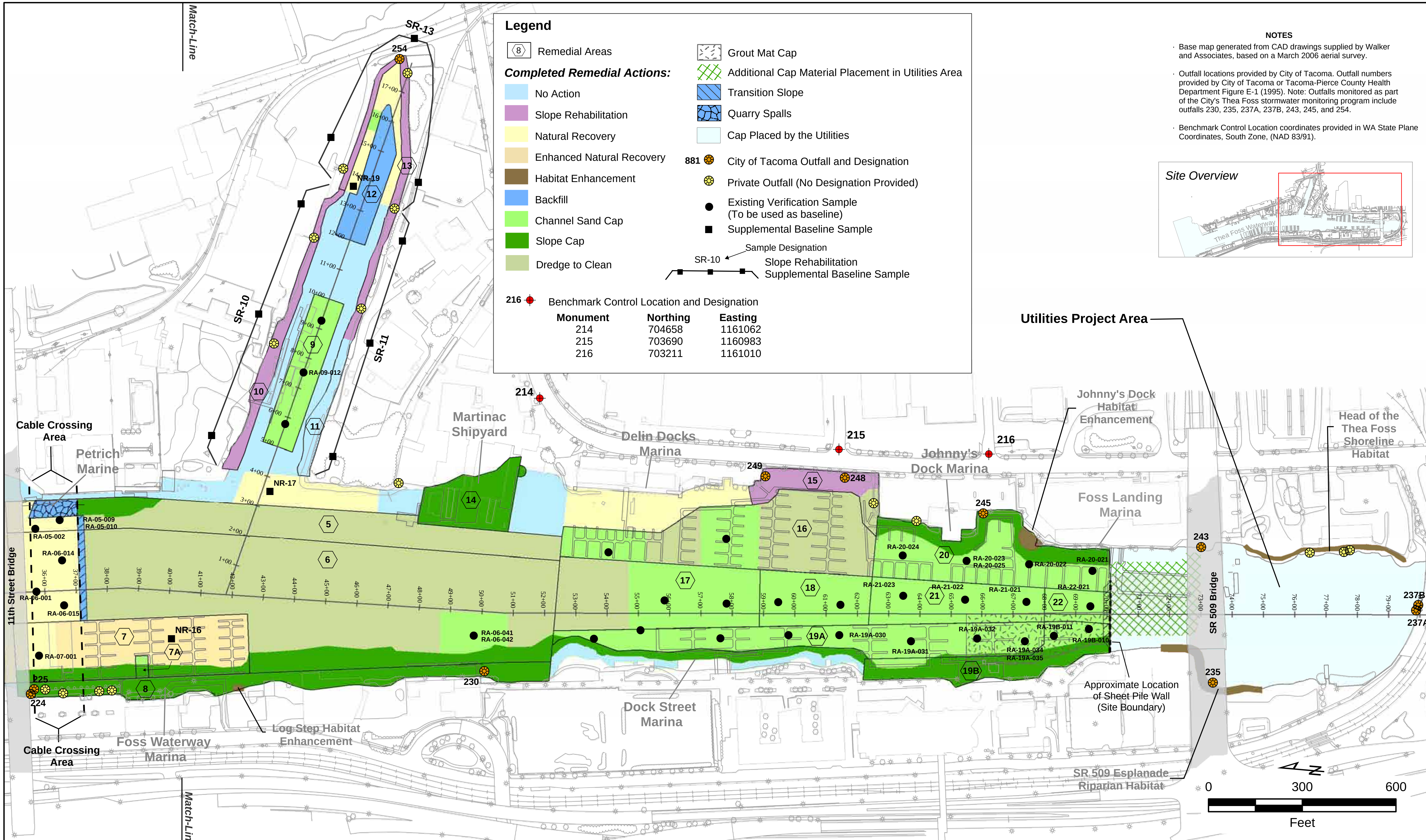

Thea Foss and Wheeler-Osgood Waterways OMMP

Figure 2-1 (Page 2 of 2)
Existing and Supplemental Sampling Locations

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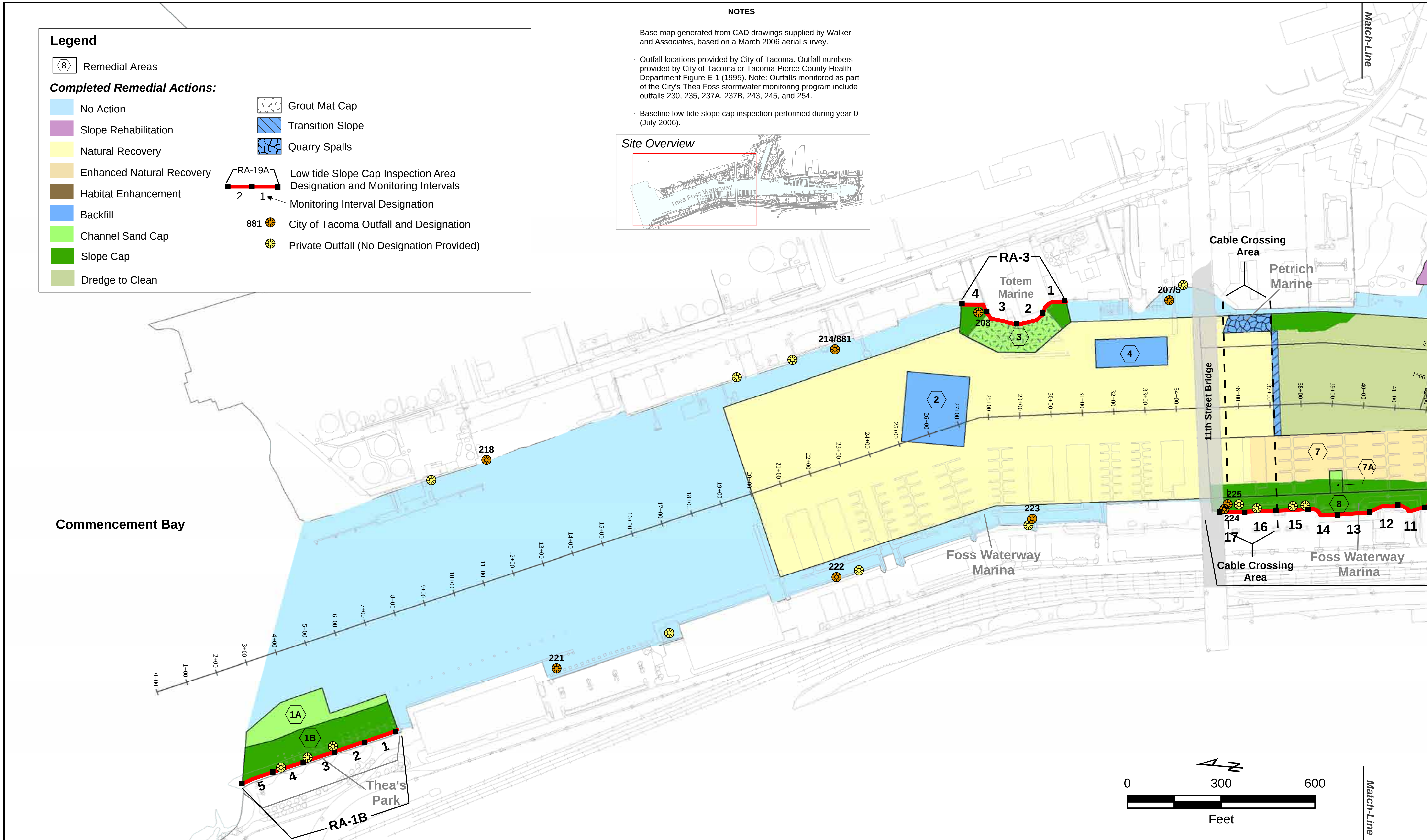

Thea Foss and Wheeler-Osgood Waterways OMMP

Figure 2-2 (Page 1 of 2)
Low Tide Slope Cap Inspection Monitoring Intervals

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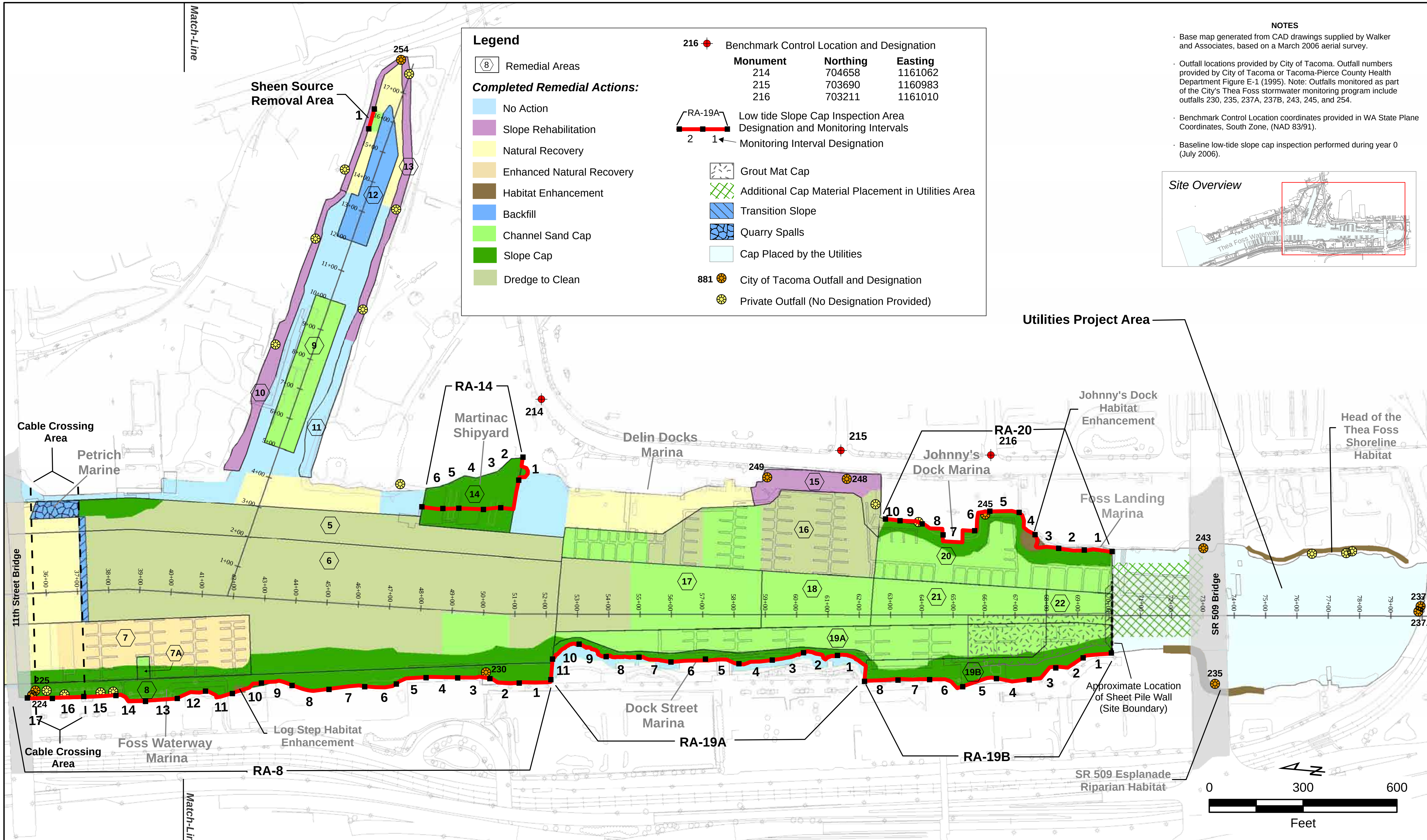

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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure 2-2 (Page 2 of 2)
Low Tide Slope Cap Inspection Monitoring Intervals

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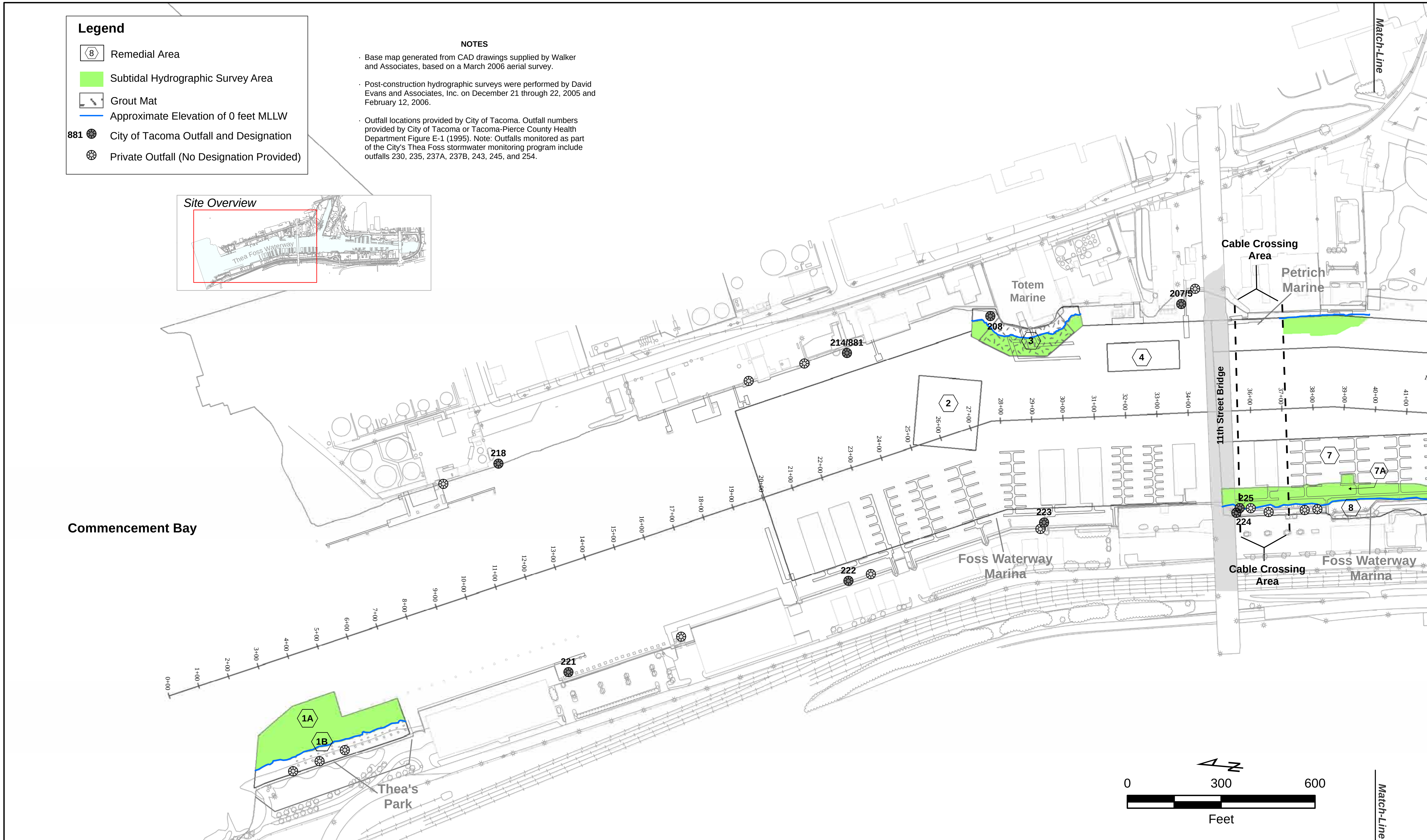

Thea Foss and Wheeler-Osgood Waterways
OMMP

Figure 2-3 (Page 1 of 2)
Subtidal Hydrographic Survey Areas

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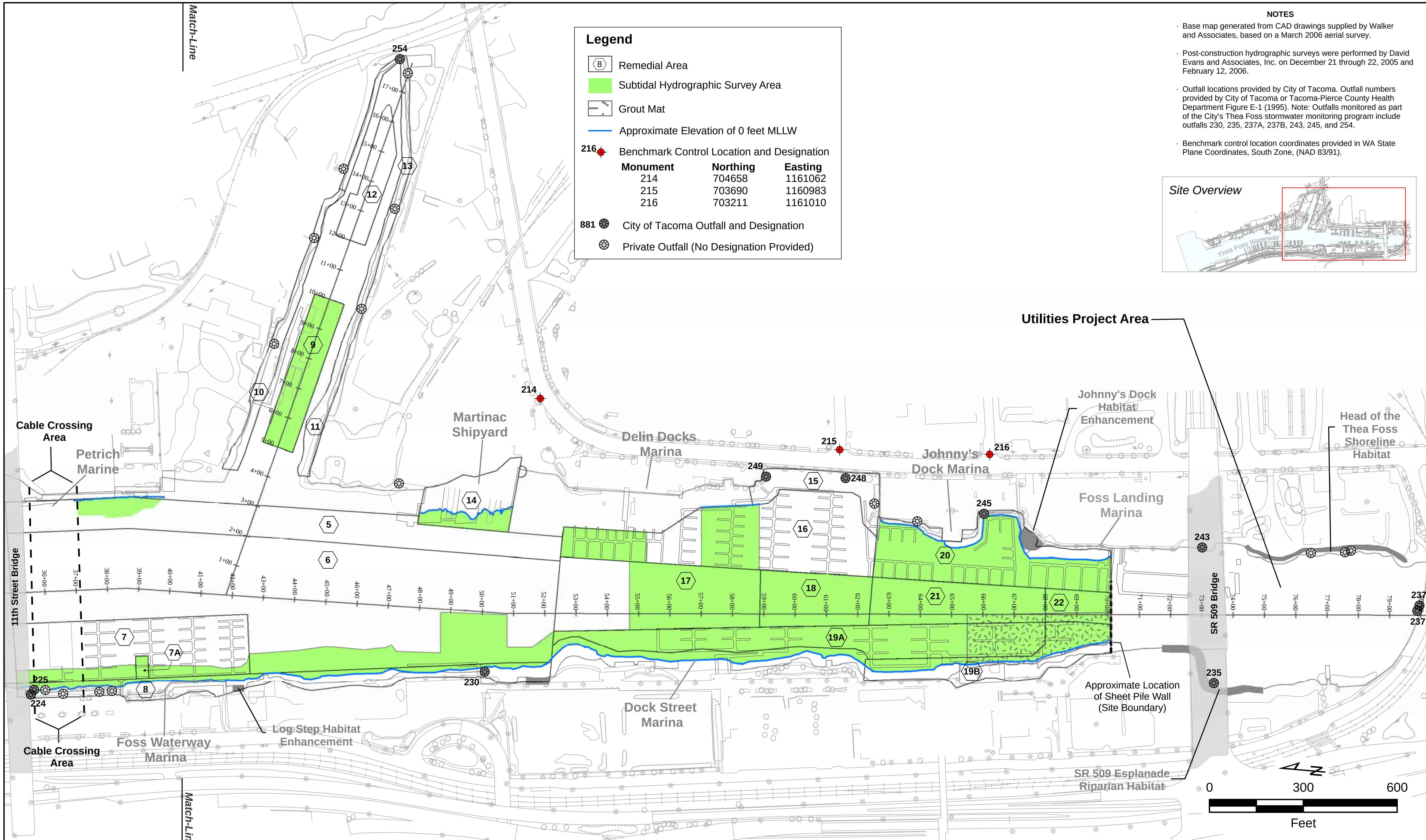

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Figure 2-3 (Page 2 of 2)
Subtidal Hydrographic Survey Areas

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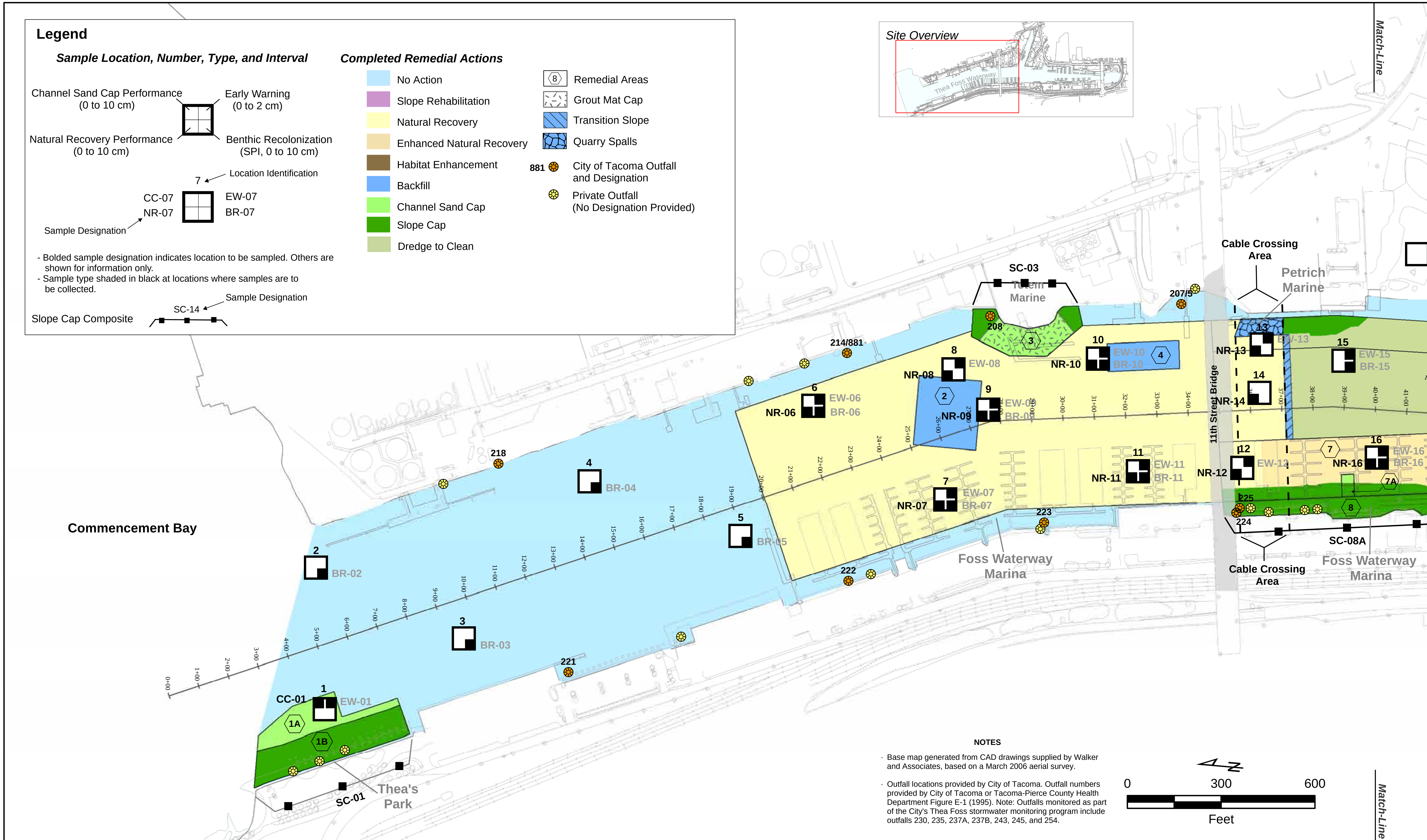

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Figure 2-4 (Page 1 of 2)
Performance Monitoring Sampling Locations

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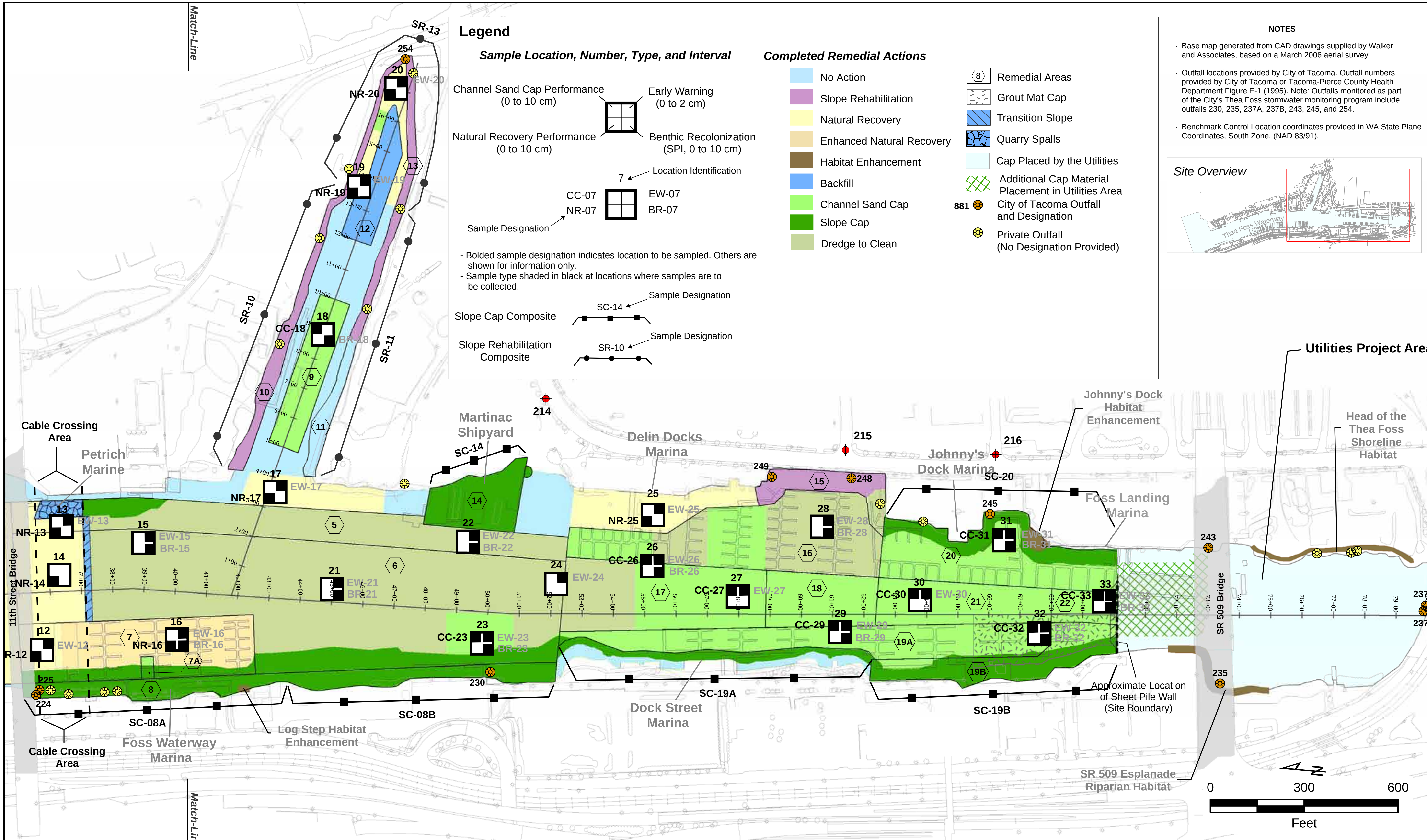

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OMMP

Figure 2-4 (Page 2 of 2)
Performance Monitoring Sampling Locations

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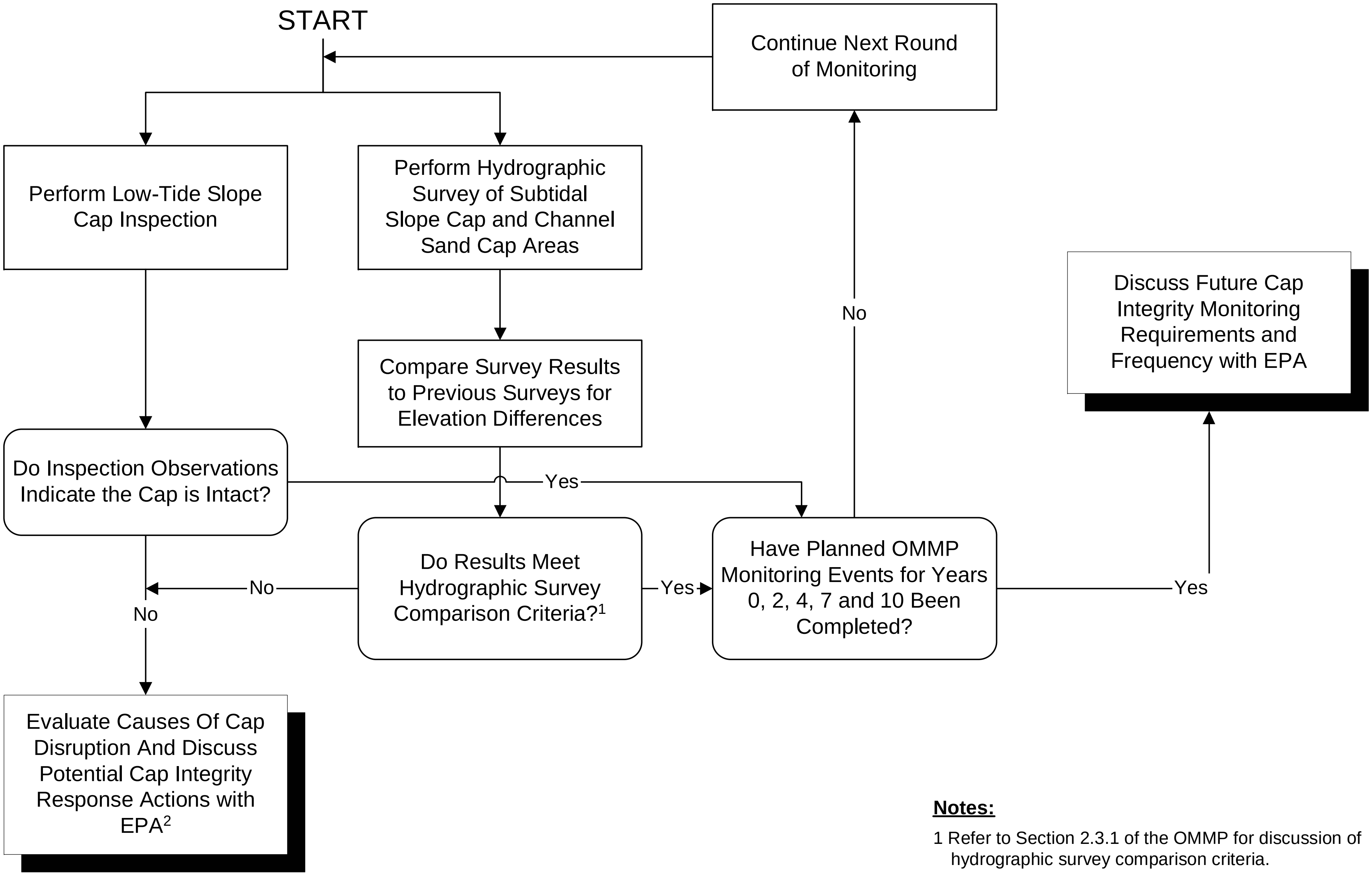

Notes:

1 Refer to Section 2.3.1 of the OMMP for discussion of hydrographic survey comparison criteria.

2 Discussion of potential cap integrity response actions is presented in Section 2.3.1 of the OMMP.

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Figure 2-5
Cap Integrity Monitoring Decision Matrix

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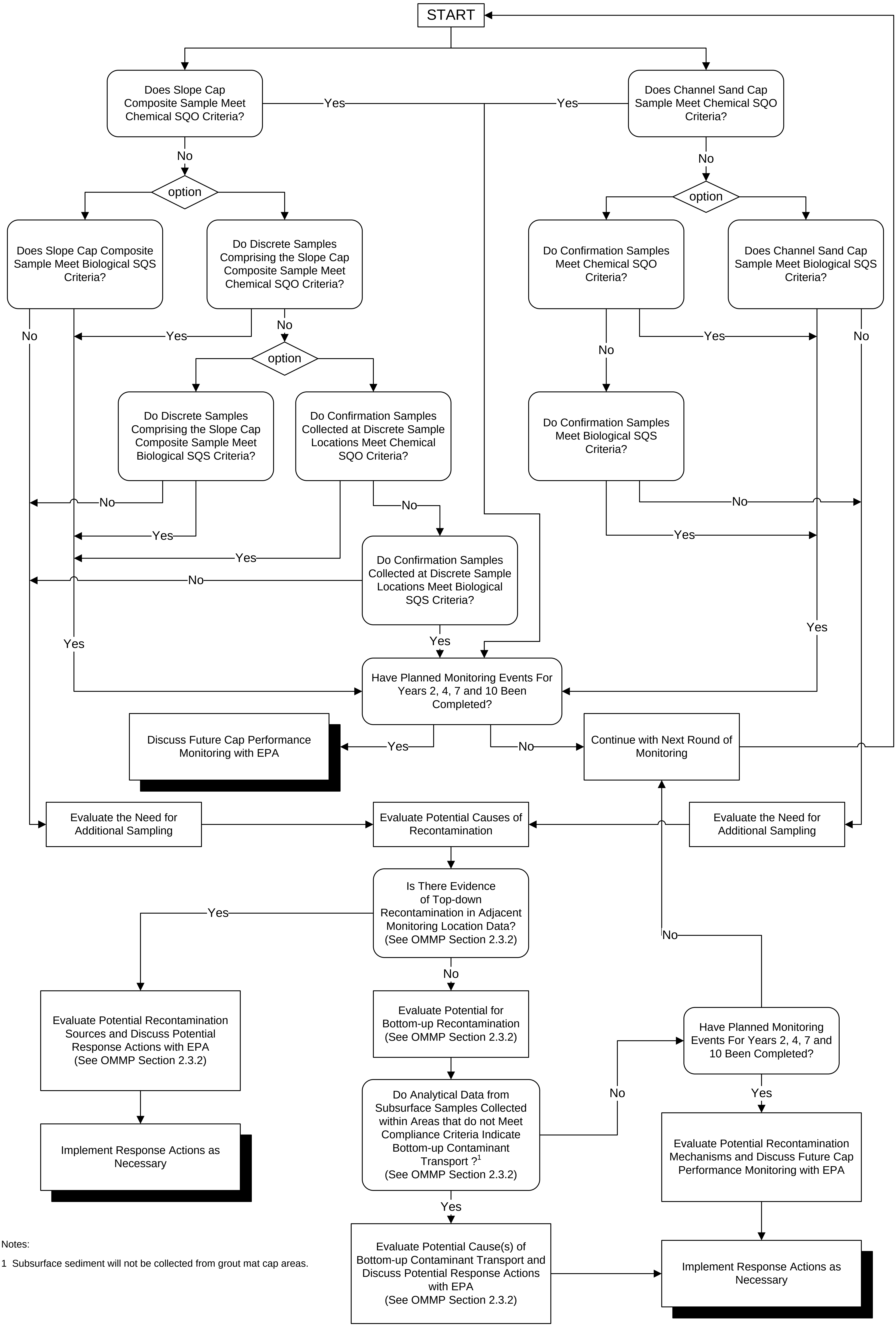

Notes:

1 Subsurface sediment will not be collected from grout mat cap areas.

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Figure 2-6
Cap Performance Monitoring Decision Matrix

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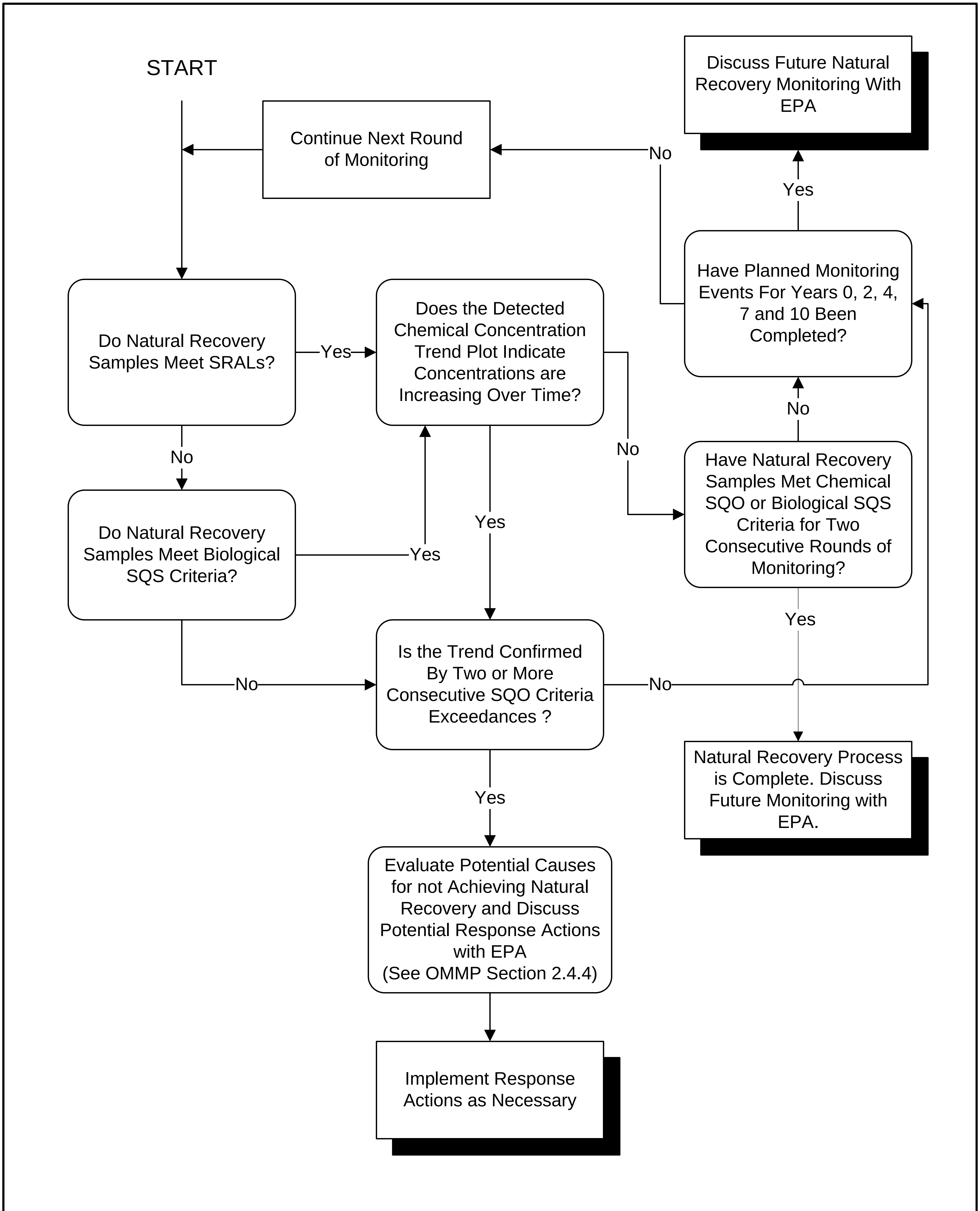

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Figure 2-7
Natural Recovery Monitoring Decision Matrix

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3.0 EARLY WARNING MONITORING FOR RECONTAMINATION

Early Warning Monitoring for Recontamination (henceforth referred to as Early Warning Monitoring) will be performed to evaluate the potential for recontamination in the Thea Foss and Wheeler-Osgood Waterways. Early Warning Monitoring includes collection and analysis of recently deposited sediments represented by the 0 to 2 cm interval of the sediment column. Sampling and analysis data will be used to evaluate the potential for recontamination and identify potential sources of recontamination (if suspected) before the remediated sediments become out of compliance with the specific remedial action and long-term monitoring objectives. Early Warning Monitoring will be performed throughout the Thea Foss and Wheeler-Osgood Waterways including dredged to clean, capped, and natural recovery areas. Dredged and capped areas were confirmed to meet the Sediment Quality Objectives (SQO) in verification samples collected during construction. Portions of the natural recovery areas may contain marginal SQO exceedances, but are expected to naturally recover within the 10-year compliance period (by 2016). Figure 3-1 presents the post-construction conditions of the Thea Foss and Wheeler-Osgood Waterways and the proposed Early Warning Monitoring locations.

This Early Warning Monitoring plan establishes the purpose, objectives, approach, and criteria for performing Early Warning Monitoring. The monitoring plan also presents the methods and procedures for field sampling and quality control/quality assurance protocols (Appendix B – Sediment Sampling Operations Manual). Health and Safety protocols are presented in Appendix F.

If Early Warning Monitoring data identify a potential for the recontamination of remediated areas, potential response actions will be evaluated and discussed with EPA as described in Section 3.3.

3.1 Early Warning Monitoring Objectives and Rationale

The Early Warning Monitoring program is designed to achieve the following objectives:

- Monitor the chemical quality of recently deposited sediments in remediation areas of the Thea Foss and Wheeler-Osgood Waterways with attention to potential sources of recontamination (i.e., marinas, outfalls, industrial facilities, etc.); and
- Identify potential sources of recontamination if exceedances of chemical SQOs and Early Warning threshold concentrations have occurred or are predicted to occur.

3.2 Early Warning Monitoring Approach

Early Warning Monitoring will be performed to evaluate the potential for recontamination and identify sources of recontamination before the remediated sediments become out of compliance with the specific remedial action and long-term monitoring objectives. Recently deposited sediments, as represented by the upper 2 cm of the sediment column, will be sampled and analyzed for Early Warning Monitoring. The upper 2 cm of sediment comprises the near surface portion of the 0 to 10 cm compliance interval. Monitoring will be performed throughout the Thea Foss and Wheeler-Osgood Waterways including areas that were dredged to clean or capped, and also in natural recovery areas. Monitoring will begin in the Year 2 sampling event. Sampling and analysis completed as part of remediation construction verified that the as-built condition of the waterway, except for some parts of the natural recovery and enhanced natural recovery areas meet the SQO cleanup criteria. The natural recovery and enhanced natural recovery areas are, however, expected to meet the SQOs within the 10-year compliance period.

Detected chemical concentration trends for Early Warning contaminants of concern (COC), as determined by the sampling and analysis, will be evaluated to identify if recontamination is occurring. The Thea Foss and Wheeler-Osgood Waterways COCs are listed in Table 2-3. Similar to the cap performance monitoring samples, parameters to be evaluated for Early Warning Monitoring include the COCs used to evaluate and confirm completion of remedial actions. Analysis for conventional parameters such as total organic carbon (TOC) and Total Solids will also be performed in all sediment samples.

The locations of the Early Warning Monitoring samples were selected to provide comprehensive coverage of the site and to target potential sources associated with shoreline and waterway uses, such as marinas, outfalls, and industrial facilities that drain to the waterway. Early Warning sampling locations are shown on Figure 3-1. The rationale for the placement of Early Warning sampling locations is presented in Table 3-1.

3.2.1 Early Warning Monitoring Activities

Early Warning Monitoring will be completed during Years 2, 4, 7 and 10. Recent sediments, represented by the 0 to 2 cm interval will be sampled and analyzed for COCs. Detected chemical concentrations will be evaluated for through-time concentration trends and compared to the SQOs and Early Warning threshold concentrations (see Table 3-2). Concentration trend data will be used to identify potential sources of recontamination, if present.

This program sets forth the proposed Early Warning Monitoring locations and frequency of sample collection and analysis for surface (0 to 2 cm) sediments. The program also presents the potential response actions that may be implemented through coordination with EPA if Early Warning Monitoring data indicate that recontamination is occurring or is likely to occur in the future. The field sampling methods and quality control/quality assurance protocols are presented in Appendix B - Sediment Sampling Operations Manual. Health and Safety protocols for recontamination monitoring are presented in Appendix F.

3.2.2 Early Warning Monitoring Criteria and Decision Matrix

Early Warning Screening Criteria. Criteria for Early Warning samples are not defined in the Record of Decision (ROD) or Explanation of Significant Differences (ESD), however, the use of model predicted threshold sediment concentrations were selected to provide a potential recontamination trigger and to be consistent with the remedial action objectives for the project. The upper 2 cm of the sediment column is not a compliance interval for remediation of the waterway, but was selected because it represents the most recently deposited sediment that can be effectively sampled. The 0 to 10 cm interval is the compliance interval for the remediation project. The results of Early Warning Monitoring will be initially compared to SQO criteria. If chemical concentrations exceed SQO criteria the results will then be compared to the threshold sediment concentrations as presented in Figure 3-2.

Threshold concentrations for the 0 to 2 cm Early Warning Monitoring sampling interval were developed during the remedial design (City of Tacoma, 2003) for use in predicting the potential for recontamination. The Early Warning threshold concentrations provide contaminant levels for the 0 to 2 cm interval which are expected to correlate to compliance with the SQOs in the 10 cm compliance interval. Several years are required to accumulate 10 cm of new sediment assuming a sedimentation rate of 1 to 2 cm/yr, during which time contaminants are attenuated by pore water advection, dispersion, and biodegradation.

The 0 to 2 cm Early Warning threshold concentrations are presented in Table 3-2. If the exceedances of the Early Warning threshold concentrations are confirmed by the chemical testing results in the 2 cm monitoring sample(s), recontamination is predicted to occur.

If sampling and analyses results show that in a given area recontamination may be occurring then the surrounding Early Warning Monitoring samples will be evaluated and the potential sources of sediment recontamination will be examined to determine possible impacts to the remediation areas and potential response actions.

Decision Matrix. A decision matrix has been developed as a guide for the interpretation of the Early Warning Monitoring data. The decision matrix is designed to facilitate the data analysis process and provide guidance regarding evaluation of response actions, and establishing future requirements for Early Warning Monitoring activities. The decision matrix is presented in Figure 3-2. Additionally, the decision matrices discussed in Section 2.0 and presented on Figures 2-5 through 2-7 should also be referred to during the analysis of Early Warning Monitoring data.

If recontamination is predicted to occur, EPA will be consulted to determine whether response actions including additional monitoring should be conducted sooner than specified in the monitoring schedule in Section 2.2.3.

3.2.3 Schedule and Reporting Overview

The schedule for Early Warning Monitoring activities and reporting is presented in Table 3-3 and Figure 1-3.

Reporting

Notification of field activities will be provided to EPA 30 days prior to the beginning of monitoring activities. Following the completion of monitoring activities, data validation, and data analysis, a Preliminary Findings Memorandum will be submitted to EPA to facilitate the next steps in the monitoring process or the implementation of response actions if necessary. The Preliminary Findings Memoranda will be incorporated into annual OMMP monitoring reports. Annual Monitoring Reports for Years 2, 4, 7, and 10 will be prepared and will include all elements performed during that monitoring year. The potential for sediment recontamination, based on the chemical concentration trends observed throughout the 10-year monitoring period will be included in the final monitoring report.

3.3 Early Warning Monitoring

Early Warning Monitoring will include collection and chemical analysis of the upper 2 cm of sediment within remediated areas of the Thea Foss and Wheeler-Osgood Waterways. The rationale for Early Warning Monitoring is that the near-surface sediments represent the most recent deposition, whereas the upper 10 cm will likely include cap material (or native sediments in dredged areas) for the first several years of monitoring (given expected sedimentation rates at the site). Therefore, if chemical concentrations are impacted by ongoing sources, such impacts should be apparent in the upper 2 cm of the sediment column.

Monitoring Frequency. Early Warning Monitoring will be completed during Years 2, 4, 7 and 10.

Field Activities. Collection and chemical analysis of the Early Warning samples will be conducted at the sampling locations shown on Figure 3-1. At locations where 0 to 2 cm and 0 to 10 cm sediment samples are co-located, the intervals should be obtained from the same grab sample (volume permitting).

Data Analysis. Results of 0 to 2 cm sediment testing (and co-located 0 to 10 cm samples where available) will be evaluated and used to develop concentration trend plots, which will be updated after each Early Warning Monitoring event. Concentration trend plots, charting the detected analyte concentration versus time, will be developed for each sampling location and analyte showing sample location detected concentrations over time. The rationale for the interpretation of monitoring results, and the evaluation of chemical exceedances is presented in the Early Warning Monitoring Decision Matrix (Figure 3-2) and is also summarized below.

Recontamination from ongoing sources will be considered likely if one or more of the following conditions are observed:

- A confirmed concentration trend comprised of a minimum of two consecutive rounds of Early Warning (0 to 2 cm) sediment quality data, show that detected chemical concentrations exceed the Early Warning threshold concentrations; and
- The concentration trend comprised of a minimum of two consecutive rounds of monitoring shows that surface sediment concentrations are predicted to exceed the Early Warning threshold concentrations and the trend for detected chemical concentrations is increasing over time.

Increasing chemical concentration trends are likely to indicate that ongoing sources of contamination are occurring. In the event that two or more sampling rounds show that detected chemical concentrations are increasing over time and exceed the Early Warning threshold concentrations then potential recontamination sources will be evaluated as described in the following section. If evidence of recontamination is observed or predicted at the completion of the Year 10 OMMP event, the City will discuss with EPA whether the development of a supplemental Early Warning Monitoring Plan is needed to confirm the observed concentration trend and if an evaluation of potential recontamination from sources is needed.

Recontamination is unlikely to occur if detected chemical concentrations do not exceed the threshold concentrations or SQOs and are not showing an increasing concentration trend over time.

Potential Top-Down (Non-Cap) Sources of Recontamination. If recontamination is determined to be likely, the potential for recontamination from ongoing top-down (non-cap) sources will be evaluated to determine if the sediment cap surface is being recontaminated. The following procedures and lines of evidence will be used to evaluate the potential for top-down sources of recontamination:

- Identify potential top-down sources (i.e., marinas, outfalls, industrial operations, etc.) and compare the unique chemical signatures of the potential recontamination sources to exceedances observed in cap surface (0 to 10 cm and/or 0 to 2 cm) samples. If the chemical signature of a potential top-down source of recontamination is similar to chemical exceedances in surface samples, the top-down source may be causing recontamination of the cap surface. Table 3-4 summarizes potential top-down sources of recontamination within each Remediation Area (RA) and chemicals associated with the sources. Potential sources in the affected RA should be evaluated along with potential sources in adjacent RAs;
- Compare the results for 0 to 2 cm Early Warning samples to the results for surface samples (0 to 10 cm) samples. If the concentrations of COCs are generally greater in the 0 to 2 cm samples than those in the 0 to 10 cm samples, top-down sources may be the source of cap recontamination. Note, however, that Dense Non Aqueous Phase Liquid (DNAPL) seepage through the cap in adjacent areas may not necessarily be ruled out where this contaminant source is present; and
- Evaluate the spatial distribution of chemical exceedances in surface samples to the location of potential top-down sources of recontamination. If an area is contiguous with a potential top-down source and the chemical signature of the potential top-down source is similar to the chemical signature in surface samples and chemical concentrations in the 0 to 2 cm interval are greater than in the 0 to 10 cm interval, top-down recontamination may be occurring.

If evidence of a top-down source of recontamination is confirmed and a potential source is identified, appropriate potential response actions will be evaluated and discussed with EPA.

Table 3-4 presents background information regarding the pre-remediation sediment quality condition and summarizes potential sources of recontamination within each RA. Table 3-5 presents background information regarding sediment quality and summarizes potential sources of recontamination in each natural recovery area. This data is presented to help identify potential sources of recontamination and to identify the possible contaminant signature that may result. The recontamination signature of these sources may be compared to exceedances observed in the surface samples to evaluate if recontamination is occurring. This data will serve as background information to aid in the interpretation of the results of Early Warning sampling and analysis.

If evidence of recontamination from sources other than cap failure is confirmed and a potential source is identified, EPA will be contacted to discuss implementation of potential response actions. A list of potential response actions is presented below.

Response Actions

If Early Warning Monitoring data indicate recontamination from ongoing sources is occurring or may potentially occur in the future, identification of appropriate response actions will be coordinated with EPA. Potential response actions may include, but are not limited to:

- Additional data collection to confirm chemical trends and delineate the extent of the exceedance area;

- Data collection to evaluate the potential impact of suspected recontamination on the compliance interval (0 to 10 cm);
- Investigation of potential source(s) for the observed or predicted sediment recontamination. Source identification may include a spatial analysis of sediment concentrations and chemical gradients in the waterway, and/or forensics analysis ("fingerprinting") of the chemical composition of impacted sediments;
- Implementation of supplemental remedial actions or monitoring if the compliance interval exceeds the SQO, to address impacted areas or to rectify potential sources; and
- Evaluation and implementation of additional source controls, including institutional and/or engineering controls to reduce contaminant discharges to the waterway (Note: This will need to be done in coordination with Ecology for some sources.).

If early warning monitoring data indicate that bottom-up recontamination is occurring, the appropriate response actions for addressing bottom-up recontamination, as presented in Section 2.3.2, will be evaluated and proposed to EPA.

One or more of the response actions, or other actions not listed above but determined to be appropriate in the future, may be warranted depending on the specific sediment quality conditions indicated by the monitoring data. Based on the data, the City will establish a response plan for discussion with and approval by EPA.

REFERENCES

City of Tacoma. 2003. Final Design, Design Analysis Report, Thea Foss and Wheeler-Osgood Waterways. January 31, 2003.

U.S. Environmental Protection Agency (EPA). 1989. Commencement Bay Nearshore/Tideflats Record of Decision (ROD). Region 10. September.

U.S. Environmental Protection Agency (EPA). 2000. Explanation of Significant Differences – Commencement Bay Nearshore/Tideflats Superfund Site. Region 10. 3 August.

TABLES

FIGURES

Table 3-1
Proposed Early Warning Sediment Sampling Rationale and Data Quality Objectives

Sample Location	Rationale
EW-01	Located to assess the potential for recontamination of capped area at mouth of Thea Foss Waterway, including adjacent outfalls discharging to RA 1B.
EW-06	Located to assess the potential for recontamination in the channel portion of the Thea Foss Waterway, including adjacent outfalls.
EW-07	Located to assess the potential for recontamination in harbor area from marina activities and adjacent outfalls.
EW-08	Positioned to be co-located with RA 2 construction verification samples and to obtain adequate areal distribution of early warning samples in the channel portion of the Thea Foss Waterway.
EW-09	Positioned to be co-located with RA 2 construction verification samples and to obtain adequate areal distribution of early warning samples in the channel portion of the Thea Foss Waterway.
EW-10	Located to assess the potential for recontamination in harbor area from marina activities and adjacent outfalls.
EW-11	Located to assess the potential for recontamination in harbor area from marina activities and adjacent outfalls.
EW-12	Located to assess the potential for recontamination in harbor area from marina activities and adjacent outfalls discharging to RA 8.
EW-13	Located to assess the potential for recontamination in near-shore area from adjacent commercial activities, including Petrich Marine.
EW-15	Located to obtain areal distribution of early warning samples in dredged to clean areas located in the channel portion of the Thea Foss Waterway.
EW-16	Located to assess the potential for recontamination in harbor area from marina activities and adjacent outfall discharging to RA 8.
EW-17	Located to assess potential for recontamination at mouth of Wheeler-Osgood Waterway and to obtain adequate areal distribution of early warning samples.
EW-19	Located to assess the potential for recontamination in the Wheeler-Osgood Waterway, including adjacent outfalls and the capped sheen source area.

Sample Location	Rationale
EW-20	Located to assess the potential for recontamination in the Wheeler-Osgood Waterway, including Outfall 254.
EW-21	Located to obtain areal distribution of early warning samples in dredged to clean areas located in the channel portion of the Thea Foss Waterway.
EW-22	Located to assess the potential for recontamination in nearshore area from adjacent commercial activities, including Martinac Shipyard.
EW-23	Located to assess the potential for recontamination in nearshore area from adjacent Outfall 230.
EW-24	Located to obtain areal distribution of early warning samples in dredged to clean areas located in the channel portion of the Thea Foss Waterway.
EW-25	Located to assess the potential for recontamination in harbor area from marina activities located in adjacent RA 16.
EW-26	Located to assess the potential for recontamination in near-shore area from marina activities in adjacent RA 16.
EW-27	Located to obtain adequate areal distribution of early warning samples in the capped portion of channel of the Thea Foss Waterway.
EW-28	Located to assess the potential for recontamination in harbor area from marina activities and outfalls discharging to RA 15.
EW-29	Located to assess the potential for recontamination in harbor area from marina activities.
EW-30	Located to obtain adequate areal distribution of early warning samples in the capped portion of the channel of the Thea Foss Waterway.
EW-31	Located to assess the potential for recontamination in harbor area from marina activities and adjacent outfalls discharging to RA 20.
EW-32	Located to assess the potential for recontamination in harbor area from marina activities.
EW-33	Located to obtain adequate areal distribution of early warning samples in the capped portion of the channel of the Thea Foss Waterway.

Notes:

EW Early Warning

Table 3-2
Early Warning Threshold Concentrations

Analyte	Early Warning Threshold Concentration[1]	Sediment Quality Objectives (SQO)	Threshold Enrichment[1]
Conventionals			
Total Organic Carbon in %	NA	NA	NA
Total Solids in %	NA	NA	NA
Metals in mg/kg			
Antimony	150	150	1
Arsenic	57	57	1
Cadmium	5.1	5.1	1
Copper	390	390	1
Lead	450	450	1
Mercury	0.59	0.59	1
Nickel	140	140	1
Silver	6.1	6.1	1
Zinc	410	410	1
LPAHs in µg/kg			
2-Methylnaphthalene	3,350	670	5
Acenaphthene	2,500	500	5
Acenaphthylene	6,500	1,300	5
Anthracene	4,319	960	4.5
Fluorene	2,700	540	5
Naphthalene	10,500	2,100	5
Phenanthrene	7,500	1,500	5
HPAHs in µg/kg			
Benzo(a)Anthracene	2,080	1,600	1.3
Benzo(a)Pyrene	1,850	1,600	1.2
Benzo(b)Fluoranthene	NA	NA	NA
Benzo(k)Fluoranthene	NA	NA	NA
Total Benzofluoranthenes	4,140	3,600	1.2
Benzo(g,h,i)Perylene	768	720	1.1
Chrysene	3,360	2,800	1.2
Dibenz(a,h)Anthracene	288	230	1.3
Fluoranthene	7,251	2,500	2.9
Indeno(1,2,3-c,d)Pyrene	828	690	1.2
Pyrene	8,580	3,300	2.6
Phthalates in µg/kg			

Analyte	Early Warning Threshold Concentration[1]	Sediment Quality Objectives (SQO)	Threshold Enrichment[1]
Dimethylphthalate	160	160	1
Diethylphthalate	200	200	1
Di-n-butylphthalate	1,400	1,400	1
Butylbenzylphthalate	900	900	1
Bis(2-Ethylhexyl)Phthalate	3,250	1,300	2.5
Di-n-octylphthalate	6,200	6,200	1
Acid Compounds in µg/kg	NA	NA	1
Phenol	420	420	1
2-Methylphenol	63	63	1
4-Methylphenol	670	670	1
2,4-Dimethylphenol	29	29	1
Pentachlorophenol	360	360	1
Benzyl alcohol	73	73	1
Benzoic acid	650	650	1
Miscellaneous Compounds in µg/kg			
1,2-Dichlorobenzene	50	50	1
1,3-Dichlorobenzene	170	170	1
1,4-Dichlorobenzene	110	110	1
1,2,4-Trichlorobenzene	51	51	1
Hexachlorobenzene	22	22	1
Dibenzofuran	540	540	1
Hexachlorobutadiene	11	11	1
N-Nitrosodiphenylamine	28	28	1
Pesticide/PCBs in µg/kg			
4,4'-DDD	16	16	1
4,4'-DDE	9	9	1
4,4'-DDT	34	34	1
PCB-1016	NA	NA	1
PCB-1221	NA	NA	1
PCB-1232	NA	NA	1
PCB-1242	NA	NA	1
PCB-1248	NA	NA	1
PCB-1254	NA	NA	1
PCB-1260	NA	NA	1
Total PCBs	300	300	1

[1] Early Warning Threshold Concentrations for polycyclic aromatic hydrocarbons and bis(2-ethylhexyl)phthalate are based on contaminant transport modeling (MODFLOW/MT3D) Thea Foss and Wheeler-Osgood Waterways Remediation Project Final Design Analysis Report, City of Tacoma, 2002. All other threshold concentrations are based on Sediment Quality Objectives.

Table 3-3
Early Warning Monitoring and Reporting Schedule

Task		Task Type	Timeline and Description
1	Perform Year 2 Early Warning Surface (0-2cm) Sediment Sampling	Field Activities	Two years after completion of baseline performance data collection activities
2	Prepare and Submit the Year 2 Early Warning Monitoring Report to EPA	Reporting	Within 45 days of completion of all Year 2 data validation activities or as otherwise approved by EPA
3	Perform Year 4 Early Warning Surface (0-2cm) Sediment Sampling	Field Activities	Two years after completion of Year 2 early warning data collection activities
4	Prepare and Submit the Year 4 Early Warning Monitoring Report to EPA	Reporting	Within 45 days of completion of all Year 4 data validation activities or as otherwise approved by EPA
5	Perform Year 7 Early Warning Surface (0-2cm) Sediment Sampling	Field Activities	Three years after completion of Year 4 early warning data collection activities
6	Prepare and Submit the Year 7 Early Warning Monitoring Report to EPA	Reporting	Within 45 days of completion of all Year 7 data validation activities or as otherwise approved by EPA
7	Perform Year 10 Early Warning Surface (0-2cm) Sediment Sampling	Field Activities	Three years after completion of Year 7 early warning data collection activities
8	Prepare and Submit the Year 10 Final Early Warning Monitoring Report to EPA	Reporting	Within 45 days of completion of all Year 10 data validation activities or as otherwise approved by EPA

Table 3-4
Summary of Remedial Area Condition

Remedial Area (RA)	Completed Remedial Actions	Pre-Construction Condition: Sample Interval[1]	Pre-Construction Condition: Detected SQO Exceedances	Pre-Construction Condition: Date	Construction Condition: Sample Interval[1]	Construction Condition: Detected SQO Exceedances	Construction Condition: Sampling Event	Construction Condition: Date	Post-Construction Use	Adjacent Private or City Outfalls	Potential Sources of Recontamination	Remedial Area (RA)
RA 1A	Channel sand cap	Surface	HPAHs, Anthracene, Phenanthrene	1995	Surface	No SQO Exceedances	Cap Verification	2/19/2003	Navigational Channel	Private (1) (outfall discharges to RA 1B)	Capped Sediments (see Pre-Construction Conditions column)	RA 1A
RA 1B	Slope cap	Surface	Hexachlorobenzene, HPAHs, Phenanthrene	1995	Sampling Not Required				Shoreline	Private (3)	Outfall Discharge Capped Sediments (see Pre-Construction Conditions column)	RA 1B
RA 2	Dredge to 3 foot depth and backfill	Surface	Hg, BEHP, Acenaphthylene, Anthracene, Fluorene, Phenanthrene, HPAHs	1994	Surface	No SQO Exceedances	Dredge Boundary Verification	10/22/2004	Navigational Channel	None	Outfall Discharge Commercial Operations	RA 2
		Surface	BEHP, Dimethyl Phthalate, LPAHs, HPAHs	1995								
		Subsurface	Hg, HPAHs, Anthracene, Phenanthrene	1995	Surface	DDE (average concentration below SQO)	Post-Dredge, Prior to Backfill	10/22/2004				
		Surface	BEHP, (No Suggestions), (No Suggestions), (No Suggestions), Pyrene	1997								
RA 3	Slope and grout mat caps	Surface	Dibenzo(a,h)anthracene, Benzofluoranthenes (total)	1994	Sampling Not Required				Shoreline, adjacent to Totem Marine	COT-208	Marina Outfall Discharge Capped Sediments (see Pre-Construction Conditions column)	RA 3
		Surface	(No Suggestions), (No Suggestions), Indeno(1,2,3-c,d)Pyrene, Phenol, BEHP	1995								
RA 4	Dredge to 3 foot depth and backfill	Surface	BEHP, Hg, HPAHs, Anthracene, Phenanthrene	1995	Surface	Zinc[2]	Dredge Boundary Verification	11/15/2004	Navigational Channel	None	Outfall Discharge Commercial Operations	RA 4
					Surface	No SQO Exceedances	Post-Dredge, Prior to Backfill	11/15/2004				
		Surface	BEHP	1997	Surface	No SQO Exceedances	Dredge Boundary Verification Offset Confirmation	12/29/2004				
RA 5	Dredge to clean, Natural Recovery along northern boundary of RA, and slope cap between Stations 37+00 and 39+80 (Petrich)	Surface	BEHP, DDD, PCBs, Benzofluoranthenes (total)	1997	Surface	No SQO Exceedances	Remedial Action Modification Evaluation	6/29/2005	Navigational Channel, adjacent to Petrich	None	Naturally Recovering In Situ Sediments Capped Sediments (see Pre-Construction Conditions and Construction Conditions columns)	RA 5
					Surface	No SQO Exceedances	Post-Dredge, No Cap or Backfill	10/24/2005				
					Surface	BEHP[3]	Dredge Boundary Verification	12/15/2005				
RA 6	Dredge to clean, Natural Recovery along northern boundary of RA, and channel sand cap between Stations 48+70 and 50+90 on the western side of RA 6	Surface	Hg, Pb, Zn, BEHP, PCBs, HPAHs, Phenanthrene	1994	Surface	No SQO Exceedances	Remedial Action Modification Evaluation	6/29/2005	Navigational Channel	None	Naturally Recovering In Situ Sediments Capped Sediments (see Pre-Construction Conditions and Construction Conditions columns)	RA 6
					Surface	No SQO Exceedances	Post-Dredge, Prior to Cap on Transition Slope	10/7/2005				
		Surface	Hg, BEHP, (No Suggestions), (No Suggestions)	1995	Surface	Hg, DDD, DDE[4]	Post-Dredge, No Cap or Backfill	10/7/2005				
					Surface	No SQO Exceedances	Post-Redredge, No Cap or Backfill	10/24/2005				
		Subsurface	Hg, As, BEHP, DDD, DDE, PCBs, HPAHs	1995	Surface	Acenaphthene, Phenanthrene, Fluoranthene, Dibenzofuran	Post-Dredge, Prior to Cap, Resampling	11/10/2005				
					Surface	No SQO Exceedances	Dredge Boundary Verification	12/15/2005				
		Subsurface	Hg, BEHP, DDE, (No Suggestions)	1997	Surface	No SQO Exceedances	Cap Verification, Cap on Transition Slope	12/15/2005				
					Surface	No SQO Exceedances	Cap Verification, Cap Over	1/26/2006				
RA 7	Enhanced Natural Recovery (i.e., placed 6 inches of channel sand cap material)	Surface	Hg, BEHP, PCBs, DDD, Dibenzo(a,h)anthracene, Benzofluoranthenes (total), Pyrene	1994	Surface	DDE	Remedial Action Modification Evaluation	6/29/2005	Foss Waterway Marina	Private (4) COT-224 COT-225 (outfalls discharge to RA 8)	Marina Outfall Discharge in RA 8 Naturally Recovery In Situ Sediments and Adjacent Capped Sediments (see Construction Conditions column)	RA 7
		Surface	Hg, BEHP, (No Suggestions)	1995								
RA 7A	Dredge to 3 foot depth and channel sand cap	Surface	Hg, BEHP, PCBs, Dibenzo(a,h)anthracene, Benzofluoranthenes (total), Pyrene	1994	Sampling Not Required				Foss Waterway Marina	None	Marina RA 7A and Adjacent Capped Sediments (see Pre-Construction Conditions column)	RA 7A
RA 8	Dredge to achieve a 2:1 slope and slope cap	Surface	Hg, Pb, Cu, Zn, PCBs, BEHP, HPAHs	1994	Sampling Not Required				Shoreline, adjacent to Foss Waterway Marina	Private (4) COT-230 COT-224 COT-225	Marina Outfall Discharge Capped Sediments (see Pre-Construction Conditions column)	RA 8
RA 9	Dredge to target elevation and channel sand cap	Surface	BEHP, PCBs, HPAHs, Phenanthrene, 1,2-Dichlorobenzene	1994	Surface	Zn, LPAHs, Benzo(a)anthracene, Pyrene, N-Nitrosodiphenylamine, DDD, DDE, DDT	Post-Dredge, Prior to Cap	10/12/2005	Navigational Channel	None	Outfall Discharge Capped Sediments (see Pre-Construction Conditions and Construction Conditions columns)	RA 9
		Surface	BEHP, PCBs, HPAHs	1995	Surface	No SQO Exceedances	Dredge Boundary Verification	10/12/2005				
		Subsurface	Hg, BEHP, PCBs, DDD, DDE, HPAHs, LPAHs (Anthracene, Phenanthrene)	1995	Surface	No SQO Exceedances	Cap Verification	12/14/2005				
		Surface	BEHP, (No Suggestions)	1997								
		Subsurface	BEHP, HPAHs, Phenanthrene	1997								
RA 10	Slope rehabilitation	Surface	BEHP, Pyrene	1994	Sampling Not Required[5]				Shoreline	Private (2)	Outfall Discharge	RA 10

Remedial Area (RA)	Completed Remedial Actions	Pre-Construction Condition			Construction Condition				Post-Construction Use	Adjacent Private or City Outfalls	Potential Sources of Recontamination	Remedial Area (RA)
		Sample Interval[1]	Detected SQO Exceedances	Date	Sample Interval[1]	Detected SQO Exceedances	Sampling Event	Date				
RA 11	Slope rehabilitation	Surface	PCBs, Anthracene, Phenanthrene, HPAHs	1994	Sampling Not Required[5]				Shoreline	Private (2)	Outfall Discharge	RA 11
RA 12	Dredge to 3 foot depth and backfill	Surface	BEHP, PCBs, DDE, HPAHs, 1,2-Dichlorobenzene	1994	Surface	No SQO Exceedances	Dredge Boundary Verification	3/9/2005	Channel Area	COT-254 (outfall discharges to RA 13)	Outfall Discharge in RA 13	RA 12
		Surface	BEHP, HPAHs	1995	Surface	Acenaphthene, Anthracene, Flourene, Phenanthrene (average concentration below SQO)	Post-Dredge, Prior to Backfill	3/9/2005				
		Surface	DDD, DDE, DDT, HPAHs, LPAHs	1995								
					Surface	LPAHs, Dibenzo(a,h)anthracene, DDE	Post-Dredge, Prior to Cap	7/11/2005				
		Surface	Benzo(c)anthracene, Pyrene	1997								
	Sheen source area	Sheen observed during construction			Surface	LPAHs, Dibenzo(a,h)anthracene, DDE	Post-Dredge, Prior to Cap	7/11/2005	Channel Area	COT-254 (outfall discharges to RA 13)	Outfall Discharge in RA 13 Capped Sediments (see Pre-Construction Conditions column)	
RA 13	Slope rehabilitation	Surface	BEHP, PCBs, HPAHs, Phenanthrene, 1,2-Dichlorobenzene	1994	Sampling Not Required[5]				Shoreline	Private (4) COT-254	Outfall Discharge	RA 13
RA 14	Slope cap	Surface	As, Cu, Zn, PCBs, Phenanthrene, Fluoranthene, Benzofluoranthenes (total)	1994	Sampling Not Required				Martinac Shipbuilding	None	Shipbuilding Activities Capped Sediments (see Pre-Construction Conditions column)	RA 14
		Surface	Cu, Zn, BEHP, LPAHs, HPAHs, PCBs	1995								
RA 15	Slope rehabilitation	Surface	No SQO Exceedances	1994	Sampling Not Required				Shoreline	Private (1) COT-249 COT-248	Outfall Discharge Capped Sediments	RA 15
RA 16	Dredge to clean and channel sand cap between northern RA boundary to Station 55+30 and from Stations 57+00 to 58+90	Surface	Hg, PCBs, DDD, DDE, BEHP, Dimethyl Phthalate, HPAHs,	1994	Surface	Hg, Pb, Zn, LPAHs, HPAHs, Butyl benzyl phthalate, 2,4-Dimethylphenol, Dibenzofuran, DDE, PCBs[4]	Post-Dredge, No Cap or Backfill	8/12/2005, 9/23/2005	Delin Docks	Private (1) COT-249 COT-248 (outfalls discharge to RA 15)	Marina Outfall Discharge Capped Sediments (see Pre-Construction Conditions and Construction Conditions columns)	RA 16
					Surface	Hg, Zn, Acenaphthene, Anthracene, HPAHs[6]	Post-Redredge	8/22/05, 10/3/2005				
		Surface	Hg, BEHP, DDD, (No Suggestions), Benzofluoranthenes (total)	1995	Surface	No SQO Exceedances	Cap Verification Sample	10/19/2005				
		Subsurface	Hg, DDD, BEHP, Pyrene, Chrysene	1995	Surface	No SQO Exceedances	Cap Boundary Verification	1/20/2006				
RA 17	Dredge to clean and channel sand cap between Station 54+70 and southern boundary of RA	Surface	Hg, BEHP, PCBs, DDD, HPAHs	1994	Surface	DDD, DDE[4]	Post-Dredge, No Cap or Backfill	9/23/2005	Navigational Channel	None	Capped Sediments (see Pre-Construction Conditions and Construction Conditions columns)	RA 17
		Surface	Hg, BEHP, PCBs, HPAHs	1995	Surface	DDD, DDE, DDT	Post-Dredge, Prior to Cap	10/14/2005				
		Subsurface	Hg, BEHP, DDD, PCBs, HPAHs	1995	Surface	BEHP, PCBs, DDE	Cap Boundary Verification	1/23/2006				
		Subsurface	HPAHs, Acenaphthene, Fluorene, Phenanthrene	1997	Surface	No SQO Exceedances	Cap Verification, Final Lift	2/6/2006				
RA 18	Dredge to target elevation and channel sand cap	Surface	Hg, BEHP, DDD, PCBs, HPAHs	1994	Surface	Hg, Pb, Zn, Benzo(g,h,i)perylene, Dibenzo(a,h)anthracene, Indeno(1,2,3-cd)pyrene, BEHP, 3- & 4-Methylphenol, DDE, DDT, PCBs	Post-Dredge, Prior to Cap	8/12/2005	Navigational Channel	None	Capped Sediments (see Pre-Construction Conditions and Construction Conditions columns)	RA 18
		Surface	Hg, BEHP, HPAHs	1995								
		Subsurface	Hg, BEHP, PCBs, DDD, Pyrene,Acenaphthene, Fluorene, Phenanthrene, N-Nitroso-Diphenylamine	1995	Surface	No SQO Exceedances	Cap Verification, First Lift	8/22/2005				
		Surface	Hg, Zn, BEHP, HPAHs	1997	Surface	No SQO Exceedances	Cap Verification, Final Lift	1/20/2006				
RA 19A	Dredge to target elevation or a 2:1 slope and channel sand, slope, or grout mat cap	Surface	Hg, Pb, Zn, As, BEHP, DDD, PCBs, HPAHs, LPAHs, Hexachlorobenzene	1994	Surface	Hg, LPAHs, HPAHs, Butyl benzyl phthalate, BEHP, DDD, DDE, DDT, PCBs	Post-Dredge, Prior to Cap	1/8/2004, 2/6/2004	Dock Street Marina	None	Marina Capped Sediments (see Pre-Construction Conditions and Construction Conditions columns)	RA 19A
					Surface	2,4-Dimethylphenol	Cap Verification, First Lift	2/27/2004, 7/26/2004				
					Surface	2,4-Dimethylphenol	Cap Verification, Final Lift	2/27/2004, 8/9/2004				
					Surface	Acenaphthene, Phenanthrene, DDD, DDE, DDT, PCBs	Supplemental Sampling	12/2/2004				
		Subsurface	LPAHs, HPAHs	2002	Surface	DDD, DDE	Supplemental Sampling	10/12/2005				
					Surface	No SQO Exceedances	Post-Additional Cap Material Placement Verification	1/4/2006				
RA 19B	Dredge to target elevation or a 2:1 slope and channel sand, slope, or grout mat cap	Surface	Hg, Pb, BEHP, DDD, PCBs, HPAHs, Phenanthrene	1994	Surface	LPAHs, HPAHs, DDD, DDE, DDT, PCBs	Supplemental Sampling	11/9/2004	Dock Street Marina	None	Marina Capped Sediments (see Pre-Construction Conditions and Construction Conditions columns)	RA 19B
		Surface	Hg, Pb, BEHP, DDD, PCBs, HPAHs, Phenanthrene	1995	Surface	Acenaphthene, Phenanthrene, DDE, PCBs	Supplemental Sampling	5/10/2005				
		Subsurface	Hg, Pb, Zn, BEHP, DDD, DDE, PCBs, HPAHs, LPAHs, Dibenzofuran	1995	Surface	No SQO Exceedances	Post-Additional Cap Material Placement Verification	1/4/2006				
		Subsurface	LPAHs, HPAHs	2002								

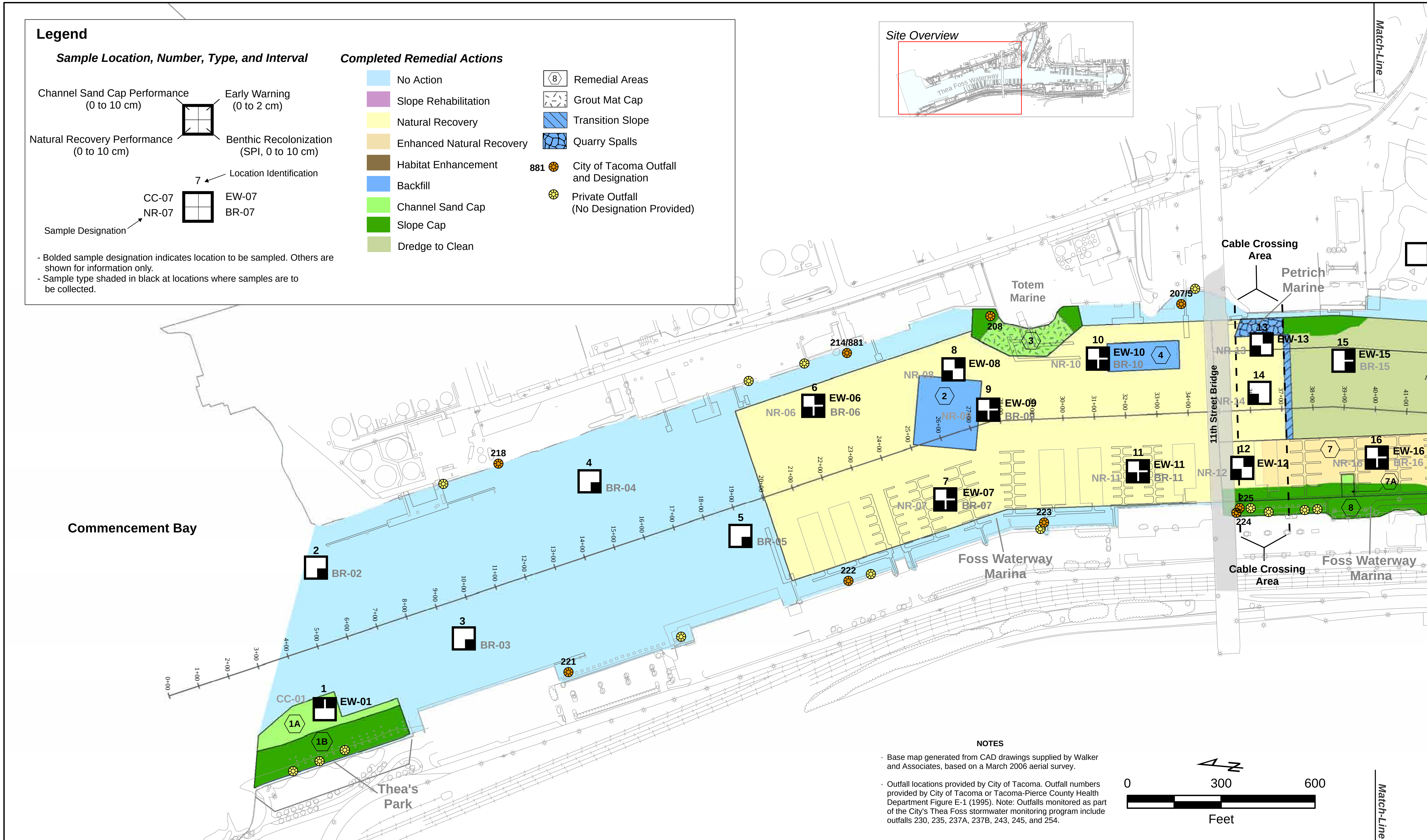
Remedial Area (RA)	Completed Remedial Actions	Pre-Construction Condition			Construction Condition				Post-Construction Use	Adjacent Private or City Outfalls	Potential Sources of Recontamination	Remedial Area (RA)
		Sample Interval[1]	Detected SQO Exceedances	Date	Sample Interval[1]	Detected SQO Exceedances	Sampling Event	Date				
RA 20	Dredge to target elevation and channel sand and slope cap	Surface	Hg,BEHP, PCBs, DDD, DDE,. Dimethyl Phthalate, HPAHs, Phenanthrene	1994	Surface	Hg, Pb, LPAHs, BEHP, Butyl benzyl phthalate, 2,4-Dimethylphenol, DDD, DDE, DDT, PCBs	Post-Dredge, Prior to Cap	9/17/2004, 12/8/2004, 12/29/2004	Johnny's Dock Marina and Foss Landing Marina	Private (1) COT-245	Marina Outfall Discharge Capped Sediments (see Pre-Construction Conditions and Construction Conditions column)	RA 20
		Surface	Hg, BEHP, DDD, PCBs, HPAHs, Phenanthrene, Dimethyl Phthalate	1995	Surface	LPAHs, DDD, DDE, DDT, PCBs	Supplemental Sampling	11/9/2004				
		Subsurface	Hg, BEHP, DDD, PCBs, HPAHs, LPAHs, Dibenzofuran, N-Nitroso-Diphenylamine	1995	Subsurface	LPAHs, HPAHs, BEHP, DDD, DDE, DDT,PCBs	Supplemental Core Sampling	12/1/2004				
					Surface	No SQO Exceedances	Cap Verification, First Lift	10/7/2004, 3/10/2005				
					Surface	No SQO Exceedances	Supplemental Sampling	5/10/2005				
		Surface	BEHP, (No Suggestions)	1997	Surface	No SQO Exceedances	Resampling and Analysis	9/14/2005				
					Surface	No SQO Exceedances	Cap Verification, Final Lift	1/4/2006, 1/16/2006				
RA 21	Dredge to target elevation and channel sand cap	Surface	Hg, BEHP, DDD, PCBs, HPAHs	1994	Surface	Hg, LPAHs, HPAHs, Dibenzofuran, DDD, DDE, DDT, PCBs	Post-Dredge, Prior to Cap	12/8/2004, 12/29/2004	Navigational Channel	None	Capped Sediments (see Pre-Construction Conditions and Construction Conditions columns)	RA 21
		Surface	Hg, Pb, BEHP, HPAHs	1995	Surface	No SQO Exceedances	Cap Verification, First Lift	3/10/2005				
					Surface	No SQO Exceedances	Cap Verification, First Lift	3/10/2005				
		Subsurface	Hg, Pb, Zn, BEHP, DDD, PCBs, HPAHs, LPAHs, Dibenzofuran	1995	Surface	No SQO Exceedances	Resampling	9/14/2005				
		Surface	Hg, BEHP, DDD, HPAHs, Phenanthrene	1997	Subsurface	No SQO Exceedances	Supplemental Core Sampling	10/14/2005				
					Surface	No SQO Exceedances	Cap Verification, Final Lift	1/4/2006, 1/20/2006				
RA 22	Dredge to target elevation and channel sand cap	Subsurface	LPAHs, HPAHs	2002	Surface	Hg, LPAHs, HPAHs, Butyl benzyl phthalate, Dibenzofuran, DDD, DDE, PCBs	Post-Dredge, Prior to Cap	9/17/2004	Navigational Channel	None	Capped Sediments (see Pre-Construction Conditions and Construction Conditions columns)	RA 22
					Surface	No SQO Exceedances	Cap Verification, First Lift	10/7/2004				
					Surface	Hg, LPAHs, HPAHs, DDD, DDE, DDT, PCBs	Supplemental Sampling	11/9/2004				
					Surface	No SQO Exceedances	Supplemental Core Sampling	12/1/2004				
					Surface	LPAHs, HPAHs, DDE, PCBs	Supplemental Sampling	5/10/2005				
					Surface	No SQO Exceedances	Cap Verification, Final Lift	1/4/2006				

Notes:
1. Surface sample interval is the 0 to 10 cm compliance layer.
2. Additional offset dredge boundary verification did not detect zinc concentrations greater than the SQO.
3. Sample collected from natural recovery area.
4. Area(s) with chemical concentrations exceeding the SQOs were subsequently redredged to remove chemical concentrations greater than SQOs or were capped to contain sediments with chemical concentrations exceeding the SQOs.
5. Supplemental Natural Recovery Baseline (Year 0) samples to be collected in RA during Year 0 of OMMP.
6. Areas(s) with chemical concentrations greater than the SQOs were subsequently capped.

BEHP - bis(2-ethylhexyl)phthalate
COT - City of Tacoma
HPAH - High molecular weight polycyclic aromatic hydrocarbons
LPAH - Low molecular weight polycyclic aromatic hydrocarbons
NA - Not Applicable
PCB - Polychlorinated biphenyls
SQOs - Sediment Quality Objectives

Table 3-5
Summary of Natural Recovery Area Conditions

Natural Recovery Area	Remedial Actions	Pre-Construction Condition			Construction Condition				Post-Construction Use	Adjacent Private or City Outfalls[2]	Potential Sources of Recontamination	Natural Recovery Area
		Sample Interval[1]	Detected SQO Exceedances	Date	Sample Interval[1]	Detected SQO Exceedances	Sampling Event	Date				
North of the 11th Street Bridge	Natural Recovery Area between Stations 20+00 and 35+00	Surface Surface Surface Subsurface	Hg, BEHP, HPAHs, LPAHs Hg, BEHP, HPAHs BEHP, Pyrene Hg, HPAHs, LPAHs	1994 1995 1997 1995	Surface Surface	No SQO exceedances No SQO exceedances	Dredge Boundary Verification Dredge Boundary Verification Offset Confirmation	10/22/2004 11/15/2004 12/29/2004	Navigation Channel Marina Operations Tug and Fire Boat Moorage	Private (5) COT-207/5 COT-208 COT-214/881 COT-222 COT-223 (outfalls discharge to adjacent shoreline)	Marinas Outfall Discharge Commercial Operations Naturally Recovering In-Situ Sediments Adjacent Capped Sediment (i.e., RA 3)	North of the 11th Street Bridge
Northern Portion of RA 5	Natural Recovery Area in northern portion of RA between Stations 35+00 and 37+10 with area of quarry	Surface	BEHP, DDD	1994	Surface Surface	No SQO Exceedances BEHP	Remedial Action Modification Evaluation Dredge Boundary Verification	6/29/2005 12/15/2005	Navigational Channel, Moorage adjacent to Petrich	None	Moorage Naturally Recovering In-Situ Sediments	Northern Portion of RA 5
Northern Portion of RA 6	Natural Recovery Area in northern portion of RA between Stations 35+00 to 37+10	Surface Surface Subsurface	Hg, BEHP (No Suggestions) As, Hg, BEHP, DDD, DDE, HPAHs	1994 1995 1995	Surface Surface	No SQO Exceedances No SQO Exceedances	Remedial Action Modification Evaluation Dredge Boundary Verification	6/29/2005 12/15/2005	Navigational Channel	None	Naturally Recovering In-Situ Sediments	Northern Portion of RA 6
Northern Portion of RA 7	Natural Recovery Area in northern portion of RA between Stations 35+00 to 36+30	Surface	No SQO exceedances	1994	Surface	DDE	Remedial Action Modification Evaluation	6/29/2005	Foss Waterway Marina	Private (2) COT-224 COT-225 (outfalls discharge	Marina Outfall Discharge in RA 8 Naturally Recovering In-Situ Sediments	Northern Portion of RA 7
Mouth of Wheeler-Osgood Waterway	Natural Recovery Area at mouth of Wheeler-Osgood Waterway	Surface	Hg, BEHP, Phenanthrene	1994	Sampling Not Required				Off-Channel / Nearshore Area	None	Sources and Operations in Wheeler-Osgood Waterway	Mouth of Wheeler-Osgood Waterway
RA 10	Natural Recovery Area along northwestern shoreline in Wheeler-Osgood Waterway	Surface	BEHP, HPAHs, Phenanthrene	1994	Sampling Not Required				Shoreline	Private (2)	Outfall Discharge Commercial Operations	RA 10
RA 11	Natural Recovery Area along southwestern shoreline in Wheeler-	Surface Surface	HPAHs, Fluoranthene, Phenanthrene, PCBs No SQO exceedances	1994 1995	Sampling Not Required				Shoreline	Private (2)	Outfall Discharge Commercial Operations	RA 11
RA 13	Natural Recovery Area along shoreline in head of the Wheeler-Osgood Waterway	Surface	BEHP, HPAHs, Phenanthrene, 1,2-Dichlorobenzene	1994	Sampling Not Required				Shoreline	COT-254	Outfall Discharge Commercial Operations	RA 13
Head of Wheeler-Osgood	Natural Recovery Area at head of Wheeler-Osgood Waterway (i.e., between RA 13 and RA 12)	Surface Surface	Hg, Zn, BEHP, Dimethyl Phthalate, DDD, DDE, HPAHs HPAHs, Anthracene, Phenanthrene	1995 1997	Sampling Not Required				Off-Channel / Nearshore Area	COT-254 (outfall discharges to RA 13)	Outfall Discharge in RA 13 Naturally Recovering In-Situ Sediments	Head of Wheeler-Osgood
Shoreline and Harbor Area Adjacent to RA 15 and RA 16	Natural Recovery Area including harbor and shoreline area adjacent to RA 15 and RA 16	Surface	HPAHs, BEHP	1994	Sampling Not Required				Delin Docks Marina	None	Marina	Shoreline and Harbor Area Adjacent to RA 15 and RA 16



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Thea Foss and Wheeler-Osgood Waterways
OMMP

Figure 3-1 (Page 1 of 2)
Early Warning Monitoring Locations

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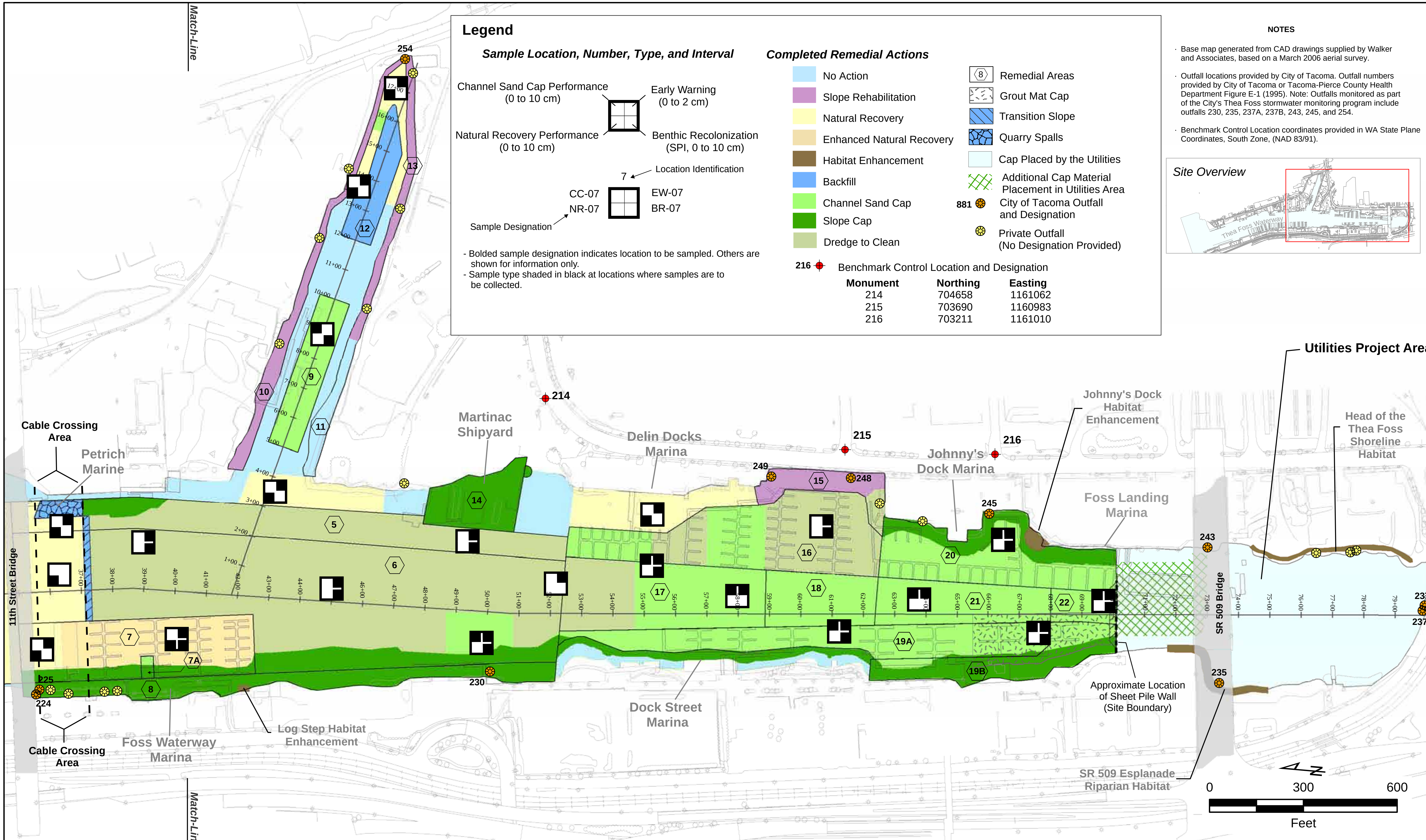

Thea Foss and Wheeler-Osgood Waterways OMMP

Figure 3-1 (Page 2 of 2) Early Warning Monitoring Locations

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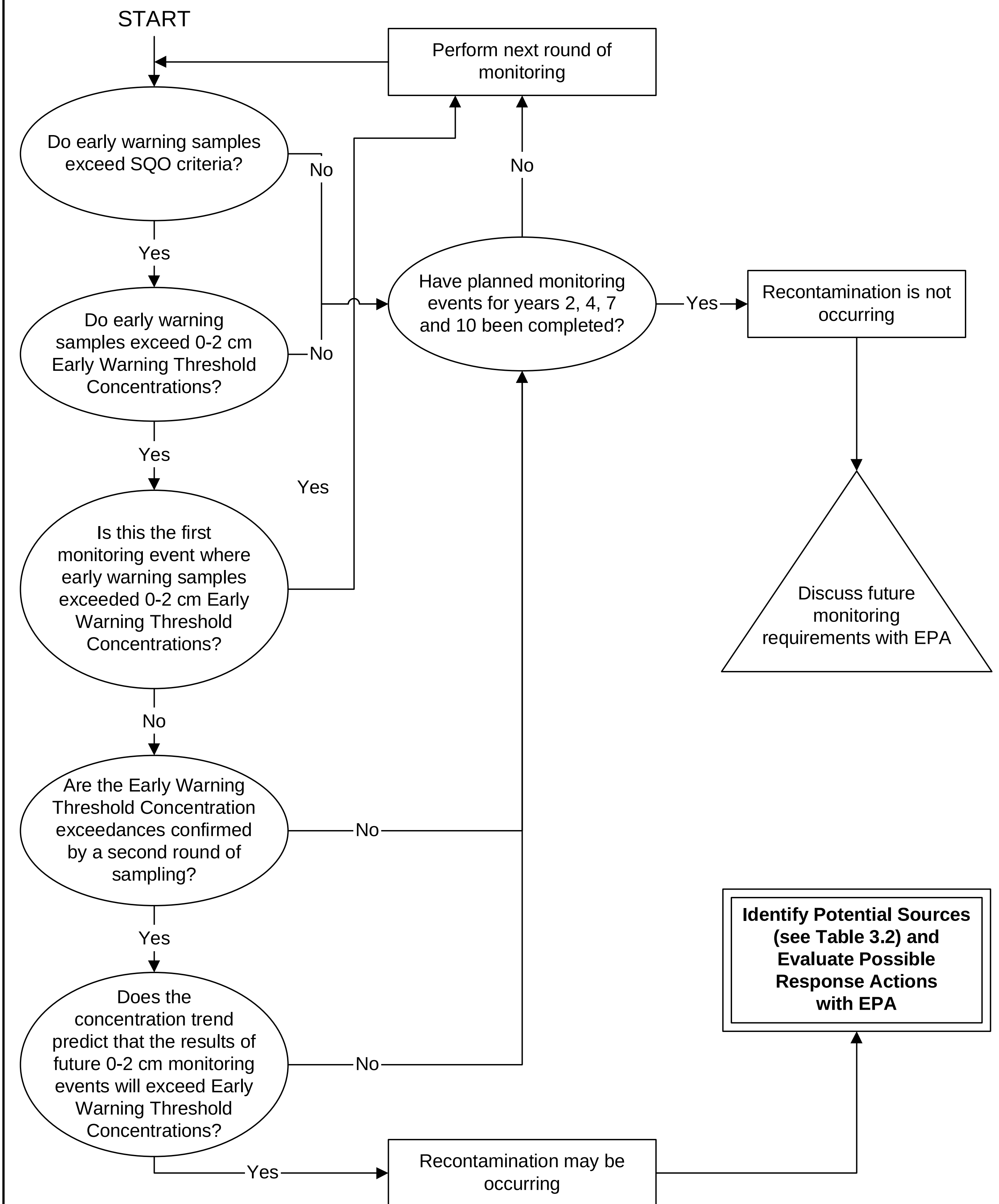

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Thea Foss and Osgood-Wheeler Waterways OMMP

Figure 3-2
Early Warning Monitoring Decision Matrix

4.0 BENTHIC RECOLONIZATION MONITORING

Monitoring will be performed in the Thea Foss and Wheeler-Osgood Waterways to track the post-remediation progress of benthic recolonization. Benthic habitat was altered by historical contamination and the sediment dredging and capping actions completed in the waterways. Given the habitat improvements resulting from the completed remedial actions, the waterway is expected to be recolonized by benthic infauna and epifauna common to Commencement Bay.

4.1 Objectives and Rationale

In accordance with the Record of Decision (ROD) (EPA 1989), the objective of the benthic recolonization monitoring is to document and evaluate the success of benthic recolonization in the Thea Foss and Wheeler-Osgood Waterways. Benthic recolonization will be evaluated throughout the Thea Foss and Wheeler-Osgood Waterways using data on habitat characteristics, organism type, and number as described below.

4.2 Benthic Recolonization Monitoring Approach

The monitoring approach utilizes standard Sediment Profile Imagery (SPI) technology to collect data. SPI will allow for data to be collected on sediment composition, benthic habitat classification, infaunal successional stages, redox potential discontinuity (RPD) and organism-sediment index (OSI), as described in Section 4.3.2. Data from each location within the remediation areas will be evaluated relative to previous years of monitoring at the same locations to assess the rate and success of benthic recolonization. Additionally, four benthic monitoring locations outside of the remediated areas, near the mouth of the waterway are included to serve as background locations.

4.2.1 Monitoring Activities

The scope of work for this monitoring program includes the following:

- Conduct SPI assessment in Years 2, 4, 7, and 10;
- Collect and archive bulk surface sediment samples; perform confirmation of the SPI results and sediment chemistry analyses if determined to be necessary (Section 4.2.2 or Figure 4-1); and
- Collect and archive benthic infaunal samples from bulk surface sediment samples; perform benthic community analysis if determined to be necessary (Section 4.2.2 or Figure 4-1).

Benthic recolonization monitoring locations, where the SPI survey and benthic infaunal samples will be collected are shown in Figure 4-2.

4.2.2 Qualitative Evaluation and Decision Matrix

A decision matrix flow chart for benthic recolonization is presented in Figure 4-1. The success of benthic recolonization will be qualitatively and semi-quantitatively evaluated based on the parameters measured using SPI. Benthic organisms will be screened from bulk surface sediment samples collected at each SPI location during monitoring and archived for later benthic community analysis, if necessary. Archived samples would be analyzed if SPI results are inconclusive or require verification. If the results of SPI require confirmation, existing sediment chemistry data (0 to 10 cm and 0 to 2 cm) will be reviewed, where co-located cap performance chemistry locations were performed as part of the OMMP. At those benthic monitoring locations that are not co-located with a 0-10 cm sediment chemistry location, archived bulk surface sediment samples collected during the SPI and benthic monitoring will be analyzed for chemicals of concern (COC).

4.2.3 Schedule and Reporting Overview

The proposed schedule for recolonization monitoring is presented in Table 4-1.

Benthic Recolonization Monitoring Schedule

SPI benthic recolonization monitoring will be conducted in Years 2, 4, 7, and 10. All monitoring activities will be conducted using the same procedures to provide comparability between monitoring events. Sampling protocols, location control and methods are presented in the Benthic Recolonization Monitoring Operations Manual (Appendix C). Procedures for surface sediment sample collection and chemical analysis are described in the Sediment Sampling Operations Manual (Appendix B).

Reporting

Recolonization monitoring results will be included in OMMP monitoring reports submitted to EPA within 45 days of completion of that monitoring year's data validation or as otherwise approved by EPA. After the final year of monitoring (Year 10), the final monitoring report will include an overall summary of the results of benthic recolonization monitoring.

The benthic recolonization monitoring reports will include the following information:

- A summary of field activities;
- Field and laboratory data;
- Calculations and results of SPI analysis, and
- Calculations and results of archive sample analysis (if performed).

The benthic recolonization monitoring report will be submitted for review and approval by EPA as part of that year's monitoring report.

4.3 Benthic Recolonization Monitoring

An SPI camera will be used to photograph the surface sediment profile up to a depth of approximately 20 cm at each benthic monitoring location. The photographs provide direct observation of the benthic organisms found at the survey sites, as well as the physical conditions of the biologically active sediment zone (upper 10 cm). Sediment color is also evident with the SPI camera, allowing for the determination of the probable oxidative state of the sediment (aerobic or anaerobic).

4.3.1 Field Activities

SPI photographs will be recorded at all locations in the Thea Foss and Wheeler-Osgood Waterways. Proposed locations are shown on Figure 4-2 and described in Table C-2 of the Benthic Recolonization Monitoring Operations Manual (Appendix C). The survey locations were randomly selected, i.e., without knowledge of the specific conditions affecting benthos in each remedial area and selected to adequately evaluate each remedial action completed. Sample locations were placed without consideration of the remedial action conducted in an area so that the surveys are representative of the overall waterway condition following the remedy. Four of the benthic recolonization monitoring locations are located near the mouth of the waterway and will be used as background locations to provide additional information on the benthic community located outside of the remediated areas.

In addition to the SPI survey, bulk samples of the surface sediment will be collected and screened for benthic organisms at all benthic recolonization sampling locations and archived for potential benthic community analysis. Many of SPI survey locations are co-located with 0 to 10 cm chemical quality sampling locations established for the performance monitoring of sediment caps (see Figure 4-2). At these locations, chemical quality data (if needed) will be derived from the cap performance samples. At locations that are co-located with an early warning sediment sample location (0 to 2 cm) and not co-located with a cap performance sample (0 to 10 cm), sediment will be collected and archived for potential future chemical analysis if needed. Surface sediment grab samples (0 to 10 cm) will be collected as part of the SPI field work. Surface samples will be collected in accordance with the protocols described in the Sediment Sampling Operations Manual (Appendix B), with a few notable modifications that are described in the Benthic Recolonization Monitoring Operations Manual (Appendix C).

4.3.2 Data Analysis

The success of benthic recolonization will be evaluated at each monitoring location over the course of OMMP monitoring relative to previous years of monitoring results at the same location based on the parameters measured using SPI, as described below. Intra-location comparisons will be made to evaluate the quality of the benthic habitat in remediated areas (i.e., individual monitoring location results will not be compared to background benthic monitoring results). Background benthic monitoring results will provide additional information on the benthic community in non-remediated areas and provide information on how environmental conditions, other than those associated with remedial actions, may impact the benthic community. Other environmental conditions may include substantial storm events and temperature changes. If the results of SPI require confirmation (i.e., SPI indicates that benthic recolonization may not be occurring) or additional assessment, sediment archived benthic community samples will be analyzed for clarification. Multiple lines of evidence will be used to evaluate if the benthic community has progressed towards benthic recolonization. Generally accepted measures of benthic community structure analysis will be used to determine lines of evidence and assess the SPI data.

SPI Data

The SPI photographs will be analyzed with a full-color analysis system. The SPI system photographs up to the upper 20 cm of the sediment surface. Three replicate SPI images will be obtained and analyzed at each survey location. Analysis of three replicate images at each location allows for the characterization of any variability in habitat conditions that may exist on the spatial scale of a few meters between individual camera probes.

The parameters that are monitored using the SPI method allow for the comparison of measurements over time to evaluate benthic habitat conditions, characterize sediment types, map disturbance gradients if observed, and assess benthic habitat quality and recolonization. SPI parameters that will be estimated and mapped from the SPI images as part of the qualitative evaluation include:

- Sediment Type Determination;
- Benthic Habitat Classification;
- Prism Penetration Depth;
- Surface (Sediment-Water Interface) Boundary Roughness;
- Infaunal Successional Stages;
- Apparent Redox Potential Discontinuity (RPD) Depth; and
- Organism-Sediment Index (OSI).

These parameters are described in detail in the following sections. The benthic community at individual survey locations in remediated areas will be evaluated by comparing the results of the measurements described below over time to determine if substantial differences in the data parameters exist. If substantial differences do exist and they suggest a lack of recolonization, an assessment of the sediment chemistry and the benthic community may be necessary. The sediment chemistry will be reviewed to determine if COC concentrations are present which could result in adverse biological effects. In addition, the benthic community analysis of archived sediment samples will be conducted.

It is expected that sediment type will differ from background locations and locations in remedial areas, e.g., in capped areas the surface sediment sample will consist of sand cap and not native sediment. It is also expected that early stages of infaunal success may be observed in remediated areas of the waterway where a more established and developed community may exist at background locations.

Sediment Type Determination. The sediment grain-size mode and range will be visually estimated from the SPI photograph by overlaying a grain size comparator of the same scale. The lower limit of optical resolution of the photographic system is about 62 microns (4 phi), allowing recognition of grain sizes equal to or greater than coarse silt.

The dominant grain size observed in the photograph that is estimated by the area within the imaged sediment column is determined to be the major modal grain size. In images that show distinct stratigraphy (i.e., layering) of sediments having different grain major modes (e.g., sand layer versus a clay layer), the dominant major mode assigned to the photograph depends on how much area of the photograph is represented by one sediment type versus the other. The presence of different sedimentary layers in SPI photographs typically indicates that a depositional event has occurred (e.g., a sand cap placed on top of fine-grained dredged material). Changes in the thickness of the surface depositional layers over time can be used to estimate sediment deposition rates.

Benthic Habitat Classification. Benthic habitat types will be classified based on the features that are observed in the waterway. Examples of potential benthic habitat types include, but are not limited to the following:

- **Hard Bottom:** Cobble or mussel beds that prevent adequate camera prism penetration;
- **Sandy Silt Bottom:** Light gray to black silt/clay with a high percentage of very fine sand present;
- **Silty Sand Bottom:** Very fine sandy bottom with high percentage of silt present; and
- **Oligozoic Bottom:** Organic-rich fine-grained sediment with high sediment-oxygen demand, little or no apparent infauna, and sulfur-reducing bacterial colonies present.

Within each of these habitat types, several sub-habitat types may be identified. It is possible to have two or more different major habitat types, which is an indication of small-scale spatial variability in bottom conditions. In the event that multiple habitat types are observed, the location will be mapped based on the predominant type and the benthic habitat conditions noted as “variable”.

Prism Penetration Depth. The optical prism of the SPI sediment-profile camera penetrates the bottom under a static driving force impacted by the equipment’s weight. The penetration depth depends on the force exerted by the optical prism and the bearing strength of the sediment. If the weight of the prism remains constant, the variation in the penetration depth between survey locations will reflect the variations in the general geotechnical properties of the bottom sediments. The SPI depth of penetration can be used to map gradients in the bearing strength (hardness) of the sediments, if desired.

Surface Boundary Roughness. Small-scale surface boundary roughness is measured from the SPI photograph with a computer image analysis system. The roughness is a vertical measurement from the highest point at the sediment water interface to the lowest point. This measurement of vertical relief is made within a horizontal distance of 14 cm (the total width of the optical window) and within the optical window vertical height of 20 cm. Therefore, the greatest possible roughness value is 20 cm. If the source of the roughness can be determined it will be described. In general, surface roughness is a result of either biogenic (i.e., mounds and depressions formed by bioturbation or foraging activity) or relief formed by physical processes (i.e., ripples, scour depressions, rip-ups, mud clasts, etc.).

Infaunal Successional Stages. An important aspect of using this successional approach to interpret benthic monitoring results is relating organism-sediment relationships to the dynamic aspect of end-member successional stages (i.e., Stage I, II, or III communities as defined in the following paragraphs). The application to benthic monitoring requires in situ measurements of salient structural features of organism-sediment relationships as imaged through SPI technology. Mapping and monitoring of successional stages is based on the theory that organism-sediment interactions in fine-grained sediments follow a predictable sequence after a major seafloor perturbation. This theory states that primary succession results in “the predictable appearance of macrobenthic invertebrates belonging to specific functional types following a benthic disturbance. These invertebrates interact with sediment in specific ways (Rhoads and Boyer 1982)".

Pioneering assemblages (Stage I assemblages) usually consist of dense aggregations of near-surface living, tube-dwelling polychaetes; alternately, opportunistic bivalves may colonize in dense aggregations after a disturbance (Rhoads and Germano 1982, Santos and Simon 1980). These functional types are usually associated with a shallow redox boundary and shallow bioturbation depths, particularly in the earliest stages of colonization. In the absence of further disturbance (i.e. natural processes and anthropogenic impacts), these early successional assemblages are eventually replaced by infaunal deposit feeders; the start of this "infaunalization" process is designated arbitrarily as Stage II. Typical Stage II species are shallow dwelling bivalves or tubiculous amphipods.

Stage III taxa, in turn, represent high-order successional stages typically found in low disturbance regimes. These invertebrates are infaunal, and many feed at depth in a head-down orientation. The localized feeding activity results in distinctive excavations called feeding voids. Other subsurface structures, such as burrows or methane gas bubbles are quite distinguishable from these distinctive feeding structures. The bioturbation activities of these deposit-feeders are responsible for aerating the sediment and causing the redox horizon to be located several centimeters below the sediment water interface. In the retrograde transition of Stage III to Stage I, it is sometimes possible to recognize the presence of relict (i.e., collapsed and inactive) feeding voids.

The end-member stages (Stages I and III) are easily recognized in SPI images by the presence of dense assemblages of near-surface polychaetes (Stage I) or the presence of subsurface feeding voids (Stage III). The presence of tubiculous amphipods at the sediment surface is indicative of Stage II. It is possible for Stage I polychaetes or Stage II tubiculous amphipods to be present at the sediment surface, while at the same time, Stage III organisms are present at depth within the sediment. In such instances, where two types of assemblages are visible in a SPI image, the image is designated as having either a Stage I or Stage III (I-III) or Stage II on Stage III (II-III) successional state. Additional information on SPI image interpretation can be found in Rhoads and Germano (1982, 1986).

Apparent Redox Potential Discontinuity (RPD) Depth. Aerobic near-surface marine sediments typically have higher reflectance values relative to underlying anoxic sediments. Sand also has higher optical reflectance than mud. These differences in optical reflectance are apparent in SPI images. For example the oxidized surface sediment contains particles coated with ferric hydroxide (an olive color when associate with particles), while in contrast reduced and muddy sediments below the oxygenated layer are darker, and generally grey to black. This boundary located between the colored ferric hydroxide surface sediment and underlying grey to black sediment is called the apparent RPD.

The depth of the RPD in the sediment column provides information regarding the dissolved oxygen conditions within sediment pore waters. In the absence of bioturbation, this reflectance layer (in mud) will typically extend 2 mm into the sediment surface. The RPD depth is related to the supply rate of molecular oxygen by diffusion into the sediments and the consumption of that oxygen by the sediment and microflora. In sediments that have very high sediment-oxygen demand, the sediment may lack a high reflectance layer even when the overlying water column is aerobic.

Organism-Sediment Index (OSI). The organism-sediment index (OSI) is a summary mapping statistic that is calculated on the basis of four independently measured SPI parameters: mean apparent RPD depth, presence of methane gas, low/no oxygen at the sediment-water interface, and successional status (Table 4-2). The SPI OSI shows relative disturbance gradients, which can be associated with habitat quality. High OSI values are typically associated with undisturbed, high quality habitat and low OSI values can indicate habitats that have experienced a physical disturbance, organic enrichments, or contamination in the recent past. However, a moderate or low OSI value can also be found in a physically energetic environment that does not necessarily reflect low habitat quality. Habitat quality is defined relative to two end-member standards. The lowest value is given to those bottoms which have low or no dissolved oxygen in the overlying bottom water, no apparent macrofaunal life, and methane gas present in the sediment (see Rhoads and Germano 1982, 1986, for SPI criteria for these conditions). The OSI for such a condition is -10. At the other end of the scale, an aerobic bottom with a deep RPD, evidence of a mature macrofaunal assemblage, and no apparent methane gas bubbles at depth will have an OSI value of +11.

The OSI is calculated automatically by macros in an excel spreadsheet after completion of all measurements from each SPI photographic negative. The index has proven to be a useful parameter for mapping disturbance gradients in an area and documenting ecosystem recolonization after disturbance (Germano and Rhoads 1984; Revelas et al. 1987; Valente et al. 1992).

In summary, the OSI is a metric which defines overall benthic habitat quality in soft-bottom environments by reflecting the depth of the apparent redox layer, successional stage of infauna, the presence/absence of methane gas in the sediment, and the presence/absence of reduced (i.e., anaerobic) sediment at the sediment-water interface. OSI values less than +3 are considered to be indicative of disturbed habitat quality, values between +3 and +6 are considered to be reflective of intermediate quality (i.e., moderately disturbed), and values greater than +6 are considered indicative of non-disturbed benthic habitat quality. Figure 4-3 shows the relationship between SPI parameters including: RPD depth, OSI values, and benthic infaunal successional stages.

Sediment Chemistry Data

At those benthic SPI survey locations that are not co-located with sediment performance chemistry locations (i.e., background locations at the mouth of the waterway and those located in dredged areas), a surface (0 to 10 cm) sediment sample will be collected during SPI monitoring and archived for chemical COC analysis if determined to be necessary based on SPI results. COC concentrations will be compared to project Sediment Quality Objectives (SQO).

Benthic Abundance Community Data

If the SPI results indicate that benthic recolonization may not be occurring and confirmation is needed, benthic community analysis of archived samples will be used for corroboration of SPI results. The majority of benthic recolonization monitoring locations are co-located with sediment chemistry performance locations. Therefore, as part of the OMMP sediment quality monitoring and the benthic recolonization monitoring, the following data will be available, if needed, for each remedial area:

- Sediment Quality Data (Chemical COCs, grain size, TOC);
- Major taxon data at each location; and
- Lowest practicable taxon data at each location.

This data may be used for the following types of analyses:

- Qualitative assessments of the dominance of known pollution sensitive and pollution tolerant organisms at various locations throughout the waterway;
- Analysis of variance (ANOVA; unbalanced design) to test for significant differences among the treatments in total density, densities and richness of major benthic taxa, and selected assemblage parameters (e.g., SPI, diversity, evenness), at the time of sampling and over the long-term monitoring period;
- T-tests for differences in the variables listed above between monitoring events at co-located locations; and
- Use of regression and covariate analyses to examine relationships between measures of sediment quality and measures of benthic assemblages.

Interpretations of the above analyses will recognize that substantial natural differences in benthos can exist between locations near the mouth of the waterway and those located along the waterway, away from the mouth, due to the gradient in energy conditions and water quality. It is expected that there will also be a gradient in sediment grain size (excluding capped areas) and dissolved oxygen levels.

Benthic Community Analysis. The number of species per unit area, the numbers of individuals, and dominance are good indicators of environmental stresses and provide very informative data that contributes to key issues that ecological indices are judged on: biological meaning, ease of interpretation, and sensitivity to changes caused by disturbance or pollutant impacts. Organism biomass used in conjunction with species composition and abundance can be a useful indicator of natural benthic recolonization. Benthic abundances, taxa richness, and community assemblages will be compared and evaluated for each monitoring event. The following measures of community structure will be used to evaluate the benthic biota data:

- Numbers of individuals per unit area (abundance);
- Wet-weight biomass per replicate (i.e., total and major taxa biomass);
- Ecological indices (i.e., diversity, dominance, and richness), in particular the Shannon-Wiener index, the Evenness index, and Swartz dominance index will be used; and
- Community similarity, the Bray-Curtis index showing community similarity among replicates and locations.

The Shannon-Wiener index (H') is a commonly used diversity index used in benthic infaunal surveys and represents the distribution of individuals among the species of taxa present. The advantage of this index over other diversity measurements is that it is normally distributed, relatively independent of sample size, and statistically testable. The index values or H' values can range from 0 to 4, depending on the number of species in the sample, and tend to have minimal statistical variability. Theoretically in environments with no pollution or environmental stress, the H' values should be large, while in environments where pollution and/or environmental stress is high the H' values should be low. The Shannon-Wiener index consists of the following formula:

$$H' = \Sigma\, p_i \ln (p_i)$$

$$i = 1$$

Where:

H'= the Shannon-Wiener (or information theory) index of diversity

p_i = the proportion of taxon "i" in the sample

The Evenness index (J) is a measure of the dominance of the sample by one or a few taxa. Values of H', as described above, are determined by the equitability of individuals among species, and species richness. Therefore, when values of H' are calculated, Evenness (J) should also be calculated, to allow for the importance of equitability component to be assessed. Evenness values range from 0 to 1, with values close to 1.0 indicative of a homogeneously distributed population with little or no dominance by only a few taxa. Typical values for less diversity are less than 0.7 and more than 0.9 for higher diversity. The Evenness index consists of the following formula:

$$J = H' / \ln s$$

Where:

J = Evenness index

H' = the Shannon-Wiener index

s = the total number of taxa in the sample

The Swartz dominance index (SDI) is a measure of the degree to which one or a few species dominate the community. The SDI is defined as the minimum number of taxa that account for 75 percent of the total number of individuals in a sample and is useful in describing community structure (Swartz et al. 1985). The advantages of the SDI are that it is calculated easily, does not assume an underlying distribution of the individuals among taxa, and is statistically testable.

The presence of sensitive species and the reduction of opportunistic species can be interpreted as an indication of natural recolonization processes. In areas of severe disturbance the benthic communities consist of opportunistic, tolerant taxa, while in less severely disturbed areas (or in recovering areas) less tolerant and more competitively dominant taxa are present.

Analysis of Similarity Among Sample Replicates. Cluster analysis as determined by the Bray-Curtis index will be used to compare the similarity between samples. The Bray-Curtis index is a quantitative similarity index, which is based on the identity and abundance of each species at each location. The formula for the Bray-Curtis dissimilarity measure is:

$$\text{Dissimilarity} = 1 - \frac{\sum_{j=1}^{n} X_{1j} + X_{2j}}{\sum_{j=1}^{n} (X_{1j} + X_{2j})}$$

Where:

X_{1j} and X_{2j} = the abundance values of the taxa at two respective sites (or replicates)

n = the total number of species at the two sites (or replicates)

The measure equals 1.0 for complete similarity and 0.0 or complete dissimilarity. The data will likely be log-transformed [ln (x+1)] because the Bray-Curtis index tends to be biased by high abundances. The similarity values will be put into a clustering algorithm. The results of the classification analyses will be groups of locations (clusters) that exhibit similar structural relationships. Structural components (species and abundance) of each cluster would be examined and related (if possible) to the successional stages. Classification analysis will be conducted because it generates a visual representation of species relationships among locations. These relationships will also be evaluated to identify changes in the community assemblages over time.

4.3.3 Response Actions

Multiple lines of evidence will be used to evaluate if the benthic community has progressed towards benthic recolonization. If multiple lines of evidence indicate that benthic recolonization, is not occurring then the City will work with EPA to identify potential explanations for the absence of recolonization and determine the appropriate response actions. An initial potential response action will be to evaluate sediment chemistry at co-located performance monitoring locations. At those benthic monitoring locations where a 0 to 10 cm sediment sample was not co-located for chemical analyses, an archived sediment sample collected during the SPI survey will be submitted for chemical analyses (with the exception of background monitoring locations). In addition to evaluating sediment chemical quality conditions, benthic community and environmental conditions will also be evaluated.

Explanations for low benthic recolonization, other than unsuitable habitat substrate and/or chemical contamination, may include environmental factors such as abundant predator organisms, below optimal light conditions, and lack of available food sources. These factors can have adverse impacts on the benthic community beyond the impact of the remedial actions. If the SPI measured parameters and potential results of the benthic community analyses (if performed) indicate that the performance standard of a suitable benthic habitat to allow for recolonization has been achieved for two consecutive monitoring events then the City and EPA will evaluate the need for further monitoring.

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TABLES

FIGURES

Table 4-1
Benthic Recolonization Monitoring and Reporting Schedule

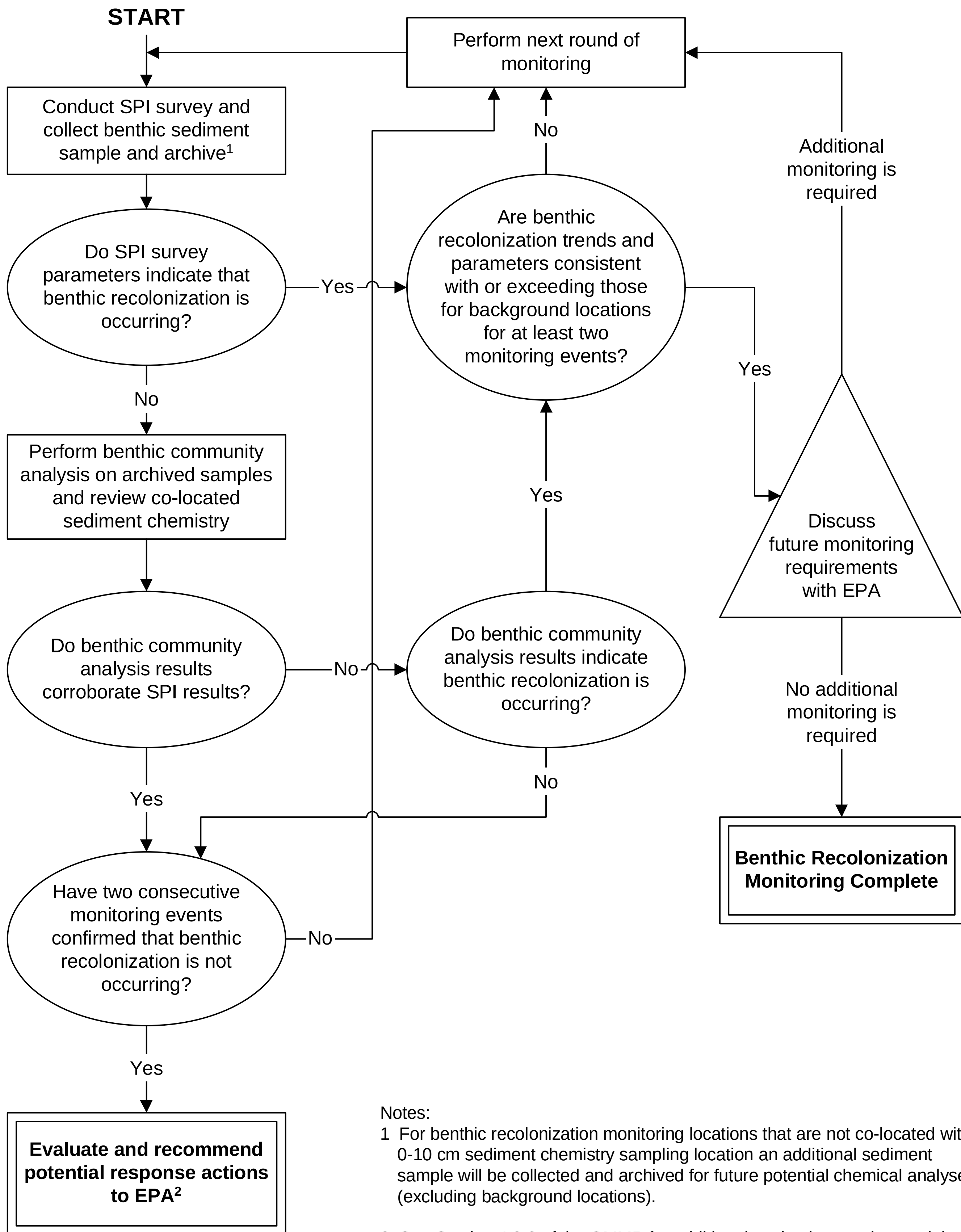
Task		Task Type	Timeline and Description
1	Conduct Year 2 benthic recolonization monitoring	Field Activities	Two years after completion of the OMMP Baseline (Year 0) field activities
2	Preparation and submittal of Year 2 Monitoring Report to EPA	Reporting	Within 45 days of completion of all Year 2 data validation activities or as otherwise approved by EPA
3	Conduct Year 4 benthic recolonization monitoring	Field Activities	Two years after completion of Year 2 field activities
4	Preparation and submittal of Year 4 Monitoring Report to EPA	Reporting	Within 45 days of completion of all Year 4 data validation activities or as otherwise approved by EPA
5	Conduct Year 7 benthic recolonization monitoring	Field Activities	Three years after completion of Year 4 field activities
6	Preparation and submittal of Year 7 Monitoring Report to EPA	Reporting	Within 45 days of completion of all Year 7 data validation activities or as otherwise approved by EPA
7	Conduct Year 10 benthic recolonization monitoring	Field Activities	Three years after completion of Year 7 field activities
8	Preparation and submittal of Final Year 10 Monitoring Report to EPA	Reporting	Within 45 days of completion of all Year 10 data validation activities or as otherwise approved by EPA

Table 4-2
Calculation of the SPI Organism-Sediment Index (OSI) Value

A. Choose One Value	
Mean RPD Depth (cm)	**Index Value**
0.00	0
> 0–0.75	1
0.76–1.50	2
1.51–2.25	3
2.26–3.00	4
3.01–3.75	5
> 3.75	6
B. Choose One Value	
Successional Stage	**Index Value**
Azoic	-4
Stage I	1
Stage I → II	2
Stage II	3
Stage II → III	4
Stage III	5
Stage I on III	5
Stage II on III	5
C. Choose one or both (if appropriate)	
Chemical Parameters	**Index Value**
Methane present	-2
No/low dissolved oxygen [a]	-4
Organism-Sediment Index Value	
Total of subset indices (A+B+C)	
Range: -10 to 11	

Note:

This is not based on a Winkler or polarigraphic electrode measurement. It is based on the imaged evidence of reduced, low reflectance (i.e., high oxygen demand) sediment at the sediment-water interface.



Notes:

1 For benthic recolonization monitoring locations that are not co-located with a 0-10 cm sediment chemistry sampling location an additional sediment sample will be collected and archived for future potential chemical analyses (excluding background locations).

2 See Section 4.3.3 of the OMMP for additional evaluations and potential response actions.

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Figure 4-1
Benthic Recolonization Monitoring Decision Matrix Flow Chart

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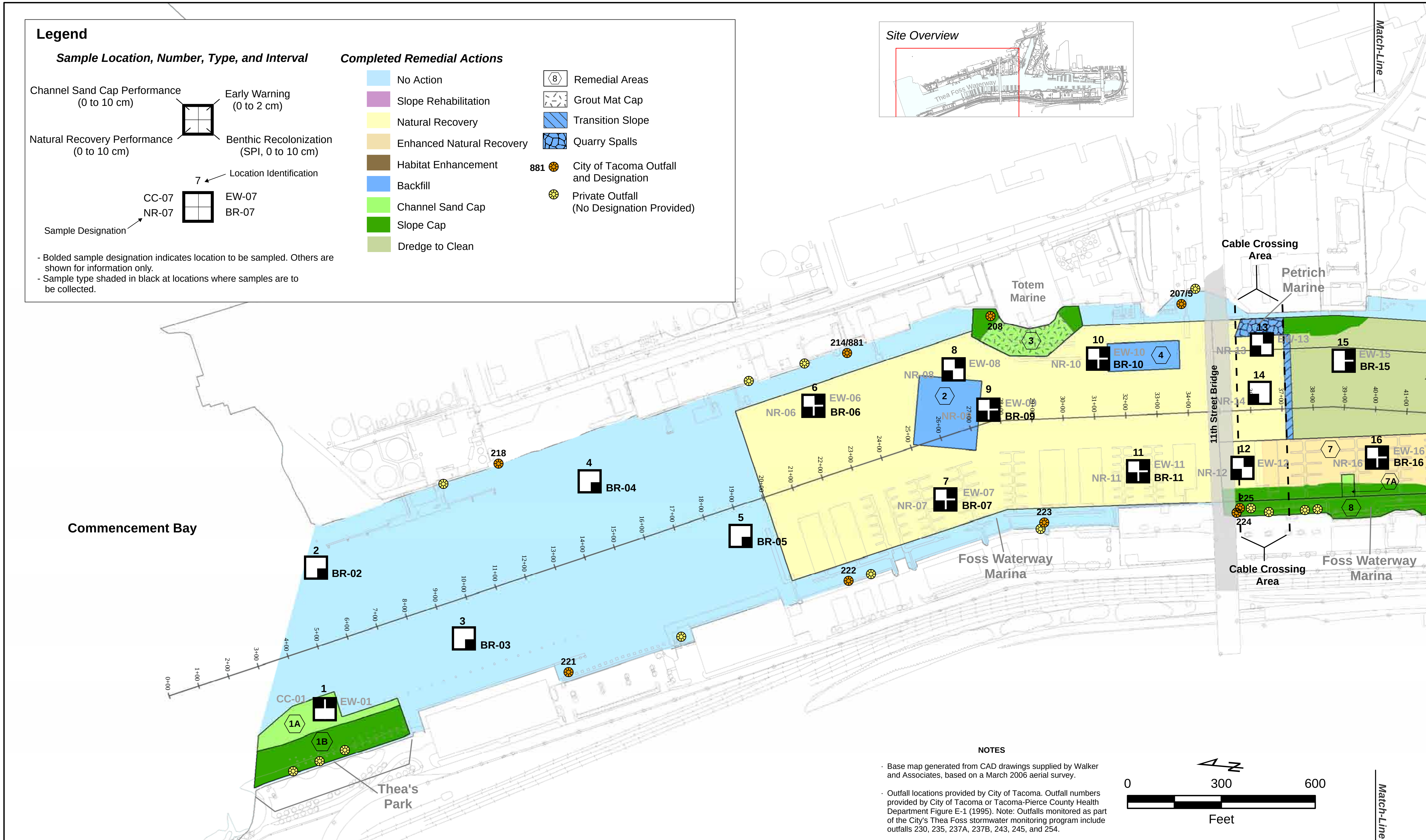

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Figure 4-2 (Page 1 of 2)
Benthic Recolonization Monitoring Locations

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MXD NAME: F:\projects\KPFF Foss\GIS\Revised OMMP\Final OMMP Report Figures\Figure 4-2 Benthic Recolonization Monitoring Locations (1of2) 031407.mxd

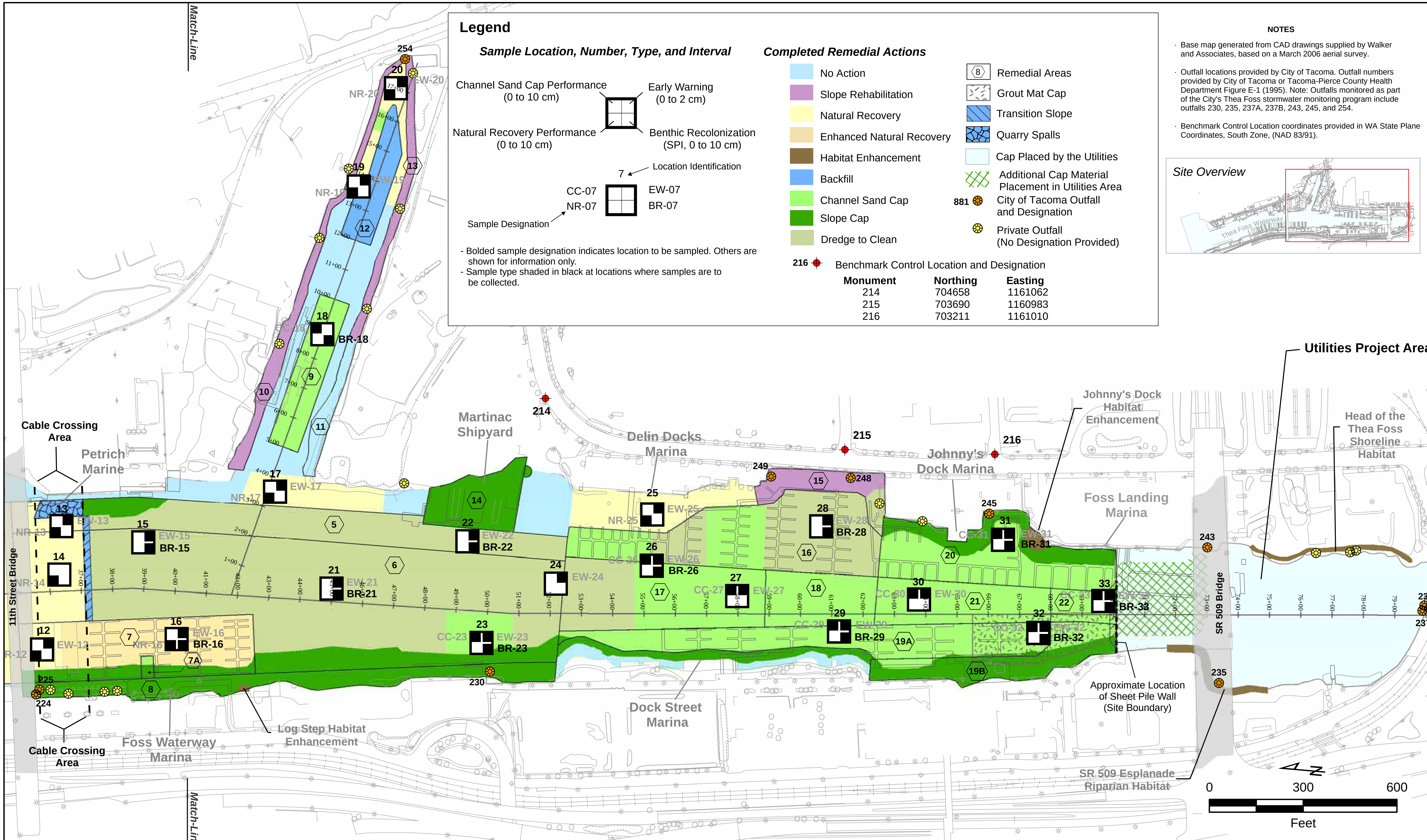

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Figure 4-2 (Page 2 of 2) Benthic Recolonization Monitoring Locations

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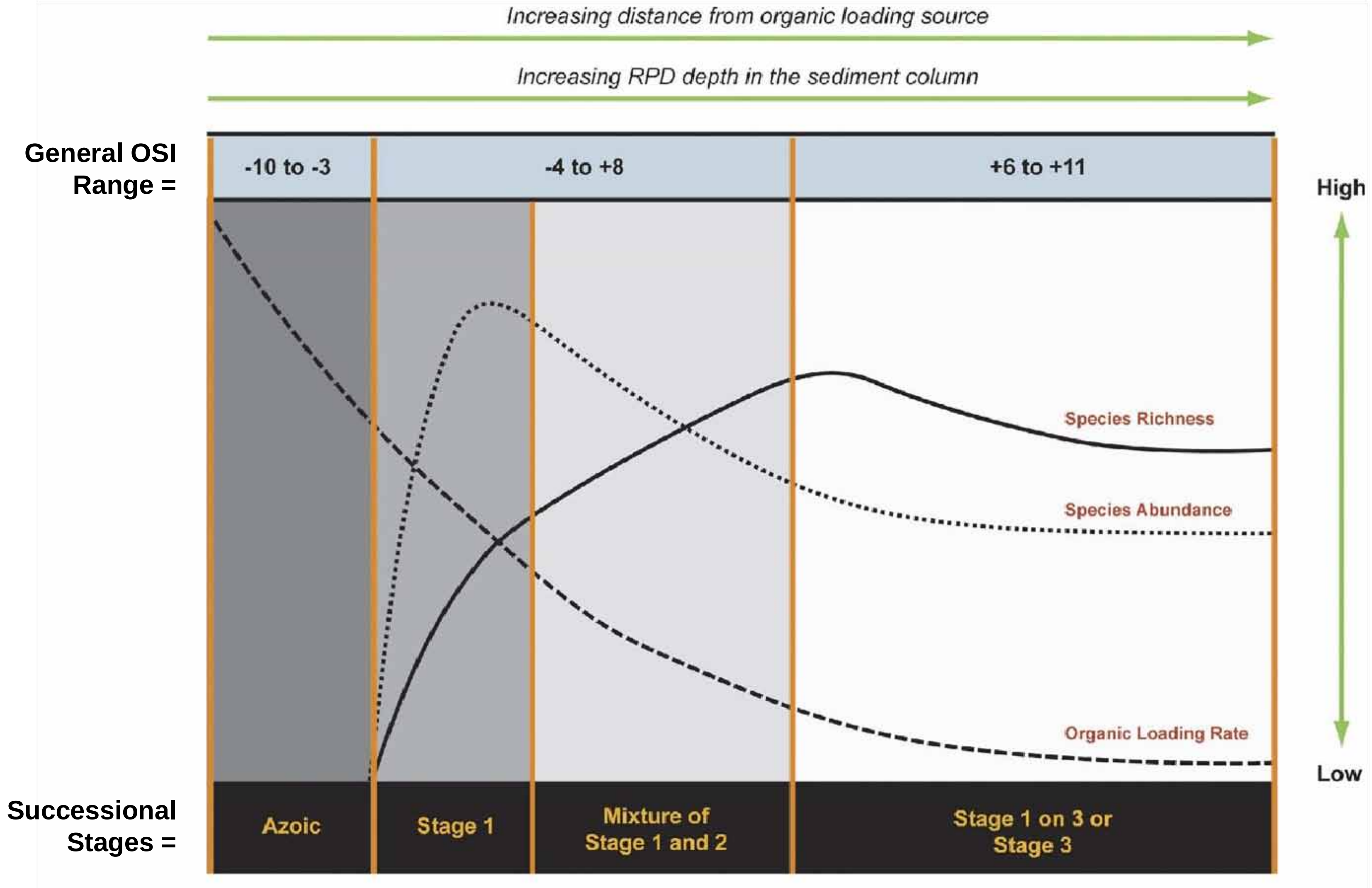
Tacoma

DATE: 3/14/2007 3:52:37 PM
MXD NAME: F:\projects\KPFF Foss\GIS\Revised OMMP\Final OMMP Report Figures\Figure 4-2 Benthic Recolonization Monitoring Locations (2of2) 031407.mxd



Note:
Figure provided courtesy of Joe Germano (Germano & Associates, Inc.)

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Figure 4-3
SPI Parameter and Organic Loading Interpretation

5.0 CONFINED DISPOSAL FACILITY MONITORING

The St. Paul Waterway Confined Disposal Facility (CDF) was constructed to confine contaminated sediments that were dredged as part of the Thea Foss and Wheeler-Osgood Waterways Remediation Project. Contaminated sediments are contained within the CDF and separated from direct contact with surface water by a containment berm constructed across the St. Paul Waterway on the north, the St. Paul/Middle Waterway Peninsula on the west, the Simpson Tacoma Kraft property to the east, and the Simpson log storage property to the south. Commencement Bay, the outer St. Paul Waterway, Middle Waterway, and the Puyallup River are surface waters located in proximity to the CDF (Figure 5-1). Monitoring of the CDF will be performed to characterize post-construction groundwater quality and flow conditions to ensure the protection of adjacent surface water. Additionally, visual observations of the CDF containment and offset berms and CDF cap will be performed to document the condition of berms and cap.

CDF monitoring includes identifying baseline groundwater and surface water conditions followed by performance monitoring that includes comparison of the results of baseline monitoring to the results of subsequent groundwater monitoring. Baseline groundwater quality will be measured at monitoring well locations selected based on post-construction groundwater flow conditions. Once baseline groundwater quality has been established, performance monitoring will commence. The performance monitoring program is designed to assess whether concentrations of selected constituents demonstrate a statistically significant increase, relative to baseline groundwater quality, as a result of the construction of the CDF.

The CDF monitoring program presented in this section describes the purpose, objectives, approach, and procedures for performing post-construction monitoring of the CDF. The monitoring plan also presents the methods and procedures for field sampling and quality control/quality assurance protocols (Appendix D – Confined Disposal Facility Monitoring Operations Manual). Health and Safety protocols regarding CDF monitoring activities are presented in Appendix F.

5.1 Monitoring Objectives and Rationale

The objective of this monitoring program is to protect water quality in adjacent surface water bodies from contaminants which could potentially migrate in groundwater from the CDF. The monitoring program is designed to evaluate groundwater quality at and in areas surrounding the CDF to ensure compliance with the performance criteria. The monitoring program includes the collection, analysis, and interpretation of groundwater data from 15 new monitoring wells installed within and around the perimeter of the CDF (Figure 5-2). Additionally, visual observations of the CDF containment and offset berms and surface of the CDF cap will be made to document the condition of berms and cap.

The CDF monitoring objectives as described in this plan are consistent with the Record of Decision (ROD) (EPA 1989), Administrative Order on Consent (AOC) (EPA 1994), Explanation of Significant Differences (ESD) (EPA 2000, EPA 2004), and Consent Decree (CD) Statement of Work (SOW) (EPA 2003) for the Thea Foss and Wheeler-Osgood Waterways Remediation Project. CDF monitoring activities specifically address the following objectives stated in the ROD and CD SOW:

- Monitoring at the disposal site to evaluate the effectiveness of the remedy; and
- The St. Paul disposal site will be subject to long-term monitoring to ensure that the selected remedy remains protective, including that marine chronic water quality standards or background concentrations, whichever are higher, are not exceeded in surface water outside of the CDF after construction.

5.2 Monitoring Approach

5.2.1 Overview of Monitoring Activities

The CDF monitoring approach is designed to characterize and monitor groundwater conditions and quality to evaluate the protection of surface water adjacent to the CDF.

The scope of work for the CDF monitoring activities is as follows:

- Install new monitoring wells in and adjacent to the CDF (i.e., MW-01 through MW-15);
- Conduct a 72-hour tidal study and slug tests to evaluate the post-construction groundwater flow conditions in the area of the CDF;
- Document the post-construction hydrogeologic conditions in a report to be submitted to EPA;
- Select monitoring wells to be used for baseline groundwater quality monitoring;
- Perform quarterly groundwater and surface water monitoring for two years to identify baseline conditions;
- Document the baseline conditions in a report to be submitted to EPA;
- Identify the performance monitoring program for the CDF;
- Monitor groundwater quality over time in accordance with the performance monitoring program;
- Perform visual observations of the berms and CDF cap; and
- Implement appropriate response actions, as necessary.

All monitoring activities, including groundwater and surface water sampling activities will be conducted using the same procedures to provide consistency of data for use in establishing baseline conditions as well as statistical evaluations. The field sampling and quality control/quality assurance protocols are presented in Appendix D – Confined Disposal Facility Monitoring Operations Manual. Health and Safety protocols for CDF monitoring are presented in Appendix F.

5.2.2 Performance Monitoring Criteria and Decision Matrix

The decision matrix flow chart for CDF performance groundwater monitoring is presented in Figure 5-3. The performance standard for this groundwater monitoring program is the evaluation of statistically significant increases in contaminant concentrations relative to the established groundwater baseline concentrations.

An intra-well evaluation will be performed for the CDF groundwater monitoring results. Baseline CDF groundwater monitoring is being performed for the purpose of establishing the baseline (i.e., background) groundwater quality conditions in individual wells that are selected for monitoring prior to possible impacts from contaminated sediment placed in the CDF. Baseline groundwater conditions for individual wells will be established based on the results of monitoring to be done quarterly for two years. Statistical analysis of the results of quarterly analyses performed on an individual well will establish the baseline groundwater quality for each individual well and will be used to evaluate possible changes in groundwater quality in the individual well during performance monitoring. The results of performance monitoring for an individual well will be compared to the baseline groundwater quality conditions for that individual well (i.e., intra-well comparison) to evaluate whether there is a significant change in groundwater quality conditions at that location.

If statistically significant increases in groundwater concentrations are observed, the City will propose to EPA whether to initiate one or more response actions appropriate to the nature of the increase as described in Section 5.8.

The point of compliance for CDF monitoring is the sediment/surface water interface outside of the berm and peninsula surrounding the CDF. Surface water criteria (WAC 173-201A) or ambient surface water concentrations (whichever are higher) are performance criteria at the point of compliance.

Surface water monitoring is also being performed at a station adjacent to the CDF, post-CDF construction and prior to possible impacts from groundwater discharge to identify baseline surface water conditions and to evaluate changes in surface water quality conditions due to seasonal effects. The results of performance monitoring of groundwater quality will not be compared to the surface water monitoring results. The results from performance monitoring of groundwater will be compared to the results of baseline groundwater quality conditions as described above. The surface water monitoring is being done to provide an understanding of baseline, ambient surface water conditions in the area of the CDF, for possible future reference should evaluation of possible impacts to surface water conditions be needed.

Visual observations of the containment and offset berms will be made to document the condition of berms and noticeable changes to the berm structures. Visual observations will also be made of the surface of the CDF cap to document the integrity of the cap. If observations indicate noticeable changes in the berm structures or integrity of the cap, the City will propose to EPA whether to initiate response actions as described in Section 5.9.

5.2.3 Schedule and Reporting Overview

The schedule for CDF monitoring activities is presented in Table 5-1 and includes the following:

- Installation of new monitoring wells;
- A 72-hour tidal study and slug tests will be completed within six weeks of the completion of well installation and development;
- Baseline monitoring will be performed following EPA's approval of the Post-Construction Hydrogeologic Conditions Report and identification of baseline

monitoring wells. Baseline monitoring activities will be conducted quarterly for a period of two years;

- Performance monitoring will be performed following EPA's approval of the Baseline Water Quality Conditions Report and development of the performance monitoring program. The frequency of performance monitoring will be determined based on groundwater flow conditions as well as the results of the baseline monitoring; and
- Visual observations of the containment and offset berms and CDF cap will be performed quarterly during the first two years, coincident with quarterly groundwater and surface water monitoring. Recommendations on the schedule for subsequent observations will be included in the Performance Monitoring Plan.

Reporting

The following reporting will be performed and submitted to EPA to document the results of CDF monitoring activities:

- **Post-construction hydrogeologic conditions** determined from the results of the 72-hour tidal study and slug tests will be documented in a report that will be used to identify baseline monitoring locations and support selection of monitoring locations for performance monitoring. The components of the Post-Construction Hydrogeologic Conditions Report are discussed in Section 5.5. The Post-Construction Hydrogeologic Conditions Report will be submitted for EPA review and approval;
- **Baseline water quality conditions** determined from the results of two years of quarterly monitoring will be documented in Preliminary Findings Memoranda completed quarterly and in a Baseline Water Quality Conditions Report that will be produced at the end of the Baseline Monitoring period. This information will be used in combination with post-construction hydrogeologic conditions to identify analytes and locations for performance monitoring. The Preliminary Findings Memoranda will be submitted following the completion of quarterly monitoring activities, data analysis, and data validation. The components of the Baseline Water Quality Conditions Report are discussed in Section 5.6.2. The Baseline Groundwater Quality Conditions Report will be submitted for EPA review and approval;
- **The performance monitoring program** will be developed following completion of the baseline monitoring period. The City will submit a proposed long-term performance monitoring program for the CDF to EPA within 120 days of EPA approval of the baseline monitoring report. The components of the Performance Monitoring Plan are discussed Section 5.7. The Performance Monitoring Plan will be submitted for EPA review and approval;
- **Performance monitoring results** will be documented in a report that will compare the results of performance monitoring to baseline conditions as discussed in Section 5.7. The schedule for reporting of performance monitoring results will be identified as part of the performance monitoring program; and
- **Visual observations of the CDF containment and offset berms and CDF cap** will be reported as separate technical memoranda that will be submitted to EPA to provide timely transmittal of the results and facilitate implementation of response

actions, if necessary. The technical memoranda will be incorporated into the annual OMMP reports.

5.3 Hydrogeologic Conditions

This section briefly summarizes the current and expected future subsurface physical conditions pertinent to the design and operation of the monitoring program for the CDF. The CDF was built as designed and described in the Design Analysis Report (DAR) (City 2002). Construction included dredging the southern portion of the St. Paul Waterway to elevation -60 feet Mean Lower Low Water (MLLW), building a containment berm across the St. Paul Waterway, placing contaminated sediments into the southern portion of the waterway to elevations below the surface of the water table (9 feet MLLW), and placing a cap on the CDF to bring the surface of the CDF to the existing upland grade. A more detailed discussion of CDF construction is presented in the Remedial Action Construction Report (RACR; City of Tacoma 2006). Cross sectional illustrations of the CDF are shown on Figures 5-4 through 5-6. The monitoring wells and screening intervals are also shown on these figures.

The remainder of this section presents soil stratigraphy, groundwater occurrence and flow, and groundwater quality at the disposal site based on previous field investigations, as well as expected future conditions at the CDF based on experience with similar CDF sites and predictive groundwater modeling.

5.3.1 Subsurface Soil Stratigraphy

Based on previous field explorations summarized in the DAR, soil and sediments adjacent to and beneath the St. Paul Waterway have been divided into three distinct units. The following units are expected to be encountered below and/or adjacent to the dredged sediments deposited in the CDF:

- **Fill Material (Upland Areas).** Upland areas adjacent to the waterway are underlain by sandy fill material overlying natural deposited silts and sands. The fill material was present at all upland soil boring locations, with a thickness ranging from 16 to 31 feet. The fill consists predominantly of poorly graded sand and occasional wood fragments and silt layers;
- **Recent Sediment Deposits (Waterway).** Sediment cores advanced in the waterway encountered a very distinct geologic contact occurring in the upper 4-foot section of the cores. Material above this horizon, indicative of recent sediment deposits, was characterized by black silt/clay material with approximately 10 percent wood debris. Material below the horizon was comprised of gray silt and sand material with less than one percent wood debris and is interpreted as Deltaic/Marine Deposits. With the exception of the sediments at the mouth of the waterway, the recent sediments were removed during CDF construction; and
- **Deltaic/Marine Deposits (Uplands and Waterway).** The deeper geotechnical and sediment borings indicate the presence of variable layers of sand, silty sand, and sandy silt beginning at approximately 5 feet MLLW to -10 feet MLLW, and continuing to at least elevation -100 feet MLLW. These deposits are interpreted as deltaic and shallow marine deposits associated with sedimentation from the Puyallup River.

5.3.2 Groundwater Occurrence and Flow

The following two distinct hydrogeologic units are present in the vicinity of the CDF:

- **Shallow Unconfined Zone.** Groundwater was observed at depths ranging from 8 to 10 feet below ground surface in September 1997 and March 1999. In situ hydraulic conductivity tests (slug tests) were performed on three shallow groundwater monitoring wells (RD3-UMW-6, RD3-UMW-7, and RD3-UMW-8) (Figure 5-2). Horizontal hydraulic conductivity values estimated from these tests range from 7 x 10^3 to 4 x 10^2 cm/sec; and
- **Deeper Water-Bearing Zone.** One monitoring well, RD3-UMW-10, was completed below the Recent Fill Unit in the Deltaic/Marine Deposits (Figure 5-2). Due to the presence of interbedded silt and sand observed in the deeper borings completed in the waterway, the deeper water-bearing zone (below elevation 0 feet MLLW) appears to be confined near the site.

Net groundwater flow is toward Commencement Bay. Groundwater flow in sediments adjacent to the CDF is periodically reversed during tidal fluctuations. There is an assumed shallow groundwater divide to the east of the site, between the CDF and the Puyallup River. A second shallow groundwater divide exists between Middle Waterway and the CDF on the southwest side of the site. Because Commencement Bay and the remaining portion of the St. Paul Waterway are groundwater discharge areas, groundwater flow in the Deltaic/Marine Deposits offshore of the CDF is expected to be upward.

5.3.3 Groundwater Quality

Groundwater quality data beneath and adjacent to the St. Paul Waterway were collected during remedial design. Low salinity (less than 0.2 ppt) was observed in three monitoring wells (RD3-UMW-6, RD3-UMW-7, and RD3-UMW-8) completed near the south and east margin of the waterway. Higher salinity readings of up to 4 ppt were observed in a shallow monitoring well (RD3-UMW-5) completed on the peninsula between the St. Paul and Middle Waterways. The deep well (RD3-UMW-10) had a relatively high salinity reading of 14 ppt, reflecting a mixing zone of fresh groundwater and saline surface water.

5.3.4 Expected Future Conditions

The post-construction groundwater conditions below the CDF are expected to be similar to other fill areas of Commencement Bay (i.e., the Milwaukee fill) and the groundwater flow system will eventually establish a new equilibrium, with groundwater likely flowing generally to the northwest toward Commencement Bay and the Middle Waterway.

Numerical groundwater modeling was completed to predict the post-construction groundwater flow system within and around the CDF (City 1999). Based on this modeling, the predicted net groundwater flow from the CDF is northwestward through the berm and westward through the peninsula between the CDF and Middle Waterway. While the net hydraulic gradient will be toward Commencement Bay and Middle Waterway, short-term reversals (i.e., flow toward the CDF) will occur during high tides.

Based on this predictive groundwater flow and contaminant transport modeling, the shortest flow path is through the peninsula to the Middle Waterway. The shortest time for the leading edge of the contaminant front to travel from the fill to the adjacent surface water would be on the order of 50 to 100 years. Water quality exceedances are not expected due to a combination of factors, as explained in Section 5.2 of the DAR.

5.4 Groundwater Monitoring Well Network

The groundwater monitoring well network has been designed to provide data for post-construction groundwater flow conditions and quality within and around the CDF. The monitoring well network will consist of newly installed monitoring wells that include the following (Figure 5-2):

- One shallow monitoring well in the CDF containment berm (MW-01);
- One shallow monitoring well on the northwestern end of the St. Paul/Middle Waterway Peninsula (MW-02);
- One shallow monitoring well east of the CDF (MW-03);
- One shallow monitoring well and one deep well in the CDF fill (MW-04 and MW-05);
- One shallow monitoring well (MW-06), one intermediate monitoring well (MW-07), and one deep monitoring well (MW-08) in the peninsula between the northern portion of the CDF and Middle Waterway;
- One shallow monitoring well in the CDF offset berm (MW-09);
- One shallow monitoring well (MW-10), one intermediate monitoring well (MW-11), and one deep well (MW-12) in the peninsula between the southern portion of the CDF and the Middle Waterway; and
- One shallow well (MW-13), one intermediate well (MW-14), and one deep well (MW-15) south of the CDF.

All of the wells in the monitoring well network will be used to evaluate the groundwater flow direction and gradients as part of the 72-hour tidal study. A subset of the wells included in the monitoring well network identified above will be selected for baseline monitoring based on the results of the 72-hour tidal study. The wells within the monitoring well network that will be sampled as part of performance monitoring will be selected based on the results of the 72-hour tidal study and baseline monitoring.

Monitoring wells RD3-UMW-5 through RD3-UMW-10 were installed prior to construction of the CDF (Figure 5-2). Monitoring wells RD3-UMW-5 through and RD3-UMW-8 were installed in August 1997 (Anchor Environmental and Parametrix 1998) and wells RD3-UMW-9 and RD3-UMW-10 were installed in February 1999 (City of Tacoma 1999) to support predictive contaminant transport modeling. Monitoring wells RD3-UMW-5 and RD3-UMW-10 were within the footprint of the CDF and were subsequently decommissioned during construction of the CDF. Monitoring wells RD3-UMW-6, RD3-UMW-7, and RD3-UMW-9 have not been located and are not currently included in the monitoring well network. Monitoring well RD3-UMW-8 has been located and is present east of the CDF (Figure 5-2). Monitoring well RD3-UMW-8 is anticipated to be upgradient of the CDF based on predicted post-construction groundwater flow directions and may be used to monitor groundwater elevations.

5.4.1 Groundwater Well Installation

A total of 15 new wells (MW-01 through MW-15) will be installed as part of the monitoring well network (Figure 5-2). The actual location of the new wells may be adjusted during well installation based on field conditions and to reduce potential conflict with current and future property uses. Eight of the 15 new wells will be completed at shallow depths. The new shallow wells will be constructed with a 10-foot screened interval, set approximately from 10 feet MLLW to 0 feet MLLW, consistent with the shallow wells used to support predictive contaminant transport modeling. The shallow wells are located and screened to evaluate hydrogeologic conditions in near-surface soil, fill, and material used to construct the containment and offset berms and to allow characterization and monitoring of the quality of groundwater that is most likely to be impacted by the saltwater washout effect (i.e., where the lowest saline groundwater and stormwater infiltration come in contact with and flow over the surface of contaminated sediment placed in the CDF). Intermediate depth wells will also be constructed with a 10-foot screened interval, set approximately from 0 feet MLLW to -10 feet MLLW, an intermediate elevation within the shallow unconfined groundwater zone. The intermediate wells are located and screened to evaluate hydrogeologic conditions and allow characterization and monitoring of the quality of groundwater in the upper deltaic / marine deposits. Three deep wells will be constructed with a 20-foot screened interval, set approximately from -40 feet MLLW to -60 feet MLLW, the elevation of the bottom of the CDF. The deep wells are located and screened to evaluate hydrogeologic conditions and allow characterization and monitoring of the quality of groundwater in the deltaic / marine deposits at the bottom of the CDF. Details on the methods that will be used for well drilling explorations, well installations, and development are described in the CDF Monitoring Operations Manual (Appendix D).

The monitoring well network was designed to monitor the assumed "worst-case" groundwater quality at the CDF. It is anticipated that the highest potential for mobilization of contaminants from the CDF will occur with progressive flushing of the contaminated, dredged sediment with less saline groundwater (salt washout effect; Brannon et al. 1994). Comparison of salinity measurements from the deep well and the shallow wells indicate that the shallow groundwater will be the least saline groundwater entering and leaving the CDF. Therefore, the shallow well screens in the CDF monitoring well network are positioned vertically to provide a conservative representation of groundwater quality at the CDF.

5.5 Post-Construction Hydrogeologic Conditions (Tidal Study)

Upon completion of the installation of the monitoring well network, the post-construction groundwater flow conditions will be evaluated by performing a 72-hour tidal study and slug tests. Data collection will include continuous (every 15 minutes) water level measurements in wells MW-01 through MW-15, in the surface water swale between Simpson's clarifier tanks and the offset berm, and in the Middle Waterway using electronic data loggers and well transducers.

Net groundwater flow directions determined from the tidal study will provide the basis for selection of wells to be included in the baseline and performance monitoring programs. In addition, aquifer hydraulic conductivity will be determined by conducting aquifer well slug tests. These data, with the net hydraulic gradient calculated from the tidal study, can be used to calculate groundwater flow velocities and travel times, which will be used to identify the appropriate frequency for performance monitoring.

The post-construction hydrogeologic conditions will be documented in a report. The Post-Construction Hydrogeologic Conditions Report will present the geologic and tidal study data collected as part of the CDF monitoring program, an assessment of subsurface conditions, groundwater flow directions and velocities, and estimated times for groundwater to travel from the CDF to reach wells adjacent to the CDF and to adjacent surface water. The Post-Construction Hydrogeologic Conditions Report will be submitted for EPA review and approval.

5.6 Baseline Water Quality

Baseline water quality monitoring will consist of sampling groundwater from selected monitoring wells and surface water adjacent to the Peninsula Habitat Area at the end of the Middle/St. Paul Peninsula.

Because groundwater quality can vary by both location and time, comparisons of performance water quality data against baseline conditions will need to be made on an intra-well basis. As discussed above, the wells to be included in the groundwater monitoring program (both baseline and subsequent performance monitoring) will be determined based on the post-construction groundwater flow conditions. To establish baseline groundwater quality in the selected monitoring wells, and evaluate whether seasonal trends are apparent, the baseline monitoring will consist of quarterly groundwater sampling for two years (eight total events).

The wells installed within the CDF (MW-04 and MW-05) will be included in the baseline monitoring program. However, the primary objective for installing these wells is to determine hydraulic gradients within the CDF. Therefore, these wells will not be sampled as part of the performance monitoring program. The wells installed within the CDF may be decommissioned after baseline monitoring has been completed if it is determined that the wells are no longer needed.

Although baseline groundwater conditions will be established during the first two years following construction of the CDF, groundwater velocities are expected to be slow enough that groundwater from the CDF would not reach the performance monitoring wells until several years, possibly decades, after the baseline monitoring is completed.

To establish a baseline for ambient surface water conditions, surface water monitoring will also be performed quarterly as part of baseline monitoring. Surface water monitoring will be performed at high, slack tide at the northern end of the Middle/St. Paul Peninsula and Peninsula Habitat area (i.e., North Beach Habitat) (Figure 5-2). The surface water sampling location will provide water quality data representative of ambient surface water from Commencement Bay and the Puyallup River that enters the St. Paul and Middle Waterways adjacent to the CDF. Surface water samples will be collected from three feet below the water surface.

5.6.1 Baseline Monitoring Parameters

Leaching test data representative of the dredged sediments placed in the CDF indicate that high molecular-weight polycyclic aromatic hydrocarbons (HPAHs) (e.g., benzo(a)anthracene) and the metals mercury, lead, copper, nickel, and zinc could leach at concentrations above ambient water quality criteria (City 1999). Thin-layer column leaching tests (TCLT) were performed to evaluate leaching and transport of contaminants in groundwater from sediment disposed of in the St. Paul CDF. Analysis for metals including arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc were performed on 30 TCLT samples. Arsenic, cadmium, chromium, and silver were not detected at concentrations greater than surface water criteria in the TCLT samples. Copper, lead, mercury, and zinc were detected in multiple samples at concentrations greater than the surface water criteria. Nickel was detected in four samples at concentrations slightly above the surface water criteria. As copper, lead, mercury, nickel, and zinc were detected in multiple samples at concentrations greater than the surface water criteria, the five metals were chosen as indicator chemicals for CDF monitoring. Due to this result, baseline monitoring will involve sampling and analysis of groundwater for the five metals and PAHs.

Total organic carbon (TOC) and salinity analyses will also be performed on groundwater during the baseline monitoring to provide a baseline against which to compare potential changes in general groundwater chemistry over time (e.g., monitor for salt washout effect). Total suspended solids (TSS) analysis will be performed to assess potential turbidity bias in the total mercury results. Field parameters (temperature, pH, electrical conductivity, dissolved oxygen, and turbidity) will also be measured in the field during groundwater sampling. Baseline surface water samples will be collected and analyzed for salinity, total and dissolved mercury, and dissolved lead, copper, nickel, and zinc.

Groundwater and surface water sampling and analysis will be performed in accordance with sampling and quality assurance protocols presented in Appendix D – Confined Disposal Facility Monitoring Operations Manual.

5.6.2 Baseline Data Evaluation and Statistical Analysis

The baseline monitoring data will be evaluated to determine whether seasonality exists in detected concentrations (i.e., seasonal concentration fluctuations). Additional samples may be performed if data from the two years of quarterly monitoring show a seasonal variation. Assuming that seasonal variations are not evident, the baseline data will be summarized statistically to support subsequent data evaluation during performance monitoring, as discussed in Section 5.7.

The statistical analysis of baseline monitoring data will consist of the following:

- Assessing the overall range and statistical characteristics of the CDF baseline water quality at each well location for each analyte of concern using probability plots;
- Evaluating the degree of variation in the baseline water quality as detected in individual wells using box plots and analysis of variance (ANOVA); and
- Characterizing each individual data set for each analyte monitored at each well by identifying outliers, confirming data distributions, and trend analysis.

Probability Distribution Analysis

The statistical analysis initially involves looking at the site-wide characteristics of the baseline data after pooling the results for each analyte from the monitoring wells that were selected for baseline monitoring. This analysis will provide an overview of groundwater quality for the analytes of concern and allows the overall consistency of the data and groundwater quality to be assessed by examining the statistical frequency distribution of the data using probability plots. This analysis will also provide an estimate of the 95th percentile value for each analyte across the CDF, based on the probability distribution. Additionally, the baseline values for analytes will be defined by the one-sided tolerance level providing 95% coverage of the observed data, with 95% confidence. This analysis provides the 95th percentile upper tolerance limit (UTL) for each analyte for the baseline data set that the performance monitoring results can be compared to (Gibbons 1994).

Site-Wide Variability

The degree of variability across the CDF for each analyte of concern will be examined by comparing box plots of the data from each well for each analyte. These data groups will also be compared statistically using the single factor analysis of variance (ANOVA), which will help to quantify spatial versus temporal variability in the data over the course of the baseline monitoring. The site-wide data will be divided into groups where each group consists of data from one monitoring well. ANOVA provides an analysis of the distribution of total variance in the data set between the groups and within the groups.

The use of box plots will provide graphic illustration of site-wide variability between wells, in addition to providing comparative ranges of values within wells over time. These analyses will help to establish the appropriate range of baseline concentrations observed during the baseline monitoring for each analyte as well as aiding in well selection for performance monitoring.

Intra-Well Data Sets

The statistical characteristics for each analyte at each individual well location will be determined on an intra-well basis by: assessing the probability distribution, addressing non-detect values, and testing for outliers.

The data distribution of each intra-well data set for each analyte will be initially assumed to have a log-normal distribution. This assumption will be confirmed by transforming the baseline analytical data to natural logs and then performing the Shapiro-Wilk Test (Gibbons 1994).

Additionally, a linear regression analysis on the time series data for each analyte in each well will be conducted to assess the presence of any statistically significant trend in the data. The trend that has been anticipated and will be evaluated is seasonality of the data. Data trends will be evaluated by linear regression to determine the slope of the best-fitting trendline to the data.

The statistical analysis of the baseline data will allow for the comparison of performance monitoring data to the established CDF baseline data and the determination of statistically significant changes in concentrations and analyte concentration trends. These statistical analyses will also be used for the surface water baseline data set.

5.6.3 Baseline Data Reporting

The baseline water conditions will be documented in Preliminary Findings Memoranda and in the Baseline Water Quality Conditions Report prepared at the end of the two years of quarterly monitoring. The Preliminary Findings Memoranda will provide a summary of field activities, data summary tables, and identify any deviations from planned activities or significant findings. The Preliminary Findings Memoranda will be submitted following the completion of monitoring activities, data analysis, and data validation. The Baseline Water Quality Conditions Report will present the baseline data collected, assessment of seasonality, the results of the statistical analysis of the baseline data set, and a recommendation on whether the baseline monitoring completed is sufficient to establish baseline conditions. The Baseline Water Quality Conditions Report will be submitted for review and approval by EPA.

5.7 Performance Monitoring

The objective of performance monitoring is to compare post-construction groundwater quality to baseline conditions to determine if constituents are being transported in groundwater from the CDF at concentrations that could pose a potential threat to surface water quality at the point of compliance. The performance standard for the performance monitoring program is to evaluate if statistically significant increases in contaminant concentrations relative to the established groundwater baseline concentrations are observed. The decision matrix flow chart for CDF performance monitoring is presented in Figure 5-3.

Following completion of the baseline monitoring period, the City will submit a proposed long-term performance monitoring program for the CDF to EPA within 120 days of EPA approval of the baseline monitoring report. The performance monitoring program will be based on the post-construction hydrogeologic assessment and the baseline groundwater quality program. The proposed performance monitoring program will identify wells to sample, the sampling frequency and schedule, and chemical analyses to be performed. It will also identify periodic reporting and reviews to re-evaluate the program based on performance monitoring data trends.

The wells to be included in performance monitoring will be adequate in number to characterize groundwater quality conditions. The determination of wells to be used will be based on the post-construction groundwater flow conditions (groundwater flow direction and estimated travel times for the groundwater within the CDF to reach the monitoring wells). If it is demonstrated that groundwater within the CDF would reach one or more of the monitoring wells in substantially shorter time than the others, it is expected that these wells would be selected as indicator wells for performance monitoring. Surface water monitoring will be conducted as part of the baseline monitoring program and will not be conducted during the performance monitoring program unless it is determined to be necessary as part of a potential response action. If statistically significant increases in chemical concentrations above baseline groundwater conditions are observed in indicator wells or trends are observed in several wells that are screened at the same elevation (e.g., shallow, intermediate, or deep), monitoring of additional wells could be conducted as one of the potential response actions (discussed below). Similarly, during the course of the monitoring program, the City may propose to EPA to reduce the number of wells to be monitored, reduce the sampling frequency, or the analyte list based on the performance monitoring data.

If statistically significant increases in an analyte are observed EPA will be notified immediately and resampling of the well(s) where the increase was observed will be conducted to confirm the analytical results prior to the evaluation of potential response actions. If concentration trends or gradients are observed in several wells that are screened at the same elevation (e.g., shallow, intermediate, or deep), the concentration data will be evaluated in consultation with EPA to assess if additional monitoring or response action is needed. EPA notification of a statistically significant increase will initially be verbal or by email (i.e., if verbal communication is not possible) followed by written communication of the results.

In addition to the analytes that will be monitored during performance monitoring, as determined by the baseline monitoring data, TOC and salinity will be analyzed to track potential general changes in groundwater chemistry over time. TSS will be analyzed to assess potential turbidity bias in total mercury results. Field parameters (temperature, pH, electrical conductivity, dissolved oxygen, and turbidity) will also be measured in the field during groundwater sampling (see Appendix D – Confined Disposal Facility Monitoring Operations Manual).

5.7.1 Performance Monitoring Data Evaluation and Statistical Analysis

Analytical results of samples collected from performance monitoring wells will be statistically compared to each analyte's distribution observed during the two-year baseline monitoring program. First the data collected from performance monitoring wells will be compared to the baseline analyte geometric mean and 95th percentile UTL for each analyte in each monitoring well. If an analyte concentration measured during the performance monitoring program exceeds the baseline 95th percentile UTL for the specific analyte and well then the performance monitoring data will be further statistically evaluated relative to the baseline data set.

For baseline datasets that were determined statistically to be normally or log-normally distributed, the calculated geometric mean and the geometric standard deviation (GSD) will be used with a two-sided Student's t-distribution to determine whether the analytical results from the performance monitoring wells are statistically comparable to the baseline monitoring data set.

If baseline data sets did not conform to the normal or log-normal distributions, the observed maximum and minimums will be considered to bound the data set for comparative purposes. These data sets will be assessed by comparing the analytical results of the performance monitoring with the maximum and minimum detections observed in the baseline data set.

If the results of these analyses indicate no statistically significant increase in chemical concentrations at a given monitoring well, performance monitoring will continue as identified in the performance monitoring program, subject to changes proposed by the City or EPA over the course of the program. However, if statistically significant increases are indicated, the City will notify EPA immediately and propose to EPA that one or more response actions be initiated to further evaluate the potential for groundwater flowing from the CDF to adversely impact the adjacent surface water. If sampling adjacent surface water quality is determined to be necessary as part of a potential response action, the same statistical analyses will be employed to evaluate surface water performance data relative to the surface water baseline data set.

5.8 Potential Response Actions

If statistically significant increases in chemical concentrations are observed during performance groundwater quality monitoring of the CDF, potential response actions could include but are not limited to:

- Increase the frequency of sampling of the existing well(s) of concern and/or other performance monitoring well(s);
- Evaluate analyte concentrations of concern in upgradient monitoring wells adjacent to the CDF;
- Install additional monitoring well(s) around the existing well(s) of concern to further delineate whether the concentration increase(s) is a point anomaly or if the increase(s) appears to be representative of a larger aerial extent;
- Install sentinel monitoring well(s) near the surface water, downgradient of the detected increase in chemical concentration(s);
- Establish or refine predictive groundwater transport analyses, including tidal mixing, for the chemical(s) of concern to evaluate the potential for exceedance of performance criteria at the point of compliance;
- Complete a site-specific study of tidal mixing in the aquifer upgradient of the point of compliance;
- Conduct groundwater sampling during low tide at a well point (i.e., monitoring well-like screened sample location) located on the intertidal beach at the point of expected groundwater discharge (i.e., point of compliance).
- Sample ambient surface water quality to define the potential impact;
- Sediment quality monitoring to evaluate possible impacts of groundwater discharge on sediment quality; and/or
- Implement appropriate remediation techniques to prevent exceedance of the performance criteria.

One or more of the response actions, or other actions not listed above but determined to be appropriate in the future, may be warranted depending on the specific groundwater quality conditions indicated by the monitoring data. Based on the data, the City will establish a response plan for discussion with and approval by EPA.

5.9 Observations of CDF Berms and Cap

Visual observations of the CDF containment and offset berms will be performed to document the integrity of the berm structures. The exposed surfaces of the berms will be inspected to identify visible changes in the berm surfaces including possible settlement or sloughing. Additionally, the berm surfaces will be inspected for the presence of seeps and possible signs of contamination including sheen or discoloration. Visual observations of the CDF cap will also be performed to document the integrity of the cap. The surface of the cap will be inspected to identify whether operations on the cap have affected cap integrity including possible penetrations into the cap or actions causing loss of cap material. Additionally, the cap surface will be inspected for possible signs of contamination including sheen or discoloration.

Procedures for performing and documenting visual observations are presented in Appendix D.

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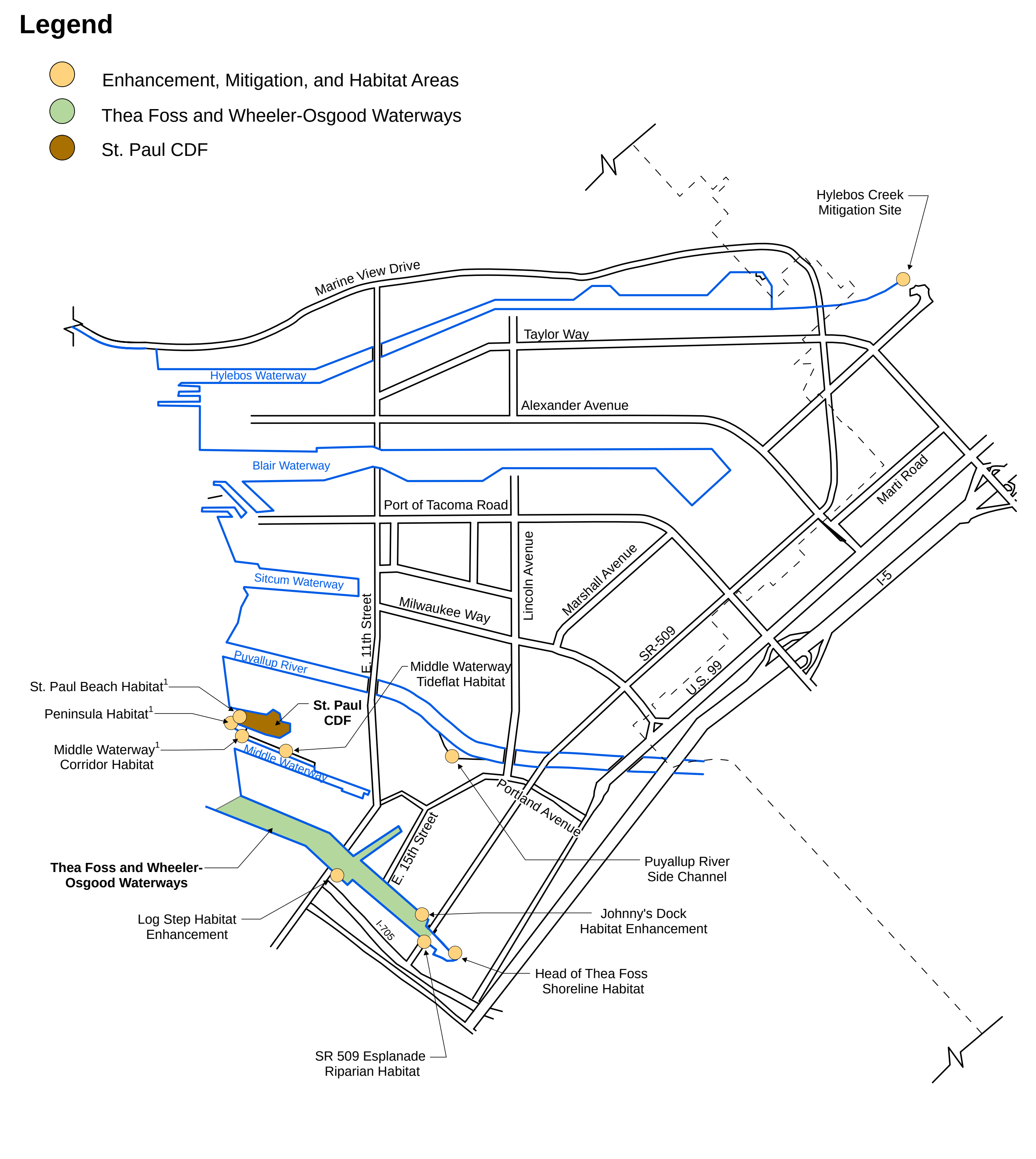
TABLE

FIGURES

Table 5-1
CDF Monitoring and Reporting Schedule

Task		Task Type	Timeline and Description
1	Installation and Development of New Monitoring Wells	Field Activities	Following approval of OMMP
2	Conduct 72-Hour Tidal Study	Field Activities	Within 6 weeks of the completion of the well installation and development
3	Preparation of a Post-Construction Hydrogeologic Conditions Report	Reporting	Within 45 days of completing data validation following completion of the tidal study and data analysis
4	Identify Baseline Monitoring Wells	Meeting /Reporting	Following EPA review of Post-Construction Hydrogeologic Conditions Report
5	Perform Baseline Monitoring—Quarterly Wells and Surface Water Sampling and Observations of CDF Berms and Cap	Field Activities	Quarterly sampling for 2 years
6	Preparation of Report Presenting Baseline Water Quality Conditions	Reporting	Within 45 days of completing data validation following completion of eight quarterly sampling events
7	Identify Compliance Monitoring Program	Meeting/Reporting	120 days following EPA review of the Baseline Water Quality Conditions Report
8	Conduct Compliance Monitoring	Field Activities	To be determined



NOTES

1. The St. Paul Beach Habitat, Peninsula Habitat, and the Middle Waterway Corridor Habitat are collectively called the North Beach Habitat.
2. All locations are approximate.

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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure 5-1
Vicinity Map

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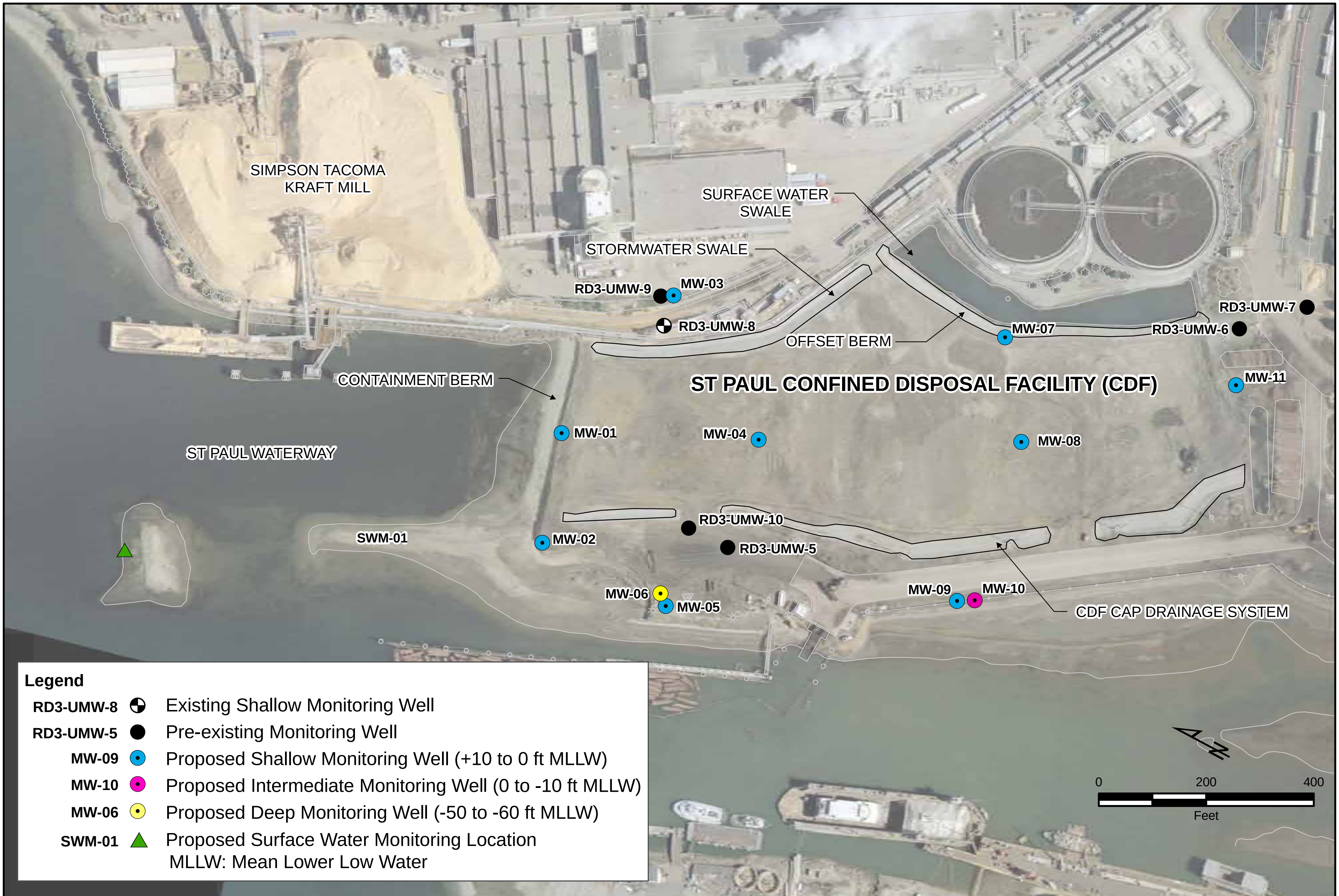

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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure 5-2
Monitoring Well and Surface Water Sampling Location Plan

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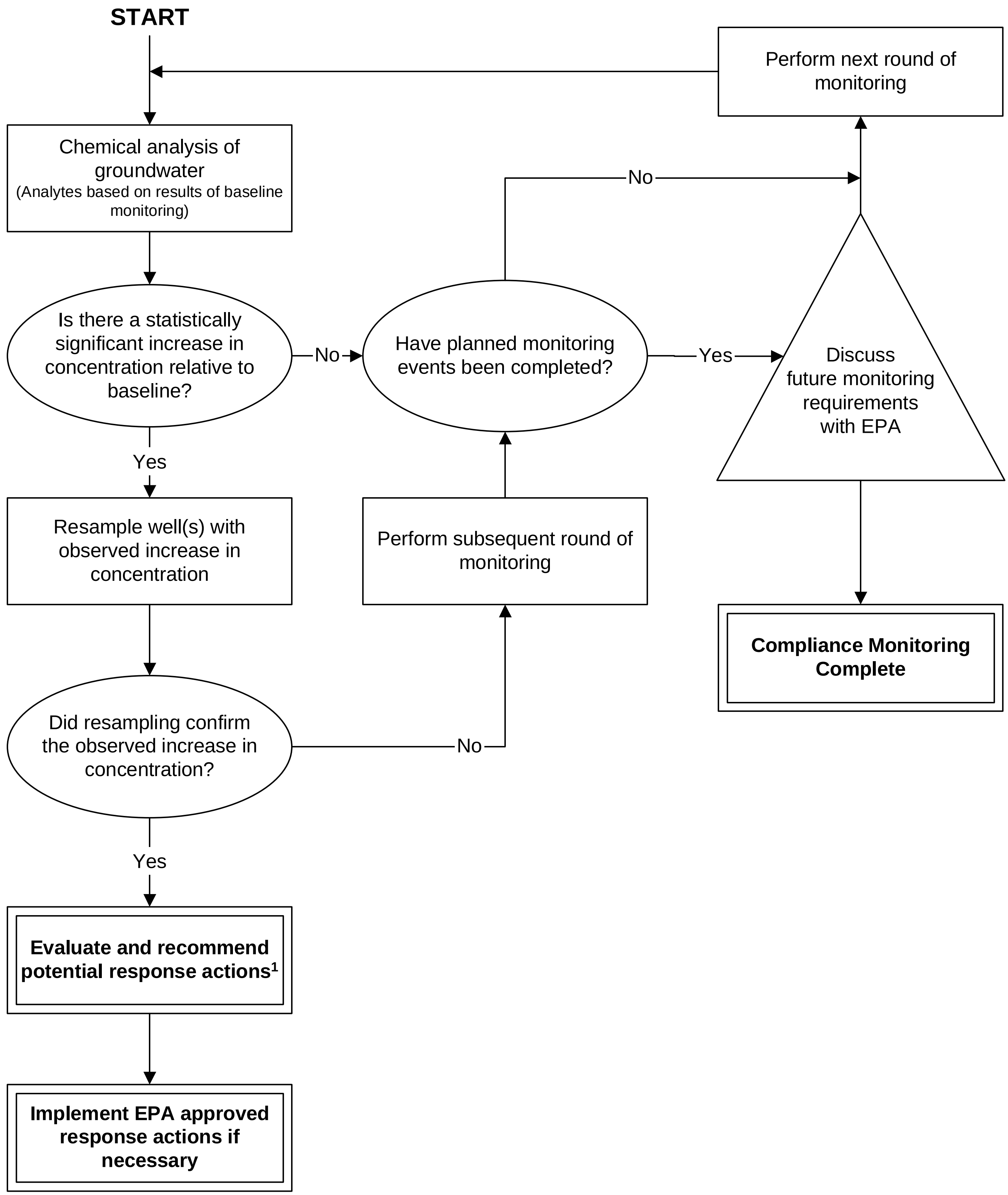

Notes:
1 See Section 5.8 of the OMMP for additional evaluations and potential response actions.

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Figure 5-3
CDF Performance Monitoring Decision Matrix

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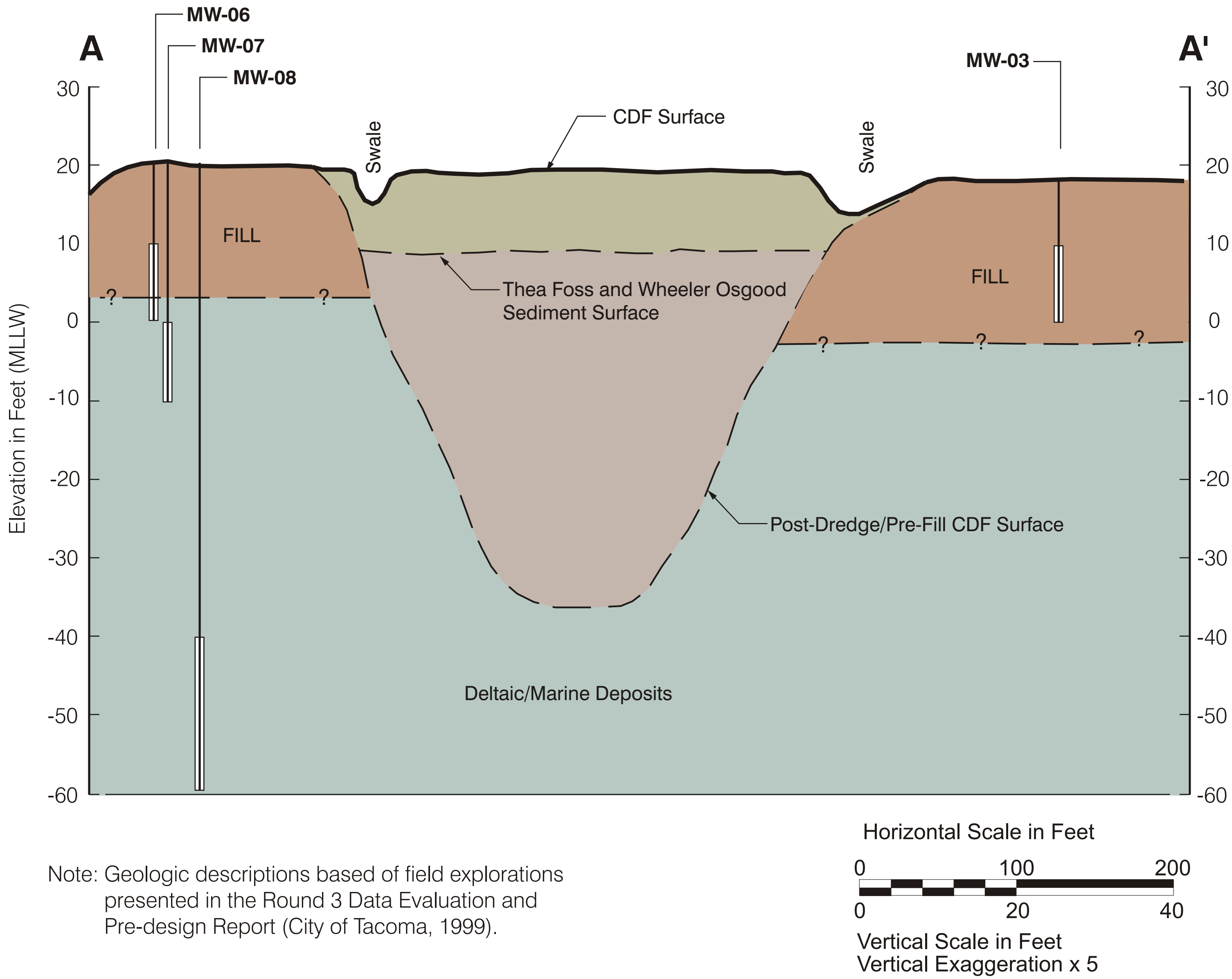

Note: Geologic descriptions based of field explorations presented in the Round 3 Data Evaluation and Pre-design Report (City of Tacoma, 1999).

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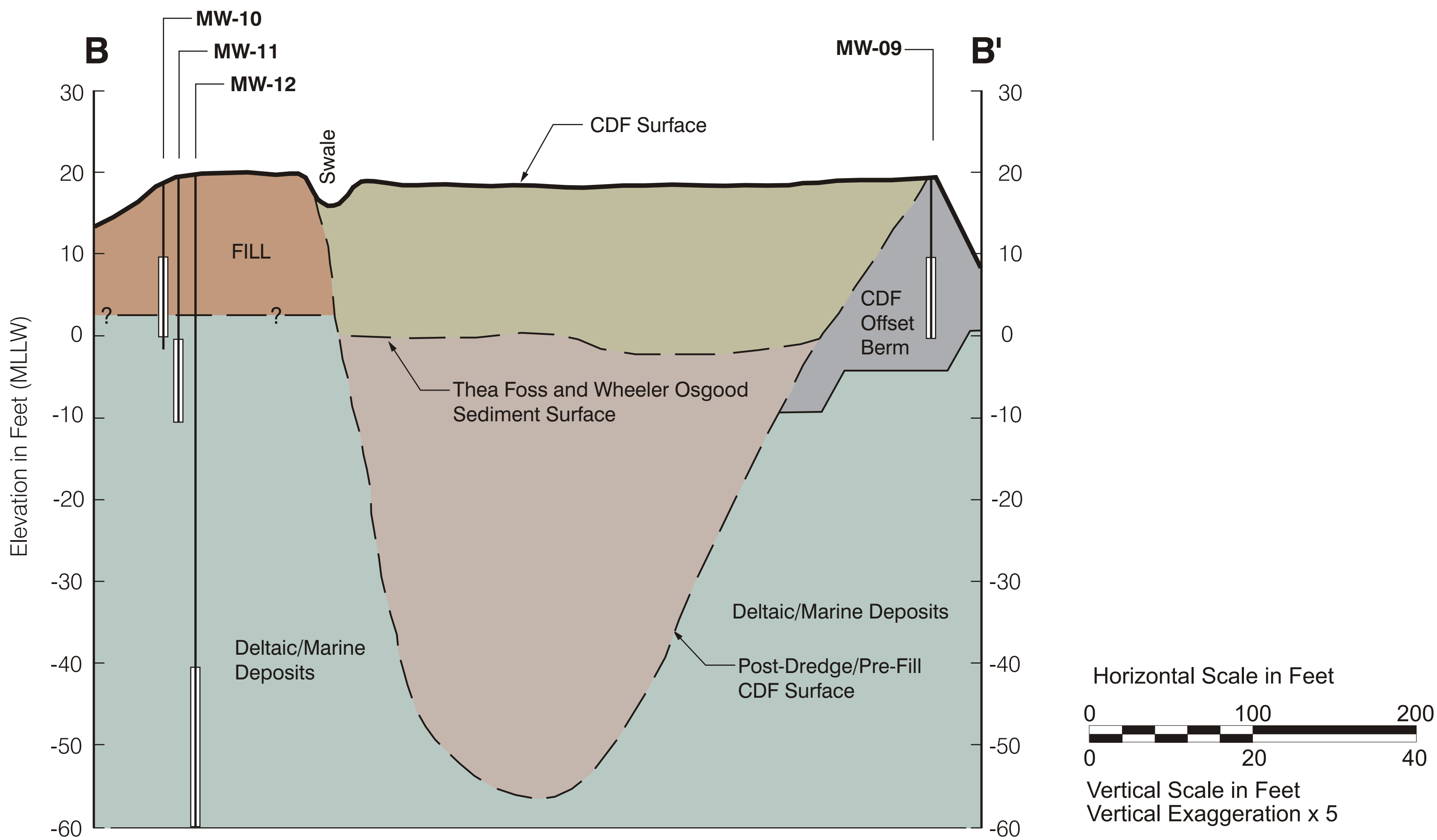
Thea Foss and Wheeler-Osgood Waterways OMMP

Figure 5-4
Generalized Subsurface Cross Section A-A'
St. Paul Confined Disposal Facility



Geologic descriptions based of field explorations presented in the Round 3 Data Evaluation and Pre-design Report (City of Tacoma, 1999).

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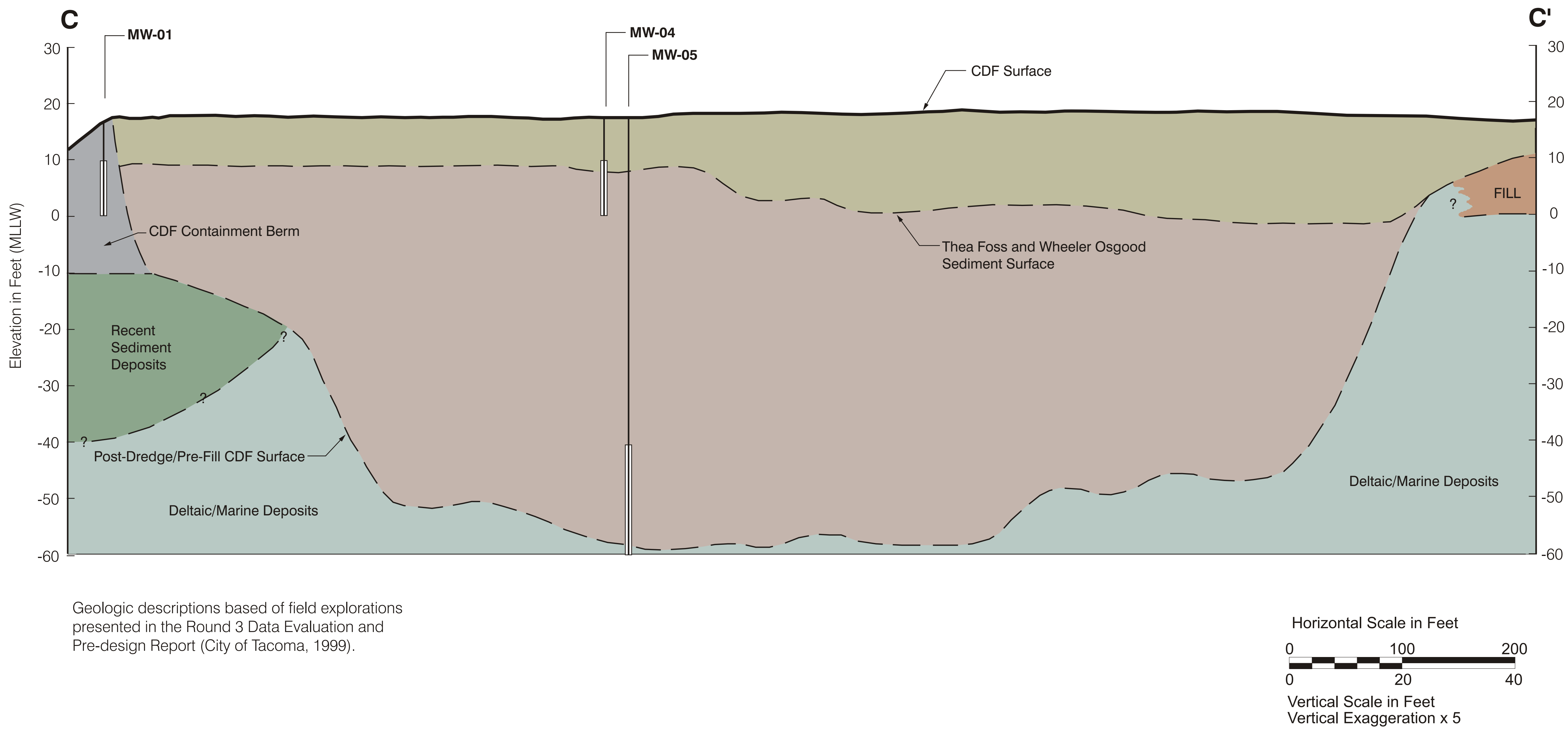
Thea Foss and Wheeler-Osgood Waterways OMMP

Figure 5-5
Generalized Subsurface Cross Section B-B'
St. Paul Confined Disposal Facility



Geologic descriptions based on field explorations presented in the Round 3 Data Evaluation and Pre-design Report (City of Tacoma, 1999).

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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure 5-6
Generalized Subsurface Cross Section C-C'
St. Paul Confined Disposal Facility

6.0 HABITAT MITIGATION AREA MONITORING

As mitigation for effects of the remediation project on aquatic habitat, the City has constructed four habitat sites elsewhere in Commencement Bay (see Figure 1-1): two in the Middle Waterway (North Beach Habitat and Middle Waterway Tideflat Habitat), one in the intertidal reach of the Puyallup River main stem (Puyallup River Side Channel), and one in the intertidal reach of Hylebos Creek (Hylebos Creek Mitigation Site). Additionally, the City was responsible for construction of four enhancement areas within the Thea Foss. These various sites have been identified by different names in past documents. Table 1-3 provides the current names, to be used during the OMMP period, and the names which were used in past documents.

This mitigation and enhancement area monitoring plan describes the areas, mitigation or enhancement objectives, general monitoring methods, monitoring schedule, performance goals, and adaptive management strategy. Specific monitoring methods are described in Appendix E – Habitat Mitigation Area Monitoring Operations Manual. Health and Safety protocols regarding mitigation and restoration site monitoring activities are presented in Appendix F. The plan covers the first ten years of monitoring for each of the project sites described. During Year 10, a comprehensive review will occur, sites will be evaluated, and modifications to the monitoring program will be discussed and developed to assure that performance criteria are attained or continue to be met.

6.1 Objectives and Rationale

The mitigation and enhancement area monitoring program is designed to achieve the following objectives:

- To evaluate the effectiveness of the development of biological features and physical features at the mitigation and enhancement sites to confirm that they are on a trajectory to provide habitat function necessary to meet the objectives for each site as further described below; and
- To confirm that the habitat sites have attained and continue to meet the objectives for each site over time, as further described below.

The monitoring program includes the collection, analysis, and interpretation of qualitative and quantitative information from the various mitigation and enhancement areas.

The following is a site by site description of the various areas for evaluating the sites (see Figures E-1 through E-8).

6.1.1 North Beach Habitat

The St. Paul Beach Habitat, Peninsula Habitat, and Middle Waterway Corridor Habitat areas as defined during the construction process are collectively referred to as the North Beach Habitat. These habitat areas are buffered from upland activities by a 10- to 20-foot wide riparian buffer (Figure E-5).

The completed St. Paul Beach Habitat is composed of low gradient, fine grained beach habitat. The beach slopes at a low angle (10H:1V or flatter) to approximately 8 feet Mean Lower Low Water (MLLW) and is composed of habitat mix. The beach then slopes more steeply upward (approximately 3H:1V), meeting the St. Paul Confined Disposal Facility (CDF) berm at an elevation of approximately 13.5 feet MLLW. The beach surface in this area is comprised of habitat mix and rounded cobbles similar to the nearby Olympic View Resource Area beach. The containment berm face and the adjacent area are planted with native plants to form a riparian buffer.

The Peninsula Habitat is composed of restored littoral habitat including a continuation of the shallow water habitat contours of the St. Paul Beach. Over 1,900 creosote treated piles were removed from this area so that the existing contours could be covered with sand ranging in depth from six inches to several feet. This portion of the habitat area includes the development of an undulating band of marsh habitat at an elevation of 10 feet MLLW to 12 feet MLLW, above the steeper transition between 8 feet MLLW and 10 feet MLLW. The upper beach slopes to a relatively low pass across the central area of the Peninsula. This pass allows juvenile salmonids moving across the face of the St. Paul Beach at tides above MLLW to continue their migration in relatively protected shallow water into the entrance of Middle Waterway. North of the pass, the Peninsula Habitat rises to an offshore shoal or reef at 12 feet MLLW. This shoal partially shelters areas to the south and east from waves from the northwest.

Existing uplands at the tip of the Middle/St. Paul Peninsula have been cut back and excavated to provide new marine habitat area at the southwest corner of the site. Eight nodes of marsh species appropriate for lower and upper saltmarsh elevations are planted in this habitat area. Large woody debris has been placed in the southwest corner to increase habitat complexity and to provide protective cover for juvenile salmonids.

The Middle Waterway Corridor Habitat portion of the site consists of a narrow shoreline that connects the Peninsula portion of the habitat with the broad mudflats and brackish marsh in the southern portion of Middle Waterway. Approximately 250 feet of stacked concrete bulkhead along the east shore of the Middle Waterway were removed and the slope protected with a thick slope cap and habitat mix. This design provides shallow-water, fish-passable shoreline access to and from the inner Middle Waterway habitats during most tidal conditions. Concrete rubble were removed and replaced with a gradually-sloping, gravel-cobble beach.

The following habitat objectives were developed for construction of the North Beach Habitat:

- Remove over 1,900 creosote treated piles;
- Enhance existing littoral habitat by removing piles and debris, regrading, and providing a clean habitat surface;
- Create new littoral habitat by filling deeper water and by excavating uplands;
- Create new marine habitat by excavating uplands at the tip of the peninsula between the Middle and St. Paul Waterways;
- Provide new, riparian vegetation; and
- Provide conditions for potential establishment of saltmarsh vegetation.

Performance standards for this site include minimal change in elevation; development of saltmarsh and riparian vegetation coverage; and juvenile salmonid presence. Performance standards are intended to ensure that created aquatic and riparian habitat be maintained over time, and to verify that habitat is not lost in the future. Site stewardship at all sites will provide additional maintenance and information on site conditions between monitoring events (see

Section 6.5.6). See Table 6-3 for specific performance standards and schedule for this site. Note that saltmarsh performance standards apply to only five of the eight nodes; the three nodes planted in the most exposed areas of the site were planted on a pilot basis and do not have performance standards associated with them.

6.1.2 Middle Waterway Tideflat Habitat

The Middle Waterway Tideflat Habitat with its associated mudflats and tidal channel was constructed on excavated uplands and existing tideflat along approximately 1,450 linear feet of the 1,800-foot long east shoreline of the Middle Waterway. This habitat area begins immediately south of the relocated log haul out and immediately to the north of the existing Trustees/Simpson pilot restoration project site along the southeast side of the waterway, and across from the City's NRDA settlement restoration project and the Middle Waterway Action Committee shoreline restoration project.

The habitat area was excavated from elevations of 18 feet MLLW down to approximately 0 feet MLLW. A meandering tidal channel was excavated down to -4 feet MLLW at the north end, rising to -2 feet MLLW draining the south end. The upper shoreline between 13 feet MLLW and 8 feet MLLW is enhanced with at least of six inches of topsoil to support riparian plantings.

The marsh site is buffered from adjacent industrial activities with a 10- to 25-foot wide riparian area planted with native tree and shrub species. A freshwater sprinkler irrigation system irrigates approximately 40,000 SF of the site between elevation 11.5 feet MLLW and 12.5 feet MLLW for the purpose of establishing brackish marsh habitat. Freshwater flow is considered essential to the development of the desired emergent brackish marsh community at this habitat area. The brackish marsh is in the 10 feet MLLW to 13 feet MLLW elevation range, which varies between 10 and 60 feet in width. The irrigation system generally follows the 13 feet MLLW contour and is designed to reduce sediment pore water salinity in the elevation band between 11.5 feet MLLW and 12.5 feet MLLW.

Daily irrigation is controlled by an adjustable timer, sensor switch, and rain gauge, and can be adjusted to achieve the salinity and plant health requirements. The system automatically shuts off when tidal elevations exceed 11.5 feet MLLW or when precipitation during the run time exceeds 0.1 inch. Typically the irrigation system will loop to irrigate for a short duration several times per day. For example, seven minutes of watering every 30 minutes, 24 hours per day, with no watering during high tide or heavy rainfall. The frequency and duration of watering may be adjusted depending on, but not limited to, field observations of soil and vegetation, pore water salinity monitoring results, and weather conditions.

Twelve 10- by 50-foot (3- by 15-meter) nodes of brackish marsh species have been planted in this zone. Plots are planted to stimulate development of a brackish marsh at the Middle Waterway Tideflat Habitat. Brackish marsh plantings consist of Lyngby's sedge *(Carex lyngbeyi)* and sea coast bulrush *(Scirpus maritimus)*. It is anticipated that these introduced brackish marsh plants will establish a seed source allowing expansion between the initial planting nodes.

The following habitat objectives were developed for construction of the Middle Waterway Tideflat Habitat Area:

- Enhance existing littoral habitat in the Middle Waterway Tideflat Habitat by debris removal, regrading, and providing a clean habitat surface;
- Create new littoral habitat by excavating upland along the east side of Middle Waterway;
- Provide freshwater irrigation to approximately 40,000 SF of intertidal area to support the growth of a brackish marsh vegetative assemblage; and
- Provide new, riparian vegetation.

Performance standards for this site include minimal change in elevation over time; development of a brackish marsh and riparian vegetation cover; and juvenile salmonid presence. Performance standards are intended to ensure that created aquatic and riparian habitat be maintained over time, and to verify that habitat is not lost in the future. Site stewardship at all sites will provide additional maintenance and information on site conditions between monitoring events (see Section 6.5.6). See Table 6-3 for specific performance standards and schedule for this site.

6.1.3 Puyallup River Side Channel

The Puyallup River Side Channel (PRSC) provides off-channel habitat intended for use by juvenile salmonids for rearing and refuge during their outmigration to the estuary. The project merged an existing isolated wetland and an adjacent parcel that was excavated to as deep as -2 feet MLLW from existing uplands, into a single off-channel habitat area. The existing flood control levee structure was breached following construction of a new levee to allow the river and the associated tidal hydrology to enter. The excavated channel and reconfigured existing wetland contain water during most tides.

A substantial area was left between about 6 feet MLLW and 13 feet MLLW to allow development of brackish marsh and riparian assemblages. The area on the inside of the existing Puyallup River dike has been planted with riparian vegetation . The mudflat areas below Ordinary High Water (OHW) have been left for natural colonization by native brackish marsh species (as occurred at the Gog-Le-Hi-Te site just across the river).

The following objectives were established for construction of the PRSC:

- Create new littoral habitat by excavating uplands and removing the existing dike along the west side of the lower Puyallup River;
- Provide conditions for development of a brackish marsh vegetative assemblage; and
- Provide new, riparian vegetation.

Performance standards for this site include the development of riparian vegetation cover and juvenile salmonid presence. Performance standards are intended to ensure that created aquatic and riparian habitat be maintained over time, and to verify that habitat is not lost in the future. Site stewardship at all sites will provide additional maintenance and information on site conditions between monitoring events (see Section 6.5.6). See Table 6-3 for specific performance standards and schedule for this site.

6.1.4 Hylebos Creek Mitigation Site

Hylebos Creek is the major tributary to the Hylebos Waterway. The project area is located on the right bank of lower Hylebos Creek. Hylebos Creek has a large watershed, the majority of which extends north into King County. The project site is bordered by the 4th Street Bridge at its southern end and the stream reach lies completely within the saltwater wedge associated with Commencement Bay's tidal prism. Approximately 400 feet of creek reach is within the project area. The total project area includes a riparian/wetland buffer enhancement and created aquatic habitat.

On-site native vegetation includes: Oregon ash, red osier dogwood, salmonberry, and black cottonwood. The general topography of the area is steep, and gravel mining was the historical land use. This project complements the neighboring restored areas, including the Milgard mitigation project and the NRDA Trustees' Jordan project. Both projects are located to the south of the Hylebos Creek Mitigation Site. The Jordan project is designed to provide off-channel salmon habitat to the east of the creek's bank, while the Milgard project restored the creek's western wetland buffer. The Hylebos Creek Mitigation Site adds to the area's habitat value and extends the wildlife corridor already established.

Habitat was enhanced within a linear band paralleling Hylebos Creek. Enhancements include removal of non-native invasive Himalayan blackberry, reed canary grass, and yellow-flag iris. These species have been replaced with native plants appropriate to the new hydrological regime. Where possible with the least disturbance to native vegetation, small channel "fingers" were excavated into the existing bank to allow water inundation during periods of high freshwater flows or tidal surges. Preservation of the existing mature native bankside vegetation allows for the continued contribution of leaf litter, shade, and nutrients to the creek.

The creation of aquatic wetland habitat was accomplished by excavating the area northeast of the creek. The off-channel area provides habitat for the creek's out-migrating juvenile salmonids that need refuge areas while acclimatizing to saltwater. The added aquatic habitat, water retention and wetland enhancement provide a more diverse habitat and increased wildlife protection by screening it from the adjacent open areas.

The following objectives were established for construction of the Hylebos Creek Habitat Site:

- Create new aquatic habitat by excavating uplands along the east side of the lower Hylebos Creek to allow inundation periods during periods of high freshwater flows or tidal surges;
- Provide low velocity habitat outside of the main channel for juvenile salmon rearing and refuge during high freshwater flows or tidal surges;
- Provide conditions for development of emergent and forested wetland vegetative assemblages; and
- Provide enhanced riparian vegetation.

Performance standards for this site include minimal change in elevation; development of forested wetlands vegetation cover within the standards outlined in Section 6.3; and juvenile salmonid presence. Performance standards are intended to ensure that created aquatic habitat be maintained over time, and to verify that habitat is not lost in the future. Site stewardship at all sites will provide additional maintenance and information on site conditions between monitoring events (see Section 6.5.6). See Table 6-3 for specific performance standards and schedule for this site.

The performance criteria dealing with water level in the site will be quantitatively measured by surveying the mudline elevation of the centerline of the channels annually. In the Year 0 monitoring report, the City will evaluate the criteria of water elevation (NGVD29) of two feet at least 30% of the time against the data set of water level measurements collected from April 2006 through October 2006. This evaluation will be stamped by a Washington State Licensed Hydrogeologist. In subsequent monitoring years, the centerline mudline elevation of the channels will be surveyed to monitor any changes. The elevations along the centerline transects will be compared to as-built elevations on a point-by-point basis. The average of these elevation differences will be no greater than 0.2 feet.

In addition, for informational purposes, the City will take water level measurements in Years 3, 5, 7, and 10, during the low flow period (July-August). The evaluation of data during this period will consider changes in the hydro-dynamics in the creek, such as: a 10% decrease in average rain fall for summer months over 2006; or a substantial geo-fluvial morphological change in the creek and flood plain system (i.e., erosion or sedimentation in the constructed channels of greater than three inches.)

6.1.5 Thea Foss Enhancement Areas

Four locations along the Thea Foss Waterway were identified for post-remediation habitat enhancement activities as part of the overall Thea Foss and Wheeler-Osgood Waterways Remediation Project. These sites do not have specific objectives and performance goals associated with them. A brief description of activities at each site is provided below.

Johnny's Dock Habitat Enhancement. An old timber access pier and brick foundation was demolished and removed from the marine environment. A thick quarry spall cap consisting of an 18-inch deep layer of filter material overlain with an 18-inch deep layer of quarry spalls was then placed. Habitat mix was then placed on the slope over the quarry spalls between elevations -10 feet MLLW and 13 feet MLLW.

Saltmarsh vegetation has been planted at elevations between 10 feet MLLW and 13 feet MLLW. Large woody debris has also been added to the slope to add to the habitat features.

Head of Thea Foss Shoreline Habitat. A portion of the eastern shoreline at the head of the waterway was cut back as part of the Utilities' remediation project, to create aquatic habitat below ordinary high water. Saltmarsh and littoral vegetation have been planted in a 5- to 8-foot side strip landward of a log step structure (at approximately 12.4 feet MLLW) along the shoreline.

SR 509 Esplanade Riparian Habitat. Upland vegetation has been planted above the ordinary high water level along the shoreline south of Alber's Mill. In order to account for shading by the SR 509 bridge two different assemblages of riparian vegetation have been planted: one tree and shrub assemblage appropriate for full sun exposure, and a shrub assemblage appropriate for partial shade. An irrigation system was constructed under the bridge in the shaded area.

Log Step Habitat Enhancement. Approximately 35 treated timber piling, a 12- by 14-foot concrete vault, and other debris were removed from an area on the west side of the waterway between the Colonial Fruit warehouse and the Foss Waterway Marina. A portion of the area was dredged, and a thick quarry spall cap consisting of 18 inches of filter material overlain by 18 inches of riprap was constructed. Habitat mix was placed over the area between the elevations of -10 feet MLLW and 11 feet MLLW.

A 2-step log transition was constructed between elevations 11 feet MLLW and 13 feet MLLW and a 3-foot bench was constructed using 18 inches of filter material overlain with an 18-inch deep layer of quarry spalls. Habitat mix was placed over the quarry spalls, and saltmarsh grasses have been planted at 13 feet MLLW along the 65-foot long high intertidal bench.

6.2 Habitat and Enhancement Area Activities

6.2.1 Monitoring Activities

Monitoring at each of the mitigation areas consists of a combination of activities, including qualitative ground surveys, photo documentation, quantitative vegetation monitoring, elevation monitoring, and juvenile salmonid monitoring, as well as brackish marsh salinity monitoring at the Middle Waterway Tideflat Habitat , invertebrate monitoring at the Puyallup River Side Channel and Hylebos Creek, and water surface elevation monitoring at Hylebos Creek. Additional information about each of these elements and their application at the various habitat areas is provided below.

Qualitative Ground Surveys

Qualitative ground surveys will be conducted annually at each site in order to document site conditions as they develop. For yearly monitoring events, qualitative ground surveys may be conducted during site visits for other monitoring activities. The field form for qualitative ground surveys may also be a useful tool for documenting on-site conditions during additional site visits (i.e., checking sites after storm events), however only one survey is required during each monitoring year.

Qualitative ground surveys will include notes on vegetation in each stratum present on the site, soil (upland) and substrate (aquatic) conditions, erosion/deposition, wildlife, condition of exclusion grids, condition of large organic debris, presence of wrack or other organic accumulations, presence of rubbish, evidence of vandalism, and other notes as appropriate for each site.

Schedule. Qualitative ground surveys will occur in July during all monitoring years, 0 through 10 (see Figure 1-3).

Data Management. Copies of original field forms and any referenced materials (e.g., photos) shall be archived in a central file at the City. All data also will be recorded in an electronic format approved by EPA for submission to that agency.

Site-Specific Information. A brief description of site-specific monitoring is provided below; see Appendix E (Habitat Mitigation Area Monitoring Operations Manual) for specific guidance on sampling protocol for each site.

- **North Beach Habitat.** Qualitative ground surveys at this site shall include all parameters discussed above, including notes on riparian and saltmarsh vegetation in planted and naturally colonizing areas. In addition to general notes on erosion and deposition, specific notes shall be made on evidence and patterns of erosion at the landward northwest corner of the peninsula site and presence of habitat mix at the surface of the site identified through both visual monitoring and probing.
- **Middle Waterway Tideflat Habitat.** Qualitative ground surveys at this site shall include all parameters discussed above, including notes on riparian and brackish marsh vegetation in planted and naturally colonizing areas. In addition to general notes on erosion and deposition, specific notes shall be made on evidence of erosion related to the irrigation system and presence of wood and bark debris.
- **Puyallup River Side Channel.** Qualitative ground surveys at this site shall include all parameters discussed above, including notes on planted riparian vegetation and any naturally colonizing marsh vegetation. All colonizing marsh vegetation will be identified to species and generally described in terms of abundance, growth pattern, elevation, and vigor. In addition to general notes on erosion and deposition, specific notes shall be made on any evidence of rapid sediment deposition as well as the presence of fine-grained material (i.e., habitat mix) at the surface between approximate elevations 13 feet MLLW to 9 feet MLLW identified by visual observation.
- **Hylebos Creek Mitigation Site.** Qualitative ground surveys at this site shall include all parameters discussed above, including notes on emergent and forested wetland vegetation, riparian enhancement area, upland vegetation on the slope above the habitat site, general notes on erosion and deposition, and condition of large woody debris.
- **Thea Foss Enhancement Areas.** Qualitative ground surveys at the various enhancement areas will vary according to each site, depending on whether upland and/or aquatic planting areas are present. Some parameters may not be applicable at all sites, in which case field data sheets will be clearly marked with included parameters. Notes should include survival and general vigor of plantings; documentation of the presence of invasive species; condition of log steps and large woody debris; condition of goose exclusion areas, etc.

Photo Documentation

Photo documentation at each of the habitat areas will be used to record habitat development over time. A number of permanent photo-points will be established at each site during Year 0. These will be marked in the field and surveyed for reproducibility in subsequent monitoring years. Photographs will be taken at each site during low tide periods (i.e., 0 feet MLLW or lower) so as to depict substrate and vegetation conditions. In addition, photographs will be taken at high tide at the Hylebos Creek Mitigation Site to depict the conditions at the site during tidal inundation.

Schedule. Photo documentation will occur in July during monitoring years 0, 1, 2, 4, 7, and 10 (see Figure 1-3).

Data Management. Copies of all photographs shall be archived in their original media format (digital or film/print) in a central file at the City of Tacoma. Each photograph file should be labeled with the consistent file format including date and site.

Site-Specific Information. A brief description of site-specific photo documentation is provided below; see Appendix E (Habitat Mitigation Area Monitoring Operations Manual) for specific guidance, including figures, on photo documentation at each site.

- **North Beach Habitat.** There are six photo-points planned for North Beach, comprising 17 different views.
- **Middle Waterway Tideflat Habitat.** There are four photo-points planned for Middle Waterway Tideflat, comprising 11 different views.
- **Puyallup River Side Channel.** There are six photo-points planned for the PRSC, comprising 10 different views.
- **Hylebos Creek Mitigation Site.** There are seven photo-points planned for the Hylebos Creek Area, comprising 21 different views. Photographs at this site will be taken at both high(where accessible) and low tides.
- **Thea Foss Enhancement Areas.** There are one to three photo-points at each of the four sites, with one to four different views at each site.

Quantitative Vegetation Monitoring

Quantitative vegetation monitoring will be conducted at the four mitigation habitat areas, but will not be required at the four Thea Foss enhancement area sites. Initial qualitative monitoring will document the installation of plantings and goose/rabbit exclusion systems have been accomplished as directed in site plans. Quantitative vegetation monitoring will document survival and development of planted areas, colonization by new species, and presence of undesirable non-native and invasive species. Documentation will include cover and species in each applicable vegetation stratum (riparian, saltmarsh, brackish marsh, emergent wetland, forested wetland) using transects and/or grids.

Potential vegetation monitoring areas will be defined using CAD-based planting plans including elevation information. Monitoring transects or grids will be established in the CAD files, showing the slope and width of the sampling area. Coordinates for sampling locations will be assigned using random number generators and located in the field using dGPS. All sampling locations will be marked in the field for reproducibility in subsequent monitoring years.

Quantitative vegetation monitoring will focus on three primary vegetation assemblages: riparian, saltmarsh, and brackish marsh; with 25 quadrats recorded in each stratum monitored at each site. Sampling metrics will include cover (total and percent by dominant species) and diversity. Aerial coverage of all marsh vegetation also will be surveyed using dGPS, as discussed above. A CAD (or similar) map will be produced showing exclusion grids, monitoring locations, and aerial extent of marsh vegetation for each site.

Schedule. Quantitative vegetation monitoring will occur in July (see Figure 1-3). Year 0 qualitative monitoring will verify installation according to plans and confirm plants are in an appropriate healthy condition required for establishment. Reconnaissance prior to Year 1 monitoring will be used to determine whether monitoring transects and/or grids are appropriate at each site, and where they should be located. Subsequent quantitative vegetation monitoring will occur during monitoring Years 1, 2, 4, 7, and 10.

Data Management. Survey data and maps shall be archived in print and digital (i.e., AutoCAD) format along with copies of the original data sheets and electronic copies of the data in a central file at the City. All data also will be recorded in an electronic format approved by EPA for submission to that agency.

Site-Specific Information. A brief description of site-specific monitoring is provided below; see Appendix E (Habitat Mitigation Area Monitoring Operations Manual) for specific guidance on sampling protocol for each site.

- **North Beach Habitat.** Two strata of vegetation will be monitored at the North Beach Habitat: riparian and saltmarsh. Riparian vegetation will be monitored along a single transect extending the length of the planting area. Saltmarsh vegetation will be planted in eight different nodes at this site, five of which are clustered on the western landward edge of the Peninsula habitat portion of the site. For this site, the potential saltmarsh area is defined as the more sheltered area around these five nodes, and quantitative surveys for performance standards apply only to this area. Twenty-five quadrats will be sampled in this area. Vegetation in the remaining three planted nodes (which were placed on a pilot basis) will be monitored using additional randomly placed quadrats within the planted areas (five in each of these three nodes) and notes will be made on any colonizing vegetation. The extent of marsh vegetation in these areas also will be mapped using dGPS. Notes on naturally colonizing saltmarsh vegetation outside of the planted areas (e.g., along the St. Paul Beach Habitat) will be made during qualitative ground surveys.
- **Middle Waterway Tideflat Habitat.** Two strata of vegetation will be monitored at the Middle Waterway Tideflat Habitat: riparian and brackish marsh. Riparian vegetation will be monitoring along a single transect extending the length of the planting area. Brackish marsh vegetation will be monitored in the potential marsh area, which is a contiguous area including all of the planting areas. The extent of the marsh vegetation will be mapped using dGPS. Notes on naturally colonizing saltmarsh vegetation outside of potential marsh area will be made during qualitative ground surveys.
- **Puyallup River Side Channel.** Riparian vegetation is the only vegetation stratum that will be monitored at the Puyallup River Side Channel (PRSC); marsh vegetation was not planted at this site. Riparian vegetation will be monitoring along two transects, each extending the length of the planting area on either side of the levee breach. Notes on hydroseeded and naturally colonizing marsh vegetation at this site will be made during qualitative ground surveys.
- **Hylebos Creek Mitigation Site.** Forested wetland is the only vegetation stratum that will be monitored at the Hylebos Creek Mitigation Site. The monitoring area includes the shoreline and island within the habitat site, but does not include the enhanced riparian area along the banks of Hylebos Creek. This area is not included in the site and the City does not have jurisdiction to modify the area for compliance with performance standards. The fringe of planted emergent wetland vegetation in this area is expected to be highly dynamic year to year as the water level in Hylebos Creek and flow from natural seeps in the habitat sites vary with weather conditions.

Conditions in this area will be documented with qualitative ground surveys and photo points.

- **Thea Foss Enhancement Areas.** There is no quantitative vegetation monitoring required at these sites; vegetation notes made during qualitative ground surveys are sufficient to confirm installation and gather general information on survival and vigor, diversity, and presence of invasive species.

Invertebrate Monitoring

Insect fallout at the two side channel sites (PSRC, Hylebos Creek) will be sampled to confirm juvenile salmon prey presence at those sites. Insects will be sampled using fallout traps located in the upper intertidal elevations at these sites where riparian and wetland vegetation is likely to attract prey. Data will be collected as part of the qualitative ground surveys and will be recorded as presence or absence of insects in each trap with additional descriptive notes, observations, and photographs documenting trap contents. In addition, visual observations for aquatic prey will be made during the qualitative ground surveys and will be recorded on the field forms.

Schedule. Sampling will occur in Years 1 and 3 during qualitative ground surveys. Insect traps will be set 24 hours prior to the qualitative ground surveys.

Data Management. Data will be managed with qualitative ground survey data. Copies of original field forms and any referenced materials (e.g., photos) shall be archived in a central file at the City. All data also will be recorded in an electronic format approved by EPA for submission to that agency.

Elevation Monitoring

Elevation monitoring will occur at each of the four mitigation sites; it will not occur at any of the four Thea Foss Enhancement Areas. In lieu of complete topographic/bathymetric surveys or survey transects (with the exception of those performed at Hylebos Creek), elevations at the habitat sites will be monitored using a number of permanent, graduated stakes placed at various locations at each site (two feet below and one-foot above ground). Stake locations shall be determined during Year 0 and will be surveyed in case replacement is required. Stakes will be placed such that 0 is at ground level. Monitoring will consist of reading the existing substrate elevation, which will be relative to the baseline at Year 0 and also taking a measurement from the top of the stake to the adjacent ground elevation.

At Hylebos Creek, a centerline transect of each of the two channels will also be performed annually to monitor elevation changes over time.

Schedule. Elevation monitoring will occur in July during monitoring Years 0, 1, 2, 3, 5, 7, and 10 (see Figure 1-3) at all mitigation sites. At Hylebos Creek, the survey transects in the channels will be performed annually in conjunction with other elevation monitoring at the site. The final year with a performance standard for this monitoring will be Year 10 for MWTH, North Beach, and Hylebos Creek. There are no performance standards for elevation at the PRSC.

Data Management. Copies of field data sheets which include elevation information shall be archived, along with an electronic copy of the data in spreadsheet or database format, in a central file at the City. All data also will be recorded in an electronic format approved by EPA for submission to that agency.

Site-Specific Information. Elevation monitoring is similar at the various mitigation sites; see Appendix E (Habitat Mitigation Area Monitoring Operations Manual) for specific guidance on sampling protocols for the sites. Note that there are no performance standards for elevation at PRSC (see Section 6.5.7, Table 6-3).

Water Surface Elevation Monitoring

Water surface elevation at the Hylebos Creek Mitigation Site will be monitored to provide information related to inundation duration and depth using a hydrostatic pressure water level sensor attached to a data logger. The logger will record water depth during periods of inundation in 10-minute intervals.

The elevation of the data probe will be surveyed to NGVD29 datum. Based on the recorded water depths and the surveyed elevation, surface water elevation within the habitat site can be calculated to determine how much of the site is inundated at anytime during monitoring. The as-built survey and water level data can be used to confirm that the constructed elevations are within the tidally influenced elevations. Water level data will be used by the USGS to create a hydrologic stage model.

Schedule. Initial monitoring will occur in Year 0. The sensor was put in place on April 18, 2006, and remained in place through October 2006, in order to cover the majority of the anticipated salmon outmigration period and also the lower base flow and tidal extremes of early summer. In addition, monitoring will occur in Years 3, 5, 7, and 10 during the low flow period. This data is for informational purposes only and there are no performances standards associated with this monitoring.

Data Management. Copies of raw and analyzed electronic data shall be archived in a central file at the City. All data also will be recorded in an electronic format approved by EPA for submission to that agency.

Juvenile Salmonid Monitoring

Juvenile salmonid monitoring shall consist of visual observations from shore at each of the four mitigation sites; juvenile salmonid monitoring will not be performed at the Thea Foss Enhancement Areas. This method of observation will confirm use of the habitat sites by juvenile salmonids without risk of an unintentional take of species listed under the Endangered Species Act. Observations will be made from shore using polarized glasses to improve sub-surface visibility. Notes will be made on approximate school size, approximately fork length range, and species composition where it can be determined. Additional notes may include but are not limited to fish behavior, depth of school, and direction of movement.

Schedule. Visual observations will be conducted during the first and last weeks of May during Monitoring Years 1 and 3.

Data Management. Copies of the field data sheets and/or notes and electronic databases shall be archived in a central file at the City. All data also will be recorded in an electronic format approved by EPA for submission to that agency.

Site-Specific Information. See Appendix E (Habitat Area Mitigation Monitoring Operations Manual) for specific guidance on sampling protocol for each site.

Brackish Marsh Salinity Monitoring

Salinity of the substrate pore-water shall be monitored only at the Middle Waterway Tideflat Habitat site, where irrigation is being used to maintain conditions suitable for brackish marsh vegetation. Salinity measurements shall be made at six randomly placed locations along the contour between 11.5 feet MLLW and 12.5 feet MLLW in addition to three background locations. See Appendix E (Habitat Mitigation Area Monitoring Operations Manual) for specific guidance on salinity monitoring.

Schedule. Salinity measurements shall be taken prior to brackish marsh planting, and then monthly for three months in Year 0. In Year 1, salinity measurements will be taken in late March or early April. No additional monitoring is anticipated at this time.

Data Management. Salinity data shall be recorded on laboratory data sheets and maintained in a central file at the City. All data also will be recorded in an electronic format approved by EPA for submission to that agency.

6.2.2 Reporting

Annual monitoring reports will be prepared for submittal to EPA within 45 days of completion of each monitoring event's final data validation activities. Each monitoring report prepared will include summaries of all elements performed during that monitoring year. The Year 10 Annual Monitoring Report will include recommendations for any further monitoring deemed to be necessary to achieve the performance standards.

6.3 Monitoring Schedule and Performance Standards

6.3.1 Monitoring Program and Schedule Overview

The monitoring program for the four mitigation and four enhancement sites includes eight main components (Table 6-1). Of the eight monitoring activities, only qualitative ground surveys and photo documentation will be conducted at the four enhancement areas on the Thea Foss Waterway.

Qualitative ground surveys will be conducted at all sites every year during the 10-year monitoring program, including Year 0 (Table 6-2). Other than qualitative ground surveys, there will be no monitoring required during Years 6, 8, and 9. During the remaining years, including Year 0, there are at least two activities that must be completed during the annual monitoring period (see Figure 1-3). Reporting requirements and schedules are described in Appendix E.

6.3.2 Performance Standards

Long-term monitoring programs use performance standards to provide benchmarks to determine whether the mitigation areas have developed characteristics appropriate to provide the desired biological functions for which the site was designed. For this monitoring program, these standards are focused on three main monitoring elements (elevation, vegetation, and salmonid use) which address both physical and biological site conditions directly related to aquatic habitat function. Within each of those elements, a schedule of quantitative performance standards specific to the objectives at each mitigation site has been designed to track site development and verify that habitat objectives are being met. A schedule of performance standards for each site is presented in Table 6-3. It should be noted that the primary performance criteria is the maintenance of the total habitat acreage for the project. Table 6-4 includes a summary of the acreages constructed in the various zones at each of the mitigation sites. General presence and condition of the constructed aquatic habitat will be evaluated through the monitoring activities outlined in this plan.

The habitat enhancement areas in the Thea Foss Waterway were designed to enhance habitat function where possible within the remediated area. Annual qualitative ground surveys at each site will document the development of site conditions with sufficient detail to demonstrate that habitat enhancement activities have succeeded, specifically the establishment of additional areas of native aquatic and upland vegetation within the Thea Foss Waterway.

6.4 Adaptive Management

Achievement of the project goals requires implementation of an adaptive management strategy, including identification and implementation of contingencies based on post-construction monitoring. Using the adaptive management process there is a high probability of creating sustainable and functional littoral habitats.

An Adaptive Management Team (AMT) will be established by EPA and the City to conduct the adaptive management program for this project. The following parties will be invited to participate as members of the AMT: USFWS, NOAA Fisheries, Corps of Engineers, the Puyallup Tribe, the Muckleshoot Tribe, WDNR, WDFW, Citizens for a Healthy Bay, and Simpson Timber Company. Meetings will be conducted as needed following receipt and review of the annual monitoring report for the preceding year.

As monitoring data are collected, they will be reviewed and interpreted relative to the objectives and performance standards provided in Sections 6.1 and 6.3. If monitoring data indicate that a potential problem exists, the City will provide notice to the AMT members, per the contingency planning process detailed in Section 6.5. The City will then develop a plan for review by the AMT to correct, mitigate, or otherwise address the situation. Performance standards outlined in Table 6-3 may also need to be suspended and or modified depending on site modifications implemented through the Adaptive Management process. An AMT meeting may be held to review the data and the contingencies proposed for implementation by the City. EPA will make an initial determination of the most appropriate response based on the information available. This determination will be reviewed and commented upon by AMT members before EPA makes the final decision. A detailed step-by-step process for contingency planning and approval is provided in Section 6.5.

6.5 Contingency Planning Procedures

6.5.1 Overall Process

The contingency planning procedures consist of four parts: (1) contingency screening, (2) contingency planning, (3) contingency response, and (4) expedited review (see Figure 6-1). A detailed description of these procedures is presented below. This process is based on a similar process that has been used successfully by EPA, the natural resource agencies, the public, potentially responsible parties, and the property owner for 14 years at the adjacent St. Paul Waterway sediment remediation and habitat restoration project.

The procedures set forth below are described in terms of tasks and steps. The steps are numbered consecutively rather than being renumbered under each task. However, these tasks and steps may not occur in strict chronological order, since certain actions may occur simultaneously or more than once in the planning process.

Two items should be noted with respect to those situations where final decisions are required on potential contingency actions:

1. A number of agencies have expressed a desire to be involved in such decisions because of their role in the review and approval processes for the remedial action and habitat plan. These agencies are collectively referred to below as consulted agencies and include WDNR, WDFW, Ecology, NOAA/NMFS, USFWS, the Puyallup Tribe, and the Muckleshoot Tribe.
2. Because of the need for a coordinated decision-making process and a focus on responsibility, **EPA will make final decisions under the terms of the accompanying Consent Decree**. These decisions will be subject to the consultation process set forth below. EPA will also be responsible for convening meetings and sending notices of major decision points. The City will send reports and data packages to the consulted agencies. EPA and the City shall invite the AMT members to participate in the contingency planning procedures and may update the consulted agency list in response to agency requests.

6.5.2 Contingency Screening Process

The purpose of the contingency screening process is to identify potential problems early enough to conduct a rational determination whether there is in fact a problem and how serious the problem may be. The contingency screening process will enable the agencies and the City to determine what kind of data verification or response is appropriate, so that contingency planning or response actions are based on proper assumptions.

Task 1—Screening Levels

Step 1. The City receives surveying or other habitat monitoring data collected indicating a performance standard has not been met in a specific habitat area.

Task 2—Notice and Verification

Step 2. The City will provide written and verbal notification to EPA and the consulted agencies following receipt of this information and will not wait until submitting a data report.

Step 3. Any involved party may decide to undertake verification (e.g., resampling/remonitoring, checking laboratory procedures) or EPA may direct the City to undertake verification sampling. The City will set up a meeting with EPA prior to undertaking verification actions, unless EPA determines a meeting is unnecessary. Upon approval, the City will initiate the mutually agreed-upon verification sampling.

Task 3—Meeting and Consultation

Step 4. Consulted agencies or other entities identified by EPA and the City may be invited to attend the meeting(s) discussed in Step 3. The property owner will also be invited to attend, as appropriate. Meeting notices and agendas will specify that the meeting is part of a contingency screening review to determine what kind of verification or response to the data is appropriate. EPA and the consulted agencies reserve the right to meet and consult throughout the contingency planning process and prior to final contingency planning.

Task 4—Response to Contingency Screening

Step 5. EPA will make a final determination of the most appropriate response based on all available information. Potentially appropriate responses to contingency screening data include, but are not limited to, one or more of the following actions:

- Concluding the situation does not require further action at this time;
- Verifying the data;
- Seeking expert advice on the interpretation of monitoring data;
- Initiating additional sampling consistent with the existing approach and monitoring methods to evaluate the ecological importance of the contingency screening data or compliance with the Consent Decree;
- Preparing a report of analyses needed to define or describe the problem or situation in terms of potential threat to human health and the environment;
- Developing more specific criteria to evaluate the data or future sampling;
- Revising this document or the field methods for the specific area on a temporary or ongoing basis;
- Initiating the contingency planning process (see below); and
- Initiating expedited review and planning response actions (see below).

6.5.3 Contingency Planning Process

The purpose of the contingency planning process is to develop plans for contingency actions that may become necessary, depending on future monitoring results. As monitoring data are collected, they will be examined and interpreted relative to objectives and performance standards described in Sections 6.1 and 6.3 of this document.

If the monitoring data indicate a potential problem exists, and the contingency screening process has been completed, a plan must be prepared per the contingency planning process to correct, mitigate, or otherwise address the situation.

The contingency planning process could result in an approved contingency response action to be implemented in accordance with an approved schedule. It could also result in agreement on a conceptual approach or a set of criteria for taking further action, pending the results of future monitoring. The process incorporates applicable permit requirements, interagency consultation, and public review of contingency plans prior to approval.

Task 1—Initiation

Step 1. The contingency planning process may be initiated after the contingency screening process.

Task 2—Contingency Planning Proposal

Step 2. The City will propose contingency response actions that will be taken if necessary to address the problems identified in the contingency screening process (i.e., a contingency planning proposal). The proposal will include the type of action to be initiated and a proposed schedule for implementation.

Step 3. EPA will review the contingency planning proposal and may decide to: (1) refrain from further action at this time, (2) require further planning, or (3) proceed with implementation (see contingency response process below). A meeting will be held prior to the conclusion of this review period if requested by any one party.

Task 3—Meeting, Consultation, and Further Planning

Step 4. Consulted agencies or other entities identified by EPA and the City may be invited to attend contingency planning process meetings. The property owner may also be invited to attend, as appropriate. Consulted agencies and the City will be sent a memorandum by EPA summarizing the preliminary decision and requesting comments. A meeting will be held prior to a final decision if a consulted agency so requests.

Step 5. Meeting notices and agendas will specify that the meeting is part of the contingency planning process to determine the nature and timing of appropriate response actions necessary to address potential problems identified in the contingency screening process.

Step 6. The contingency planning proposal identified in Step 2 may be conceptual in nature. The precise technology, cost, timing, and other matters may be refined through a series of revisions, consultations, and meetings as part of further planning. EPA and the City will establish a schedule for completing the planning of a contingency response action under Step 3.

Task 4—Approvals for Contingency Planning Proposal

Step 7. Prior to the conclusion of the contingency planning process, EPA will issue a final determination as to the necessity and type of further remedial action required to be implemented by the City. EPA will also determine, after consultation with the City, whether permits, other approvals, or public participation are needed to implement the contingency planning proposal. Consulted agencies and the City will be given an opportunity to review such decisions before EPA makes its final determination.

Step 8. If EPA deems it necessary, the City will develop a more detailed implementation schedule for the contingency planning proposal, including reasonable time periods for any permits, approvals, public participation, or amendments to the Consent Decree. The City will draft the implementation schedule.

Step 9. EPA will review the draft implementation schedule. EPA will not make a determination on a final schedule without prior consultation with the City and the consulted agencies, although EPA is the final decision-maker for accepting the schedule.

Step 10. Unless specifically prohibited by law, EPA will approve all facets of a contingency response action over which it has jurisdiction prior to requesting or requiring the City to seek any permits or other approvals.

Step 11. EPA and the City will initiate permit or approval processes in accordance with the agreed upon implementation schedule. EPA will assist in obtaining federal, state, or local permits or approvals, if any are required. This process may occur prior to the contingency response process (below) if obtaining prior approvals is necessary or desirable to facilitate prompt contingency response action.

6.5.4 Contingency Response Process

The purpose of the contingency response process is to implement approved plans for contingency actions. This includes agreement on a final schedule, any amendments to the Consent Decree if necessary, and completion and monitoring of the response action.

Task 1—Initiation

Step 1. The contingency response process will be initiated after the contingency planning process.

Task 2—Implementation

Step 2. Upon approval of the contingency response proposal, the resulting action may be reported in the next monitoring/adaptive management report, or, if the action is extensive in duration and scope, EPA and the City may revise the Consent Decree by adding a description of the work to be performed and a schedule for implementing the approved proposal (contingency response action).

6.5.5 Expedited Review Process

The purpose of the expedited review process is to allow the parties to shorten the timeframe of the standard process or to implement one or more of the above steps simultaneously when reliable contingency screening data indicate that a problem warrants immediate action.

Task 1—Initiation

Step 1. The expedited review process may be initiated at any time in the contingency planning procedures. EPA will inform or notify the consulted agencies and the City if this occurs.

Step 2. The City or property owner may initiate the expedited review process by submitting a written request to the other parties and EPA if either party reasonably believes that: the contingency screening process is unnecessary to commence contingency planning, or there is cause for concern about the adequate performance of the habitat areas and habitat restoration that the normal contingency planning procedures may not sufficiently address.

Step 3. In addition, any consulted agency; federal, state, or local agency with jurisdiction; Indian tribe, or citizen may request that EPA or the City consider initiating expedited review. EPA, in cooperation with the City, will establish a mailing list and inform persons on the list of the availability of any data reports submitted under this plan. If mutually agreed upon, this list may be concerned with notification systems for other Commencement Bay or EPA program activities. EPA or the City may hold informal discussions with the requester to learn about or respond to the requester's concern. The request may be withdrawn at any time. Prior to initiating the expedited review process, EPA or the City will convene a meeting to discuss the request with the requester, EPA, the City, and any other agencies or entities identified by EPA and the City.

Task 2—Expedited Procedures and Planning Schedule

Step 4. In consultation with the City and property owner (as appropriate), EPA will determine whether to conduct an expedited contingency screening process (see Step 5, below) or whether to proceed directly to the contingency planning or contingency response procedures.

Step 5. Following initiation of the expedited review process, the City and EPA will establish a schedule for accomplishing the steps set forth in the normal contingency planning procedures (expedited planning schedule). They may add or omit steps, or shorten the time periods associated with particular steps. The schedule will allow reasonable time for the City to meet with EPA and property owner and review any contingency response actions recommended by either agency. EPA will not approve an expedited planning schedule without prior consultation with the City and property owner, including a meeting (if requested).

Potentially appropriate responses include, but are not limited to, the actions noted above in response to contingency screening and detailed analyses, such as a focused remedial investigation or feasibility study.

6.5.6 Site Stewardship

The Adaptive Management Process is only successful when the situation has arisen where solutions in-hand are not successful. For example, if installed vegetation is dying after the end of the first growing season it would be imprudent to wait to decide to initiate contingency planning. The City has a site stewardship program for all habitat and mitigation sites, providing maintenance and landscape management on a regular basis. Many of the objectives and Performance Standards defined in this OMMP are associated with the success of vegetation installations. Site stewardship will ensure that irrigation systems, goose grids, LWD, etc. are all in place and functioning throughout the year rather than just an annual inspection. Site stewardship also will include maintenance such as rubbish and debris removal and invasive species control. To ensure the City receives consistent information from site stewards, qualitative ground survey forms will be filled out as appropriate in addition to documentation of stewardship activities for each visit. The forms will provide a consistent source of information for each site throughout the year.

6.5.7 Sedimentation Potential in the Puyallup River Side Channel and Hylebos Creek Mitigation Sites

The design of the Puyallup River Side Channel (PRSC) is more correctly termed a blind slough. As such, an evaluation of sedimentation was conducted to inform concerns regarding sediment deposition of fine material from the Puyallup River. The evaluation determined that deposition rates could exceed rates of deposition at the Gog-Le-Hi-Te Wetland constructed across the river in 1985. Rates in that site exceed 1-3 cm/yr (Thom and Simenstad 1991; Shreffler et al. 1990).

Based on the high rate of deposition, the evaluation concluded that dredging may be necessary every 2-3 years to maintain the constructed elevation. However, it is not known whether the channel can provide biological function on a continual basis without frequent dredging. The biological function of the PRSC will be monitored and the results reported to EPA. If the first five year's monitoring indicate the sedimentation rate is unacceptably high, contingency planning could be initiated through the Adaptive Management Team, including alternatives identified in the sedimentation evaluation, such as dredging or excavating inlet/outlet to form a flow through system.

There is potential for small sediment deposits to form and erode intermittently at the mouth of the Hylebos Creek Mitigation Site under certain flow and tide conditions. This is a result of the physical environment of the creek and site and their location in the watershed. It is anticipated that any deposits would be relatively small, and would erode over the course of a series of tidal exchanges. However, due to concern regarding fish stranding potential, when such deposits are observed during site visits by the site stewards, City monitoring team members, or fish biologists, those deposits will be breached. This action will be recorded under the "additional notes" section of the relevant data sheet for that site visit and reported to the City project manager.

If site visits and elevation monitoring indicate that sedimentation is greater than the anticipated intermittent deposits at the Hylebos Creek Mitigation Site, the Adaptive Management Team may consider alternatives including: dredging or excavating at the mouth of the habitat site; dredging or excavating a channel between the upstream extent of the habitat site and the creek to create a flow through system; or constructing a log jam to partially or fully divert Hylebos Creek into the habitat site.

6.5.8 Simpson Timber Company BMPs

The Waterway Use Authorization issued to Simpson Timber Company for the log storage and haul out area in Middle Waterway (#20-076478) specifies that Simpson conduct monitoring for the accumulation and redistribution from wood waste potentially resulting from operations. That monitoring plan and schedule are implemented under separate cover by Simpson Investment Company. Copies of the reports are to be provided to both EPA and the City during the monitoring period, and will be summarized along with any response actions required of Simpson in the Annual Monitoring Reports.

In accordance with Simpson's Best Management Plan, an Adaptive Management Team will meet after each monitoring event to discuss results and any necessary response actions. Both the City and EPA will be included in the Adaptive Management Team to discuss and respond to any impacts from wood debris that are being recognized at the Middle Waterway Tideflat Habitat or the North Beach Habitat.

REFERENCES

Shreffler, D.K., R.M. Thom, C.A. Simenstad, J.R. Cordell, and E.O. Salo. 1990. Phase III Report. Year Three Monitoring, January-December 1998. Annual Report to the Port of Tacoma.

Thom, R.M., and C.A. Simenstad. 1991. The Gog-Le-Hi-Te Wetland System in the Puyallup River Estuary, Washington: Phase V Report: Year Five Monitoring, January-December 1990. Final Report to the Port of Tacoma.

TABLES

FIGURE

Table 6-1
Habitat Monitoring Program Matrix

	North Beach	MW Tideflat	PRSC	Hylebos Creek	Thea Foss Enhancement Areas
Qualitative Ground Survey	X	X	X	X	X
Photo-Documentation	X	X	X	X	X
Quantitative Vegetation Monitoring	X	X	X	X	
Invertebrate Monitoring			X	X	
Elevation Monitoring	X	X	X	X	
Water Surface Elevation Monitoring				X	
Brackish Marsh Salinity Monitoring		X			
Juvenile Salmonid Monitoring	X	X	X	X	

Table 6-2
Generalized Monitoring Schedule

	2006 - Year 0	2007 - Year 1	2008 - Year 2	2009 - Year 3	2010 - Year 4	2011 - Year 5	2012 - Year 6	2013 - Year 7	2014 - Year 8	2015 - Year 9	2016 - Year 10
Qualitative Ground Survey	X	X	X	X	X	X	X	X	X	X	X
Photo-Documentation	X	X	X		X			X			X
Quantitative Vegetation Monitoring		X	X		X			X			X
Invertebrate Monitoring		X		X							
Elevation Monitoring[1]	X	X	X	X		X		X			X
Water Surface Elevation Monitoring	X			X		X		X			X
Brackish Marsh Salinity Monitoring	X	X									
Juvenile Salmonid Monitoring		X		X							

[1] Note that survey transects of the channels at Hylebos Creek will be performed annually while monitoring of elevation stakes at other locations will be performed on the schedule shown.

Table 6-3
Performance Standard Schedule by Site

Performance Standard	2006 - Year 0	2007 - Year 1	2008 - Year 2	2009 - Year 3	2010 - Year 4	2011 - Year 5	2012 - Year 6	2013 - Year 7	2014 - Year 8	2015 - Year 9	2016 - Year 10[1]
1.0 North Beach											
Elevation											
1.1.1 Average change is less than 1 foot from Year 0.	B	X	X	X		X		X			
1.1.2 Average change is less than 8 inches.											F
1.1.3 Presence of habitat mix at the surface.	B	X	X	X	X	X	X	X	X	X	X
Riparian Vegetation											
1.2.1 80 percent survival of planted riparian vegetation.		X			F						
1.2.2 Total cover native or naturalized plants is at least 20 percent		X	X								
1.2.3 Total cover of native or naturalized plants is at least 30 percent; ground layer cover and shrub layer cover each at least 15 percent.					X						
1.2.4 Total cover of native or naturalized plants is at least 50 percent; ground layer cover and shrub layer cover each at least 25 percent.								X			
1.2.5 Total cover of native or naturalized plants is at least 80 percent; ground layer cover and shrub layer cover each at least 60 percent.											F
1.2.6 Non-native/invasive vegetation cover is not more than 10 percent.		X	X		X			X			F
Saltmarsh Vegetation											
1.3.1 80 percent survival of saltmarsh vegetation in the potential saltmarsh area.		X			F						
1.3.2 Proportion of potential marsh area with vascular marsh vegetation will be at least 20 percent; area-weighted average cover of native or naturalized plants is at least 5 percent.		X	X								

Performance Standard		2006 - Year 0	2007 - Year 1	2008 - Year 2	2009 - Year 3	2010 - Year 4	2011 - Year 5	2012 - Year 6	2013 - Year 7	2014 - Year 8	2015 - Year 9	2016 - Year 10[1]
1.3.3	Proportion of potential marsh area with some vascular marsh vegetation will be at least 40 percent; area-weighted average cover of native or naturalized plants is at least 20 percent.					X						
1.3.4	Proportion of potential marsh area with some vascular marsh vegetation will be at least 50 percent; area-weighted average cover of native or naturalized plants is at least 30 percent.								X			
1.3.5	Proportion of potential marsh area with some vascular marsh vegetation will be at least 70 percent; area-weighted average cover of native or naturalized plants is at least 50 percent.											F
1.3.6	In planted areas, marsh vegetation density will be at least 75% of that at the time of planting.		X	X								
1.3.7	In planted areas, marsh vegetation density will be at equal to that of at the time of planting.					X						
1.3.8	In planted areas, marsh vegetation density will be at least 150% of that at the time of planting.								X			
1.3.9	In planted areas, marsh vegetation density will be at least 200% of that at the time of planting.											F
1.3.10	Non-native/invasive vegetation cover is not more than 10 percent.		X	X		X			X			F
Salmonid Presence												
1.4	Salmonids will be observed in the habitat site at two dates during the outmigration period.		X		F							
2. Middle Waterway Tideflat												
Elevation												
2.1.1	Average change is less than 1 foot from Year 0.	B	X	X	X		X		X			
2.1.2	Average change is less than 8 inches.											F

Performance Standard	2006 - Year 0	2007 - Year 1	2008 - Year 2	2009 - Year 3	2010 - Year 4	2011 - Year 5	2012 - Year 6	2013 - Year 7	2014 - Year 8	2015 - Year 9	2016 - Year 10[1]
Riparian Vegetation											
2.2.1 80 percent survival of planted riparian vegetation.		X			F						
2.2.2 Total cover of native or naturalized plants is at least 20 percent		X	X								
2.2.3 Total cover of native or naturalized plants is at least 30 percent; ground layer cover and shrub layer cover each at least 15 percent; tree cover at least 20 percent.					X						
2.2.4 Total cover of native or naturalized plants is at least 50 percent; ground layer cover and shrub layer cover each at least 25 percent; tree cover at least 25 percent.								X			
2.2.5 Total cover of native or naturalized plants is at least 80 percent; ground layer cover and shrub layer cover each at east 60 percent; tree cover at least 30 percent.											F
2.2.6 Non-native/invasive vegetation cover is not more than 10 percent.		X	X		X			X			F
Brackish Marsh Vegetation											
2.3.1 80 percent survival of brackish marsh vegetation.		X			F						
2.3.2 Proportion of potential marsh area with some vascular marsh vegetation will be at least 20 percent; area-weighted average cover of native or naturalized plants is at least 5 percent.		X	X								
2.3.3 Proportion of potential marsh area with some vascular marsh vegetation will be at least 40 percent; area-weighted average cover of native or naturalized plants is at least 20 percent.					X						
2.3.4 Proportion of potential marsh area with some vascular marsh vegetation will be at least 50 percent; area-weighted average cover of native or naturalized plants is at least 30 percent.								X			
2.3.5 Proportion of potential marsh area with some vascular marsh vegetation will be at least 70 percent; area-weighted average cover of native or naturalized plants is at least 50 percent.											F

Performance Standard	2006 - Year 0	2007 - Year 1	2008 - Year 2	2009 - Year 3	2010 - Year 4	2011 - Year 5	2012 - Year 6	2013 - Year 7	2014 - Year 8	2015 - Year 9	2016 - Year 10[1]
2.3.6 In planted areas, marsh vegetation density will be at least 75% of that at the time of planting.		X	X								
2.3.7 In planted areas, marsh vegetation density will be at least equal to that present at the time of planting.					X						
2.3.8 In planted areas, marsh vegetation density will be at least 150% of that at the time of planting.								X			
2.3.9 In planted areas, marsh vegetation density will be at least 200% of that at the time of planting.											F
2.3.10 Non-native/invasive vegetation cover is not more than 10 percent.		X	X		X			X			F
Salmonid Presence											
2.4 Salmonids will be observed in the habitat site at two dates during the outmigration period.		X		F							
3. Puyallup River Side Channel											
Elevation											
3.1.1 Sediment deposition is anticipated at this site; elevation will be monitored and reported annually to the AMT along with evaluation of its affects on biological function; there is no performance standard associated with it.	B	X	X	X		X		X			X
3.1.2 Presence of fine-grained material in interstices of riprap between elevation 13 feet MLLW and 9 feet MLLW.	B	X	X	X	X	X	X	X	X	X	X
Riparian Vegetation											
3.2.1 80 percent survival of planted riparian vegetation.		X			F						
3.2.2 Total cover native or naturalized plants is at least 20 percent		X	X								
3.2.3 Total cover of native or naturalized plants is at least 30 percent; ground layer cover and shrub layer cover each at least 15 percent; tree cover at least 20 percent.					X						

Performance Standard	2006 - Year 0	2007 - Year 1	2008 - Year 2	2009 - Year 3	2010 - Year 4	2011 - Year 5	2012 - Year 6	2013 - Year 7	2014 - Year 8	2015 - Year 9	2016 - Year 10[1]
3.2.4 Total cover of native or naturalized plants is at least 50 percent; ground layer cover and shrub layer cover each at least 25 percent; tree cover at least 25 percent.								X			
3.2.5 Total cover of native or naturalized plants is at least 80 percent; ground layer cover and shrub layer cover each at east 60 percent; tree cover at least 30 percent.											F
3.2.6 Non-native/invasive vegetation cover is not more than 10 percent.		X	X		X			X			F
Brackish Marsh Vegetation											
Brackish marsh vegetation at this site is based on colonization of volunteers; there are no performance standards associated with it.											
Salmonid Presence											
3.4 Salmonids will be observed in the habitat site at two dates during the outmigration period.		X		F							
4. Hylebos Creek											
Elevation											
4.1.1 Average change along centerline transect of channels is less than 0.2 feet from as-built elevation.	B	X	X	X	X	X	X	X	X	X	F
4.1.2 No obstruction to fish passage in channels.		X	X	X	X	X	X	X	X	X	X
Forested Wetland Vegetation											
4.2.1 80 percent survival of planted forested wetland vegetation.		X			F						
4.2.2 Total cover of native or naturalized plants is at least 20 percent		X	X								
4.2.3 Total cover of native or naturalized plants is at least 40 percent; shrub cover at least 15 percent; tree cover at least 20 percent.					X						
4.2.4 Total cover of native or naturalized plants is at least 50 percent; shrub cover at least 25 percent; tree cover at least 25 percent.								X			

Performance Standard	2006 - Year 0	2007 - Year 1	2008 - Year 2	2009 - Year 3	2010 - Year 4	2011 - Year 5	2012 - Year 6	2013 - Year 7	2014 - Year 8	2015 - Year 9	2016 - Year 10[1]
4.2.5 Total cover of native or naturalized plants is at least 80 percent; shrub cover at least 60 percent; tree cover at least 30 percent.[2]											F
4.2.6 Non-native/invasive vegetation cover is not more than 10 percent.		X	X		X			X			F
Emergent Wetland Vegetation											
There is no quantitative performance standard associated with emergent wetland vegetation at this site.											
Salmonid Presence											
4.4 Salmonids will be observed in the habitat site at two dates during the outmigration period.		X		F							
Surface Water Elevation											
4.5 Water level is greater than 2 ft during 30% of the monitoring period.	B			X		X		X			X

B = Baseline, F = Final

[1] The Year 10 monitoring report will include recommendations for any further monitoring deemed to be necessary to achieve the performance standards.

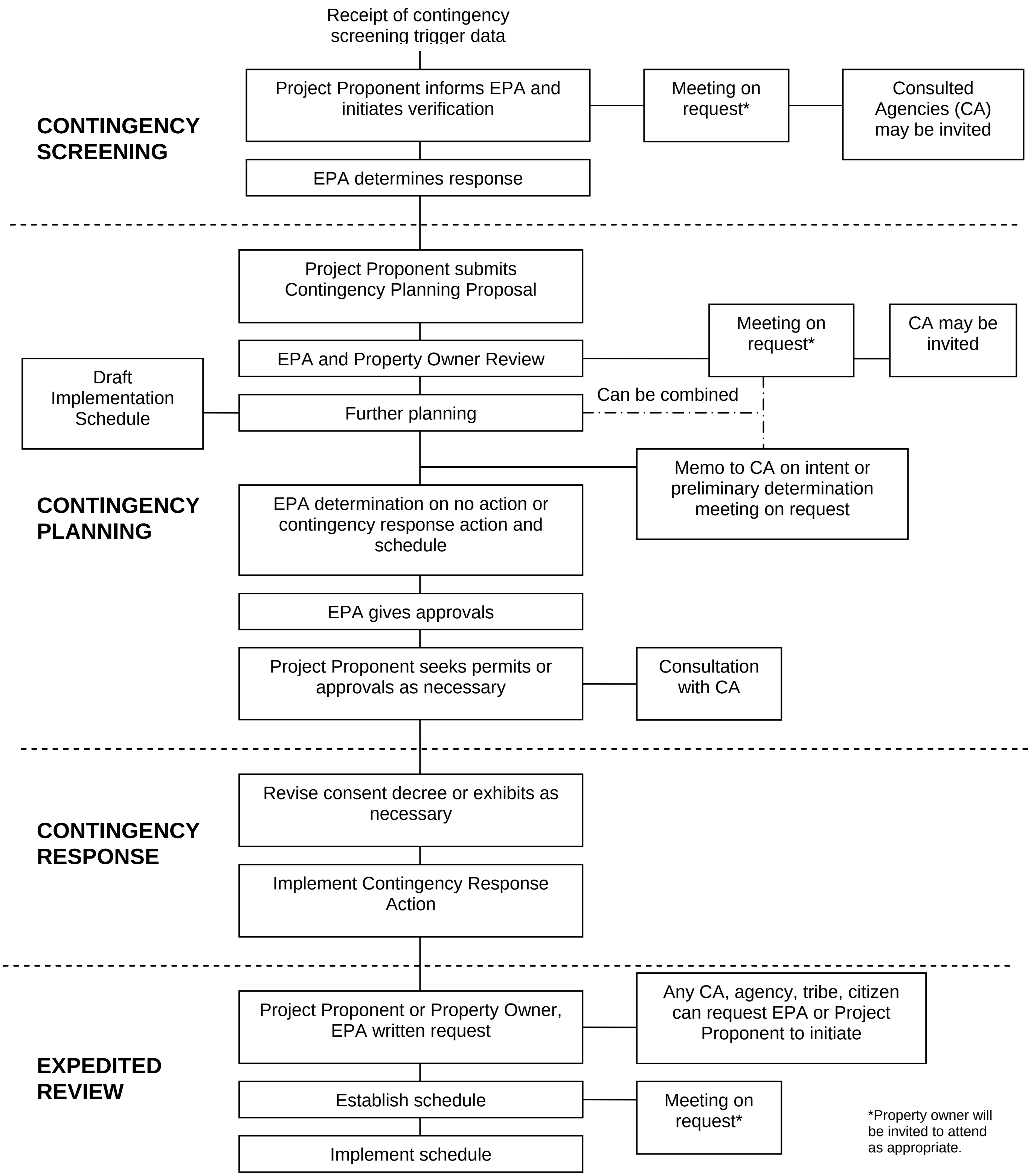
[2] At this site the separate shrub and tree performance standards may be mutually exclusive. Shrub and tree plantings are in a narrow fringe at the toe of steep upland slope. As the plants in each stratum mature and total canopy cover increases, the assemblages may begin to compete for limited space. If one stratum fails the performance standard and this competition is indicative it will trigger adaptive management to evaluate how well site habitat function goals are being met and whether the performance standards should be re-evaluated in that context..

Table 6-4
OMMP Mitigation Acreage Table

Site	Subtidal, acres (Below -10 feet MLLW)	Littoral, acres (Between OHW and -10 feet MLLW)	Total Aquatic Habitat, acres	Riparian, acres
Puyallup River Side Channel		5.39	5.39	0.44
North Beach	0.10	7.26	7.36	0.30
Middle Waterway Tideflat Habitat		8.84	8.84	0.55
Hylebos Creek Mitigation Site		0.58	0.58	0.30

[1] At the Hylebos Creek Mitigation Site, the riparian area subject to performance monitoring is identified as forested wetland (see Figure E-8).

Figure 6-1
Contingency Planning Process



Appendix A

Physical Cap Integrity Operations Manual

A.1 INTRODUCTION

This manual has been prepared to provide direction and procedures for completion of all cap integrity monitoring activities as part of the Operations, Maintenance, and Monitoring Plan (OMMP) for the Thea Foss and Wheeler-Osgood Waterways Remediation Project.

The purpose of performing cap integrity monitoring is to confirm the capped areas of the site are intact (i.e., cap has not experienced significant consolidation or erosion) through visual inspection and hydrographic survey techniques. The objectives of this program are described in Section 2.0 of the OMMP. The following field activities (and frequency of performance) are to be completed as part of cap integrity monitoring. A schedule of cap integrity monitoring activities (low tide slope cap inspections and subtidal cap hydrographic surveys) is presented in Table A-1 and summarized below.

- **Low Tide Slope Cap Inspections.** Visual inspections of slope caps will be performed during periods of low tide (when tidal elevations are below elevation 0 feet Mean Lower Low Water (MLLW) within the areas shown on Figure A-1. Low tide slope cap inspections will be performed during OMMP monitoring event Years 0, 2, 4, 7 and 10. Additionally, supplemental inspections may also be conducted after any event that could cause a sudden slope failure, such as an earthquake.
- **Subtidal Cap Hydrographic Surveys.** Hydrographic surveys will be conducted in all subtidal cap areas of the site to evaluate potential changes (i.e., loss of material) in cap thickness over time that may impact the effectiveness of the cap. A post-construction multibeam hydrographic survey has been completed within the capped areas of the site and will be used as the baseline (Year 0) conditions for comparison to future OMMP hydrographic surveys. Subtidal cap hydrographic surveys will be performed during OMMP monitoring event Years 2, 4, 7, and 10 within the areas shown on Figure A-2.

Slope cap composite sediment samples will be collected at the same time the low tide slope cap inspections are performed in OMMP monitoring Years 2, 4, 7, and 10. These activities are covered separately in Appendix B – Sediment Monitoring Operations Manual.

This manual is organized into the following sections:

- Preparation for Cap Integrity Monitoring;
- Cap Integrity Monitoring Procedures; and
- Monitoring Event Completion Procedures.

Attachment A-1 presents the Quality Assurance Project Plan (QAPP) related to the physical cap integrity monitoring program. Appendix F presents the project-specific Health and Safety Plan. The Health and Safety Plan will be reviewed prior to performing cap integrity monitoring activities. A copy of this Physical Cap Integrity Operations Manual will be available in the field when performing all cap integrity monitoring activities.

A.2 PREPARATION FOR PHYSICAL CAP INTEGRITY MONITORING

A.2.1 Review and Understand this Manual

In preparation for cap integrity monitoring and before conducting field work, all personnel involved with the work must read and become familiar with this Physical Cap Integrity Operations Manual, the Health and Safety Plan requirements, and Section 2.0 of the OMMP (including all relevant tables and figures). The following sections describe the tasks (as related to each type of monitoring) that must be completed prior to start of field activities. If questions arise, information should be requested from the City's Project Manager.

A.2.2 Determine Low Tide Periods for Visual Inspection of Intertidal Slope Caps

Review low tide predictions before performing low tide slope cap inspections and establish a schedule that incorporates completion of all inspection walks during periods when surface water elevations are below elevation 0 feet MLLW. Reliable tide prediction information can be found at www.tidesandcurrents.noaa.gov (if available, use Station Number 9446484 to obtain tide prediction data for Tacoma, WA).

A.2.3 Schedule and Site Access Notifications for Low Tide Slope Cap Inspections and Subtidal Cap Hydrographic Surveys

The City will begin contacting property owners at least 45 days in advance (or as otherwise agreed) of performing required low tide slope cap inspections and subtidal cap hydrographic surveys. The City will also be responsible for coordinating the following issues:

- Permission and access availability to all required inspection and survey areas (including capped marina areas for subtidal cap hydrographic surveys). Proposed survey dates may need to be changed depending on access availability;
- Availability of dock space for moorage of the survey vessel (as necessary);
- Locations where field vehicles should be parked while working on private properties; and
- Any other potential restrictions.

After schedules are established and site access has been arranged, EPA and its consultant will be notified of the planned cap integrity monitoring activities and schedules a minimum of 30 days prior to initiation of the work.

Table A-2 presents a list of individuals to contact prior to performing low tide slope cap inspections and subtidal cap hydrographic surveys. Table A-2 should be updated on a regular basis to facilitate pre-monitoring planning activities for each monitoring event.

A.2.4 Contact Contractor for Subtidal Cap Hydrographic Surveys

Surveyors utilized by the City to assist with completion of subtidal cap hydrographic surveys should be contacted as soon as preliminary scheduling is complete. Planned field work must be coordinated with the surveyors and the following topics should be addressed.

- Personnel availability and estimated duration of field work;
- Number of personnel needed for the desired operation;
- Proposed equipment and techniques required for compliance with the Quality Assurance Project Plan (QAPP) for physical cap integrity monitoring;
- Number of personnel that may be on-board the hydrographic survey vessel at any given time;
- Evaluation of pre-survey preparation including travel time (as necessary), contracting, equipment shipping, software/map needs, and review of this manual and other applicable sources of information.;
- Access to survey areas;
- Survey approach and layout; and
- Any other work order issues.

Prior to performing subtidal cap hydrographic surveys, the contractor will coordinate with the Project Manager to discuss the survey approach, equipment, and methods to be used. Additionally, the contractor and Project Manager will discuss potential access restrictions within heavy use areas (marinas, industrial piers, etc.) so that a sequencing plan that allows for complete coverage of the required survey area can be developed. The City will provide upland location control (horizontal and vertical) information and previous survey transect information to the contractor.

A.2.5 Organize Field Equipment and Supplies for Low Tide Slope Cap Inspections

Begin organizing required field equipment and supplies well in advance of the start of monitoring activities. Check all field equipment and supplies to ensure they are properly calibrated and in acceptable working order.

Table A-3 presents a summary checklist of field equipment and supplies that will be required to complete the low tide slope cap inspections. Field equipment required for completion of subtidal cap hydrographic surveys will be provided by the survey contractor.

A.2.6 Location Control

Low Tide Slope Cap Inspections. The location control requirement for low tide slope cap inspections is to accurately return to monitoring locations (+/- 10 feet) established during the Year 0 (baseline) monitoring event when performing subsequent event inspections. In order to accomplish this requirement, a GPS unit will be used to record monitoring coordinate locations during all low tide slope cap inspections. Established survey benchmark locations on land that will be readily accessible for the duration of the OMMP are shown on Figure A-1. The GPS unit should always be checked at a benchmark location (with known coordinates) before starting low tide slope cap inspections to ensure it is operating within the required level of accuracy (i.e., real-time differential correction is performed).

Subtidal Cap Hydrographic Surveys. The location control requirement for subtidal cap hydrographic surveys is to ensure multibeam survey coverage is consistent within the capped site areas throughout all OMMP monitoring events. All established survey benchmark location information should be given to the hydrographic survey contractor prior to survey activities. The surveyor will utilize the survey benchmarks to verify accuracy of location equipment.

A.3 IN-FIELD CAP INTEGRITY MONITORING PROCEDURES

This section describes the procedures to be used for all cap integrity monitoring activities included under this OMMP. A detailed schedule of cap integrity monitoring activities (low tide slope cap inspections and subtidal hydrographic surveys) is presented in Table A-1.

A.3.1 General Approach

Low Tide Slope Cap Inspections. Low tide slope cap inspections will be performed during OMMP monitoring event Years 0, 2, 4, 7, and 10 to achieve the cap integrity objectives described in Section 2.1 of the OMMP. Methods and procedures regarding completion of low tide slope cap inspections are discussed in Section A.3.3.1 of this manual.

As a separate activity, slope cap composite samples will be collected (for chemical analysis) during OMMP monitoring event Years 2, 4, 7, and 10 at the same time the low tide slope cap inspections are performed. Methods and procedures regarding collection, chemical analysis, and quality control for slope cap composite samples are presented in Appendix B – Sediment Sampling Operations Manual. Field personnel performing low tide slope cap inspections must review this manual prior to collecting slope cap composite samples.

Subtidal Cap Hydrographic Surveys. Hydrographic surveys will be performed during OMMP monitoring event Years 2, 4, 7, and 10 to evaluate potential bathymetric changes that could impact cap integrity as described in Section 2.3 of the OMMP. Methods and procedures regarding completion of subtidal cap hydrographic surveys are discussed in Section A.3.3.2 of this manual.

A.3.2 Arrival at the Site

Before starting a low tide slope cap inspection or leaving the dock for a subtidal cap hydrographic survey, conduct a Health and Safety meeting to establish the work zone areas and to discuss potential work hazards. Be sure that personnel working at the site understand and sign the Health and Safety Plan (Appendix F).

A.3.3 Field Surveys

The following sections detail methods and procedures related to low tide slope cap inspections and subtidal cap hydrographic surveys that must be implemented during each OMMP monitoring event. It is important these steps be completed in a consistent format throughout all monitoring events to satisfy the objectives of the OMMP.

A.3.3.1 Visual Inspections of Intertidal Slope Caps

During each monitoring event, a visual inspection of the shoreline will be completed at low tide (during tidal elevations below 0 feet MLLW) to observe the physical condition of the slope caps. The shoreline areas that will be observed during these inspections are shown on Figure A-1 and additional information regarding the specifics of each area (including approximate lineal footage of shoreline to be monitored, anticipated numbers of monitoring intervals, and the as-built conditions of the slope caps) is presented in Table A-4. The inspections will document any evidence of erosion or failure of the slope caps using field forms and photographs.

Low tide slope cap inspections will be completed in approximate 100-foot monitoring intervals along each of the slope cap areas shown on Figure A-1. Figure A-1 should be used to locate boundaries of the inspection areas with respect to known upland and offshore structures (i.e., buildings and marina docks, etc.), as well as the established waterway station line.

The 100-foot monitoring intervals should be labeled in a manner that designates the location and sequential number within that area (for example, RA 1B-1 would represent the monitoring interval in Remedial Area (RA) 1B within the first approximate 100 feet from the start of the inspection). Prior to leaving the field, inspection personnel should clearly label approximate locations of all monitoring intervals on a field copy of Figure A-1.

The Low Tide Slope Cap Inspection Form, Attachment A-2, has been developed to assist field personnel with recording observations and data during the low tide slope cap inspections. Field personnel should complete one set of the attached field forms to document slope cap observations and data within each Remedial Area to maintain consistency throughout successive monitoring events. Field personnel should use additional field forms as necessary to include all monitoring intervals within a Remedial Area.

Within each monitoring interval, the following field notes will be recorded:

- Monitoring interval label, date, time, and weather conditions;
- Horizontal coordinate locations (as read from the GPS) at the start and finish of the monitoring interval;
- Tide elevation estimate (based on tide predictions);
- Description of the cap surface material (i.e., silt, sand, habitat mix, rip rap, quarry spalls, grout mat, debris, etc.) throughout the monitoring interval. If debris (logs, garbage, etc.) is observed on the cap surface, information should be recorded on the monitoring interval transect diagram section of the field form (completed for each monitoring interval);
- Description of location of the top of cap (i.e., does the cap extend to the top of bank, terminate at a bulkhead, etc.). This observation should be recorded on the monitoring interval transect diagram section of the field form (completed for each monitoring interval); and
- Cap integrity observations relative to the as-built baseline conditions including:
    - Areas of exposed sediment due to washout of the slope cap;
    - Areas of sediment accretion;

  - Evidence of through-cap seepage;
  - Loss of cap layers from the slope cap surface;
  - Presence of debris;
  - Downslope movement of the cap; and
  - Indicators of potential contamination (i.e., sheen, discoloration, staining) within the surface sediment.

Within each monitoring interval, slope cap conditions will also be documented with digital photographs. Digital photographs should be obtained using the following procedures:

- At the start of each monitoring interval, take a digital photograph that includes the entire slope cap area, the water surface, and a stationary object to be used for location reference;
- Where multiple photographs are required within a monitoring interval, preserve the same view direction and provide adequate overlap of coverage (using stationary objects) to ensure complete continuous photo documentation of the slope cap; and
- Record horizontal coordinate locations (using the GPS) on the field forms at each photo point.

Digital photographs will be labeled with the date and time the photograph was taken.

If visible evidence of erosion, disturbance, or failure of the slope cap is observed within a monitoring interval, additional notes should be recorded (within the provided space on the field forms) for further evaluation after the low tide slope cap inspection is complete. At a minimum, additional note information should identify potential causes and extent of cap disturbance and should be clearly recorded on the monitoring interval transect diagram

Grout Mat Cap Areas. Figure A-1 shows areas where grout mats and habitat mix slope caps have been placed as part of the remediation of the Thea Foss and Wheeler-Osgood Waterways. The grout mat cap in RA 3 was constructed so that it is visible during periods of low tide (i.e., no additional cap material was placed on top of the grout mat). The grout mat cap in RAs 19A and 19B was covered with cap materials including sand, rip rap, and habitat mix. Visual monitoring will be performed during low tide slope cap inspections to verify the grout mat and habitat mix slope cap contains the underlying contaminated sediments. The following additional observations will be recorded on the field forms during all low tide slope cap inspections, at monitoring intervals located within grout mat and habitat mix slope cap areas:

- Habitat mix present at the cap surface (within RAs 19A and 19B);
- Grout mat exposed at the cap surface (within RA 3);
- Visual evidence of settlement, cracking, and/or lateral movement of the grout mat;
- Visual evidence of seepage through the grout mat; and
- Indicators of potential contamination (i.e., sheen, discoloration, staining) within the surface sediment.

If visible evidence of erosion, disturbance, or failure is observed within grout mat slope cap monitoring intervals, additional notes should be recorded (within the provided space on the field forms) for further evaluation after the low tide slope cap inspection is complete.

A.3.3.2 Hydrographic Surveys of Subtidal Cap Areas

A hydrographic survey was completed in spring 2006 to document post-construction elevations. The post-construction survey will be used as the baseline (Year 0) conditions for the subtidal slope and channel cap areas. Data from this survey will serve as the basis to evaluate long-term elevation changes within the subtidal slope and channel cap areas.

Multibeam hydrographic surveys of the subtidal slope and channel cap areas, as shown on Figure A-2, will be completed by a contractor during OMMP monitoring event Years 2, 4, 7, and 10 to evaluate elevation changes (i.e., loss of material) over time that could impact the physical integrity of the cap. Subtidal cap hydrographic surveys will generally be performed in subtidal slope and channel cap areas up to approximate elevation 0 feet MLLW. In the event of limited access due to the presence of marine structures (piers, floats, wharves, etc.) subtidal cap hydrographic survey coverage will be completed to the maximum extent possible.

The subtidal cap hydrographic surveys will be performed to provide adequate coverage of the required survey area as shown on Figure A-2 and according to the specifications listed in the attached Quality Assurance Project Plan for Cap Integrity Monitoring. Data for all multibeam hydrographic surveys will be collected in a manner to ensure comparability to previous surveys.

Upon completion of multibeam subtidal cap hydrographic survey field data collection, stamped and signed contour maps providing complete coverage within all required survey areas as identified on Figure A-2 will be submitted to the City by the licensed survey contractor. Contour maps will be provided in hard copy and as electronic deliverables.

Comparison maps, made on a 10-foot by 10-foot grid spacing, will be generated by the City or the survey contractor. These maps will compare current survey event data to previous survey event data and will also be signed and stamped by a licensed surveyor. Survey comparison maps will be completed as hard copy deliverables and in electronic format.

Additional information regarding contractor submittal requirements for subtidal cap hydrographic surveys is presented in the Quality Assurance Project Plan for Cap Integrity Monitoring.

A.4 MONITORING EVENT COMPLETION PROCEDURES

A.4.1 Organization of Field Forms and Data Analysis

Low Tide Slope Cap Inspections. After completion of low tide slope cap inspections, observations and data recorded on the field forms will be compared to previous monitoring events. Areas of potential concern will be identified as necessary and potential response actions will be evaluated using the decision matrix presented on Figure 2-5 of the OMMP. The attached Quality Assurance Project Plan for Cap Integrity Monitoring provides additional information regarding the evaluation and comparison of low tide slope cap inspection data.

Subtidal Cap Hydrographic Surveys. After receipt of subtidal cap hydrographic survey deliverables from the survey contractor, evaluation of monitoring event comparisons will be performed to assess potential bathymetric elevation changes over time and to determine if subtidal caps have remained in place. Areas of potential concern will be identified and potential actions will be evaluated as described below and using the decision matrix presented on Figure 2-5 of the OMMP.

If areas of potential concern are identified, the following procedures will be used to further evaluate disruption to cap integrity:

- Complete a detailed inspection of the subtidal cap hydrographic survey maps to delineate the nature and extent of potential cap disruption;
- Perform additional surveying (as necessary) of the area if existing data density is not sufficient to confirm the nature and extent of potential cap disruption; and
- Perform field verification of cap thickness (i.e., by coring or other acceptable methodology).

A.4.2 Preparation of Post-Monitoring Report Sections

Low Tide Slope Cap Inspections and Subtidal Cap Hydrographic Surveys. Results of low tide slope cap inspections and subtidal cap hydrographic surveys will be compiled and summarized in the OMMP Monitoring Report to be submitted to EPA at the end of each required monitoring event. Specific requirements, including a required submittal schedule, for the OMMP Monitoring Report are presented in Section 2.2.3 of the OMMP.

REFERENCES

City of Tacoma. 2003. Final Design, Design Analysis Report, Thea Foss and Wheeler-Osgood Waterways. January 31, 2003.

TABLES

FIGURES

ATTACHMENTS

Table A-1
Cap Integrity Monitoring Activity Schedule

Monitoring Activity	Monitoring Year (Calendar Year)										
	Year 0 - 2006	Year 1 - 2007	Year 2 - 2008	Year 3 - 2009	Year 4 - 2010	Year 5 - 2011	Year 6 - 2012	Year 7 - 2013	Year 8 - 2014	Year 9 - 2015	Year 10 - 2016
Low Tide Slope Cap Inspection	X		X		X			X			X
Subtidal Cap Hydrographic Survey	X		X		X			X			X

Note: The as-built post-construction hydrographic survey is considered the baseline (Year 0) survey for this OMMP.

Table A-2
Regulatory Project Manager and Private Property Owner Contact List

Regulatory Project Manager	Contact Name	Contact Address	Phone Number / Email Address
U.S. EPA, Region 10	Piper Peterson Lee	1200 Sixth Ave. Mail Stop: ECL-113 Seattle, WA 98101	(206) 553-4951 peterson-lee.piper@epa.gov

Private Property Owner	Contact Name	Contact Address	Phone Number
Totem Marine Services	Red Westgard	820 E. D St. Tacoma, WA 98421	(253) 572-2666
Foss Waterway Marina	Tracy McKendry	821 Dock St. Tacoma, WA 98402	(253) 272-4404
Martinac Shipyards	Joe Martinac, Jr.	401 E. 15th St. Tacoma, WA 98421	(253) 572-4005
Delin Docks	Doug Hicks	1616 E. D St. Tacoma, WA 98421	(253) 272-4352
Johnny’s Dock Marina	Dave Bingham	1900 E. D St. Tacoma, WA 98421	(253) 627 -3186
Dock Street Marina	Doug Hicks	1616 E. D St. Tacoma, WA 98421	(253) 272-4352
Foss Landing	Mike Norman	1940 E. D St. Tacoma, WA 98421	(253) 627-4344
Marine Floats	Wendell Stroud	1208 E. D St. Tacoma, WA 98421	(253) 383-2740
Foss Waterway Development Authority	Su Dowie	535 E. Dock St., # 204 Tacoma, WA 98402	(253) 597-8122

Table A-3
Low Tide Slope Cap Inspection Field Equipment Checklist

Item	Purpose
Private property gate keys/codes (as necessary)	Access private properties.
Cap Integrity Operations Manual	Reference inspection field procedures and Quality Assurance Plan.
Low-tide slope cap inspection field forms (also include sample completed form)	Record inspection observations and data (provide reference for required form entries).
GPS unit	Record monitoring interval and photo point coordinates.
Figure A-1 (field copy)	Template form for recording monitoring interval and photo point locations during inspections.
Digital camera	Photo-documentation of shoreline conditions.
Field notebook	Record field notes in addition to required field form entries.
Flashlight	Facilitate inspection observations for underpier areas or if performed at night.
Tape measure (minimum 100-foot length), field stakes, and flagging tape	Demarcate inspection monitoring intervals.
Sediment Sampling Operations Manual[1]	Reference sampling procedures and required equipment if slope cap composite sediment samples are to be collected.

Notes:

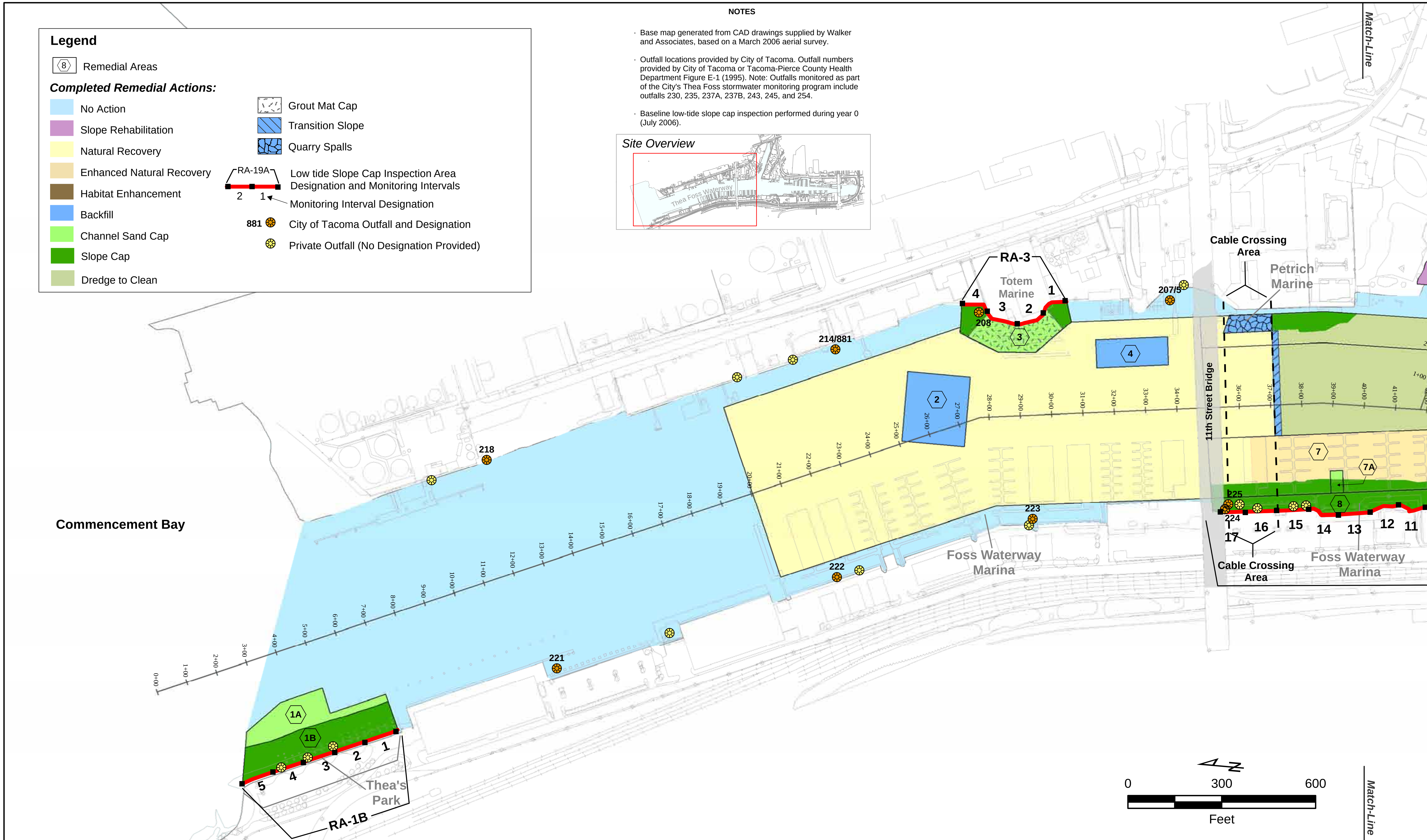
1 Refer to Sediment Sampling Operations Manual for additional required field equipment required for collecting slope cap composite sediment samples in OMMP monitoring event Years 2, 4, 7, and 10.

Table A-4
Low Tide Slope Cap Inspection Areas

Remediation Area	Approximate Waterway Station Interval	Approximate Lineal Feet of Shoreline	Anticipated Number of Monitoring Intervals[1]	Summary of Intertidal Slope Cap Construction[2]	Physical Location Comments[3]
1B	2+00 to 7+00	500	5	Slope cap.	West bank of the Thea Foss Waterway, located at the northern extent of the project site and comprised of the shoreline adjacent to Thea's Park property (owned by the City).
3	27+00 to 30+50	400	4	Grout mat cap (adjacent to Totem Marine property) and slope cap on the northern and southern remedial area boundaries.	East bank of the Thea Foss Waterway, and comprised of the shoreline adjacent to the Totem Marine property.
8	35+00 to 52+00	1,700	17	Slope cap throughout majority of remedial area. Quarry spall cap adjacent to Colonial Fruit property. Habitat mix placed underneath Colonial Fruit pier structure. Quarry spall cap at southern remedial area boundary within upper slope elevations.	West bank of the Thea Foss Waterway, located south of the 11th Street Bridge and comprised of the shoreline adjacent to the southern half of the Foss Waterway Marina and extending to the northern boundary of RA 19A.
14	48+00 to 51+00	400	4	Combination slope cap and quarry spall cap.	East bank of the Thea Foss Waterway, and comprised of the shoreline located adjacent to the Martinac Shipyard property.
19A	52+25 to 62+25	1,000	10	No slope cap material placed in RA 19A above approximate elevation 0 feet MLLW. Monitoring will be performed during low tide slope cap inspections below elevation 0 feet MLLW as feasible.	West bank of the Thea Foss Waterway, and comprised of the shoreline adjacent to the northern half of the Dock Street Marina property and extending to the southern boundary of RA 8.
19B	62+25 to 70+00	900	9	Slope cap to approximate Station 66+50. Grout mat cap from approximate Station 66+50 to southern project boundary.	West bank of the Thea Foss Waterway, and comprised of the shoreline adjacent to the southern half of the Dock Street Marina property and extending to the southern project site boundary.
20	62+75 to 70+00	900	9	Slope cap from approximate Stations 62+50 to 65+75 and from Station 67+75 to the southern project boundary. Quarry spall cap from Stations 65+75 to 67+25. Habitat mix placed underneath Johnny's Restaurant pier structure and above the slope cap in the designated habitat enhancement area.	East bank of the Thea Foss Waterway, and comprised of the shoreline adjacent to Foss Landing and Johnny's Dock Marina properties and extending to the southern project site boundary.

Notes:

1 Anticipated number of required monitoring intervals is based on measured lineal feet of shoreline. Actual number of monitoring intervals may vary during completion of low tide slope cap inspections.
2 Summary of cap construction reflects post-remediation action conditions and will serve as the basis for comparison to information recorded during low tide slope cap inspections. As-built conditions for slope caps are as follows:
Slope Cap: 18-inches filter material (sand, gravel), overlain by 18-inches riprap, overlain by habitat mix (placed at 25 tons per 1,000 square feet).
Quarry Spall Cap: 18-inches filter material (sand, gravel), overlain by 18-inches quarry spalls, overlain by habitat mix (placed at 25 tons per 1,000 square feet).
Grout Mat Cap: 6-inch grout mat, overlain by Slope Cap (RA 19B); two 6-inch grout mats with no additional material cover (RA 3).
Habitat Mix: Habitat mix placed at rate of 25 tons per 1,000 square feet in select locations (under pier/wharf structures and within habitat enhancement areas).
3 Private property owners will be contacted prior to completion of low tide slope cap inspections to coordinate site access as necessary.



FLOYD | SNIDER strategy • science • engineering Tacoma	Thea Foss and Wheeler-Osgood Waterways OMMP	Figure A-1 (Page 1 of 2) Low Tide Slope Cap Inspection Monitoring Intervals

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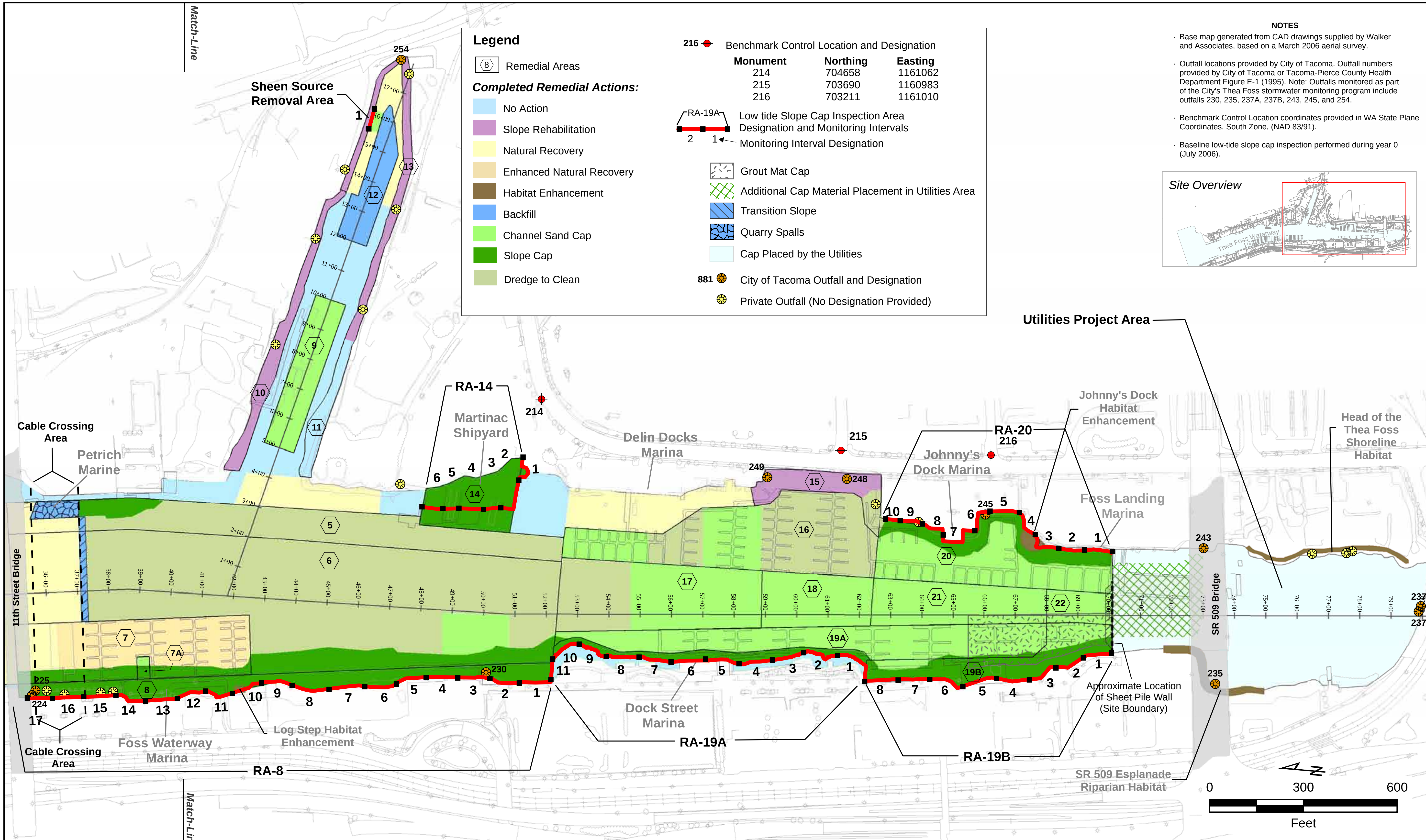

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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure A-1 (Page 2 of 2)
Low Tide Slope Cap Inspection Monitoring Intervals

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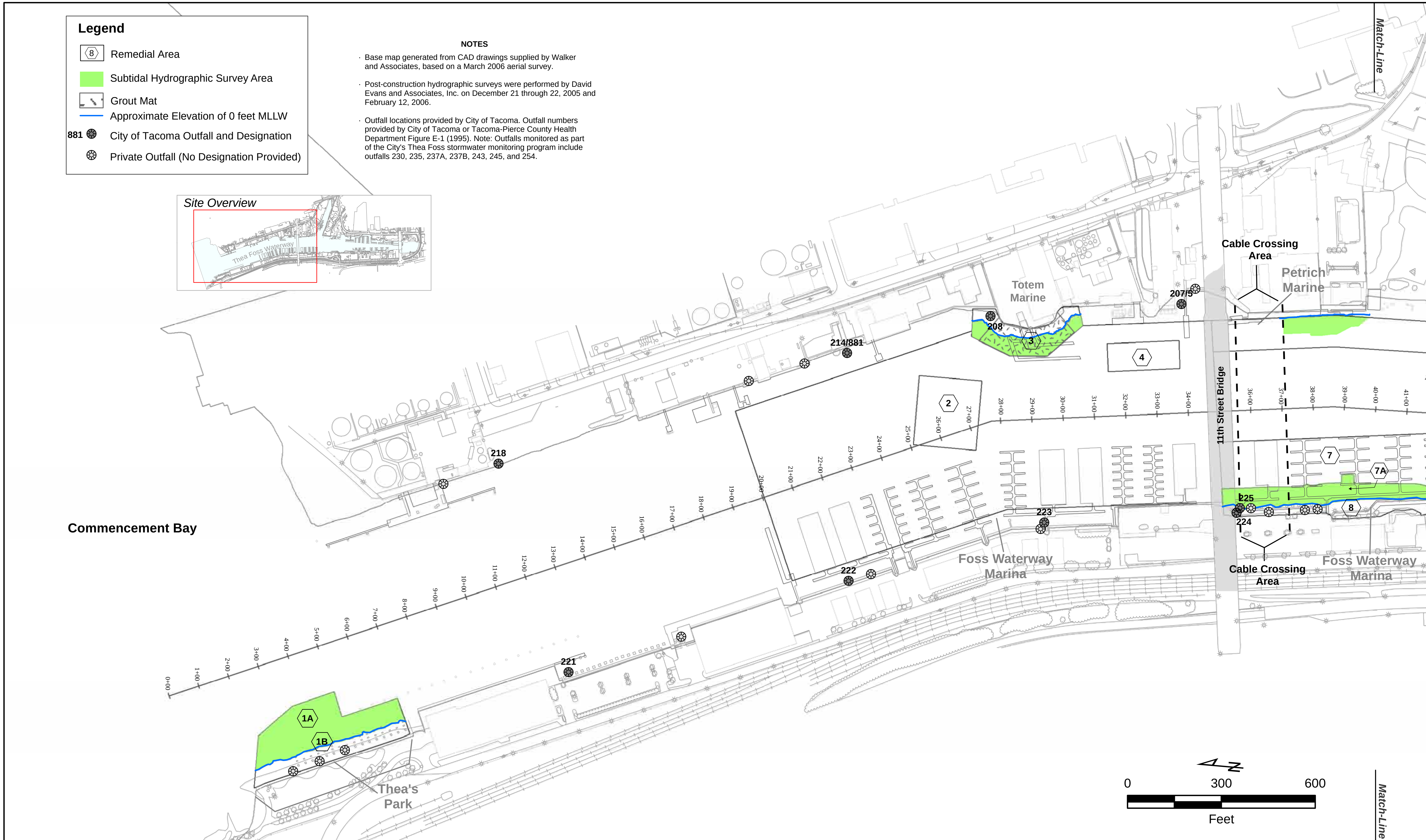

NOTES

- Base map generated from CAD drawings supplied by Walker and Associates, based on a March 2006 aerial survey.
- Post-construction hydrographic surveys were performed by David Evans and Associates, Inc. on December 21 through 22, 2005 and February 12, 2006.
- Outfall locations provided by City of Tacoma. Outfall numbers provided by City of Tacoma or Tacoma-Pierce County Health Department Figure E-1 (1995). Note: Outfalls monitored as part of the City's Thea Foss stormwater monitoring program include outfalls 230, 235, 237A, 237B, 243, 245, and 254.

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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure A-2 (Page 1 of 2)
Subtidal Hydrographic Survey Areas

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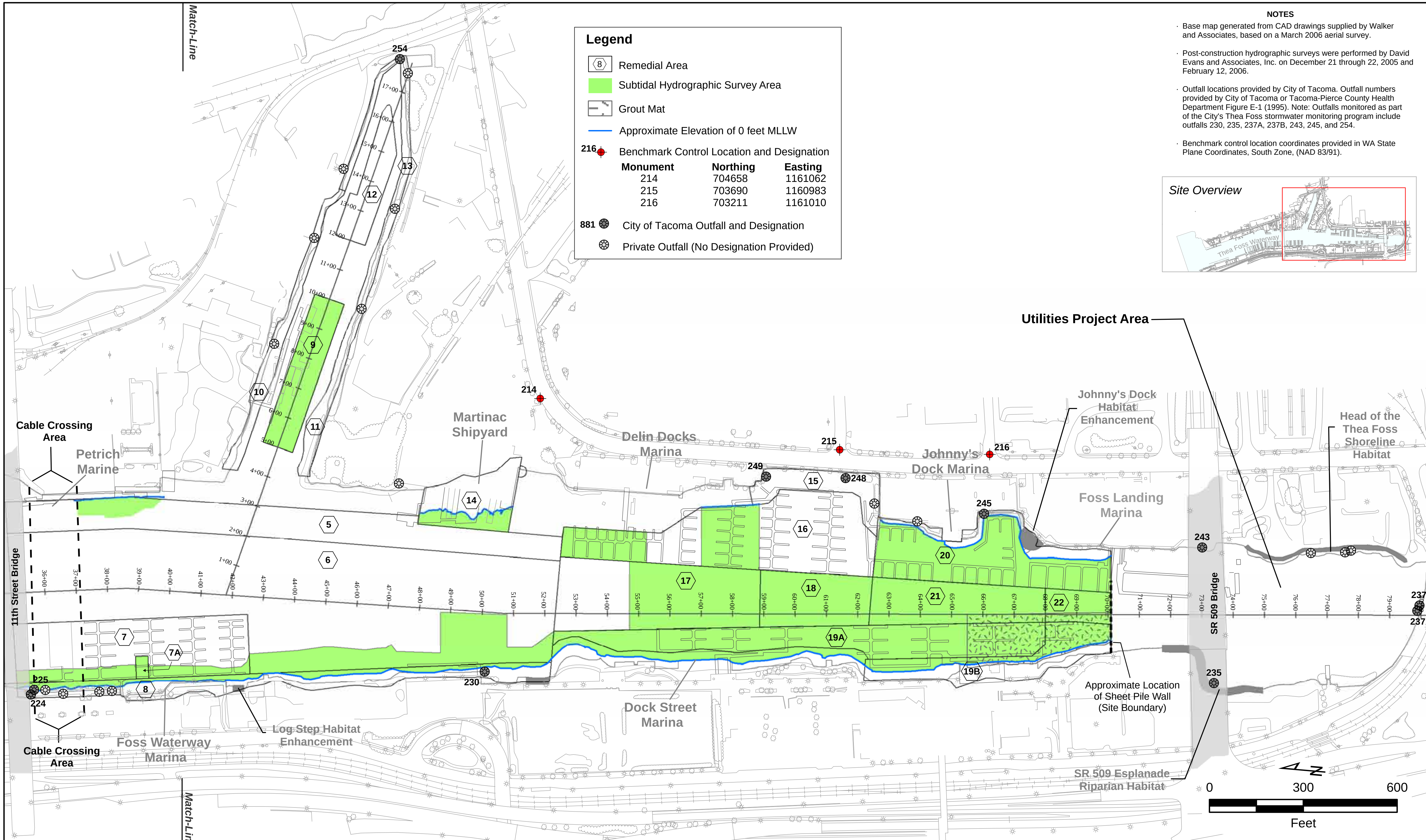

NOTES

- Base map generated from CAD drawings supplied by Walker and Associates, based on a March 2006 aerial survey.
- Post-construction hydrographic surveys were performed by David Evans and Associates, Inc. on December 21 through 22, 2005 and February 12, 2006.
- Outfall locations provided by City of Tacoma. Outfall numbers provided by City of Tacoma or Tacoma-Pierce County Health Department Figure E-1 (1995). Note: Outfalls monitored as part of the City's Thea Foss stormwater monitoring program include outfalls 230, 235, 237A, 237B, 243, 245, and 254.
- Benchmark control location coordinates provided in WA State Plane Coordinates, South Zone, (NAD 83/91).

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Figure A-2 (Page 2 of 2)
Subtidal Hydrographic Survey Areas

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MXD NAME: F:\projects\KPFF Foss\GIS\Revised OMMP\Final OMMP Report Figures\Figure 2-3 Subtidal Hydrographic Survey Areas (2of 2) 031407.mxd

Attachment A-1

Quality Assurance Project Plan for Cap Integrity Monitoring

A-1.1 INTRODUCTION

The purpose of this Quality Assurance Project Plan (QAPP) is to present the requirements/specifications and quality assurance/control for the cap integrity monitoring activities and provide guidelines for the evaluation of field data after monitoring activities have been completed.

A-1.1.1 Low Tide Slope Cap Inspections

The quality assurance objective for low tide slope cap inspections is to perform the periodic inspection activities (observations, data collection, and photo documentation within established monitoring intervals) in a consistent manner throughout the duration of the long-term monitoring period for the Thea Foss and Wheeler Osgood Waterways Remediation Project. The Cap Integrity Operations Manual has been prepared to satisfy this requirement, provided field inspections are completed as prescribed. Field personnel should utilize the attached field forms when conducting low tide slope cap inspections.

The GPS unit will serve as the tool to allow field personnel to identify the inspection locations occupied during each survey event. The GPS unit must be checked at a known survey benchmark location before performing low tide slope cap inspections. Additionally, GPS coordinates must be recorded on the field forms at all monitoring interval boundaries and photo points in order to achieve quality assurance requirements. The quality control requirement for low tide slope cap inspections is to maintain a location control tolerance of +/- 10 feet for all monitoring intervals and photo points.

After completion of low tide slope cap inspections, field observations and data will be evaluated by the project manager to identify potential areas of concern (as necessary) with respect to cap integrity. The field forms (documenting observations) and digital photographs should be carefully reviewed and compared with previous monitoring event forms and photos as applicable. Potential areas of concern may be identified as evidenced by observations of significant cap material movement, material loss, exposure of underlying sediments, or other indications.

If potential areas of concern are identified after evaluation and comparison of intertidal slope cap monitoring data, the decision matrix presented on Figure 2-5 of the OMMP will be used to determine the need for additional evaluation of potential response actions.

A-1.1.2 Subtidal Cap Hydrographic Surveys

Quality assurance requirements with respect to the subtidal cap hydrographic survey contractor are as follows:

- The surveyor must possess a valid Washington State Land Surveyor's License and qualifications that are acceptable to the City; and
- The surveyor will perform all subtidal cap hydrographic surveys in accordance with the provisions of this OMMP, the standards given in the following technical reference, and subsequent updates:
    - Engineer Manual 1110-2-1003 (January 2002) "Engineering and Design – Hydrographic Surveying", prepared by the Department of the Army, U.S. Army Corps of Engineers, Washington D.C. 20314-1000, except as noted.

Quality control requirements for subtidal cap hydrographic surveys are as follows:

- Horizontal datum will be NAD 83/91 and horizontal position tolerance will be +/- 3 feet. Field location equipment should be calibrated to established upland survey benchmarks before conducting subtidal cap hydrographic surveys;
- Vertical datum will be NVGD 29 and vertical accuracy for measured depths will have a tolerance of +/- 0.1 feet;
- Surveys will be conducted using the same (or similar) types of survey equipment;
- Calibration of survey equipment will be performed in a consistent manner for all OMMP survey events;
- Location of survey transects and density of spot elevations will be similar to previous survey events to allow for consistent interpretation of bathymetric data;
- Survey grid comparisons will be completed using a 10-foot by 10-foot grid for all hydrographic survey monitoring events;
- Method of survey grid comparison will be similar for all survey comparison events; and
- All subtidal cap hydrographic surveys will be corrected for tidal effects.

Additional quality control requirements that should be implemented to minimize potential for subtidal cap hydrographic survey error are defined in detail in Chapter 3 (Corps Accuracy Standards, Quality Control, and Quality Assurance Requirements) of the Army Corps of Engineers' Engineer Manual 1110-2-1003.

After completion of all multibeam subtidal cap hydrographic survey monitoring events, contour maps will be prepared including one-foot contour intervals for the entire area surveyed. Contour maps will be stamped and signed by the licensed survey contractor and the contractor's firm name will be printed on each map along with the project name, number, and date of the survey.

Survey comparisons will also be performed after completion of all multibeam subtidal cap hydrographic survey monitoring events to compare the current monitoring event data to baseline (Year 0) and other previous monitoring events as necessary. Survey comparisons for each monitoring event will clearly show differences between the surveys being compared at 10-foot by 10-foot grid spacing. Maps will be produced to delineate areas where cap elevations have changed by more than +/- 1 foot greater than the error inherent to the survey and comparison methods. These maps will be signed and stamped by a licensed surveyor and the contractor's firm name will be printed on each map along with the project name, number, and date of the survey.

REFERENCES

Engineer Manual 1110-2-1003 (January 2002) "Engineering and Design – Hydrographic Surveying", prepared by the Department of the Army, U.S. Army Corps of Engineers, Washington D.C. 20314-1000.

Hart Crowser, 2002. Technical Specifications – Thea Foss and Wheeler-Osgood Waterways Remediation Project, Tacoma, Washington.

Attachment A-2

Low Tide Slope Cap Inspection Form

LOW-TIDE SLOPE CAP INSPECTION FORM

Thea Foss and Wheeler Osgood Waterways OMMP

Date: ______________________

Remedial Area: ______________________ Weather: ______________________

Datum (Horiz/Vert): ______________________ Field Personnel: ______________________

Benchmark(s) Used for Location Control: ______________________

Monitoring Interval	Monitoring Interval Length (in feet)	End Point Coordinates (Latitude/Longitude or Northing/Easting)		Time	Tide Elevation (MLLW)	Material at Surface of Slope Cap (Silt, Sand, Habitat Mix, Rip Rap, Quarry Spalls, Grout Mat, Other)
		START	FINISH			

Monitoring Interval	*CHECK ALL THAT APPLY*								Other Observations (Include Potential Evidence of Recontamination; Sheen, Discoloration, Staining, Etc.)
	Sediment Accretion	Seepage	Underlying Sediment Exposed	Erosion (Cap Matl. Missing)	Debris	Downslope Movement	Grout Mat Exposed	Grout Mat Settlement or Cracking	
	☐	☐	☐	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	☐	☐	☐	
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LOW-TIDE SLOPE CAP INSPECTION FORM

Thea Foss and Wheeler Osgood Waterways OMMP

PHOTO DOCUMENTATION

Date: ______________________

Weather: ______________________

Remedial Area: ______________________

Field Personnel: ______________________

Monitoring Interval	Photograph Number	Location Along Transect (in feet)	Direction	Latitude/Longitude (Northing/Easting)	Time	Notes

Additional Notes: (For additional photo points, identify reason for taking additional photograph)

LOW-TIDE SLOPE CAP INSPECTION FORM

Thea Foss and Wheeler Osgood Waterways OMMP

MONITORING INTERVAL TRANSECT DIAGRAM

Date: ____________________

Field Personnel: ____________________

Monitoring Interval: ____________________

<u>Monitoring Interval Transect Notes:</u>

1) Provide General Sketch of Observations Along Transect
2) Delineate Extent of Cap Integrity Issues (if present)
3) Label Photo Point Locations
4) Label North Arrow
5) Draw Diagram So That Monitoring Interval Fills Diagram Box (i.e., Monitoring Interval Endpoints are Shown at Sides of Diagram Box
6) Note Approximate Location of Water Surface & Top of Bank
7) Provide Approximate Location of Upper Limits of Slope Cap
8) Delineate Presence of Debris (if present)

<u>Scale 1” = 10’</u>

Additional Notes: (If cap disturbance is observed, discuss potential causes and extent of disturbance)

Appendix B

Sediment Sampling Operations Manual

B.1 INTRODUCTION

This manual has been prepared to provide direction and procedures for completion of all sediment sampling activities as part of the Operations, Maintenance, and Monitoring Plan (OMMP) for the Thea Foss and Wheeler-Osgood Waterways Remediation Project.

The purpose of performing sediment sampling is to confirm the remediation areas of the site are in compliance with performance criteria and to provide an early warning of potential recontamination. The objectives of this program are presented below and described in Sections 2.0 and 3.0 of the OMMP.

- Confirm the chemical integrity of cap areas (i.e., cap has not been breached by migrating contaminants);
- Verify natural recovery/enhanced natural recovery is occurring within the 10-year compliance period; and
- Verify surface sediments within the remediation areas have not been recontaminated above the Sediment Quality Objectives (SQOs).

The following sediment sampling efforts are to be completed as part of this OMMP. A schedule for sediment monitoring is presented in Table B-1 and summarized below:

- **Performance Surface (0 to 10 cm) Monitoring.** Performance surface monitoring will include sampling the upper 10 cm of the sediment column in channel sand cap, slope cap and natural recovery/enhanced natural recovery areas to evaluate chemical integrity of the caps and to verify natural recovery progress. Samples will be collected for chemical and/or biological characterization using a surface grab sampling device (channel sand cap and natural recovery samples) and by hand as composite grabs (slope cap samples).

  Baseline performance surface samples will be collected during Year 0 at the locations shown on Figure B-1. Additional performance surface samples will be collected at the locations shown on Figure B-2 during Years 2, 4, 7, and 10 as part of the long-term monitoring program.

- **Early Warning Surface (0 to 2 cm) Monitoring.** Early warning surface monitoring will include sampling the upper two cm of the sediment column within all remediation areas to evaluate the potential for recontamination. Early warning samples will be collected for chemical testing using a surface grab sampling device.

  Early warning samples will be collected at the locations shown on Figure B-3 during Years 2, 4, 7, and 10.

- **Subsurface Sampling.** Pending results of chemical and/or biological testing, subsurface samples (SS) may be collected within capped areas to evaluate the potential for through-cap contaminant transport. Subsurface samples will be collected using coring or other appropriate methods.

  Subsurface sample collection locations and schedule will be determined on an as-needed basis after test data has been evaluated for the performance surface monitoring samples.

Low tide slope cap inspections will be performed at the same time slope cap composite samples are collected in OMMP monitoring Years 2, 4, 7, and 10. Activities related to low tide slope cap inspections are covered separately in the Physical Cap Integrity Operations Manual (Appendix A of the OMMP).

This manual is organized into the following sections:

- Preparation for Sediment Sampling;
- Sediment Sampling Procedures; and
- Sediment Sampling Completion Procedures.

Attachment B-1 presents the Quality Assurance Project Plan (QAPP) for performing chemical analyses for the sediment monitoring programs and Attachment B-2 presents the QAPP for performing biological toxicity testing if necessary. Appendix F presents the project-specific Health and Safety Plan. The Health and Safety Plan will be reviewed prior to performing sediment sampling activities.

B.2 PREPARATION FOR SEDIMENT SAMPLING

B.2.1 Review and Understand this Manual

In preparation for sediment sampling and before conducting field work, all personnel involved with the work must read and become familiar with this Sediment Sampling Operations Manual, the HSP requirements, and Sections 2.0 and 3.0 of the OMMP (including all relevant tables and figures). The following sections describe the tasks that must be completed prior to start of field activities. If questions arise, information should be requested from the City's Project Manager.

B.2.2 Determine Low Tide Periods for Collection of Slope Cap Composite Samples (Performance Surface Monitoring)

Review low tide predictions before collecting slope cap composite samples and establish a schedule that incorporates completion of all sample collection activities during periods when surface water elevations are below elevation 0 feet Mean Lower Low Water (MLLW). Reliable tide prediction information can be found at www.tidesandcurrents.noaa.gov (if available, use Station Number 9446484 to obtain tide prediction data for Tacoma, WA).

B.2.3 Schedule and Site Access Notifications for Performance and Early Warning Monitoring Activities

The City's Project Manager will begin contacting property owners approximately 45 days in advance (or as otherwise agreed) of performing performance and early warning monitoring activities. The Project Manager will also be responsible for coordinating the following tasks:

- Permission and access availability to all required sampling areas (e.g., marinas, slope caps located on private land, etc.). Proposed survey dates may need to be changed depending on access availability;
- Availability of dock space for moorage of the survey vessel (as necessary);
- Locations where field vehicles should be parked while working on private properties; and
- Any other potential restrictions.

After schedules are established and site access has been arranged, EPA will be notified of the sediment sampling schedule a minimum of 30 days prior to initiation of the work.

Table B-2 presents a list of individuals to contact prior to performing sediment sampling activities. Table B-2 should be updated as needed to facilitate pre-sampling planning activities for each monitoring event.

B.2.4 Coordination with the Chemical and Biological Laboratories

At least two weeks before each sampling event, the chemical laboratory should be notified and the following should be discussed with the Laboratory project manager:

- Date of sampling, number of samples to be collected, and date of sample delivery to laboratory;
- Analyses to be performed, including required detection limits and laboratory QA/QC;
- Number and type of jars needed and time of bottle delivery;
- Date results are needed (i.e., requested analytical turn-around);
- Sample disposal; and
- Other analytical requirements or work order issues.

If sediment samples are being collected for biological toxicity testing, the following topics should be discussed with the biological laboratory Project Manager in addition to those mentioned above:

- Conventional sediment parameters to be measured for each bioassay test sediment; and
- Bioassays to be performed, including test species, availability, and laboratory QA/QC.

If an outside laboratory is used (e.g., for biological testing), the requirements for analytical methods, sample quantitation limits, and quality control requirements for each analysis must be specified. Any deviations from these requirements by the laboratory must be approved beforehand by the Project Manager and EPA.

Tables B-3 and B-4 present summary lists of sampling requirements and chemical analytes and should be used during coordination with the chemical and biological laboratories. Prior to ordering sample jars from the laboratory, evaluate the need for collection of spilt samples for archive and potential additional chemical and/or biological analyses. Collection of additional sample volume may reduce future field efforts in the event test results indicate that additional analyses are required.

Upon receiving sample jars from the laboratory, verify all necessary containers are present. Review minimum required sample volumes and identify specific jars that are required for each analysis to be performed. Label containers and organize them into coolers. Prepare necessary ice packs and other materials, as necessary, for jar protection and sample preservation.

B.2.5 Contact Subcontractors

If subcontractors are to be utilized by the City to assist with completion of sediment sampling activities, appropriate individuals should be contacted as soon as preliminary scheduling is complete. Planned field work must be coordinated with the subcontractors and the following topics should be addressed.

- Personnel availability and estimated duration of field work;
- Number of personnel needed for the desired operation;
- Proposed equipment and techniques required for compliance with the QAPP for sediment sampling;
- Number of personnel that may be on-board the sampling vessel at any given time;
- Evaluation of pre-sampling preparation including travel time (as necessary), contracting, equipment shipping, software/map needs, and review of these manual and other applicable sources of information;
- Access to sampling areas;
- Sampling approach and layout; and
- Any other work order issues.

Prior to the start of sediment sampling activities, the contractor will coordinate with the Project Manager to discuss the sampling approach, equipment, and methods to be used. Additionally, the contractor and Project Manager will discuss potential access restrictions within heavy use areas (marinas, industrial piers, etc.) so that a sequencing plan can be developed that allows for sampling to be performed at all required locations. The City will provide upland and sediment sample location control to the contractor.

B.2.6 Organize Field Equipment and Supplies

Begin organizing required field equipment and supplies well in advance of the start of sampling activities. Check all field equipment and supplies to ensure they are properly calibrated and in acceptable working order.

Table B-5 presents a summary checklist of field equipment and supplies that will be required to complete sediment sampling activities.

B.2.7 Location Control

The location control requirement for collection of performance and early warning samples is to accurately return to the sampling locations (+/- 10 feet) identified on Figures B-1, B-2, and B-3 when performing subsequent sampling events. In order to accomplish this requirement, a GPS unit will be used to record monitoring coordinate locations during all sediment sampling activities. Established survey benchmark locations on land that will be readily accessible for the duration of the OMMP are also shown on Figures B-1, B-2, and B-3. The GPS unit to be used during sample collection should always be checked at two or more of these benchmark locations before starting sediment sampling activities to ensure it is operating within the required level of accuracy (i.e., real-time differential correction is performing properly).

Vertical control parameters to be measured for performance surface (excluding slope cap composite samples) and early warning monitoring are depth to sediment (mudline) and tidal elevation. The depth to sediment should be measured before and after each sampling event using a calibrated depth sounder or leadline measurement tool.

Vertical control for slope cap composite sediment sampling is the requirement that samples be collected between approximately 0 feet MLLW and -2 feet MLLW, which corresponds to the approximate midpoint of the cap that is exposed during low tide.

The following parameters will be documented at each sampling location;

- Horizontal location coordinates (latitude/northing and longitude/easting);
- Datum referencing recorded horizontal coordinates and vertical elevations;
- Predicted tidal elevation referenced to Mean Lower Low Water (MLLW);
- Estimated sample elevations in feet using predicted tide elevations and depth to mudline measurements; and
- Time and date.

Prior to performing sampling activities, field personnel should obtain predicted tidal elevation information as described in Section B.2.2 to be used to determine water surface elevations at the time of sampling. Additionally, the predicted tide elevations should be verified with actual recorded tide elevations after sampling activities are complete.

B.3 SEDIMENT SAMPLING PROCEDURES

This section describes the procedures to be used for all sediment monitoring activities included under this OMMP. A schedule of sampling events is presented in Table B-1.

B.3.1 General Approach

Performance (0 to 10 cm) Monitoring. Performance surface samples (channel sand cap and/or natural recovery) will be collected from designated natural recovery and capped areas during OMMP monitoring event Years 0, 2, 4, 7, and 10 using a surface grab sampling device to achieve the cap performance objectives described in Section 2.1 of the OMMP. Methods and procedures for collection of performance surface samples are discussed in Section B.3.3.1 of this manual.

Slope cap composite samples will be collected by hand during OMMP monitoring event Years 2, 4, 7, and 10. Methods and procedures regarding collection of slope cap composite samples are presented in Section B.3.3.2 of this manual.

Additional performance surface sediment samples may be collected for biological analysis if chemical test results indicate the sediment surface exceeds chemical SQO criteria. Sediment for use in biological tests will be collected using the same procedures as sediment collected for chemical analyses with minor modifications as described below in Section B.3.3.

The surface sample field forms provided in Attachment B-3 should be used to record required field information during collection of performance surface samples.

Subsurface Sampling. Subsurface samples (SS) will potentially be collected if results of performance surface monitoring indicate potential through-cap contaminant transport may be occurring. Methods and procedures regarding collection of subsurface samples are presented in Section B.3.3.3.

Subsurface sample field forms provided in Attachment B-4 should be used to record required field information during collection of subsurface samples.

Early Warning (0 to 2 cm) Monitoring. Early warning surface samples will be collected from all remediation areas during OMMP monitoring event Years 2, 4, 7, and 10 using a surface grab sampling device to provide early warning indication of potential recontamination. Methods and procedures regarding collection of early warning surface samples are similar to those required for performance surface sample collection and are presented in Section B.3.3.1.

Surface sample field forms should be used for recording required field information during collection of early warning surface samples.

In addition to collecting performance and early warning samples, field duplicate and rinseate blank samples will be collected at a frequency of one per twenty samples, and matrix spike/matrix spike duplicates will be conducted at a frequency of one per sample group or twenty samples (as described in Section B-1.6 of Attachment B-1). Procedures for assigning proper laboratory methods and control regarding chemical and biological analyses are presented in Attachments B-1 and B-2.

B.3.2 Arrival at the Site

As equipment is being loaded aboard the vessel, stow sampling and storage equipment in appropriate areas. Check the GPS to ensure it is properly functioning. Coordinates for the proposed sampling locations should be pre-entered into the location control software program.

Before leaving the dock or starting sample collection, conduct a Health and Safety meeting to establish the work zone areas and to identify potential vessel hazards, and to establish the boat operator's specific health and safety guidelines. Be sure that personnel working at the site understand and sign the Health and Safety Plan (Appendix F).

B.3.3 Sediment Sampling

Proposed performance and early warning surface sample locations for baseline (Year 0) and subsequent monitoring events (Years 2, 4, 7, and 10) are shown on Figures B-1, B-2, and B-3. Sampling procedures and handling protocols for these sediment sampling activities are described below.

B.3.3.1 Performance Surface (0 to 10 cm) and Early Warning Surface (0 to 2 cm) Sediment Sampling

Performance (natural recovery and channel sand cap) surface and early warning surface samples will be collected in general accordance with Puget Sound protocols as outlined in the Puget Sound Estuary Program (PSEP) (Tetra Tech 1986) and as specified herein. Methods may be updated or revised as directed by EPA or the City. If there are procedures or protocols specified below that conflict with PSEP, the statements of this document shall take precedence. A surface grab sampler will be used to collect surface sediment samples.

The general procedure for collecting surface sediment samples is as follows:

1. Follow the pre-sampling procedures discussed above and verify survey benchmarks as described in Section B.2.7.
2. Make field form and notebook entries as necessary throughout the sampling process to ensure thorough and accurate recordkeeping.
3. Maneuver the sampling vessel to the proposed sampling locations shown on Figures B-1, B-2, and B-3, and verify location control using the positioning procedures described in Section B.2.7.
4. Open the sampler and slide the locking pin into place.
5. Signal the winch operator to lift the sampler.
6. Guide the sampler overboard until it is clear of the vessel and remove the locking pin.
7. Lower the sampler through the water column to the bottom, on the sampling location at approximately 1 foot per second (fps).
8. Record the coordinate location on the field form and verify the cable is plumb.

9. Record the time, depth to mudline below water surface, and estimated tide elevation on the field form.
10. Signal the winch operator to begin retrieving the sampler and raise it at approximately 1 fps.
11. Guide the sampler on board the vessel and place it on the work surface on the deck. Use care to avoid jostling that might disturb the integrity of the sample.
12. Examine the sample for the following sediment acceptance criteria:
    - Sampler jaw is closed;
    - The sample does not contain foreign objects;
    - The sampler is not overfilled so that the sediment surface presses against the top of the sampler;
    - No leakage has occurred, as indicated by overlying water on the sediment surface;
    - No sample disturbance has occurred, as indicated by limited turbidity in the overlying water;
    - No winnowing has occurred, as indicated by a relatively flat undisturbed surface; and
    - A penetration depth of at least 11 cm has been achieved.

    If sample acceptance criteria are not achieved, the sample will be rejected and the location resampled. If the proposed sampling location cannot be achieved notify the Project Manager to determine an appropriate alternate location.
13. Siphon off any standing water from the surface of the sediment using a hose primed with site water. Care should be taken to not disturb the integrity of the sediment surface.
14. Visually classify sediment in accordance with ASTM D 2488 methods and the Unified Soil Classification System (ASTM D 2487) using the Soil and Stratigraphic and Geotechnical Field Guides (Attachments B-5 and B-6) and record on the field form. In addition to the visual classification, qualitative descriptive parameters including biota, debris, staining, sheen, etc. should also be recorded.
15. A digital photograph of the sample should be taken next. The surface of the sediment should be photographed prior to removal from the sampler. The sample location name and grab replicate number will be written with a large felt-tip marker on a sheet of paper, which will be photographed next to, but not touching, the sediment sample. Additional information regarding sample naming conventions is presented in Section B.4.1.
16. Depending upon the sampling location collect either the upper 2 cm or the upper 10 cm of sediment from the sampler using a stainless steel implement. Take care not to include any material that has been in contact with any interior sampler surface. Place sediment into a decontaminated, appropriate-sized stainless steel homogenization bowl.

17. Thoroughly rinse the interior of the sampler until all loose sediment has been washed off. Excess sediment will be returned to the sample location to prevent disturbance to other sampling locations.
18. Repeat the sampling process (if necessary) until sufficient volume is obtained to satisfy the sampling requirements for each location. Collect successive grab samples within a radius of 10 feet of the initial sampling location. Successive grab samples will be placed in a covered container until sufficient volume is obtained. Ensure sufficient sample volume is collected for split samples (as necessary) to be archived for potential future analyses.
19. Homogenize the bulk sediment until the sediment appears uniform in color and texture.
20. Distribute the homogenized sediment to appropriate sample containers identified in Table B-3 and ensure that sample labels are completely filled out and affixed to the containers (see Section B.4.1 for sample labeling conventions and additional information).

    For collection of performance samples to be submitted for biological toxicity testing, distribute the homogenized sediment to appropriate sample containers identified in Table B-2-1 and ensure that sample labels are completely filled out and affixed to the containers (see Section B.4.1 for sample labeling conventions and additional information).
21. Clean the exterior of all sample containers and store them in a cooler containing ice away from the immediate work area aboard the boat.
22. Thoroughly decontaminate the sampler by following the procedure in Section B.3.4.
23. Ensure that sediment descriptions and supporting field form entries are complete.
24. Proceed to the next proposed sampling location.

Sampling for biological toxicity testing should be conducted using the procedures described above and those discussed in Attachment B-2. Multiple surface grabs may be necessary to obtain required sediment volume for bioassay testing (a minimum of six liters of sediment is needed for each full suite of bioassay tests. Additionally, suitable reference sediments for the bioassays will be collected from Carr Inlet and a rapid grain size analysis will be performed to provide an initial match of reference sediments with that of the test sediments. Information regarding the completion of a rapid grain size analysis is presented in Attachment B-2 (Quality Assurance Project Plan for Bioassay Testing).

B.3.3.2 Slope Cap Composite Sediment Sampling

Slope cap composite samples will be collected within the areas shown on Figure B-2 during Years 2, 4, 7 and 10. Three discrete surface (0 to 10 cm) samples (A, B and C) will be collected within each area and then homogenized to form the slope cap composite sample. The general procedure for collecting slope cap composite samples is as follows:

1. Follow the pre-sampling procedures discussed above and verify survey benchmarks as described in Section B.2.7.

2. Proceed to desired sample collection area and record the sample location coordinates and number.
3. Make field form and notebook entries as necessary throughout the sampling process to ensure thorough and accurate recordkeeping.
4. Using a clean, stainless steel spoon (or shovel), collect a minimum 8-ounce sediment sample at each discrete composite location shown on Figure B-2. Additional sample volume may be required if split samples are being collected for potential confirmation and/or biological testing. Discrete samples should be placed into a large stainless steel bowl for homogenization. Collection spoons/shovels should be decontaminated as described in Section B.3.4.
5. At each discrete sample location, record the composite sample number (A, B or C, as determined in the field), time, coordinates, and predicted tide elevation on the field form. Additionally, provide any supplemental observations (i.e. staining, sheen, biota, etc.) that may be relevant. If sediment sampling is not possible within approximately 50 feet of the desired location (due to grout mat, etc.), a note should be made on the field form.
6. A digital photograph of each discrete sample should be taken. The camera should be set to print the date and time of the photograph. The surface of the sediment should also be photographed to document the condition of the slope cap.
7. After collection of all discrete samples (as indicated on Figure B-2), homogenize the bulk sediment until the sediment appears uniform in color and texture. Visually classify sediment in accordance with ASTM D 2488 methods and the Unified Soil Classification System (ASTM D 2487) using the Soil and Stratigraphic and Geotechnical Field Guides (Attachments B-5 and B-6) and record the description on the field form.
8. Distribute the homogenized sediment to appropriate sample containers identified in Table B-3 and ensure that sample labels are completely filled out and affixed to the containers (see Section B.4.1 for sample labeling conventions and additional information). Note: If sediment samples are being collected for conventional analysis for biological testing, do not homogenize sediment for total volatile solids or sulfides analyses.
9. Clean the exterior of all sample containers and store them in a cooler containing ice away from the immediate work area.
10. Thoroughly decontaminate the sampling equipment by following the procedure in Section B.3.4.
11. Ensure the sediment descriptions and supporting field form entries are complete.
12. Once sampling and decontamination is complete, proceed to the next sampling location and repeat the above procedure(s).

B.3.3.3 Subsurface Sediment Sampling

Subsurface samples (SS) may be collected to evaluate the potential for contaminant migration upwards through the cap. Subsurface sampling, if performed, will be done using a coring device or other appropriate methods as determined by sampling location conditions. The general procedure for collecting subsurface samples is as follows:

1. Follow the pre-sampling procedures discussed above and verify survey benchmarks as described in Section B.2.7.
2. Make field form and notebook entries as necessary throughout the sampling process to ensure thorough and accurate recordkeeping.
3. Maneuver the sampling equipment to the proposed sampling location.
4. Deploy subsurface sampler at designated location.
5. Record the coordinate location and number on the field form.
6. Record the time, depth to mudline, and estimated tide elevation on the field form.
7. Drive the sampling device into the sediment.
8. Collect a continuous subsurface sample to five feet depth (or entire cap thickness at the sampling location) or until refusal occurs.
9. Measure the depth of penetration and record it on the field form.
10. Extract the subsurface sample collection device.
11. Examine the sample relative to the following acceptance criteria:
    - Overlying water is present and the surface is intact;
    - Calculated compaction is not greater than 25 percent; and
    - The sampling device appears intact without obstructions or blocking.

If inspection of the sample recovery meets these criteria then proceed with sample processing. If sample processing is not performed in the field, keep the subsurface samples at 4 degrees C during shipment and storage.

Subsurface sediment samples should be processed within 24 hours of collection by a qualified scientist with sufficient logging experience. To begin processing, retrieve the samples from storage and verify sample identification (see Section B.4.1 for sample labeling information).

The general procedure for processing and logging subsurface samples is as follows:

1. Following the opening of the sample, measure and record the sediment recovered height and compare to the field records.
2. Calculate sediment compaction and establish compaction corrected depths for the entire length of the sample.
3. Record sediment descriptions on the Subsurface Sediment Sampling Form (Attachment B-4).
4. Divide the sample into desired subsamples using compaction corrected depths (maximum one-foot depth increments), and segregate the subsamples using decontaminated stainless steel dividing plates.

5. Photograph the longitudinally-sectioned sample. The digital camera should record the date and time of the photograph. The sample location name will be written on a sheet of paper or dry erase board, which will be photographed next to, but not touching, the sediment sample. The compaction corrected depth interval should be noted in the photograph.
6. Take care to avoid the sides of the sampling device when collecting sediment samples from the subsurface sampling device.
7. Homogenize the individual subsamples until the sediment appears uniform in color and texture.
8. Distribute the homogenized sediment to appropriate sample containers identified in Table B-3 and ensure that sample labels are completely filled out and affixed to the containers.
9. Clean the exterior of all sample containers and store them in a cooled ice chest away from the immediate work area.
10. Thoroughly decontaminate the sampling equipment by following the procedure in Section B.3.4.
11. Ensure that sediment descriptions and supporting field form entries are complete, including time and location of subsample collection.

Once processing is complete, proceed to the next stored sample or proposed sampling location and repeat the above procedure(s).

B.3.4 Field Equipment Decontamination

Decontamination is necessary for equipment that contacts any sample material prior to collecting the next sample. The decontamination procedure will include a phosphate-free detergent wash and successive rinse between all sampling locations. No solvent or acid washes will be used because of safety, rinseate disposal, and sample integrity considerations.

This decontamination procedure, based on PSEP protocols (Tetra Tech 1986), is designed to prevent cross-contamination between sample locations. Before each use, equipment will be decontaminated between sample locations aboard the sampling vessel or on the shore according to the following procedure:

- Spray water over equipment to dislodge and remove any remaining sediments from previous sample location;
- Scrub surfaces of equipment contacting sample material with brushes using an Alconox solution;
- Rinse equipment with clean tap water; and
- Rinse equipment with a final spray of deionized water to remove tap water impurities.

This process will be repeated prior to sampling as necessary.

B.4 SAMPLE LABELING, HANDLING AND TRANSPORT

B.4.1 Sample Labeling

A unique sample identification number is assigned to each set of sample jars and associated documentation. The sample identification number will be assigned as follows:

Sample Type - Sample Location - Monitoring Year - Sample Designation

Where:

Sample types are the following:

- CC = Channel Cap (0 to 10 cm)
- NR = Natural Recovery (0 to 10 cm)
- EW = Early Warning (0 to 2 cm)
- SC = Slope Cap (0 to 10 cm)
- BR = Benthic Recolonization (see Section 4.0 of the OMMP)
- SS = Subsurface Sample
- SR = Slope Rehabilitation (0 to 10 cm)

Sample locations and numeric identifications are shown on Figures B-1, B-2, and B-3.

Monitoring years are the following:

- Y0 (Year 0)
- Y2 (Year 2)
- Y4 (Year 4)
- Y7 (Year 7)
- Y10 (Year 10)

Sample designations are the following:

- D - designates a sample representing the discrete location associated with a slope cap composite sample;
- C - designates a confirmational sample; and
- B - designates a sample collected for biological testing.

The sample type designation should be followed by '1', '2' or '3' to identify the unique discrete sample location for slope composite samples.

For example, a sample with the identification number ***SC-34-Y7*** would represent the initial slope cap composite sample collected at location 34 during monitoring year 7.

Additionally, a sample with the identification number ***SC-34-Y7-D1-C*** would represent a confirmation sample collected at discrete location ‘1’ comprising slope cap composite sample location 34 during monitoring year 7.

Sample labels will also clearly indicate sampling locations, sample number, the project name, sampler’s initials, analysis to be performed, date, and time. Labels will be filled out prior to sampling and affixed to the sample jars. The sample jar labels, chain-of-custody forms, and field description forms should all contain the identical sample ID number for accurate cross-referencing.

B.4.2 Sample Custody

After recovery, samples will be maintained in custody until formally transferred to the laboratory. For purposes of this work, custody will be defined as follows:

- In plain view of the field representatives;
- Inside a cooler which is in plain view of the field representative; or
- Inside any locked space such as a cooler, locker, car, or truck to which the field representative has the only immediately available key(s).

A chain of custody record will be initiated at the time of sampling for each sample collected. This record will be signed by the field representative and others who subsequently hold custody of the sample. Additional fields on the custody form that need to be filled out indicate the initials of the person completing the form, the sample collection date and time, the required sample analyses, and the total number of containers for each sample. A copy of the chain of custody with all the appropriate signatures will be returned to the Project Manager.

Samples collected for biological toxicity testing typically have one chain-of-custody form for the bioassay test samples, and a second custody form for the conventional sediment parameters analysis.

B.4.3 Shipping Procedures

Prior to shipping or transport to the laboratory, sample containers will be appropriately packed and secured inside a cooler with ice packs. The original signed custody forms will be transported with the cooler. The cooler will be secured and appropriately labeled (if being shipped). Samples will be delivered to the laboratory under custody control protocols following completion of sampling activities.

The bioassay sediment containers and containers for conventional analyses should be placed in a cooler with sufficient ice packs to cool and maintain the samples at a low temperature until delivery to the laboratory.

REFERENCES

EPA. 1989. Commencement Bay Nearshore/Tideflats Record of Decision, U.S. Environmental Protection Agency, Region 10. September 1989.

Tetra Tech Inc. 1986 (as updated through 1996). Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound. Puget Sound Estuary Program.

TABLES

FIGURES

ATTACHMENTS

Table B-1
Sediment Monitoring Schedule

	Monitoring Year (Calendar Year)										
Monitoring Activity	Year 0 (2006)	Year 1 (2007)	Year 2 (2008)	Year 3 (2009)	Year 4 (2010)	Year 5 (2011)	Year 6 (2012)	Year 7 (2013)	Year 8 (2014)	Year 9 (2015)	Year 10 (2016)
Performance Surface Monitoring											
Natural Recovery Sampling	**X**		**X**		**X**			**X**			**X**
Channel Cap Sampling			**X**		**X**			**X**			**X**
Slope Cap Composite Sampling			**X**		**X**			**X**			**X**
Early Warning Monitoring			**X**		**X**			**X**			**X**

Table B-2
Regulatory Project Manager and Private Property Owner Contact List

Regulatory Project Manager	Contact Name	Contact Address	Phone Number / Email Address
U.S. EPA, Region 10	Piper Peterson Lee	1200 Sixth Ave. Mail Stop: ECL-113 Seattle, WA 98101	(206) 553-4951 peterson-lee.piper@epa.gov

Private Property Owner	Contact Name	Contact Address	Phone Number
Totem Marine Services	Red Westgard	820 E. D St. Tacoma, WA 98421	(253) 572-2666
Foss Waterway Marina	Tracy McKendry	821 Dock St. Tacoma, WA 98402	(253) 272-4404
Martinac Shipyards	Joe Martinac, Jr.	401 E. 15th St. Tacoma, WA 98421	(253) 572-4005
Delin Docks	Doug Hicks	1616 E. D St. Tacoma, WA 98421	(253) 272-4352
Johnny's Dock Marina	Dave Bingham	1900 E. D St. Tacoma, WA 98421	(253) 627 -3186
Dock Street Marina	Doug Hicks	1616 E. D St. Tacoma, WA 98421	(253) 272-4352
Foss Landing	Mike Norman	1940 E. D St. Tacoma, WA 98421	(253) 627-4344
Marine Floats	Wendell Stroud	1208 E. D St. Tacoma, WA 98421	(253) 383-2740
Foss Waterway Development Authority	Su Dowie	535 E. Dock St., # 204 Tacoma, WA 98402	(253) 597-8122

Table B-3
Summary of Sampling Requirements

Monitoring Type	Sample Collection Method	Sample Depth Interval	Analytical Parameters	Number (Type) Containers per Sample Location	Analytical Parameters per Container	Field Preservation Requirements
Channel Sand Cap Performance (CC)	Surface grab sampler	0 - 10 cm	Conventionals, Metals, SVOCs, Pesticides, PCBs	3 (8-oz. glass)	Conventionals & Metals	4°C/cool/dark
Natural Recovery Performance (NR)					SVOCs	
Slope Cap Performance (SC)	Hand grab				Pesticides & PCBs	
Early Warning (EW)	Surface grab sampler	0 - 2 cm	Conventionals, Metals, SVOCs, Pesticides, PCBs	2 (8-oz. glass)	Conventionals	4°C/cool/dark
					SVOCs	
					Pesticides & PCBs	
Biological Toxicity (B)	Surface grab sampler	0 - 10 cm	Conventionals, Metals, SVOCs, Pesticides, PCBs, Sediment Larval Test, Amphipod Bioassay, Juvenile Polychaete Bioassay	4 (8-oz. glass)	Conventionals & Metals	4°C/cool/dark
					SVOCs	4°C/cool/dark
					Pesticides & PCBs	4°C/cool/dark
					Grain Size	4°C/cool/dark
				1 (50-ml glass)	Bulk Sulfates	ZnOAc
				6 (1-liter glass)	Sediment Larval Test	Zero headspace for all bioassay sediments
					Amphipod Bioassay	
					Juvenile Polychaete Bioassay	

Notes:
1 See Table B-4 for a detailed list of analytes (per sample type), sediment quality objectives, and laboratory analytical methods.
2 Quality control samples (MS/MSDs, duplicates, etc.) will be collected on a frequency of 1 in 20 samples. Review Attachment B-1 for additional information.

Table B-4
Summary of Parameters for Sediment Sample Analysis

Monitoring Type	Analyte	Sample Type			SQO	Analytical Method
		CC/NR/SC	EW	B		
Conventionals	Total Organic Carbon in %	x	x	x	NA	EPA Method 9060
	Total Solids in %	x	x	x	NA	PSEP 1997
	Total Volatile Solids in %			x	NA	PSEP 1997
	Bulk Ammonia			x	NA	EPA/Plumb 1981
	Bulk Sulphides			x	NA	
	Grain Size			x	NA	PSEP 1997
Metals	Antimony	x	x	x	150 mg/kg	EPA Method 6010B
	Arsenic	x	x	x	57 mg/kg	
	Cadmium	x	x	x	5.1 mg/kg	
	Copper	x	x	x	390 mg/kg	
	Lead	x	x	x	450 mg/kg	
	Nickel	x	x	x	140 mg/kg	
	Silver	x	x	x	6.1 mg/kg	
	Zinc	x	x	x	410 mg/kg	
	Mercury	x	x	x	0.59 mg/kg	EPA Method 7471A
LPAHs	2-Methylnaphthalene	x	x	x	670 µg/kg	EPA Method 8270C
	Acenaphthene	x	x	x	500 µg/kg	
	Acenaphthylene	x	x	x	1,300 µg/kg	
	Anthracene	x	x	x	960 µg/kg	
	Fluorene	x	x	x	540 µg/kg	
	Naphthalene	x	x	x	2,100 µg/kg	
	Phenanthrene	x	x	x	1,500 µg/kg	
	Total LPAHs	x	x	x	5,200 µg/kg	

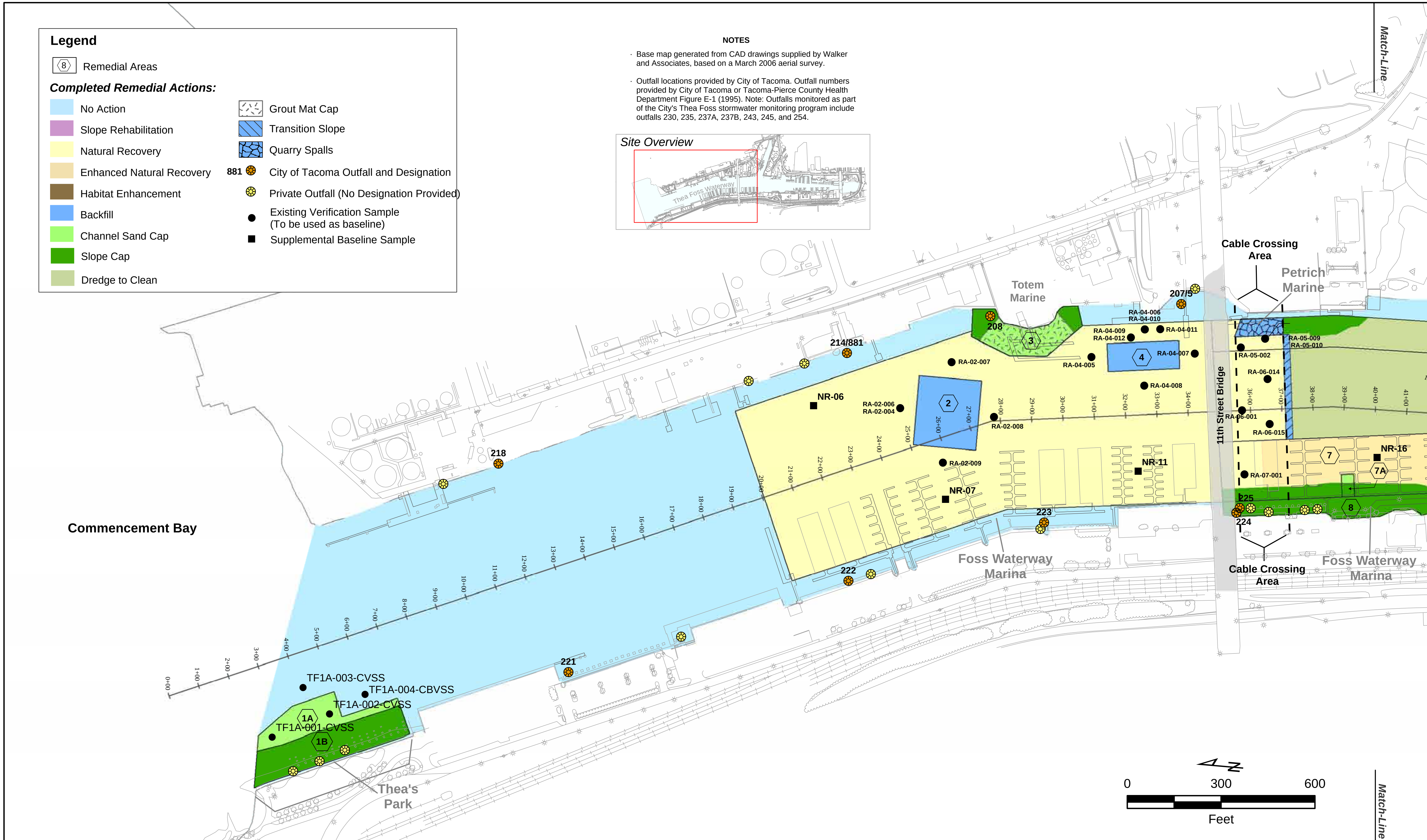
Monitoring Type	Analyte	Sample Type			SQO	Analytical Method
		CC/NR/SC	EW	B		
HPAHs	Benzo(a)Anthracene	x	x	x	1,600 µg/kg	EPA Method 8270C
	Benzo(a)Pyrene	x	x	x	1,600 µg/kg	
	Benzo(b)Fluoranthene	x	x	x	NA	
HPAHs (Continued)	Benzo(k)Fluoranthene	x	x	x	NA	EPA Method 8270C
	Total Benzofluoranthenes	x	x	x	3,600 µg/kg	
	Benzo(g,h,i)Perylene	x	x	x	720 µg/kg	
	Chrysene	x	x	x	2,800 µg/kg	
	Dibenz(a,h)Anthracene	x	x	x	230 µg/kg	
	Fluoranthene	x	x	x	2,500 µg/kg	
	Indeno(1,2,3-c,d)Pyrene	x	x	x	690 µg/kg	
	Pyrene	x	x	x	3,300 µg/kg	
	Total HPAHs	x	x	x	17,000 µg/kg	
Phthalates	Dimethylphthalate	x	x	x	160 µg/kg	EPA Method 8270C
	Diethylphthalate	x	x	x	200 µg/kg	
	Di-n-butylphthalate	x	x	x	1,400 µg/kg	
	Butylbenzylphthalate	x	x	x	900 µg/kg	
	Bis(2-Ethylhexyl)Phthalate	x	x	x	1,300 µg/kg	
	Di-n-octylphthalate	x	x	x	6,200 µg/kg	
Acid Compounds (Phenols)	Phenol	x	x	x	420 µg/kg	EPA Method 8270C
	2-Methylphenol	x	x	x	63 µg/kg	
	4-Methylphenol	x	x	x	670 µg/kg	
	2,4-Dimethylphenol	x	x	x	29 µg/kg	
	Pentachlorophenol	x	x	x	360 µg/kg	
	Benzyl alcohol	x	x	x	73 µg/kg	
	Benzoic acid	x	x	x	650 µg/kg	

Monitoring Type	Analyte	Sample Type			SQO	Analytical Method
		CC/NR/SC	EW	B		
Miscellaneous Compounds (Chlorobenzenes)	1,2-Dichlorobenzene	x	x	x	50 µg/kg	EPA Method 8270C
	1,3-Dichlorobenzene	x	x	x	170 µg/kg	
	1,4-Dichlorobenzene	x	x	x	110 µg/kg	
	1,2,4-Trichlorobenzene	x	x	x	51 µg/kg	
	Hexachlorobenzene	x	x	x	22 µg/kg	
	Dibenzofuran	x	x	x	540 µg/kg	
	Hexachlorobutadiene	x	x	x	11 µg/kg	
	N-Nitrosodiphenylamine	x	x	x	28 µg/kg	
Pesticides/PCBs	4,4'-DDD	x	x	x	16 µg/kg	EPA Method 8081 Or EPA Method 8270C
	4,4'-DDE	x	x	x	9 µg/kg	
	4,4'-DDT	x	x	x	34 µg/kg	
	PCB-1016	x	x	x	NA	EPA Method 8082 Or EPA Method 8270C
	PCB-1221	x	x	x	NA	
	PCB-1232	x	x	x	NA	
	PCB-1242	x	x	x	NA	
	PCB-1248	x	x	x	NA	
	PCB-1254	x	x	x	NA	
	PCB-1260	x	x	x	NA	
	Total PCBs	x	x	x	300 µg/kg	

Notes:
1 Analysis for Total Organic Carbon as related to biological toxicity testing will be completed using PSEP 1997 analytical method.
2 Method detection limits for sediment quality analyses must be at or below these SQOs.
3 Biological toxicity testing will include a sediment larval test, amphipod sediment bioassay, and juvenile polychaete bioassay in addition to the chemical analyses listed above.
B Biological Testing
CC Channel Cap
EW Early Warning
NA No SWO is defined for chemical analyte/parameter
NR Natural Recovery

Table B-5
Sediment Monitoring Field Equipment Checklist

Item	Purpose
Private property gate keys/codes (as necessary)	Access private properties for slope cap composite sample collection.
Sediment Sampling Operations Manual	Reference sample collection field procedures and Quality Assurance Project Plan.
Surface and subsurface sample collection field forms (also include sample completed forms)	Record inspection observations and data (provide reference for required form entries).
GPS unit	Record sample locations on field forms.
Surface Grab sampling device	Surface sample collection.
Subsurface sampling equipment	Subsurface sample collection (as necessary).
Sufficient sample jars	Sample collection for chemical and/or biological analysis.
Sufficient sample labels	Sample location designation in the field.
Sharpie pens	Recording information on sample labels.
Coolers and sufficient blue ice	Temporary sample storage.
Stainless steel spoons and bowls	Homogenizing samples in the field.
Digital camera	Photo documentation of samples and shoreline conditions.
Field notebook	Record field notes in addition to required field form entries.
Flashlight	Facilitate sampling activities if performed at night and under pier areas.
Tape measure	Used for subsurface processing (as necessary).



Thea Foss and Wheeler-Osgood Waterways OMMP	Figure B-1 (Page 1 of 2) Existing and Supplemental Sampling Locations

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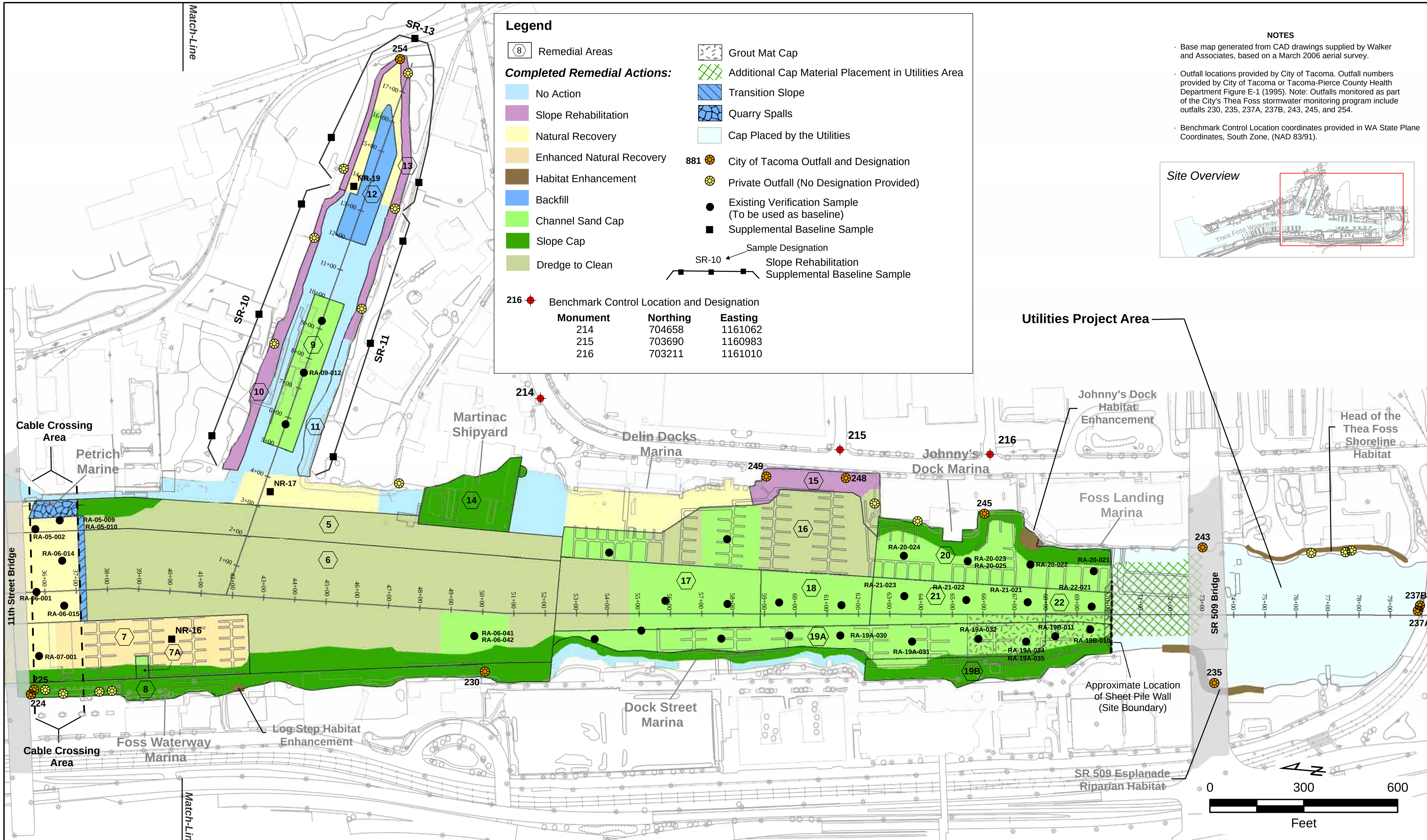

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Figure B-1 (Page 2 of 2)
Existing and Supplemental Sampling Locations

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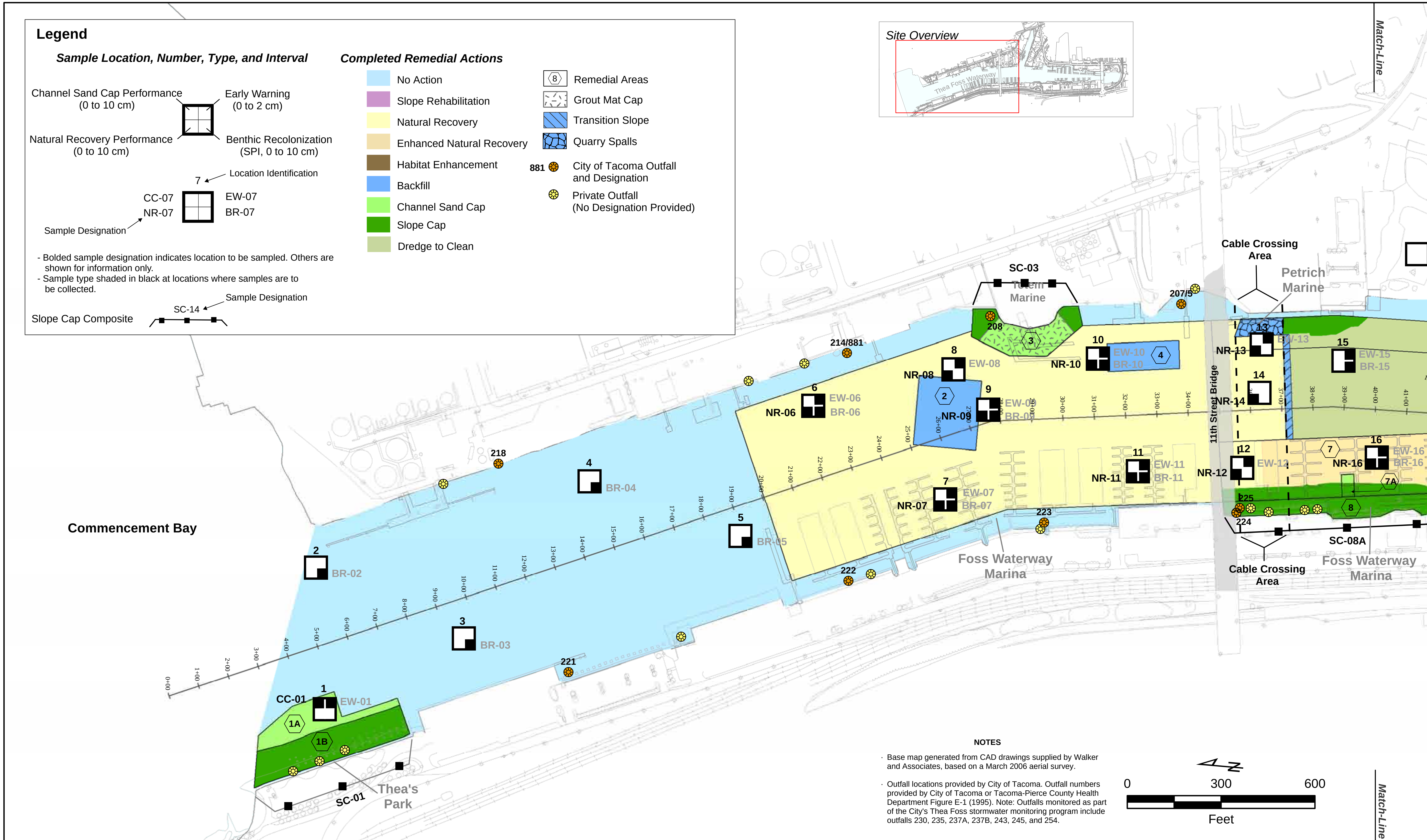

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Figure B-2 (Page 1 of 2)
Performance Monitoring Sampling Locations

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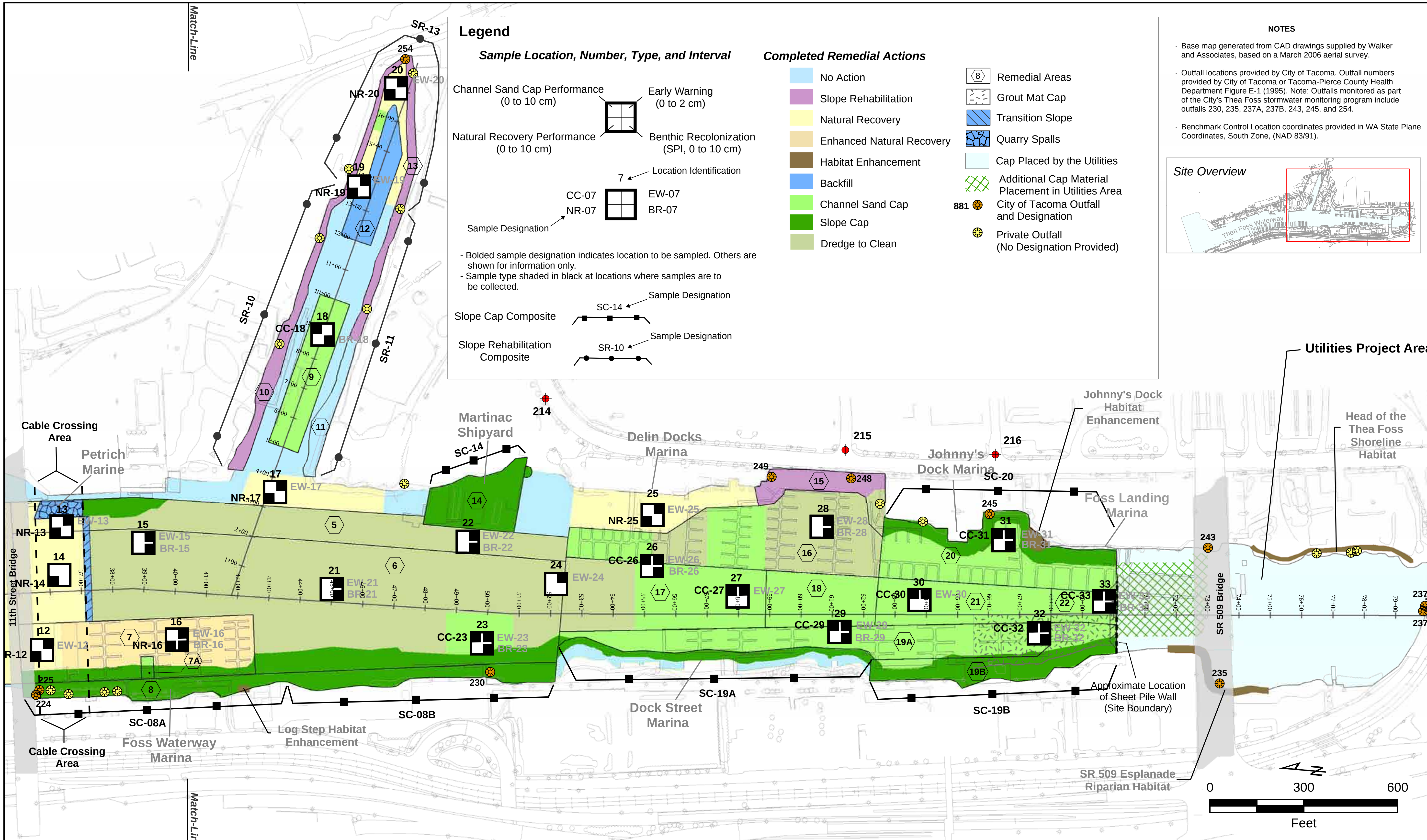

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Figure B-2 (Page 2 of 2)
Performance Monitoring Sampling Locations

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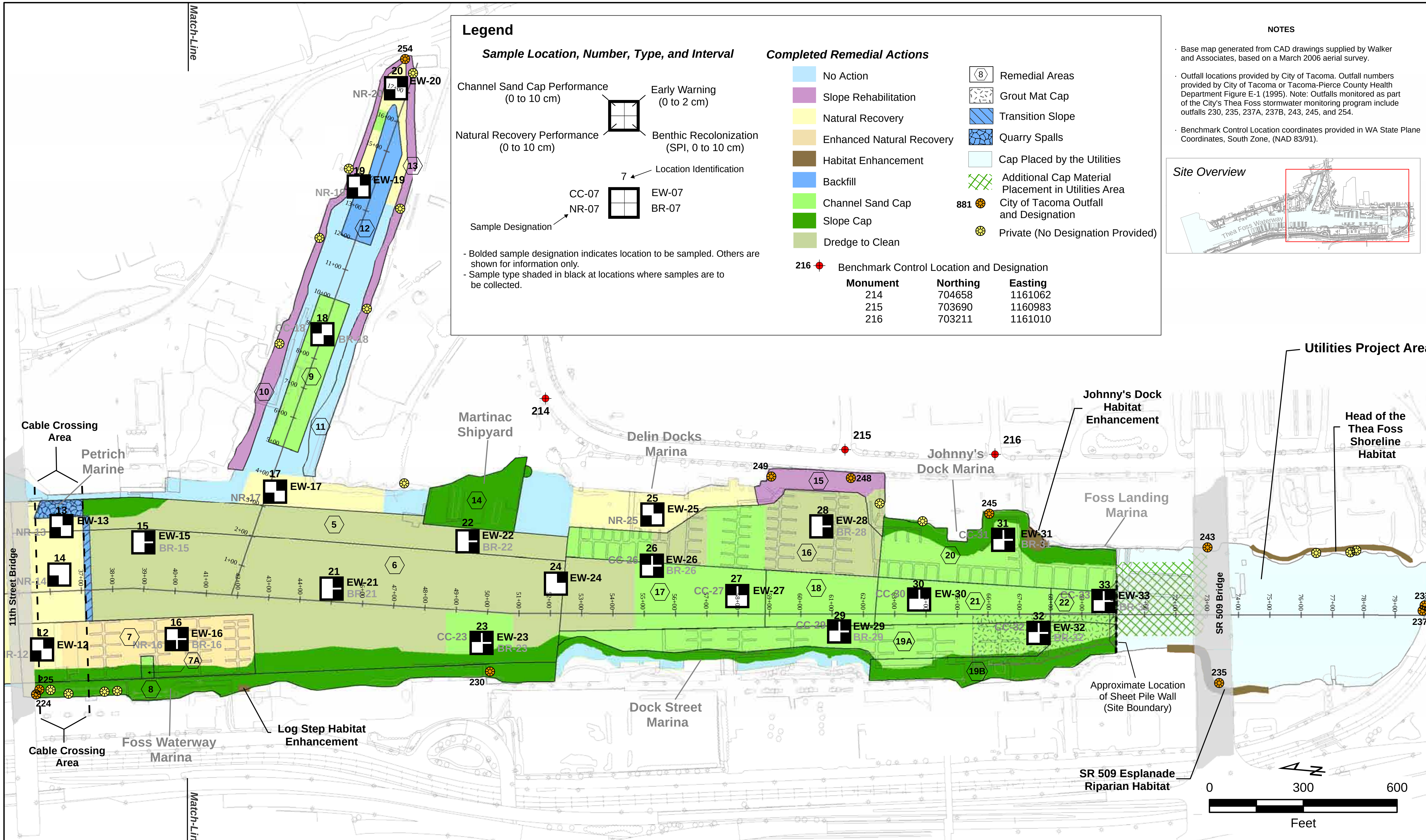

Thea Foss and Wheeler-Osgood Waterways OMMP

Figure B-3 (Page 1 of 2) Early Warning Monitoring Locations

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MXD NAME: F:\projects\KPFF Foss\GIS\Revised OMMP\Sediment Remediation Area Performance Monitoring\Figures-Revised w EPA Comment\Figure 3-1 Early Warning Monitoring (1of2) Revised 091306.mxd

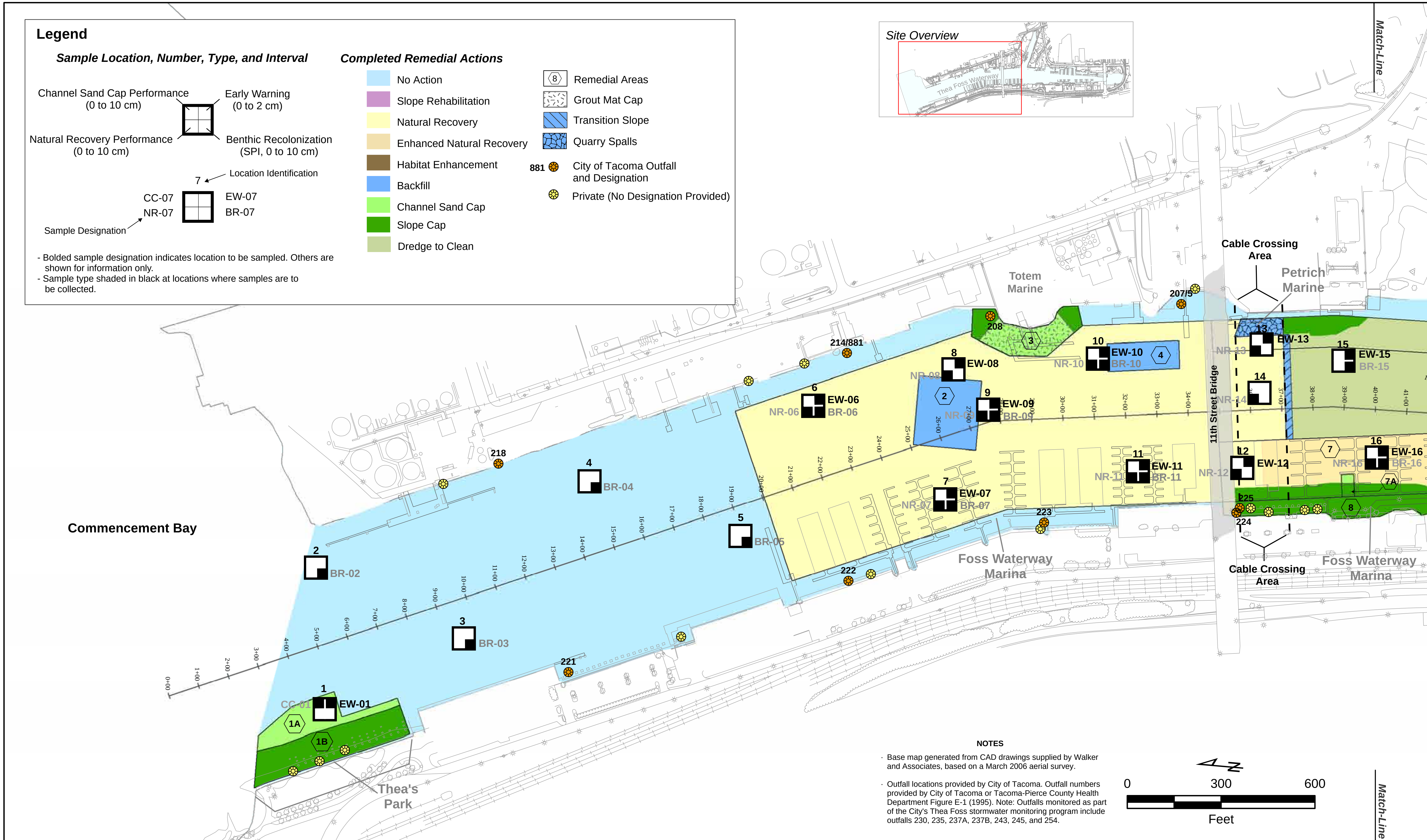

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Figure B-3 (Page 2 of 2)
Early Warning Monitoring Locations

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Attachment B-1

Quality Assurance Project Plan
for Sediment Chemistry Quality Analysis

B-1.1 INTRODUCTION

The purpose of this Quality Assurance Project Plan (QAPP) is to give the objectives, organization, and functional activities associated with the compliance sediment quality monitoring for the Thea Foss and Wheeler-Osgood Waterways Remediation Project. This QAPP covers analyses of sediment samples collected during the monitoring of recontamination, cap integrity, and natural recovery, as described in the OMMP. A number of EPA documents were used as aids in preparing this document (EPA 1986a, 1998, and 2000a).

B-1.2 QUALITY ASSURANCE OBJECTIVE

The quality assurance (QA) objective for this project is to ensure that the data collected are of known and acceptable quality so that the goal of the sediment quality monitoring program can be achieved. The goal of the sediment quality monitoring is to ensure that the project sediment capping and natural recovery activities meet the Sediment Quality Objectives (SQO) performance standards. The quality of the laboratory data is assessed by precision, accuracy, representativeness, comparability, and completeness (the "PARCC" parameters). Definitions of these parameters and the applicable quality control (QC) procedures are given below. Applicable data quality objectives for these data quality parameters are listed or referenced in Table B-1-1.

B-1.3 CONTRACT LABORATORY REQUIREMENTS

In completing chemical analyses for this project, the contract laboratory is expected to meet the following minimum requirements:

1. Be accredited in Washington State for the analyses to be performed;
2. Adhere to the methods outlined in the QAPP, including methods referenced for each analytical procedure;
3. Deliver fax, hard copy, and electronic data as specified;
4. Meet reporting requirements for deliverables;
5. Meet turnaround times for deliverables;
6. Implement QA/QC procedures, including the QAPP data quality requirements, laboratory QA requirements, and performance evaluation testing requirements; and
7. Allow laboratory and data audits to be performed, if deemed necessary.

B-1.4 CHEMICAL ANALYSES

Sediment samples will be submitted for chemical analysis of a combination of the following analytes:

- Semivolatile Organic Compounds (including Polycyclic Aromatic Hydrocarbons (PAHs));
- Polychlorinated Biphenyls (PCBs);
- Target Pesticides (4,4'-DDD, 4,4'-DDE, and 4,4'-DDT);
- Target Metals (arsenic, mercury, lead, zinc, and copper);
- Total Organic Carbon (TOC); and
- Total Solids

B-1.4.1 Semivolatile Organics Analysis

Sediment samples will be extracted by EPA Method 3545, accelerated solvent extraction. Sediment sample extracts will undergo gel permeation chromatography (GPC) cleanup using EPA Method 3640A. Other clean ups may be used. These may include but not be limited to copper, alumina, fluorocil, and sulfuric acid cleanups. Sample extracts will be analyzed by gas chromatography/mass spectrometry (GC/MS) using EPA Method 8270C.

B-1.4.2 4,4'-DDD; 4,4'-DDE; 4,4'-DDT; and PCB Analysis

The chlorinated pesticide, 4,4'-DDD, will be determined by either GC with electron capture detection (ECD), EPA Method 8081 with second column confirmation or by GC/MS according to EPA Method 8270C. If EPA Method 8081 is used for pesticide analyses, the results from EPA Method 8270 will be used to confirm the presence of pesticides that are detected above the Method 8270 reporting limits. It should be noted that the presence of hydrocarbons, nitrogen, sulfur, oxygen, or halogen containing compounds that are not removed by the GPC cleanup could cause interferences that may result in false positive results. Additionally, a PCB check standard should be run at the beginning of the pesticide analysis to be evaluated for PCB interferences (i.e., false positives for 4,4'-DDT). Professional judgment will be used during data validation to determine whether analytes reported at low level are actually present or are the result of interferences.

The extract for PCB analysis will be cleaned up with sulfuric acid, EPA Method 3665A, for removal of organics and, if required, then undergo copper cleanup for sulfur removal using EPA Method 3660B. PCBs will be determined by EPA method 8082, GC with ECD with second column confirmation or by GC/MS according to EPA Method 8270C.

B-1.4.3 Metals Analysis

Sediment samples for mercury analysis will be performed using the cold vapor atomic absorption technique, EPA Method 7471A. Sulfide is a known interference for the method, however, permanganate is added to remove any sulfide present in the sample.

Sediment samples for arsenic, copper, lead, and zinc analysis will be performed using EPA Method 6010. Microwave digestion will be performed for metals using EPA Method 3051.

B-1.4.4 Conventional Parameter Analyses

TOC will be determined using the Puget Sound Estuary Protocols (PSEP 1997) modification to EPA Method 9060.

B-1.4.5 Reporting Limits

Reporting limits will be at or below the SQOs unless elevated by sample dilution, matrix interference, or other sample-specific analytical difficulties. To achieve the SQOs specified in Table B-1-2, some modifications to the methods may be necessary. The analytical reporting limit goals are summarized in Table B-1-1 with additional data quality objectives. Any modifications from the specified analytical methods will be provided by the laboratory at the time of establishing the laboratory contract, and must be approved by the City and EPA.

B-1.5 LABORATORY QUALITY ASSURANCE OBJECTIVES

The quality of analytical data generated is assessed by the frequency and type of internal quality control checks developed for analysis type. Laboratory results will be evaluated by reviewing results for analysis of method blanks, matrix spikes, duplicate samples, laboratory control samples, calibrations, performance evaluation samples, interference checks, etc., as specified in the analytical methods used.

B-1.5.1 Precision

Precision measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average values. Analytical precision is measured through matrix spike/matrix spike duplicate (MS/MSD) samples for organic analysis and through laboratory duplicate samples for inorganic analyses.

Analytical precision measurements will be carried out on project-specific samples at a minimum frequency of one per laboratory analysis group or one in 20 samples, whichever is more frequent per matrix analyzed, as practical. Laboratory precision will be evaluated against quantitative RPD performance criteria found in the CLP statement of work.

Field precision will be evaluated by the collection of blind field duplicates at a minimum frequency of one per laboratory analysis group or one in 20 samples. Currently, no performance criteria have been established for field duplicates. Field duplicate precision will therefore be screened against a RPD of 75 percent for sediment samples. However, no data will be qualified based solely on field duplicate precision.

Precision measurements can be affected by the nearness of a chemical concentration to the method detection limit, where the percent error (expressed as RPD) increases. Therefore, precision criteria will be used to evaluate data only when analyte concentrations are greater than five times the laboratory quantitation limit. The equations used to express precision are as follows:

$$RPD = \frac{(C_1 - C_2) \times 100\%}{(C_1 + C_2)/2}$$

Where:

RPD = relative percent difference

C_1 = larger of the two observed values

C_2 = smaller of the two observed values

B-1.5.2 Accuracy

Accuracy is an expression of the degree to which a measured or computed value represents the true value. Field accuracy is controlled by adherence to sample collection procedures outlined in Section B.3 of this Sediment Sampling Operations Manual.

Analytical accuracy may be assessed by analyzing “spiked” samples with known standards (surrogates, laboratory control samples, and/or matrix spike) and measuring the percent recovery. Accuracy measurements on matrix spike samples will be carried out at a minimum frequency of one in 20 samples per matrix analyzed. Because MS/MSDs measure the effects of potential matrix interferences of a specific matrix, the laboratory will perform MS/MSDs only on samples from this investigation and not from other projects. Surrogate recoveries will be determined for every sample analyzed for organics.

Laboratory accuracy will be evaluated against quantitative laboratory control sample, matrix spike, and surrogate spike recovery using limits from Table B-1-1 for each applicable analyte. Accuracy can be expressed as a percentage of the true or reference value, or as a percent recovery in those analyses where reference materials are not available and spiked samples are analyzed. The equation used to express accuracy is as follows:

$$\%R = 100\% \times (S-U)/C_{sa}$$

Where:

%R = percent recovery

S = measured concentration in the spiked aliquot

U = measured concentration in the unspiked aliquot

C_{sa} = actual concentration of spike added

B-1.5.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Care will be taken in the design of the sampling program to ensure sample locations are selected properly, sufficient numbers of samples are collected to accurately reflect conditions at the location(s), and samples are representative of the sampling location(s). A sufficient volume of sample will be collected at each sampling location to minimize bias or errors associated with sample particle size and heterogeneity.

For this program, the selected analytes have been identified as contaminants of concern (COCs) based on previous sampling investigations.

B-1.5.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. In order to insure results are comparable, samples will be analyzed using standard EPA methods and protocols as described in Test Methods for Evaluating Solid Wastes Physical/Chemical Methods (EPA 1986b). Calibration and reference standards will be traceable to certified standards and standard data reporting formats will be employed. Data will also be reviewed to verify that precision and accuracy criteria have been achieved and, if not, that data have been appropriately qualified.

B-1.5.5 Completeness

Completeness is a measure of the amount of data that is determined to be valid in proportion to the amount of data collected. Completeness will be calculated as follows:

$$C = \frac{\text{(Number of acceptable data points)} \times 100}{\text{(Total number of data points)}}$$

The data quality objective for completeness for all components of this project is 95 percent. Data that have been qualified as estimated because the quality control criteria were not met will be considered valid for the purpose of assessing completeness. Data that have been qualified as rejected will not be considered valid for the purpose of assessing completeness.

B-1.6 QUALITY CONTROL PROCEDURES

Sampling procedures for this investigation are described in detail in the Sediment Sampling Operations Manual for this project. Table B-1-1 presents the field sample preservation and holding time information.

B-1.6.1 Field Quality Control Procedures

To control the quality of field samples, field duplicate of surface sediments will be collected at a minimum frequency of one per laboratory analysis group or one in 20 samples. Although validation guidelines have not been established by EPA for field quality control samples, their analysis is useful in identifying possible problems resulting from sample collection or sample processing in the field. All field quality control samples will be documented in the field logbook and verified by the QA Manager, or designee.

B-1.6.2 Laboratory Quality Control Procedures

Laboratory Quality Control Criteria. Results of the quality control samples from each sample group will be reviewed by the analyst immediately after a sample group has been analyzed. The quality control sample results will then be evaluated to determine whether control limits have been exceeded. If control limits are exceeded in the sample group, the Project QA Manager will be contacted immediately, and corrective action (e.g., method modifications followed by reprocessing the affected samples) will be initiated prior to processing a subsequent group of samples.

All primary chemical standards and standard solutions used in this project will be traceable to documented, reliable, commercial sources. Standards will be validated to determine their accuracy by comparison with an independent standard. Any impurities identified in the standard will be documented.

The following sections summarize the procedures that will be used to assess data quality throughout sample analysis.

Initial and Continuing Calibration. Initial and continuing calibration will be performed in accordance with each analytical method requirements. Multipoint initial calibration will be performed on each instrument at the start of the project, after each major interruption to the analytical instrument, and when any ongoing calibration does not meet control criteria. Ongoing calibration will be performed daily for metals and organic analyses and with every sample batch for conventional parameters (when applicable) to track instrument performance.

Instrument blanks or continuing calibration blanks provide information on the stability of the baseline established. Continuing calibration blanks will be analyzed immediately prior to continuing calibration verification at a frequency of one continuing calibration blank for every 10 samples analyzed at the instrument for inorganic analyses and every 12 hours for organic analyses. If the ongoing calibration is out of control, the analysis must come to a halt until the source of the control failure is eliminated or reduced to meet control specifications. All project samples analyzed while instrument calibration was out of control will be reanalyzed.

Laboratory Duplicates. Analytical duplicates provide information on the precision of the analysis and are useful in assessing potential sample heterogeneity and matrix effects. Analytical duplicates are subsamples of the original sample that are prepared and analyzed as a separate sample. A minimum of one duplicate will be analyzed per sample group or for every 20 samples, whichever is more frequent.

Matrix Spikes and Matrix Spike Duplicates (MS/MSD). Analysis of MS samples provides information on the extraction efficiency of the method on the sample matrix. By performing MSD analyses, information on the precision of the method is also provided for organic analyses. A minimum of one MS/MSD will be analyzed for every sample group or for every 20 samples, whichever is more frequent. MS/MSD analyses will be performed on project-specific samples (i.e., batch QC using samples from other projects is not permitted).

Laboratory Control Samples. A laboratory control sample (LCS) is a method blank sample carried throughout the same process as the samples to be analyzed, with a known amount of standard added. The blank spike compound recovery assesses analytical accuracy in the absence of any sample heterogeneity or matrix effects.

Surrogate Spikes. All project samples analyzed for organic compounds will be spiked with appropriate surrogate compounds as defined in the analytical methods. Surrogate recoveries will be reported by the laboratories; however, no sample result will be corrected for recovery using these values.

Method Blanks. Method blanks are analyzed to assess possible laboratory contamination at all stages of sample preparation and analysis. A minimum of one method blank will be analyzed for every extraction batch or for every 20 samples (10 samples for conventional parameters), whichever is more frequent.

B-1.7 SAMPLE DOCUMENTATION

Sample documentation is a critical aspect of environmental investigations. Sample possession and handling must be traceable from the time of sample collection, through laboratory and data analysis, to the time sample results are reported. A sample log form and field logbook entries will be completed for each location occupied and each sample collected. Documentation procedures for sampling are provided in greater detail in the main text of the Sediment Sampling Operations Manual.

B-1.7.1 Sample Handling

Sample collection and handling procedures are detailed in the Sediment Sampling Operations Manual. To control the integrity of the samples during transit to the laboratory and during hold prior to analysis, established preservation and storage measures will be taken. Table B-1-1 presents container type, preservation, and maximum holding times for various chemical analyses of sediment. Sample containers will be labeled with the client name, survey number, sample number, sampling date and time, required analyses, and initials of the individual processing the sample. The Field QA Manager or designee will check all container labels, custody form entries, and logbook entries for completeness and accuracy at the end of each sampling day.

B-1.7.2 Sample Chain of Custody

Sample labeling and custody documentation will be performed as described in this document. Custody procedures will be used for all samples at all stages in the sample collection, transfer, and delivery to the laboratory.

B-1.7.3 Sample Preservation

The requirements for preserving sample aliquots destined for each type of analysis for sediment are listed in Table B-1-1. Immediately after the sample jars are filled with sediment they will be placed in the appropriate coolers with a sufficient number of ice packs (or crushed ice) to keep them at approximately 4 ± 2°C through the completion of that day's sampling and transport to the laboratories.

B-1.7.4 Sample Shipment

The lead field technician will be responsible for all sample tracking and custody procedures in the field. The QA Coordinator will be responsible for final sample inventory and will maintain sample custody documentation. The field technician, or designee, will complete custody forms prior to removing samples from the sampling vessel. At the end of each day, and prior to transfer, custody form entries will be made for all samples. Finally, information on the sample labels will be checked against sample logbook entries and custody forms, and samples will be recounted. All samples will be accompanied by custody forms; the forms will be signed at each point of transfer and will include sample numbers. All custody forms will be completed in indelible ink. Copies of all forms will be retained as appropriate and included as appendices to QA/QC reports to management.

Prior to shipping, sample containers will be wrapped and securely packed inside the cooler with ice packs or crushed ice by the field technician or designee. The original, signed custody forms will be transferred with the cooler. The cooler will be secured and appropriately sealed and labeled for shipping immediately. Samples will be delivered to the laboratory under custody following completion of sampling activities.

B-1.7.5 Sample Receipt

The designated sample custodian at the laboratory will accept custody of the samples and verify that the chain of custody matches the samples received. The Project Manager at the laboratory will ensure that the custody forms are properly signed upon receipt of the samples and will note questions or observations concerning sample integrity on the custody forms. The laboratory will contact the Project QA Coordinator immediately if discrepancies are discovered between the custody forms and the sample shipment upon receipt. The laboratory Project Manager or designee will specifically note any coolers that do not contain ice packs or are not sufficiently cold ($4 \pm 2°C$) upon receipt.

B-1.8 DATA REDUCTION, REPORTING, AND REVIEW

Initial data reduction, evaluation, and reporting at the laboratory will be carried out as described in the appropriate analytical protocols and the laboratory's QA Manual. Quality control data resulting from methods and procedures described in this document will also be reported.

B-1.8.1 Data Reduction and Reporting

The laboratory will be responsible for internal checks on data reporting and will correct errors identified during the quality assurance review. Close contact will be maintained with the laboratories to resolve any quality control problems in a timely manner. The analytical laboratories will be required, where applicable, to report the following:

- **Project Narrative.** This summary, in the form of a cover letter, will discuss problems, if any, encountered during any aspect of analysis. This summary should discuss, but not be limited to, quality control, sample shipment, sample storage, and analytical difficulties. Any problems encountered, actual or perceived and their resolutions will be documented in as much detail as necessary.

- **Sample IDs.** Records will be produced that clearly match all blind duplicate QA samples with laboratory sample IDs.
- **Chain of Custody Records.** Legible copies of the custody forms will be provided as part of the data package. This documentation will include the time of receipt and condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory will also be documented.
- **Sample Results**. The data package will summarize the results for each sample analyzed. This summary will be in a CLP-like format (EPA 1999a and 2000b). The summary will include the following information when applicable:
    - Field sample identification code and the corresponding laboratory identification code:
        - Sample matrix;
        - Date of sample extraction;
        - Date and time of analysis;
        - Percent moisture in the sediment sample;
        - Method reporting and quantitation limits; and
        - Analytical results reported to three significant figures with reporting units identified;
    - All data qualifiers and their definitions; and
    - A computer diskette with the data.
- **Quality Assurance/Quality Control Summaries.** This section will contain the results of all QA/QC procedures. Each QA/QC sample analysis will be documented with the same information required for the sample results (see above). No recovery or blank corrections will be made by the laboratory. The required summaries are listed below; additional information may be requested.
- **Calibration Data Summary.** Report the concentrations of the initial calibration and daily calibration standards and the date and time of analysis. List the response factor, %RSD, percent difference, and retention time for each analyte as appropriate. Report results for standards to indicate instrument sensitivity.
- **Internal Standard Area Summary.** Report the stability of internal standard areas.
- **Method Blank Analysis.** Report the method blank analyses associated with each sample and the concentration of all compounds of interest identified in these blanks.
- **Surrogate Spike Recovery.** Report all surrogate spike recovery data for organic compounds. List the name and concentration of all compounds added, percent recoveries, and range of recoveries.
- **Matrix Spike Recovery.** Report all matrix spike recovery data for metals and organic compounds. List the name and concentration of all compounds added, percent recoveries, and range of recoveries. Report the RPD for all duplicate analyses.
- **Matrix Duplicate.** Report the RPD for all matrix duplicate analyses.

- **Relative Retention Time.** Report the relative retention time of each analyte detected in the samples for both primary and conformational analyses.
- **Original Data.** Legible copies of the original data generated by the laboratory will include:
  - Weight and/or volume used for analysis;
  - Final dilution volumes or concentration factor for the sample;
  - Identification of the instrument used for analysis; and
  - Sample refrigerator temperature log;
  - Sample extraction, preparation, and cleanup logs;
  - Instrument logs for all instruments used on days of calibration and analysis;
  - Reconstructed ion chromatograms for all samples, standards, blanks, calibrations, spikes, replicates, and reference materials;
  - Printouts and quantitation reports for each instrument used, including reports for all samples, standards, blanks, calibrations, spikes, replicates, and reference materials;
  - Original data quantification reports for each sample; and
  - Original data for blanks and samples not reported.
- **Blind Duplicates.** Blind duplicates will be reported as any other sample. Relative percent differences will be calculated for duplicate samples and evaluated as part of the data quality review.

B-1.8.2 Data Validation

Once data are received from the laboratory, a number of QC procedures will be followed to provide an accurate evaluation of the data quality. Specific procedures will be followed to assess data precision, accuracy, and completeness.

A data quality review of the analytical data will follow EPA National Functional Guidelines (EPA 1999b and EPA 2002), in accordance with the QAPP limits. All chemical data will be reviewed with regard to the following, as appropriate to the particular analysis:

- Chain of custody/documentation;
- Holding times;
- Instrument calibration;
- Method blanks;
- Reporting limits;
- Surrogate recoveries;
- Matrix spike/matrix spike recoveries;

- Laboratory control sample recoveries; and
- Laboratory and field duplicate relative percent differences.

Additionally, chromatograms will be reviewed to confirm the absence of weathered analyte patterns (i.e., false negatives for PCB aroclors, etc.) not identified by the analytical instrument. The results of the data quality review including text assigning qualifiers in accordance with the EPA National Functional Guidelines and a tabular summary of qualifiers, will be generated by the Data Validation Specialist and submitted to the Project QA Coordinator for final review and confirmation of the validity of the data. A Quality Assurance summary of the review will be generated by the Project QA Coordinator. This summary and copies of the complete review will be presented as an appendix to the monitoring reports.

B-1.9 LABORATORY AUDITS AND CORRECTIVE ACTIONS

Laboratory and field performance audits and corrective action procedures are described in this section.

B-1.9.1 Laboratory and Field Performance Audits

Laboratory and field performance audits consist of on-site reviews of quality assurance systems and equipment for sampling, calibration, and measurement. Laboratory audits will not be conducted as part of this study; however, all laboratory audit reports will be made available to the Project QA Coordinator upon request. The laboratory is required to have written procedures addressing internal QA/QC. The laboratory must ensure that personnel engaged in sampling and analysis tasks have appropriate training.

The laboratory will, as part of the audit process, provide written details of any and all method modifications planned, for consultant's review.

B-1.9.2 Corrective Action Procedures

Corrective Action for Field Sampling. The Field QA Officer will be responsible for correcting equipment malfunctions during the field sampling effort. The Project QA Coordinator will be responsible for resolving situations in the field that may result in non-compliance with the QAPP. All corrective measures will be immediately documented in the field logbook.

Corrective Action for Laboratory Analyses. The laboratory is required to comply with their Standard Operating Procedures (SOPs). The laboratory Project Manager will be responsible for ensuring that appropriate corrective actions are initiated as required for conformance with this QAPP. All laboratory personnel will be responsible for reporting problems that may compromise the quality of the data.

If any quality control sample exceeds the project-specified control limits the analyst will identify and correct the anomaly before continuing with the sample analysis. The analyst will document the corrective action taken in a memorandum submitted to the Project QA Coordinator. A narrative describing the anomaly, the steps taken to identify and correct the anomaly, and the treatment of the relevant sample batch (i.e., recalculation, reanalysis, re-extraction) will be submitted with the data package.

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TABLES

Table B-1-1
Data Quality Objectives for Sediment Quality Analyses

Parameter	Units	Reporting Limit Goals	Precision	Accuracy	Completeness	Reference	Sample Container	Container Type	Holding Time[1]	Preservative
Total Solids	% (wet weight)	0.1	+/- 25%	+/- 20%	95%	PSEP 1997	From metals container	Glass	6 months	cool/4°C
Total organic carbon	mg/kg or %	200 or 0.02	+/- 20%	+/- 20%	95%	EPA Method 9060 (PSEP modification)	from metals container	Glass	28 days	cool/4°C
Semivolatiles	µg/kg	½ SQO	+/- 50%	+/- 50%	95%	EPA Method 8270C	8 oz.	Glass	14 days/ 40 days	cool/4°C
PCBs	µg/kg	½ SQO	+/- 50%	+/- 50%	95%	EPA Method 8082	8 oz.	Glass	14 days/ 40 days	cool/4°C
Pesticides	µg/kg	½ SQO	+/- 50%	+/- 50%	95%	EPA Method 8081	from PCBs	Glass	14 days/ 40 days	cool/4°C
Arsenic, Copper, Lead, Zinc	mg/kg	½ SQO	+/- 25%	+/- 25%	95%	EPA Method 6010	4 oz.	Glass	6 months	cool, 4°C/freeze, -18°C
Mercury	mg/kg	½ SQO	+/- 25%	+/- 25%	95%	EPA Method 7471A	8 oz.	Glass	28 days	cool/4°C

Notes:
[1] When two holding times are listed, the first holding time is until extraction, the second is until analysis.

Table B-1-2
Sediment Quality Objectives (SQOs)

Analyte	SQO	Analytical Method
Conventionals		
Total Organic Carbon in %	NA	EPA Method 9060
Total Solids in %	NA	PSEP 1997
Metals in mg/kg		
Antimony	150	EPA Method 6010B
Arsenic	57	EPA Method 6010B
Cadmium	5.1	EPA Method 6010B
Copper	390	EPA Method 6010B
Lead	450	EPA Method 6010B
Mercury	0.59	EPA Method 7471A
Nickel	140	EPA Method 6010B
Silver	6.1	EPA Method 6010B
Zinc	410	EPA Method 6010B
LPAHs in µg/kg		EPA Method 8270C
2-Methylnaphthalene	670	
Acenaphthene	500	
Acenaphthylene	1,300	
Anthracene	960	
Fluorene	540	
Naphthalene	2,100	
Phenanthrene	1,500	
Total LPAHs	5,200	
HPAHs in µg/kg		EPA Method 8270C
Benzo(a)Anthracene	1,600	
Benzo(a)Pyrene	1,600	
Benzo(b)Fluoranthene	NA	
Benzo(k)Fluoranthene	NA	
Total Benzofluoranthenes	3,600	
Benzo(g,h,i)Perylene	720	
Chrysene	2,800	
Dibenz(a,h)Anthracene	230	
Fluoranthene	2,500	
Indeno(1,2,3-c,d)Pyrene	690	
Pyrene	3,300	
Total HPAHs	17,000	
Phthalates in µg/kg		EPA Method 8270C
Dimethylphthalate	160	
Diethylphthalate	200	
Di-n-butylphthalate	1,400	
Butylbenzylphthalate	900	
Bis(2-Ethylhexyl)Phthalate	1,300	
Di-n-octylphthalate	6,200	

Acid Compounds in µg/kg		EPA Method 8270C
Phenol	420	
2-Methylphenol	63	
4-Methylphenol	670	
2,4-Dimethylphenol	29	
Pentachlorophenol	360	
Benzyl alcohol	73	
Benzoic acid	650	
Miscellaneous Compounds in µg/kg		EPA Method 8270C
1,2-Dichlorobenzene	50	
1,3-Dichlorobenzene	170	
1,4-Dichlorobenzene	110	
1,2,4-Trichlorobenzene	51	
Hexachlorobenzene	22	
Dibenzofuran	540	
Hexachlorobutadiene	11	
N-Nitrosodiphenylamine	28	
Pesticide/PCBs in µg/kg		
4,4'-DDD	16	EPA Method 8081
4,4'-DDE	9	Or EPA Method 8270C
4,4'-DDT	34	
PCB-1016	NA	EPA Method 8082
PCB-1221	NA	Or EPA Method 8270C
PCB-1232	NA	
PCB-1242	NA	
PCB-1248	NA	
PCB-1254	NA	
PCB-1260	NA	
Total PCBs	300	

NA: No SQO is defined for chemical analyte/parameter.
Method detection limits for sediment quality analyses must be at or below these SQOs.

Attachment B-2

Quality Assurance Project Plan for Bioassay Testing

B-2.1 CONTRACT LABORATORY REQUIREMENTS

In completing chemical and biological testing for this project, the contract laboratory is expected to meet the following minimum requirements:

1. Be accredited in Washington State for the testing to be performed;
2. Adhere to the methods outlined in the QAPP, including methods referenced for each analytical procedure;
3. Deliver fax, hard copy, and electronic data as specified;
4. Meet reporting requirements for deliverables;
5. Meet turnaround times for deliverables;
6. Implement QA/QC procedures, including the QAPP data quality requirements, laboratory QA requirements, and performance evaluation testing requirements; and
7. Allow laboratory and data audits to be performed, as necessary.

B-2.2 CONVENTIONAL SEDIMENT PARAMETERS ANALYSIS

Test and reference sediment samples will be submitted for analysis of:

- Total organic carbon;
- Bulk ammonia;
- Bulk sulfide;
- Total solids;
- Total volatile solids; and
- Grain size analysis.

B-2.2.1 Total Organic Carbon Analysis

TOC will be determined using the Puget Sound Estuary Protocols (PSEP 1997) modification to EPA Method 9060.

B-2.2.2 Bulk Ammonia and Bulk Sulfides

Ammonia and sulfides will be determined using the EPA methods presented in Plumb (1981).

B-2.2.3 Total Solids, Total Volatile Solids, and Grain Size

Total solids, total volatile solids, and grain size analysis will be determined using the PSEP methods (PSEP 1997).

B-2.2.4 Reporting Limits

Reporting limits for the conventional sediment parameters are summarized in Table B-2-1. Any modifications from the specified analytical methods will be provided by the laboratory at the time of establishing the laboratory contract, and must be approved by the City.

B-2.3 SEDIMENT BIOASSAY TESTING

B-2.3.1 General Requirements

Bioassay testing will begin as soon as possible after the collection of the test and reference sediments. If retesting is required, it must be started within the 56-day holding time guideline. Bioassay testing will consist of two acute tests and one chronic test and will follow the protocols presented in the Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments (PSEP 1995), as updated through the Sediment Management Annual Review Meetings of the Sediment Management Standards (SMS) and Puget Sound Dredged Disposal Analysis (PSDDA) agencies. General requirements for bioassay testing include the following:

- Testing will be blind with random assignment of test sediments to experimental aquaria;
- Water quality (salinity, DO, pH, and temperature) will be monitored daily. Measurements of total sulfides and ammonia will be recorded at the beginning and end of each test;
- Standard PSEP protocols will be followed for each bioassay. The protocols specify required documentation, proper test conditions, cleaning and decontamination procedures for glassware;
- Bioassay-specific performance requirements will be met for control and reference sediments. If performance requirements are not met, retesting will be required;
- Deviations from the protocols will be documented; and
- Reference sediments will be matched with test sediments on the basis of the percentage of fine sediments (< 63μ).

B-2.3.2 Sediment Larval Test

The sediment larval test will be run using either a bivalve or an echinoderm species. The test is a 48- to 96-hour test with a mortality/abnormality development endpoint. Species selection will depend on time of year and species availability. Each test will be run with an appropriate negative seawater control and a positive reference toxicant control. Determination of the developmental endpoint is made microscopically. The following information is required: initial stocking density and aliquot size; positive control results; negative control results; test and reference sediment results; initial counts for the seawater control; counts of normal and abnormal embryos in each test container at completion of the test; and information on test conditions.

B-2.3.3 Amphipod Sediment Bioassay

The amphipod bioassay will be run using either Rhepoxynius abronis or Ampelisca abdita. The test is a 10-day acute/lethal test with a mortality endpoint. The choice of test species will depend on sediment grain size and TOC content. Each test will be run with the appropriate negative control (native sediment provided by the vendor) and a positive reference toxicant control. Mortality will be determined after 10 days. In addition, test aquaria will be inspected daily and number of amphipods that fail to rebury will be recorded. The following information is required: positive control results, negative control results, test and reference sediment results, and information on test conditions.

B-2.3.4 Juvenile Polychaete Bioassay

The juvenile polychaete bioassay will be run using laboratory-cultured *Neanthes* sp. juveniles. The test is a 20-day chronic/sublethal test with a growth endpoint. Each test will be run with the appropriate negative control sediment and a positive reference toxicant control. Growth reflected by a change in biomass will be determined after 20 days. The following information is required: positive control results, negative control results, test and reference sediment results, counts of surviving animals in each test container at completion of the test, and information on test conditions.

B-2.4 QUALITY ASSURANCE OBJECTIVE

The quality assurance (QA) objective for this project is to ensure that the data collected are of known and acceptable quality so that the goal of the biological monitoring program can be achieved. The goal of the biological monitoring is to ensure that the remedial dredging, capping, and natural recovery activities in the Thea Foss and Wheeler-Osgood Waterways comply with the Sediment Quality Objectives (SQO) and the Record of Decision (ROD). The goal of the field quality assurance program is to document sample collection and processing in sufficient detail that sample possession and handling is traceable from the time of sample collection, through laboratory and data analysis, to the time sample results are reported. The quality of the laboratory data is assessed by precision, accuracy, representativeness, comparability, and completeness (the "PARCC" parameters). Definitions of these parameters and the applicable quality control (QC) procedures are given below.

B-2.5 FIELD QUALITY ASSURANCE

B-2.5.1 Sample Documentation

Sample documentation is a critical aspect of environmental investigations. A field description form and field logbook entries will be completed for each location occupied and each sample collected. Documentation procedures for sampling are provided in greater detail in the Sediment Sampling Operations Manual.

B-2.5.2 Sample Handling

Sample collection and handling procedures are detailed in the Bioassay Sediment Sampling Operations Manual. To control the integrity of the samples during transit to the laboratory and during hold prior to analysis, established preservation and storage measures will be taken. Sample labels will include a unique sample ID number, sampling date and time, required analyses, and initials of the individual processing the sample. The Field QA Manager or designee will check all container labels, custody form entries, and logbook entries for completeness and accuracy at the end of each sampling day.

B-2.5.3 Sample Chain of Custody

Sample labeling and custody documentation will be performed as described in the sampling operations manual. Custody procedures will be used for all samples at all stages in the analytical or transfer process and for all data and data documentation whether in hard copy or electronic format.

B-2.5.4 Sample Preservation

Immediately after the sample jars are filled with sediment they will be placed in the appropriate coolers with a sufficient number of ice packs (or crushed ice) to keep them at approximately $4 \pm 2°C$ through the completion of that day's sampling and transport to the laboratories.

B-2.5.5 Sample Shipment

The Project QA Coordinator and Field QA Officer will be responsible for all sample tracking and custody procedures in the field. The QA Coordinator will be responsible for final sample inventory and will maintain sample custody documentation. The Field QA Officer, or designee, will complete custody forms prior to removing samples from the sampling vessel. At the end of each day, and prior to transfer, custody form entries will be made for all samples. Finally, information on the sample labels will be checked against sample logbook entries and custody forms, and samples will be recounted. All samples will be accompanied by custody forms; the forms will be signed at each point of transfer and will include sample numbers. All custody forms will be completed in indelible ink. Copies of all forms will be retained as appropriate and included as appendices to QA/QC reports to management.

Prior to shipping, sample containers will be wrapped and securely packed inside the cooler with ice packs or crushed ice by the Field QA Officer or designee. The original, signed custody forms will be transferred with the cooler. The cooler will be secured and appropriately sealed and labeled for shipping immediately. Samples will be delivered to the laboratory under custody following completion of sampling activities.

B-2.5.6 Sample Receipt

The designated sample custodian at the laboratory will accept custody of the samples and verify that the chain of custody matches the samples received. A cooler receipt form will be filled out to document conditions of the cooler. The Project Manager at the laboratory will ensure that the custody forms are properly signed upon receipt of the samples and will note questions or observations concerning sample integrity on the custody forms. The laboratory will contact the

Project QA Coordinator immediately if discrepancies are discovered between the custody forms and the sample shipment upon receipt. The laboratory Project Manager will specifically note any coolers that do not contain ice packs or are not sufficiently cold (4 ± 2°C) upon receipt.

B-2.6 LABORATORY QUALITY ASSURANCE OBJECTIVES

The quality of analytical laboratory data generated is assessed by the frequency and type of internal quality control checks developed for analysis type. Analytical laboratory results will be evaluated by reviewing results for analysis of method blanks, matrix spikes, duplicate samples, laboratory control samples, calibrations, performance evaluation samples, interference checks, etc., as specified in the analytical methods used.

The quality of biological data generated by the bioassay laboratory will be evaluated by reviewing results of sample replicate variability, results of positive control tests, and results of both internal and external audits conducted during testing.

B-2.6.1 Precision

Precision measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average values. Analytical laboratory precision measurements are determined using the methods outlined in Section B-1.5.1 in Attachment B-1.

Precision in the bioassay measurements will be assessed by monitoring the variability between replicates for each test, reference, and control sediment. If "outliers" are identified that appear to be clearly affected by out-of limit parameters such as low DO or exceedingly high or low pH, the data points will be removed from the data set. "Outliers" that cannot be explained with out-of-limit physical or chemical measurements, the resultant data points will be included in the data sets.

B-2.6.2 Accuracy

Accuracy is an expression of the degree to which a measured or computed value represents the true value. Field accuracy is controlled by adherence to sample collection procedures outlined in Section B-3 of this QAPP for Bioassay Testing.

Analytical laboratory accuracy may be assessed by analyzing "spiked" samples with known standards (surrogates, laboratory control samples, and/or matrix spike) and measuring the percent recovery as described in Section B-1.5.2 of Attachment B-1.

During bioassay testing, accuracy is assessed by the positive control tests. Each bioassay animal is exposed to a reference toxicant with known toxicity. The results of the positive control tests are plotted on a laboratory control chart and compared with the upper and lower control limits. Results outside the control limits will indicate a possible need for re-testing.

B-2.6.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Care will be taken in the design of the sampling program to ensure sample locations are selected properly, sufficient numbers of samples are collected to accurately reflect conditions at the location(s), and samples are representative of the sampling location(s). A sufficient volume of sample will be collected at each sampling location to minimize bias or errors associated with sample heterogeneity.

B-2.6.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. In order to insure results are comparable, samples for conventional sediment parameters will be analyzed using standard PSEP or EPA methods and protocols.

Comparability of bioassay results from this study with other bioassay results in Puget Sound will be assured by the following methods:

- Standardized PSEP protocols will be followed for each test;
- Bioassay testing will be conducted by an accredited State of Washington laboratory certified to perform sediment bioassays;
- Both internal and external audits will be conducted both before the tests start and during the tests to insure compliance with required procedures;
- Grain size matched reference sediments from identified Puget Sound reference areas will be run for each batch; and
- Positive control tests with a reference toxicant will be run for each group of bioassay test organisms.

B-2.6.5 Completeness

Completeness is a measure of the amount of data that is determined to be valid in proportion to the amount of data collected. Completeness will be calculated as follows:

$$C = \frac{(\text{Number of acceptable data points}) \times 100}{(\text{Total number of data points})}$$

The data quality objective for completeness for all components of this project is 95 percent. Data that have been qualified as estimated because the quality control criteria were not met will be considered valid for the purpose of assessing completeness. Data that have been qualified as rejected will not be considered valid for the purpose of assessing completeness.

B-2.7 QUALITY CONTROL PROCEDURES

Sampling procedures are described in detail in the Sediment Sampling Operations Manual for this project. Table B-2-1 presents the field sample preservation and holding time information.

Sample preservation and holding time requirements are presented as follows.

B-2.7.1 Laboratory Quality Control Procedures

Analytical Laboratory Quality Control Criteria. Quality control sample results will be reviewed to assess the quality of the data provided by the laboratory analyzing the conventional sediment parameters. In addition, the procedures outlined under Section B-1.6.2 in Attachment B-1 will be used to assess data quality throughout sample analysis.

Bioassay Laboratory Quality Control Criteria. The following quality control performance criteria will be used to assess the quality of data provided by the bioassay testing laboratory:

- **Amphipod Bioassay.** Negative control performance standard—The mortality of the amphipods in the control sediment (M_C) is less than or equal to 10 percent (i.e., $M_C \leq 10$ percent). Reference sediment performance standard—The mortality of the amphipods in the reference sediment (M_R) is less than or equal to 25 percent (i.e., $M_R \leq 25$ percent).
- **Juvenile Polychaete Bioassay.** Negative control performance standard—The mortality of the polychaetes in the control sediment (M_C) is less than or equal to 10 percent (i.e., $M_C \leq 10$ percent) and the mean individual growth rate in the control (MIG_C) is greater than or equal to 0.72 (i.e., $MIG_C \geq 0.72$ mg/individual/day). Reference sediment performance standard—The mortality of the polychaetes in the reference sediment (M_R expressed as a percent) is less than or equal to 20 percent (i.e., $M_R \leq 20$ percent) and the ratio of mean individual growth rate of the worms in the reference sediment (MIG_R) to the mean individual growth rate of the worms in the control sediment (MIG_C) is greater than or equal to 0.80 (i.e., $MIG_R/MIG_C \geq 0.80$).
- **Sediment Larval Bioassay.** Negative control performance standard—The ratio of normal larvae in the seawater control (N_C) to the initial count of larvae used to inoculate the test containers (I) is greater than or equal to 0.70 (i.e., $N_C/I \geq 0.70$). Reference sediment performance standard—The ratio of normal larvae in the reference sediment (N_R) to the normal larvae in the seawater control (N_C) is greater than or equal to 0.65 (i.e., $N_C/ N_R \geq 0.65$).

The biological testing performance standards and criteria are summarized in Table B-2-2.

B-2.8 DATA REDUCTION, REPORTING, AND REVIEW

All data will undergo two levels of QA/QC evaluation: one at the laboratory, and one by a qualified data validator.

Initial data reduction, evaluation, and reporting at the laboratory will be carried out as described in the appropriate analytical protocols and the laboratory's QA Manual. Quality control data resulting from methods and procedures described in this document will also be reported.

B-2.8.1 Data Reduction and Reporting

The laboratory will be responsible for internal checks on data reporting and will correct errors identified during the quality assurance review. Close contact will be maintained with the laboratories to resolve any quality control problems in a timely manner. The laboratories will be required, where applicable, to report the following:

- **Project Narrative.** This summary, in the form of a cover letter, will discuss problems, if any, encountered during any aspect of analysis. This summary should discuss, but not be limited to, quality control, sample shipment, sample storage, and analytical difficulties. Any problems encountered, actual or perceived, and their resolutions will be documented in as much detail as necessary.
- **Sample IDs.** Records will be produced that clearly match all blind duplicate QA samples with laboratory sample IDs.
- **Chain of Custody Records.** Legible copies of the custody forms will be provided as part of the data package. This documentation will include the time of receipt and condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory will also be documented.
- **Test Results.** The data package will summarize the results for each test conducted. For reporting of the conventional sediment parameters this summary will be in a CLP-like format following the requirements presented in Section B-1.8.1 in Attachment B-1. Data packages for bioassay testing will include copies of daily water quality logs and bench sheets recording bioassay results on all positive, negative, and experimental test and reference sediments. Table summaries of each bioassay test will be provided in hard and electronic formats.
- **Quality Assurance/Quality Control Summaries.** This section will contain the results of all QA/QC procedures. Each QA/QC sample analysis will be documented with the same information required for the sample results (see above). No recovery or blank corrections will be made by the laboratory.

B-2.8.2 Independent Data Validation

Once data are received from the laboratory, a number of QC procedures will be followed to provide an accurate evaluation of the data quality. Specific procedures will be followed to assess data precision, accuracy, and completeness.

Sediment Conventionals. A data quality review of the conventional sediment parameter data will be performed by a qualified Data Validation Specialist, in accordance with EPA National Functional Guidelines (EPA 1994). The data will be evaluated in accordance with the QAPP. All chemical data will be reviewed with regard to the following, as appropriate to the particular analysis.

- Chain of custody/documentation;
- Holding times;
- Instrument calibration;
- Method blanks;
- Reporting limits;
- Surrogate recoveries;

- Matrix spike/matrix spike recoveries;
- Laboratory control sample recoveries; and
- Laboratory and field duplicate relative percent differences.

The results of the data quality review including qualifiers assigned in accordance with the EPA National Functional Guidelines (EPA 1994) and a tabular summary of qualifiers, will be generated by the Data Validation Specialist and submitted to the Project QA Coordinator for final review and confirmation of the validity of the data. A Quality Assurance summary of the review will be generated by the Project QA Coordinator. This summary and copies of the complete review will be presented as an appendix to the monitoring reports.

Bioassay Tests. A data quality review of the bioassay data will be performed using guidance from EPA (1990), Sturgis (1990), and Moore et al. (1993). A written summary of the findings will be submitted to the Project QA Coordinator for final review and confirmation of the validity of the data. A Quality Assurance summary of the review will be generated by the Project QA Coordinator. This summary and copies of the complete review will be presented as an appendix to the monitoring reports.

B-2.9 LABORATORY AUDITS AND CORRECTIVE ACTIONS

Laboratory performance audits and corrective action procedures are described in this section.

B-2.9.1 Laboratory and Field Performance Audits

Sediment Conventionals. Audits of the analytical laboratory will not be conducted as part of this study; however, all internal laboratory audit reports will be made available to the Project QA Coordinator upon request. The laboratory is required to have written procedures addressing internal QA/QC. The laboratory must ensure that personnel engaged in sampling and analysis tasks have appropriate training.

Bioassay Tests. The bioassay laboratory will undergo audits before the start of testing to verify the laboratory's internal QA/QC procedures. The independent audit will include the review of the laboratory's SOPs for each bioassay and a review of the laboratory's written internal QA/QC procedures. After test initiation, unannounced external audits will be initiated. Any deviations from the accepted protocols will be brought to the attention of the laboratory QA manager and the Project QA Coordinator. Minor deficiencies will be noted. If necessary, subsequent qualification of the bioassay data may be required. Significant deviations that affect the data quality may require retesting of the sediments.

B-2.9.2 Corrective Action Procedures

Project laboratories are required to comply with their Standard Operating Procedures (SOPs). The laboratory Project Manager will be responsible for ensuring that appropriate corrective actions are initiated as required for conformance with this QAPP. All laboratory personnel will be responsible for reporting problems that may compromise the quality of the data.

The Project QA Coordinator will be notified immediately if any quality control sample exceeds the project-specified control limits. The analyst will identify and correct the anomaly before continuing with the sample analysis. The laboratory Project Manager will document the corrective action taken in a memorandum submitted to the Project QA Coordinator within five days of the initial notification. A narrative describing the anomaly, the steps taken to identify and correct the anomaly, and the treatment of the relevant sample batch (i.e., recalculation, reanalysis, re-extraction, retesting) will be submitted with the data package in the form of a cover letter.

REFERENCES

EPA. 1990. Manual for the Evaluation of Laboratories Performing Aquatic Toxicity Tests. EPA 600/4-90/031.

EPA. 1994. Laboratory Validation Functional Guidelines for Evaluating Inorganics and Organics Analysis. Prepared for the Hazardous Site Evaluation Division, USEPA. February 1994.

PSEP. 1997. Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound. Prepared for US Environmental Protection Agency, Region X, Seattle, Washington, by Puget Sound Estuary Program Puget Sound Water Quality Action Team, Olympia, Washington.

Sturgis, T. C., 1990. Guidance for Conducting Biological and Chemical Evaluations of Dredged Materials. Technical Report D-90-10, US Army Corps of Engineers Waterway Experimental Station, Vicksburg, Mississippi.

Moore, D. W., T. D. Dillon, J. Q. Ward and J. A. Ward. 1993. Quality Assurance/Quality Control (QA/QC) Guidance for Laboratory Dredged Material Bioassays. Results of a workshop held May 26-27, 1993 in Seattle, Washington. Miscellaneous papers D-94-3, Waterways Experimental Station, US Army Corps of Engineers, Vicksburg, Mississippi.

PSEP. 1995. Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments. Prepared for US Environmental Protection Agency, Region X, Seattle, Washington, by Puget Sound Estuary Program Puget Sound Water Quality Action Team, Olympia, Washington.

TABLES

Table B-2-1
Data Quality Objectives for Sediment Quality Analyses for Bioassay Testing

Parameter	Units	Reporting Limit	Precision	Accuracy	Completeness	Reference	Sample Container	Container Type	Holding Time	Preservative
Grain Size	%	0.01	+/- 25%	+/- 20%	95%	PSEP 1997	4 oz.	Glass	6 months	cool/4^oC
Total Solids	% (wet weight)	0.1	+/- 25%	+/- 20%	95%	PSEP 1997	4 oz.	Glass	6 months	cool/4^oC
Total Volatile Solids	% (wet weight)	0.1	+/- 25%	+/- 20%	95%	PSEP 1997	1 liter	HDPE	7 days	cool/4^oC
Total Organic Carbon	mg/kg or %	200 or 0.02	+/- 20%	+/- 20%	95%	EPA Method 9060 (PSEP modification)	from mercury container	Glass	28 days	cool/4^oC
Bulk Ammonia	mg/kg	0.1	+/- 25%	+/- 20%	95%	Plumb 1981	4 oz.	Glass	28 days	cool/4^oC
Bulk Sulfides	mg/kg	5	+/- 35%	+/- 35%	95%	Plumb 1981	2 oz.	Glass	7 days	ZnOAc [1], cool/4^oC
Bioassay Sediments	NA	NA	Monitor variability between replicates	Positive Control Tests	NA	PSEP 1995	(3) 1 liter	Polyethylene	56 days	4^oC, no headspace or headspace purged with nitrogen

Notes:

[1] The volume of ZnAOc added to the sediment sample container is enough to cover the surface of the sediment, approximately 1 ml.

HDPE – High density polyethylene

Table B-2-2
Biological Testing Criteria

Biological Test	Control Performance Standard	Reference Performance Standard	SQS	CSL
			Test sediment has higher (statistically significant, t-test, p [0.05) mean mortality than the reference sediment[1]	
Amphipod (acute)				
Survival	M_C <10%	M_R < 25%	M_T > 25 %	$M_T - M_R$ > 30%
Larval (acute)				
Survival	$N_C \div I \geq 0.7$ [2]	$N_C \div N_R \geq 0.65$ (per QA/QC guidance)	$N_T / N_C \div N_R / N_C < 0.85$	$N_T / N_C \div N_R / N_C < 0.70$
Juvenile polychaete (chronic)				
Survival	M_C < 10%	$MIG_R \div MIG_C \geq 0.80$	$MIG_T \div MIG_R < 0.70$	$MIG_T \div MIG_R < 0.50$
Growth	$MIG_C \geq$ 0.72 mg/ind/day (dry)			

Notes:

Any two exceedances of the SQS criteria also constitute a CSL exceedance

1 The SQS and CSL criteria for the acute larval test require results that are statistically significant, t-test, p[0.1

2 Control performance standard for larval is equal to a 30 percent combined abnormality and mortality

I Initial count of larvae used to inoculate the test containers

M_C Control sediment

M_R Reference sediment

M_T Test sediment

MIG_C Mean individual growth rate – control

MIG_R Mean individual growth rate – reference

MIG_T Mean individual growth rate – test

N_C Normal survivorship of the control sediment

N_R Normal survivorship of the reference sediment

N_T Normal survivorship of the test sediment

Attachment B-3

Surface Sediment Sample Collection Form

SURFACE SEDIMENT SAMPLE COLLECTION FORM

Thea Foss and Wheeler-Osgood Waterways OMMP

Date: ______________________

Weather: ______________________

Field Personnel: ______________________

Sample Type

☐ 1. Performance Surface (0-10 cm)
☐ 2. Early Warning Recontamination (0-2 cm)
☐ 3. Performance Subsurface
☐ 4. Bioassay
☐ 5. Benthic Recolonization

Sample Designation: ______________________

Sample Method (Van Veen Surface Grab/Slope Composite): ______________________

Datum (Horizontal/Vertical): ______________________

Sample Types 1, 2, 3, 4, 5
*If sample type 4, were reference samples collected? ☐ Yes ☐ No

Leadline Water Dept __________ (A)

Predicted Tide Elevation __________ (B)

Mudline Elevation __________ (B-A)

Actual Tide Elevation __________

Run # or Composite Pt	Time	Latitude (Northing)	Longitude (Easting	Sample Criteria (Surface Grab Only)					Accept Sample Y/N	Comments (Include depth of sample)
				1	2	3	4	5		

Acceptance criteria: 1 Overlying water is present; 2 Water has low turbidity; 3 Sampler is not over filled; 4 Sample surface is flat; or 5 Desired sample depth is reached.

Sediment Sample Description

Sediment Sample Description (density, moisture, color, minor constituents, major constituents, other obs - *see field ref cards):

Sample containers filled (number and type):

Laboratory analysis:

Thick Slope Cap Composite Sampling

Predicted tide elevation: ______________________

Remediation area: ______________________

Number of composite points: ______________________

Attachment B-4

Subsurface Sediment Collection Form and Log

SUBSURFACE SEDIMENT COLLECTION FORM AND LOG

Thea Foss and Wheeler-Osgood Waterways OMMP
Date: ____________ Time: ____________ ☐ am ☐ pm
Field Personnel: ____________
Weather: ____________

Monitoring Event Number ☐ 0 ☐ 2 ☐ 4 ☐ 7 ☐ 10

Sampling Location: ____________

Datum Horizontal: ____________

Datum Vertical: ____________

Lat/Northing: ____________

Long/Easting: ____________

Drive Method: ☐ Vibracore ☐ Impact   Photograph: ☐ Yes ☐ No

(A) Leadline Water Depth: ____________ ft

(B) Predicted Tide Elevation: ____________ ft

(B-A) Mudline Elevation: ____________ ft

Core Tube Length: ____________ ft

(C) Drive Length: ____________ ft

(D) Recovered Length: ____________ ft

(E) % Recovery (D/C x 100): ____________

In Tube (ft)	Corrected (ft)	Drive Length (C)	Sample ID	Analytes*	Sediment Description Density, Moisture, Minor Constituents, Major Constituents, Odor, Organics, Sheen, Etc
0					
(0.33 x E/100)	0.33				
(1 x E/100)	1				
(2 x E/100)	2				
(3 x E/100)	3				
(4 x E/100)	4				
(5 x E/100)	5				

*Note: See Table B.2 for Required Analytes

Attachment B-5

Field Guide for Soil and Stratigraphic Analysis

FIELD GUIDE FOR SOIL AND STRATIGRAPHIC ANALYSIS V.2

midwest GEOSCIENCES group
www.midwestgeo.com

START HERE

DENSITY OR CONSISTENCY

COARSE GRAINED DEPOSITS N-VALUE	
0-4	VERY LOOSE
5-10	LOOSE
11-29	MEDIUM DENSE
30-49	DENSE
>50	VERY DENSE

FINE GRAINED DEPOSITS N-VALUE	q_u (tsf)	
0-2	<0.25	VERY SOFT
3-4	0.25-0.50	SOFT
5-8	0.50-1.0	MEDIUM
9-15	1.0-2.0	STIFF
16-30	2.0-4.0	VERY STIFF
>30	>4.0	HARD

COLOR
Use Standard Munsell Color Notation

IS THE COLOR A MATRIX COLOR?
- YES → **MATRIX COLOR** — List in sequence, dominant first
- NO → IS THE COLOR FROM A COATING OR CONCENTRATION?
  - YES → **COATING or CONCENTRATION** — Note frequency, color, and size
  - NO → **MOTTLE** — Note contrast, color, and size

CLASSIFICATION
Unified Soil Classification System - adopted ASTM D2488

COARSE-GRAINED DEPOSITS
>50% coarse-grained sediments, <50% fines

STEP 1: IS SEDIMENT COARSE GRAINED OR FINE GRAINED?

>50% fines, <50% coarse-grained sediments
FINE-GRAINED DEPOSITS
(organic and inorganic)

STEP 2: DETERMINE SAND VS. GRAVEL RATIO

INCREASING GRAIN SIZE

SAND			GRAVEL	
FINE	MEDIUM	COARSE	SMALL	LARGE

0.075 MM — 0.425 MM — 2.0 MM — 4.75 MM — 19.0 MM — 75.0 MM

STEP 3: *CONTINUE WITH SAND OR GRAVEL ON FLOW CHART (REVERSE)*

STEP 2: DETERMINE PLASTICITY AND ASSIGN USCS GROUP SYMBOL

INCREASING PLASTICITY

NON PLASTIC	LOW PLASTICITY	MEDIUM PLASTICITY	HIGH PLASTICITY
ML		CL	CH

STEP 3: *CONTINUE WITH GROUP SYMBOL ON FLOW CHART (REVERSE)*

MOISTURE

MOISTURE ABSENT	DRY
DAMP	MOIST
VISIBLE WATER	WET

FOR NON-PLASTIC FINES

WATER RISES TO SURFACE SLOWLY	SLOW DILATENCY
WATER RISES TO SURFACE QUICKLY	RAPID DILATENCY

PLASTICITY
(Use with CLASSIFICATION)

WILL NOT SUPPORT 6mm DIAMETER ROLL IF HELD ON END	NON-PLASTIC
6mm DIA. ROLL CAN BE REPEATEDLY ROLLED AND SUPPORTS ITSELF, 4mm DIA. ROLL DOES NOT	LOW PLASTICITY
4mm DIA. ROLL CAN BE REPEATEDLY ROLLED AND SUPPORTS ITSELF, 2mm DIA. ROLL DOES NOT	MEDIUM PLASTICITY
2mm DIA. ROLL CAN BE REPEATEDLY ROLLED AND SUPPORTS ITSELF	HIGH PLASTICITY

6mm 4 2

COHESIVENESS

6mm DIAMETER ROLL CANNOT BE FORMED	NONCOHESIVE
6mm DIAMETER ROLL CAN BE FORMED	COHESIVE

SEDIMENTARY STRUCTURE

UNIFORM	MASSIVE
BEDS >30cm	THICKLY BEDDED
BEDS 3cm to 30cm	BEDDED
BEDS 0.5cm to 3cm	THINLY BEDDED
BEDS <0.5cm	LAMINATED

SECONDARY SOIL STRUCTURE (IN SOLUM ONLY)

Spheroidal peds or granules usually packed loosely	GRANULAR
Irregular, roughly cubelike peds with planar faces (angular or subangular)	BLOCKY
Flat and horizontal peds	PLATY
Vertical, pillarlike peds with flat tops	PRISMATIC
Vertical, pillarlike peds with curved tops (which are commonly "bleached")	COLUMNAR

WEATHERING ZONE ABBREVIATION

MODIFIER SYMBOL (if present)		1st SYMBOL		2nd SYMBOL		LAST SYMBOL (if present)	
MOTTLED	M	OXIDIZED	O	LEACHED	L	SECONDARY	2
JOINTED	J	REDUCED	R	UNLEACHED	U	CARBONATE	
		UNOXIDIZED	U				

EXAMPLE

solum	
OJL	MRJU
MOJL	RJU
MOJL2	RU
MOJU	UU

SECONDARY GRAIN SIZE INFORMATION

< 5%	TRACE
6% to 15%	LITTLE
16% to 30%	FEW
31% to 49%	SOME

UNIFORM (poorly graded)

NON-UNIFORM (well graded)

- FINE SAND
- MEDIUM-GRAINED SAND
- COARSE-GRAINED SAND
- FINE GRAVEL
- COARSE GRAVEL

FOR GLACIAL DIAMICTONS
- CLAST FRACTION
- CLAST LITHOLOGY

DEPOSITIONAL ENVIRONMENT

VARIOUS DEPOSITIONAL ENVIRONMENTS (interpretation)
- EOLIAN (LOESS)
- FLUVIAL
- ALLUVIAL
- LACUSTRINE
- COASTAL
- RESEDIMENTED

GLACIAL DEPOSITIONAL PROCESSES
- SUBGLACIAL
- GLACIOFLUVIAL
- GLACIOLACUSTRINE
- RESEDIMENTED

GENERALIZED RESEDIMENTATION PROCESSES
- MASS SLUMP
- SEDIMENT FLOW
- COLLUVIUM

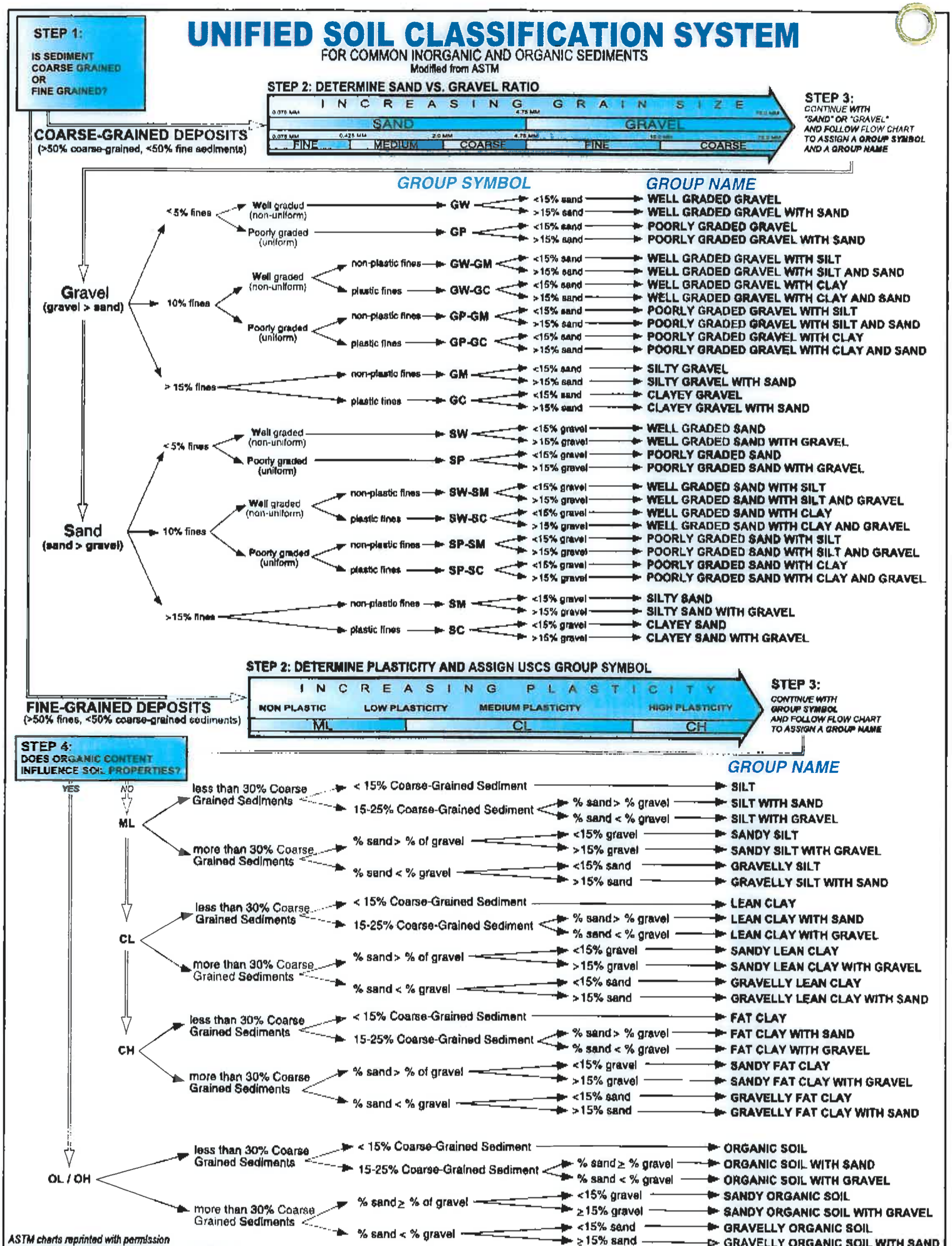
STRATIGRAPHIC NAME

USE FORMAL STATE GEOLOGICAL SURVEY NOMENCLATURE WHEN POSSIBLE;
IF NOT POSSIBLE, ASSIGN SITE-SPECIFIC UNIT NAME ACCORDING TO DEPOSITIONAL ENVIRONMENT / FACIES ASSEMBLAGE

STRATIGRAPHIC CONTACT

< 10 cm	SHARP (or ABRUPT for pedogenic alteration)
> 10 cm (Note transition interval)	GRADATIONAL (or TRANSITIONAL for weathering zone change)

010106



UNIFIED SOIL CLASSIFICATION SYSTEM
FOR COMMON INORGANIC AND ORGANIC SEDIMENTS
Modified from ASTM
STEP 1:
IS SEDIMENT COARSE GRAINED OR FINE GRAINED?
COARSE-GRAINED DEPOSITS
(>50% coarse-grained, <50% fine sediments)
STEP 2: DETERMINE SAND VS. GRAVEL RATIO
INCREASING GRAIN SIZE
0.075 MM
4.75 MM
75.0 MM
SAND
GRAVEL
0.075 MM
0.425 MM
2.0 MM
4.75 MM
19.0 MM
75.0 MM
FINE
MEDIUM
COARSE
FINE
COARSE
STEP 3:
CONTINUE WITH "SAND" OR "GRAVEL" AND FOLLOW FLOW CHART TO ASSIGN A GROUP SYMBOL AND A GROUP NAME
GROUP SYMBOL
GROUP NAME
Gravel
(gravel > sand)
<5% fines
Well graded (non-uniform)
GW
<15% sand
WELL GRADED GRAVEL
>15% sand
WELL GRADED GRAVEL WITH SAND
Poorly graded (uniform)
GP
<15% sand
POORLY GRADED GRAVEL
>15% sand
POORLY GRADED GRAVEL WITH SAND
10% fines
Well graded (non-uniform)
non-plastic fines
GW-GM
<15% sand
WELL GRADED GRAVEL WITH SILT
>15% sand
WELL GRADED GRAVEL WITH SILT AND SAND
plastic fines
GW-GC
<15% sand
WELL GRADED GRAVEL WITH CLAY
>15% sand
WELL GRADED GRAVEL WITH CLAY AND SAND
Poorly graded (uniform)
non-plastic fines
GP-GM
<15% sand
POORLY GRADED GRAVEL WITH SILT
>15% sand
POORLY GRADED GRAVEL WITH SILT AND SAND
plastic fines
GP-GC
<15% sand
POORLY GRADED GRAVEL WITH CLAY
>15% sand
POORLY GRADED GRAVEL WITH CLAY AND SAND
> 15% fines
non-plastic fines
GM
<15% sand
SILTY GRAVEL
>15% sand
SILTY GRAVEL WITH SAND
plastic fines
GC
<15% sand
CLAYEY GRAVEL
>15% sand
CLAYEY GRAVEL WITH SAND
Sand
(sand > gravel)
<5% fines
Well graded (non-uniform)
SW
<15% gravel
WELL GRADED SAND
>15% gravel
WELL GRADED SAND WITH GRAVEL
Poorly graded (uniform)
SP
<15% gravel
POORLY GRADED SAND
>15% gravel
POORLY GRADED SAND WITH GRAVEL
10% fines
Well graded (non-uniform)
non-plastic fines
SW-SM
<15% gravel
WELL GRADED SAND WITH SILT
>15% gravel
WELL GRADED SAND WITH SILT AND GRAVEL
plastic fines
SW-SC
<15% gravel
WELL GRADED SAND WITH CLAY
>15% gravel
WELL GRADED SAND WITH CLAY AND GRAVEL
Poorly graded (uniform)
non-plastic fines
SP-SM
<15% gravel
POORLY GRADED SAND WITH SILT
>15% gravel
POORLY GRADED SAND WITH SILT AND GRAVEL
plastic fines
SP-SC
<15% gravel
POORLY GRADED SAND WITH CLAY
>15% gravel
POORLY GRADED SAND WITH CLAY AND GRAVEL
>15% fines
non-plastic fines
SM
<15% gravel
SILTY SAND
>15% gravel
SILTY SAND WITH GRAVEL
plastic fines
SC
<15% gravel
CLAYEY SAND
>15% gravel
CLAYEY SAND WITH GRAVEL
STEP 2: DETERMINE PLASTICITY AND ASSIGN USCS GROUP SYMBOL
INCREASING PLASTICITY
NON PLASTIC
LOW PLASTICITY
MEDIUM PLASTICITY
HIGH PLASTICITY
ML
CL
CH
STEP 3:
CONTINUE WITH GROUP SYMBOL AND FOLLOW FLOW CHART TO ASSIGN A GROUP NAME
FINE-GRAINED DEPOSITS
(>50% fines, <50% coarse-grained sediments)
STEP 4:
DOES ORGANIC CONTENT INFLUENCE SOIL PROPERTIES?
YES
NO
GROUP NAME
ML
less than 30% Coarse Grained Sediments
< 15% Coarse-Grained Sediment
SILT
15-25% Coarse-Grained Sediment
% sand > % gravel
SILT WITH SAND
% sand < % gravel
SILT WITH GRAVEL
more than 30% Coarse Grained Sediments
% sand > % of gravel
<15% gravel
SANDY SILT
>15% gravel
SANDY SILT WITH GRAVEL
% sand < % gravel
<15% sand
GRAVELLY SILT
>15% sand
GRAVELLY SILT WITH SAND
CL
less than 30% Coarse Grained Sediments
< 15% Coarse-Grained Sediment
LEAN CLAY
15-25% Coarse-Grained Sediment
% sand > % gravel
LEAN CLAY WITH SAND
% sand < % gravel
LEAN CLAY WITH GRAVEL
more than 30% Coarse Grained Sediments
% sand > % of gravel
<15% gravel
SANDY LEAN CLAY
>15% gravel
SANDY LEAN CLAY WITH GRAVEL
% sand < % gravel
<15% sand
GRAVELLY LEAN CLAY
>15% sand
GRAVELLY LEAN CLAY WITH SAND
CH
less than 30% Coarse Grained Sediments
< 15% Coarse-Grained Sediment
FAT CLAY
15-25% Coarse-Grained Sediment
% sand > % gravel
FAT CLAY WITH SAND
% sand < % gravel
FAT CLAY WITH GRAVEL
more than 30% Coarse Grained Sediments
% sand > % of gravel
<15% gravel
SANDY FAT CLAY
>15% gravel
SANDY FAT CLAY WITH GRAVEL
% sand < % gravel
<15% sand
GRAVELLY FAT CLAY
>15% sand
GRAVELLY FAT CLAY WITH SAND
OL / OH
less than 30% Coarse Grained Sediments
< 15% Coarse-Grained Sediment
ORGANIC SOIL
15-25% Coarse-Grained Sediment
% sand ≥ % gravel
ORGANIC SOIL WITH SAND
% sand < % gravel
ORGANIC SOIL WITH GRAVEL
more than 30% Coarse Grained Sediments
% sand ≥ % of gravel
<15% gravel
SANDY ORGANIC SOIL
≥15% gravel
SANDY ORGANIC SOIL WITH GRAVEL
% sand < % gravel
<15% sand
GRAVELLY ORGANIC SOIL
≥15% sand
GRAVELLY ORGANIC SOIL WITH SAND
ASTM charts reprinted with permission

Attachment B-6

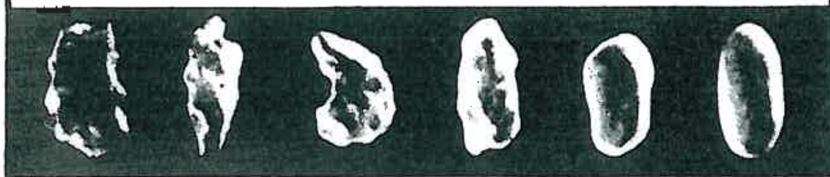
Sediment Geotechnical Gauge

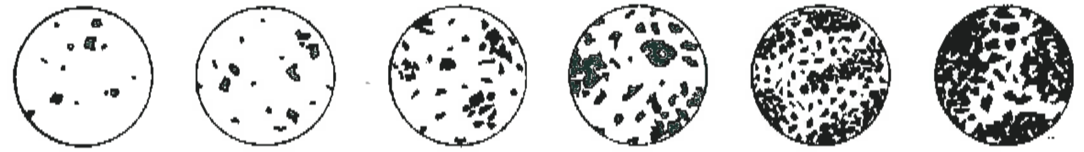
0 mm 10 20 30 40 50 60 70 80 90 100 110

Geotechnical Gauge

Manuf. by:
W.F. McCollough
3101 Elkridge Ct.
Beltsville, MD 20705

Very Angular | Angular | Sub Angular | Sub Rounded | Rounded | Well Rounded





3 % | 5 % | 15 % | 25 % | 40 % | 50 %

MAJOR DIVISIONS			GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL - GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES.
				GP	POORLY - GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES.
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES.
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES.
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL - GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.
				SP	POORLY - GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY - SANDS, SAND - SILT MIXTURES.
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES.
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY.
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS.
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS.

Light Brow

Yellowish Orange

Greenish Gray

Olive Gray

Light Gray

Dark Gray

0 inches 1 2 3 4 5 6

CLAY

CLAY CONSISTENCY	THUMB PENETRATION	SPT, N BLOWS/ FT.	Undrained Shear Strength c (PSF) TORVANE	Unconfined Compressive Strength q_u Pocket Penetrometer
VERY SOFT	Easily penetrated several inches by thumb. Exudes between thumb and finger's when squeezed in hand.	< 2	250	500
SOFT	Easily penetrated one inch by thumb. Molded by light finger pressure.	2 - 4	250 - 500	500 - 1000
MEDIUM STIFF	Can be penetrated over 1/4" by thumb with moderate effort. Molded by strong finger pressure.	4 - 8	500 - 1000	1000 - 2000
STIFF	Indented about 1/4" by thumb but penetrated only with great effort.	8 - 15	1000 - 2000	2000 - 4000
VERY STIFF	Readily indented by thumbnail.	15 - 30	2000 - 4000	4000 - 8000
HARD	Indented with difficulty by thumbnail.	> 30	> 4000	> 8000

SAND

SOILTYPE	SPT, N Blows/ft	Relative Density,%	FIELD TEST
VERY LOOSE SAND	4	0 - 15	Easily penetrated with 1/2" reinforcing rod pushed by hand.
LOOSE SAND	4 - 10	15 - 35	Easily penetrated with 1/2" reinforcing rod pushed by hand.
MEDIUM DENSE SAND	10 - 30	35 - 65	Penetrated a foot with 1/2" reinforcing rod driven with 5-lb hammer.
DENSE SAND	30 - 50	65 - 85	Penetrated a foot with 1/2" reinforcing rod driven with 5-lb hammer.
VERY DENSE SAND	50	85 - 100	Penetrated only a few inches with 1/2" reinforcing rod driven with 5-lb hammer.

Unified Soil Classification System (USCS)

	MILLIMETERS	INCHES	SIEVE SIZES	
BOULDERS	> 300	> 11.8	-	
COBBLES	75 - 300	2.9 - 11.8	-	
GRAVEL:				
COARSE	75 - 19	2.9 - .75	-	
FINE	19 - 4.8	.75 - .19	3/4" - No. 4	
SAND:				
COARSE	4.8 - 2.0	.19 - .08	No. 4 - No. 10	
MEDIUM	2.0 - .43	.08 - .02	No. 10 - No. 40	
FINE	.43 - .08	.02 - .003	No. 40 - No. 200	
FINES:				
SILTS	< .08	< .003	< No. 200	
CLAYS	< .08	< .003	< No. 200	

Appendix C

Benthic Recolonization Monitoring Operations Manual

C.1 INTRODUCTION

The purpose of this benthic recolonization monitoring program is to evaluate the success of the Thea Foss and Wheeler-Osgood Waterways sediment remediation at restoring benthic community to the remediation areas. The objectives of this program are described in further detail in Section 4.0 of the OMMP. This field manual provides guidance to field personnel involved in this benthic recolonization program by providing the necessary information to perform the field activities required as part of the monitoring.

This manual is organized in three general sections:

- Preparation for Sampling;
- Sediment Sampling Procedures; and
- Post-Sampling Procedures.

Attachment C-1 presents the Quality Assurance Project Plan (QAPP) for the benthic recolonization monitoring program. Appendix F presents a project-specific Health and Safety Plan that includes benthic recolonization monitoring activities, such as surface sediment sampling. Refer to the Sediment Sampling Operations Manual (Appendix B) for methods and procedures regarding surface grab sediment sampling and chemical analysis of archived sediment samples. A copy of this Benthic Recolonization Monitoring Operations Manual and the Sediment Sampling Operations Manual should be carried in the field when completing benthic recolonization monitoring.

C.2 PREPARATION FOR SAMPLING

Before going into the field, the following steps should be completed.

C.2.1 Review and Understand this Manual

In preparation for benthic organisms and sediment sampling and before conducting field work, all personnel must become familiar with this Benthic Recolonization Monitoring Operations Manual, the Sediment Sampling Operations Manual, the Health and Safety Plan requirements, and Section 4.0 of the OMMP (including all relevant tables and figures). If questions arise, contact the City's Project Manager.

C.2.2 Contact Appropriate People for Site Access

The City's Project Manager will notify EPA of the survey and sampling schedule. In addition, the appropriate people will be contacted to coordinate boat launching and dock space availability for the survey and sampling vessel.

C.2.3 Contact Analytical Laboratory

Arrange with the analytical laboratory for the appropriate storage methods and procedures for archived benthic community and sediment chemistry samples.

Prior to the sampling event, call the analytical laboratory and verify the following:

- Date of sampling, number of samples to be collected, and date of sample delivery to lab;
- Formalin Solution Concentration;
- When sample containers are needed and appropriate size (with chain of custody form);
- Storage requirements for archived samples;
- Sample disposal; and
- Any other work order issues.

Upon receiving jars from the lab, verify that all necessary containers are present. Label containers and organize them into coolers. Prepare necessary ice packs and bubble wrap for jar protection and sample preservation.

A copy of the Benthic Recolonization Monitoring QAPP (see Attachment C -1) and the Sediment Chemistry Quality QAPP (see Attachment B -1) should be provided to the laboratory. Any deviations from these requirements by the laboratory must be approved beforehand by the City and EPA.

C.2.4 Contact Subcontractors

Specialty subcontractors will be used for the Sediment Profile Imagery (SPI) and potentially sediment sampling operations. Planned field work must be coordinated with the sampling vessel owner/ operator, and the location control specialists, as necessary. The following should be discussed:

- Personnel availability and estimated duration of field work;
- Number of personnel needed for the operation and how many personnel can be onboard the sampling vessel at one time;
- Evaluation of pre-sampling preparation including travel time (as necessary), contracting, equipment shipping, software/map needs, and review of this manual and other applicable sources of information; and
- Any other work order issues

C.2.5 Organize Field Equipment and Supplies

Start organizing field equipment and supplies at least one week in advance of the established sampling date. Ensure that all equipment and supplies are in good working order, and calibrated if necessary.

Table C-1 provides a summary checklist of required field equipment for collection of surface sediment samples that will be archived for benthic community analysis and sediment chemistry.

C.2.6 Establish GPS Control Locations

Use of GPS benchmarks and sample location control points are key elements to the successful completion of all sediment sampling activities. All field personnel must be familiar with the Contractor's GPS equipment to be used during the SPI survey so that accurate position control can be established (at the benchmark control locations shown on Figure C-1) prior to the start of the survey and sediment sample collection.

C.3 SEDIMENT SAMPLING PROCEDURES

This section describes the protocol to be used for SPI surveys and surface sediment collection for archival included under this OMMP. If the results of SPI require confirmation and additional assessment, sediment chemistry quality will be reviewed and archived benthic community samples will be used for clarification (see Section 4.3.2 of the OMMP).

C.3.1 General Approach

The following field activities will be conducted as part of the Benthic Recolonization Monitoring included in this OMMP:

- **SPI Survey.** The SPI camera will photograph and document the conditions of the upper 20 cm of the sediment profile. Three replicate images (three camera deployments) will be taken at each survey location to obtain a mean depth for the redox discontinuity layer and any information on location heterogeneity. The sediment profile camera may be positioned by a diver or remotely operated on a frame lowered from the survey/sampling vessel.
- **Surface Sediment Samples.** Surface sediment samples will be collected using a grab sampler within the top 10 cm of the sediment column. Benthic organisms will be screened and archived for future benthic community analysis. At background locations and locations not co-located with cap performance monitoring locations sediment samples will be collected and archived for sediment chemistry if determined to be necessary. Additional information on the monitoring locations is presented in Table C-2. A field form has been developed and should be used during sampling to assist in collection of surface sediment samples (see Attachment B-3).

Collection methods related to surface sediment samples are discussed in detail in Section B.3.3 of the Sediment Sampling Operations Manual and sampling modifications are presented in Section C.3.4 of this manual.

C.3.2 Arrival at the Site

As equipment is being loaded aboard the vessel, stow sampling and storage equipment in appropriate areas. Check the GPS to ensure it is properly functioning. Coordinates for the proposed sampling locations should be pre-entered into the location control software program for referencing.

Before leaving the dock conduct a Health and Safety meeting to establish the work zone areas, discuss potential contamination migration pathways and their preventions, identify potential vessel hazards, and establish the boat operator's specific health and safety guidelines. Be sure that personnel working at the site understand and sign the Health and Safety Plan (Appendix F).

C.3.3 SPI Survey

SPI will be performed at 17 survey locations as shown on Figure C-1 to evaluate the success of remediation actions at providing an environment suitable for benthic recolonization. An additional four locations, located in the mouth of the waterway, will also be surveyed and as representative background locations for the benthic community of the Thea Foss Waterway and Commencement Bay. Collection of the SPI photographs will be conducted by a specialty subcontractor and overseen by City field personnel.

Specific procedures for this method will be dictated by the contractor performing the work; in general the following procedures will be used. The SPI camera prism will be mounted on an assembly that can be raised and lowered with a winch. The SPI camera will be deployed to penetrate the sediment, to approximately two-thirds of the height of the face plate, but not above the top of the face plate. If over- or under-penetration is noted from the first deployment, the equipment weights will be adjusted accordingly.

The upper 20 cm of sediment are photographed in high resolution by a camera. Three replicate images will be taken at each survey location to obtain a mean depth for the redox discontinuity layer and any information on location heterogeneity for statistical purposes. The sediment profile camera may be assisted by a diver or remotely operated on a frame lowered from the survey/sampling vessel as determined by the contractor and the City. The SPI parameters that will be documented at each survey location and used to assess benthic recolonization are described in detail in Section 4.3.2 of the OMMP.

C.3.4 Sediment Sampling and Processing

Surface sediment samples for potential benthic community analysis will be collected at each SPI survey location as described in Section 4.3.1 of the OMMP and presented in Figure C-1. A total of five replicate sediment samples to be used to obtain benthic organisms will be collected at each location. At benthic recolonization monitoring locations that are not co-located with chemical quality sampling locations for the performance monitoring, a surface sediment sample will also be collected and archived for possible future sediment chemistry analyses if needed (see Sediment Sampling Operations Manual – Appendix B for procedures). At locations that are co-located with performance monitoring sample locations, chemical quality data (if needed) will be derived from the cap performance samples. Sample collection will be conducted in accordance with standard PSEP protocols. Sediment samples will be collected using a grab sampler or similar equipment capable of collecting samples that are relatively consistent in volume and penetration depth. Methods may be updated or revised as directed by EPA or the City.

The surface sediment sampling procedure used to collect benthic community samples will be similar to the methods used for sediment chemistry quality surface sampling (Sediment Sampling Operations Manual – Appendix B), with the following modifications:

- All sediment in the sampler can be used for the benthic sample (provided it is an acceptable grab – See Appendix B). It is not necessary to avoid sediments that have come in contact with the sampler since chemical cross-contamination is not of issue; and
- Sample processing includes sediment sample screening and preservation of the benthic organisms retained on the screens, rather than homogenization that is included in chemical quality sampling.

The methods used to collect surface sediment samples are described in detail in the Sediment Sampling Operations Manual (Appendix B).

Following the collection of sediment the sampler will be raised to the surface where the collected sample will be evaluated for acceptability. If the sample is determined to be acceptable, the overlying water will be decanted and the entire sediment sample will be removed for benthic analysis archival. The general procedure for collecting benthic community samples is as follows:

1. Each sample should be placed in a container and labeled. Either on the boat or once on shore, the sample will be screened through a 1.0 mm mesh sieve, nested within a 0.5 mm sieve.
2. Gently wash the sediment sample through the screen with seawater until all particulate matter capable of passing through the mesh is removed and the rinse water is clear. Direct application of high pressure water on the material and organisms collected on the sieve should be avoided. Sediment clumps can be broken up gently by hand.
3. Carefully remove the material remaining on the screen to a labeled sample container. The sample should not fill more than 85 to 90 percent of the sample container to allow room for the fixative.
4. Check the screen for organisms trapped in the sieve. If organisms cannot be dislodged, use a pair of tissue forceps to remove them, with care to avoid damaging the organism.
5. Add a quantity of buffered formalin/Rose Bengal solution sufficient to achieve a final concentration in the sample container of 10 percent formalin solution to each container. The sample label should include notice that the sample jar contains formalin. Firmly fasten the sample container lid and rinse the outside of the container to remove any traces of formalin.
6. Gently invert the container several times to mix the sample and the formalin preservative.
7. Re-mix or agitate the sample approximately one hour after sample collection.

Samples should be re-screened from the formalin solution into 70 percent ethanol within two weeks of sample collection. This will be performed by the laboratory.

If confirmation of SPI results is needed, and/or the SPI parameters do not indicate benthic recolonization, benthic community analysis will be performed and the stored archived samples will be sorted, weighed, and the organisms identified and enumerated at the laboratory. The procedures for sample re-screening, sorting, and enumeration are described in the QAPP (see Attachment C-1). Co-located sediment chemistry results will also be reviewed.

C.3.5 Location Control and Documentation

The methods of location control utilized for the survey and sampling activities described in this manual are the same as those requirements summarized in Section B.3.5 of the Sediment Sampling Operations Manual.

C.3.6 Sediment Quality Sample Handling

Field personnel will log each sample and package samples for transport.

Sample Logging in the Field. After samples are deemed acceptable, the following information will be recorded on the field log sheet:

- Date, time, and name of person logging sample;
- Location coordinates;
- Sample location number;
- Depth of water at the location (including predicted tide elevation at the time of sampling);
- Sediment sample depth;
- Sampling equipment used;
- Sample recovery; and
- Sample description (including texture, odor, color, presence of biological structures, and presence of debris structures).

The vertical changes in sediment characteristics and the presence and depth of the redox potential discontinuity layer, etc. will be described and recorded as part of the SPI analyses, however, this information should also be recorded for the sediment samples collected for potential future benthic community analyses to identify localized sediment heterogeneity. Following the collection of bulk sediment samples for benthic community collection, sediment samples will be returned to a shore-based processing area between survey and sample locations for screening and preservation. Samples will be transported to the analytical laboratory at the end of the day.

C.4 POST-SAMPLING PROCEDURES

C.4.1 Sample Labeling

A unique sample identification number is assigned to the benthic community sample containers and associated documentation. The sample identification number will be assigned using the monitoring event followed by the sample location (e.g., a benthic community sample collected at location 03 during the Year 2 monitoring event would be labeled BR-03-Y2). Sediment (0 to 10 cm) samples that will be archived for sediment chemistry analyses in the event that confirmation of the SPI results is required will also be labeled BR-03-Y2. Sample labels will also clearly indicate sampling locations, sample number, the project name, sampler's initials, sample archival, date, and time. Labels will be filled out prior to sampling and affixed to the sample jars. For benthic infauna, duplicate labels will be placed within each jar with the samples. The sample jar labels, chain-of-custody forms, and field description forms should all contain the identical sample ID number for accurate cross-referencing.

C.4.2 Sample Custody

Definition of Custody. After recovery, samples will be maintained in custody until formally transferred to laboratory. For purposes of this work, custody will be defined as follows:

- In plain view of the field representatives; or
- Inside any locked space such as a cooler, locker, car, or truck to which the field representative has the only immediately available key(s).

Custody Records. A chain of custody record will be initiated at the time of sampling for each sample collected. This record will be signed by the field representative and others who subsequently hold custody of the sample. Additional fields on the custody form that need to be filled out indicate the initials of the person completing the form, the sample collection date and time, the required sample analyses, and the total number of containers for each sample. A copy of the chain of custody with all the appropriate signatures will be returned to the Project Manager.

C.4.3 Shipping Requirements and Receipt

Benthic community samples and/or sediment samples are not anticipated to require shipping. However, in the event that it is needed, the following procedures will be conducted. Prior to shipping, sample containers will be appropriately packed and secured inside the shipping container, most likely a cooler, and extra care will be taken to securely wrap the sample containers to prevent breakage and leakage of the fixative. The original signed custody forms will be transported with the cooler. The cooler will be secured and appropriately labeled for shipping and handling. Samples will be delivered to the laboratory under custody control protocols following completion of sampling activities.

C.4.4 Laboratory Analysis

In completing the benthic community analyses for this project, the contract laboratory is expected to adhere to the methods outlined in the QAPP as well as provide hard copies and electronic data deliverables of the statistical results for the benthic abundance analysis. The QA/QC procedures to be followed in the event that archived sediment samples are chemically analyzed for COCs are presented in Attachment B-1 to the Sediment Sampling Operations Manual.

The following laboratory procedures will be followed to prepare the benthic samples for identification and enumeration:

1. The buffered formalin solution used to preserve the samples after initial field screening will be decanted from the sample containers and the samples will be rescreened using a sieve at least one size smaller than that used to screen samples in the field (typically a 0.5 mm sieve).
2. The samples will be preserved in a 70 percent ethanol solution.
3. Benthic samples will be sorted by placing an aliquot of sample in a Petri dish and, while viewing the sample through a dissection microscope, removing each organism or fragment.
4. The organisms will be sorted into the following major taxonomic groups: polychaetes, crustaceans, molluscs, echinoderms, and other miscellaneous taxa.
5. The wet-weight biomass of each major taxa from each sample will be determined by pouring the animals from the sorted sample through a preweighed screen. This screen will be placed on absorbent paper and either blotted dry from underneath, or allowed to remain on the paper until no more fluid is removed. The sample should be dried for no more than 30 seconds as smaller organisms may dry out and rupture or tear.
6. The screen and sample will then be weighed. The organisms are then washed back into the vial with 70 percent ethanol, and the wet-weight biomass determined by subtracting the container weight.
7. All organisms will be stored in 70 percent ethanol solution. Sorted organisms will be identified and enumerated to two taxonomic levels. The first will be to the major taxa level as discussed above, and the second will be to the lowest taxonomic level possible, generally the species level. For fragments of organisms, count only the anterior portions.
8. The data from the laboratory analysis will be in the form of wet-weight biomass of the major taxa by sample and numerical abundance or densities of biological organisms by species. These benthic data will be used to characterize the benthic communities present and to document the recolonization process along with the SPI photographs.

Specific laboratory procedures, or procedures providing an equivalent level of control, will be employed for receiving, tracking, and processing benthic samples.

C.4.4.1 Benthic Abundance

All samples will initially be archived for potential benthic analysis. Prior to archiving benthic abundance samples, formalin will be replaced with 70 percent ethanol. The sample collection jars will be examined by the laboratory at a minimum frequency of once a month for evidence of ethanol preservative loss and condition of the sample. If preservative loss is detected, the City Project Manager will be notified and the appropriate action taken.

If benthic abundance analyses are performed, initially, three of the five collected replicate samples from each location will be analyzed. The analyses endpoints include major taxa abundance (i.e., polychaetes, crustaceans, molluscs, echinoderms, and miscellaneous phyla) and species richness. In the event that benthic analysis conducted for the initial three samples and the abundance of a major taxa are less than 50 percent of the abundance in the reference sediment, but the difference is not statistically significant, a power analysis will be performed, or the additional two archived benthic samples will be analyzed without a power analysis. If the power analysis is conducted and determines that a 50 percent difference can be statistically discerned with both the initial three benthic samples and the additional two archived replicates then all five samples will be analyzed. However, if the power analysis determines that a statistically significant difference can not be achieved then only the initial three samples will be analyzed. The analysis of benthic community data is described in Section 4.3.2 of the OMMP.

REFERENCES

Tetra Tech Inc. 1986 (as updated through 1996). Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound. Puget Sound Estuary Program.

U.S. Environmental Protection Agency. 1989. Commencement Bay Nearshore/Tideflats Record of Decision, U.S. Environmental Protection Agency, Region 10. September 1989.

TABLES

Table C-1 – Benthic and Sediment Sampling Field Equipment Checklist

Table C-2 – Benthic Recolonization Survey and Sampling Locations

FIGURES

Figure C-1 – Benthic Recolonization Monitoring Locations

ATTACHMENTS

Attachment C-1 – Quality Assurance Project Plan for Benthic Recolonization and Community Analysis

Attachment C-2 – Benthic Recolonization Sample Collection Form

Attachment C-3 – Benthic Sample Tracking Log

Attachment C-4 – Benthic Vial Tracking Log

Attachment C-5 – Benthic Taxonomy Form

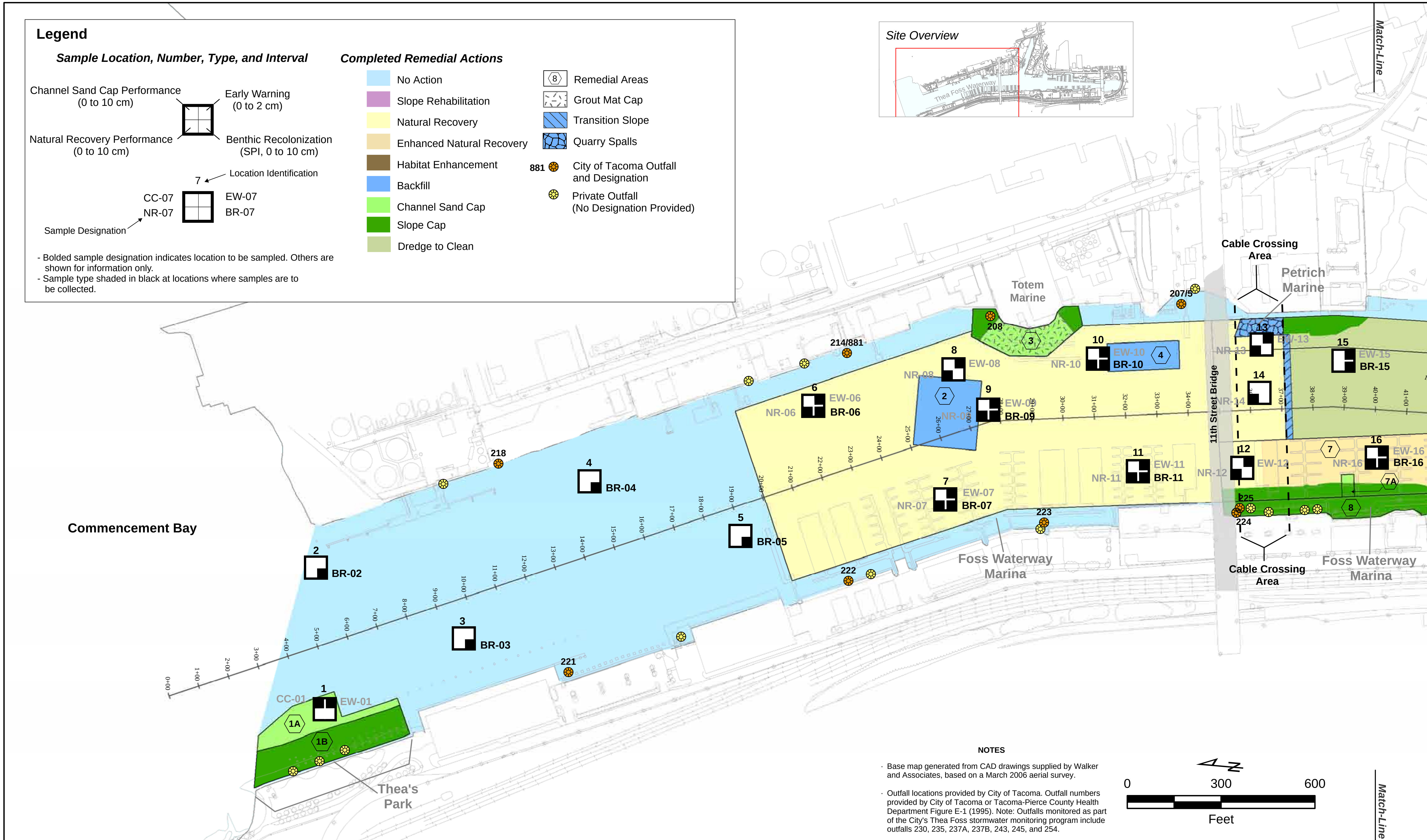
Table C-1
Benthic and Sediment Sampling Field Equipment Checklist

□	Site map showing monitoring points locations (Figure C-1)
□	Sediment Sampling Operations Manual
□	Benthic Recolonization Monitoring Operations Manual
□	Field Notebook
□	Surface Sediment Sampling Field Form
□	Field Guide for Soil and Stratigraphic Analysis
□	Geotechnical Gauge Field Guide
□	Formalin Solution
□	1.0 mm and 0.5 mm mesh sediment sieve
□	0.06m^2 or 0.1m^2 surface grab sampler
□	Deionized (DI) Water Pump Sprayer and Brush
□	Alconox and DI Water Pump Sprayer and Brush
□	Sufficient Laboratory Sampling Jars (see Appendix B, Table B.2)
□	Stainless Steel Bowls
□	Stainless Steel Spoons
□	Aluminum Foil
□	Paper Towels
□	Sharpie Pens for Marking Sample Labels
□	Camera
□	Forceps
□	Spatual
□	Funnel
□	Laboratory Chain-Of-Custody (COC) Forms
□	Large Ziplock Bags
□	Clipboards

Table C-2
Benthic Recolonization Survey and Sampling Locations

SPI Survey Location	Benthic Community Sample (Archived)	Sediment Chemistry Sample (0 to 10 cm) (Archived)	Co-located Sediment Chemistry Analyses	Background or Remedial Action
BR-02	X			Background
BR-03	X			Background
BR-04	X			Background
BR-05	X			Background
BR-06	X		TBD	Natural Recovery
BR-07	X		TBD	Natural Recovery
BR-09	X		TBD	Natural Recovery
BR-10	X		TBD	Natural Recovery
BR-11	X		TBD	Natural Recovery
BR-15	X	X	TBD	Dredge to Clean
BR-16	X		TBD	Enhanced Natural Recovery
BR-18	X		TBD	Cap
BR-21	X	X	TBD	Dredge to Clean
BR-22	X	X	TBD	Dredge to Clean
BR-23	X		TBD	Cap
BR-26	X		TBD	Cap
BR-28	X	X	TBD	Dredge to Clean
BR-29	X		TBD	Cap
BR-31	X		TBD	Cap
BR-32	X		TBD	Cap
BR-33	X		TBD	Cap

Notes:
SPI Sediment Profile Imagery.
TBD To be determined.



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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure C-1 (Page 1 of 2)
Benthic Recolonization Monitoring Locations

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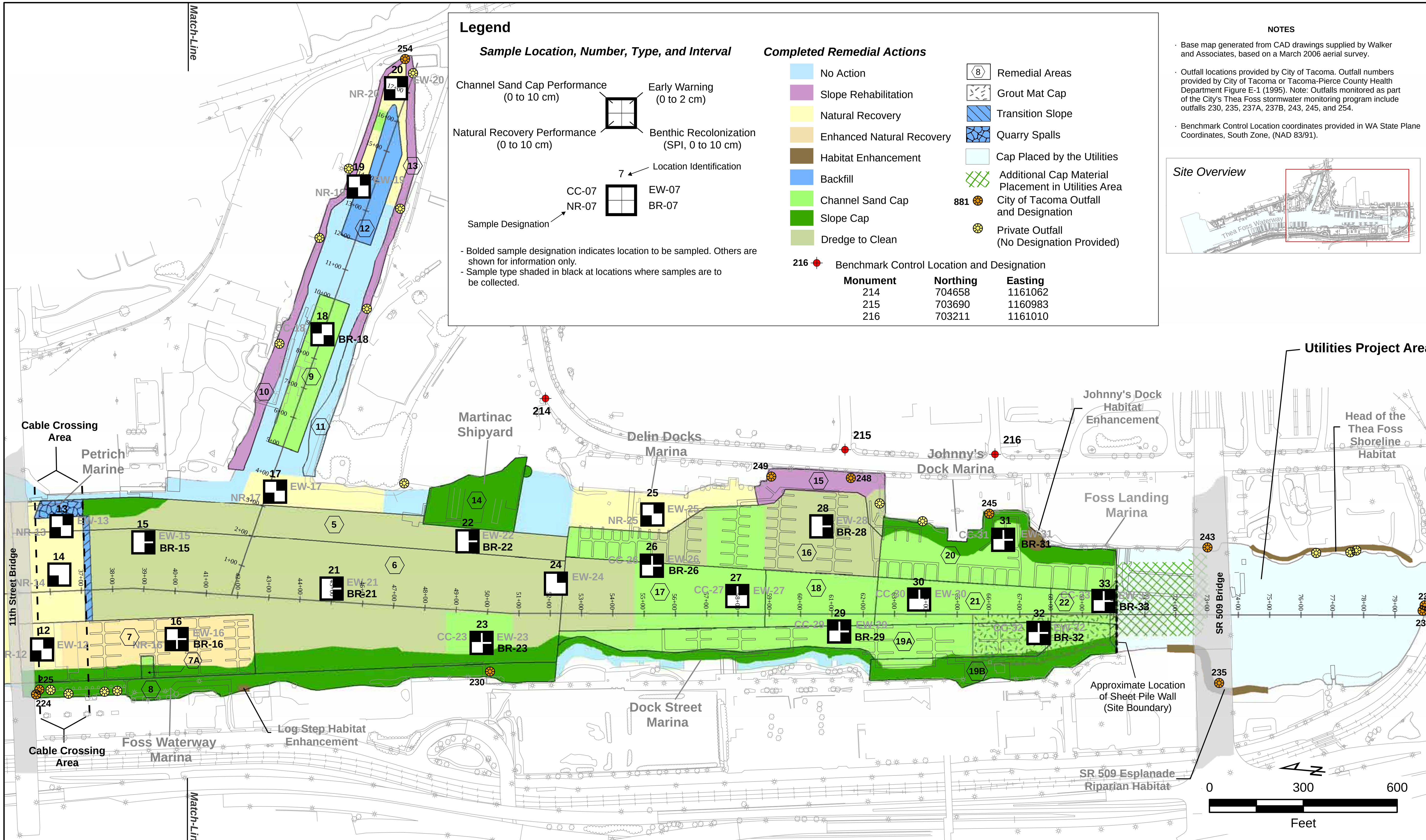

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Attachment C-1

Quality Assurance Project Plan for Benthic Recolonization and Community Analysis

C-1.1 INTRODUCTION

The purpose of this Quality Assurance Project Plan (QAPP) is to provide the requirements for the organization and functional activities associated with the benthic recolonization monitoring for the Thea Foss and Wheeler-Osgood Waterways Remediation Project. This QAPP covers benthic abundance data analysis and laboratory procedures for the benthic samples collected during the benthic recolonization monitoring as well as SPI quality assurance and quality confirmation, as described in the OMMP.

C-1.2 QUALITY ASSURANCE OBJECTIVE

The quality assurance (QA) objectives for the benthic abundance analysis are to ensure that the data collected are of known and acceptable quality and that the identification and enumeration of the benthic organisms is performed in a consistent manner throughout the duration of the long-term monitoring period. The Benthic Recolonization Monitoring Operations Manual has been prepared to satisfy this requirement, provided field inspections are completed as prescribed, and the procedures for benthic community analysis as described in this QAPP are followed. Field personnel should utilize manual field forms when collecting surface sediment chemistry and benthic community samples for archival.

C-1.3 SPI QA/QC PROCEDURES

Quality control requirements for the SPI survey and contractor are as follows;

- Horizontal datum will be NAD83/91 and horizontal position tolerance will be +/- 3 feet. Field location equipment should be calibrated to established upland survey benchmarks before conducting SPI surveys;
- Vertical datum will be NVGD 29 and vertical accuracy for measured depths will have a tolerance of +/- 0.1 feet;
- Care will be taken so that the SPI camera is deployed to penetrate the sediment to approximately two-thirds of the height of the face plate, but not above the top of the face plate. If over- or under-penetration is noted from the first deployment, the equipment weights will be adjusted accordingly; and
- Three replicate SPI images will be obtained and analyzed at each survey location to account for sediment location heterogeneity as well as verifying survey results.

Following the completion of SPI survey events, the SPI parameters (i.e., Sediment Type Determination, Benthic Habitat Classification, Surface Boundary Roughness, etc.) will be compiled, tabulated and provided to the City. SPI survey comparisons will also be performed after completion of all SPI survey events to compare the current event data to baseline (Year 0) and other previous survey events.

C-1.4 LABORATORY QA/QC PROCEDURES

C-1.4.1 Benthic Infauna Laboratory Standard Procedures

Laboratory analyses will be performed by a qualified biologist in a qualified laboratory with taxonomic support from other institutions as appropriate.

Standard laboratory procedures used for sample processing include:

1. Writing using permanent ink, unless otherwise required;
2. Errors or corrections are crossed out with one horizontal line, initialed and dated;
3. Weekly updated photocopies of all forms are kept either on-site in a fireproof cabinet, or secured off-site; and
4. Screen over all sink drains when samples are screened or otherwise handled.

After delivery, samples are removed from shipping containers and compared against the chain of custody manifest. Conflicts are resolved using the interior labels. The chain of custody is then signed with date and time. The bench sheets and tracking logs are filled out as appropriate during the sorting process. All blank spaces must be filled in.

C-1.4.2 Sorting and Taxonomy Quality Control

Sorting Quality Control. Twenty percent of each sample will be re-examined by an independent sorter. All organisms found are verified by a taxonomist to assure they are countable parts. Ninety-five percent initial recovery is considered satisfactory (for example, one found in QC, check to 100 total in the 20 percent sample portion). Additional samples not extracted by the initial sorter should be recorded separately on a Sample Tracking Log (Attachment C-3). The recovered organisms should be added to the initial organisms sorted. If 95 percent of the organism samples are not recovered in the initial sorting, the sample must be re-sorted.

Taxonomy Quality Control. Following the initial sorting of the benthic organisms and the re-examination, a taxonomist will perform a taxonomic count of each of the organism groups. For example, the taxonomist should identify each species of annelid or mollusk that was previously sorted. The taxonomist will also provide the associated taxon code for each species on a separate Tracking Log and Taxonomy Form (Attachments C-4 and C-5) and retain one of each specimen for the project reference collection.

C-1.4.3 Data Management

If benthic abundance analyses are performed, the laboratory will provide spreadsheets of raw data (bench sheets) consisting of species counts by replicate and sample location. If sediment chemical analyses are performed hardcopy and EDDs will be provided to the City. The data set for this project will require a computer-based data management system to facilitate data review and analysis. All electronic data will be reported in a format consistent with guidance contained in Instructions for Formatting of Digital Data – Sediment (Chemical, Benthic, Bioassay), Water Column, and Shellfish Monitoring Data – Commencement Bay Nearshore/Tideflats Superfund Site (USEPA 1994).

REFERENCES

Canning, Douglas J. (compiler). 1994. Washington state tidal and terrestrial datum plans. (Version 1.2). Shorelands and Coastal Zone Management Program, Washington Department of Ecology, Olympia.

U.S. Environmental Protection Agency. 1994. Instructions for Formatting of Digital Data – Sediment (Chemical, Benthic, Bioassay), Water Column, and Shellfish Monitoring Data – Commencement Bay Nearshore/Tideflats Superfund Site.

Attachment C-2

Benthic Recolonization Sample Collection Form

BENTHIC RECOLONIZATION SAMPLE COLLECTION FORM

Sample Location Designation: ______________ Date of Collection: ______________

Sample Collection Method: ______________ Weather: ______________

Field Personnel: ______________

1. Was a Surface Sediment Sample Collection Form filled out for sediment samples collected for benthic organisms (*Record location coordinates, water depth, etc. on sediment collection form) ☐ Yes ☐ No
2. Was the SPI survey performed at sample location? ☐ Yes ☐ No
3. Was a surface sediment sample collected for archival and potential chemical analysis? ☐ Yes ☐ No

Surficial Sediment Characteristics: (circle most descriptive)

Texture:	Smooth	Fine	Coarse	Clay	Silt	Sand	Gravel	Cobble
Color:	Light	Dark	Gray	Brown	Black	Other: ______		
Odor:	Normal	Petroleum	Chemical	H_2S	None	Other: ______		

Presence of:

	Y/N	Percent	Description Type
Biological Structures:			
Debris:			
Oily Sheen:			

Vertical Profile Characteristics:

	Description:
Changes in Sediment Characteristics:	
Presence & Depth of Redox Potential Discontinuity Layer:	

Benthic Community Samples

Approximate quantity/volume of sediment from grab screen for benthos: ______________

Size of sieve used for screening: ______________

Formalin added to sample container: ______________

Sample containers filled (number and type): ______________

Comments/Notes ______________

Attachment C-3

Benthic Sample Tracking Log

Benthic Sample Tracking Log

BENTHIC - SAMPLE TRACKING LOG

Page ______ of ______

Project # _____________ Reviewed by __________ Keyed by __________ Verified by __________

Received at Laboratory by ___________ Date ________ Date __________ Date __________ Verified by __________

(Revised 2/25/91)

Sample Type	Lab I.D.			Logged In		Rescreened		Sorted		Sorting QC			Sample Total	Sent to Subcontractor			Returned from Subcontractor		Lab Storage Location	Archived		Disposal Returned	
	Sample No.	Stom./ Rep	Adden.	Initials	Date	Initials	Date	Initials	Date	Initials	Date	# found	Organism count		Initials	Date	Initials	Date		Initials	Date	Initials	Date

Attachment C-4

Benthic Vial Tracking Log

Benthic Vial Tracking Log

BENTHIC - VIAL TRACKING LOG

Page ______ of ______

Project # ____________

Reviewed by __________ Keyed by __________ Verified by __________

Received at Laboratory by ___________ Date ________

Date __________ Date __________ Verified by __________

Sample Type	Lab I.D.			Taxonomy		Taxonomy QC						Sent to Subcontractor			Returned from Subcontractor		Lab Storage Location	Archived		Disposal Returned	
	Sample No.	Stom./ Rep	Adden.	Initials	Date	Initials	Date						Initials	Date	Initials	Date		Initials	Date	Initials	Date

Attachment C-5

Benthic Taxonomy Form

Benthic Taxonomy Form

BENTHIC- TAXONOMY FORM

Reviewed by __________ Page ______ of ______

Project # ____________ Keyed by __________ Verified by __________

Date ________ Date __________ Verified by __________

Sample Type	Sample I.D.			No. of specimen to Voucher collection	Total sample volume (ml)	Sub-sample Volume (ml)	Rep	NODC Code	Parts Code	L.H. Code	Count	Mult.	Weight (g)	I.D. By		Form	Comments
	Sample No.	Stom./ Rep	Adden.											Initial	mo day yr		
																T	
																T	
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Appendix D

Confined Disposal Facility Monitoring Operations Manual

D.1 INTRODUCTION

The purpose of the Confined Disposal Facility (CDF) monitoring program is to assess possible changes in groundwater quality as a result of the construction of the St. Paul CDF. The objectives of this program are described in further detail in Section 5.0 of the OMMP. Construction of the CDF is part of the Thea Foss and Wheeler-Osgood Waterways Remediation Project. This field manual provides guidance to field personnel involved in the CDF monitoring program. Any future changes to the CDF monitoring program (such as changes in wells to be sampled, sampling frequency, and/or chemical analyses) will be described in addenda to this manual.

This manual is organized in five general sections:

- Preparation for Sampling;
- Well Installation and Development;
- Tidal Study/Slug Test and Sampling Protocols;
- Post-Sampling Procedures; and
- Visual Observations of CDF Berms and Cap.

Attachment D-1 presents the Quality Assurance Project Plan (QAPP) for the CDF monitoring program. Attachment D-2 provides the field forms for Groundwater and Surface Water Sample Collection. Attachment D-3 provides the Well Installation Log. Attachment D-4 provides the field form for CDF Berms and Cap Observation. Appendix F presents a project-specific Health and Safety Plan that includes CDF monitoring activities. A copy of the CDF Monitoring Operations Manual should be carried in the field when completing groundwater and surface water sampling.

D.2 PREPARATION FOR SAMPLING

Before going to the field, the following steps should be completed.

D.2.1 Review and Understand this Manual

In preparation for well installation, the tidal study and slug tests, groundwater and surface water sampling, and before conducting field work, all personnel must read and become familiar with this manual, the Health and Safety Plan requirements, and Section 5.0 of the OMMP. If questions arise, contact the City's Project Manager.

D.2.2 Contact Appropriate People for Site Access

The existing and new groundwater monitoring wells are located on Simpson property. Therefore, well inspection, installation, and testing must be coordinated with Simpson personnel. The Simpson contact person is the following:

- Dave McEntee, Director – Environment, Health and Safety, Simpson Investment Company, 253-779-6405

If the Simpson contact person changes, the new contact person will be provided in an addendum to this manual.

Coordination with Simpson will occur prior to accessing Simpson property for CDF monitoring activities. Simpson will be notified of monitoring activities, site access needs, schedule, and the personnel to perform the work. EPA will also be contacted and notified of monitoring activities and schedule prior to performing monitoring activities. Additionally, any request to move equipment or other objects obstructing access to work areas will be made to Simpson.

Personnel accessing Simpson property must have Simpson's site-specific health and safety training. If personnel performing field activities do not have Simpson's site-specific training, the training will be arranged through Simpson.

D.2.3 Contact Analytical Laboratory

The analytical laboratory will be contacted prior to initiation of CDF monitoring activities that include sampling and chemical analysis. Coordination with the analytical laboratory will occur to ensure appropriate sample storage and handling as well as to ensure that the appropriate analytical methods and procedures are performed for surface water and/or groundwater samples. A copy of the QAPP (Attachment D-1) should be provided to the laboratory prior to collection and transfer of samples to the laboratory. Any deviations from the requirements specified in the QAPP by the laboratory need to be approved by the City and EPA prior to use.

At least one week before sample collection and analysis, the analytical laboratory will be contacted to provide the laboratory with the following information:

- Date of sampling, number of samples to be collected, and date of sample delivery to the laboratory;
- Analyses to be performed, including required detection limits and laboratory Quality Assurance/Quality Control (QA/QC) requirements. Also notify the laboratory that sample filtering for dissolved copper, lead, mercury, nickel, and zinc analyses will be performed in the field. Analyses to be performed on baseline groundwater samples are dissolved copper, lead, mercury, nickel, zinc, total mercury, polycyclic aromatic hydrocarbons (PAHs), total organic carbon, total suspended solids, and salinity (analytical methods are listed in the QAPP; Attachment D-1). The analyses to be performed on performance monitoring groundwater samples will be selected based on the results of baseline sampling and analysis and groundwater flow conditions. Analyses to be performed on baseline surface water samples are dissolved copper,

lead, mercury, nickel, zinc, total mercury, and salinity. Table D-1 summarizes the analyses to be performed for each sampling event;

- When sample bottles will be needed (with cooler, blue ice, labels, and chain of custody form);
- Date analytical results are needed (i.e., requested analytical turn-around);
- Sample disposal; and
- Any other analytical requirements.

Upon receiving sample bottles from the laboratory, verify that all necessary containers are present. Review which bottles are required for which analyses and minimum required sample volumes. Label containers and organize them into coolers. Prepare necessary ice packs and other materials, as necessary, for bottle protection and sample preservation.

D.2.4 Ensure Field Equipment is Working and Calibrated

The required field equipment for each of the field activities included in this manual are presented in Table D-2.

The field parameter meter(s) should be calibrated on the day of sampling using commercially available calibration solutions and following the instrument manufacturers' directions.

D.2.5 Know Where to Go

A map of the CDF and vicinity is provided on Figure 5-1 of the OMMP and the monitoring well locations are presented on Figure D-1 of this manual. Following the installation of new monitoring wells, the well network figure (i.e., Figure D-1) will be revised if actual locations of the newly installed wells differ from the locations currently shown. The revised figure will be provided as an addendum to this manual.

D.3 WELL INSTALLATION AND DEVELOPMENT

The monitoring wells will be installed following the "Minimum Standards for Construction and Maintenance of Wells" in WAC 173-160. Borings will be advanced and wells completed by Holt Drilling, Inc. (Puyallup, WA) beginning August 28, 2006. The boreholes for the wells will be drilled using standard Hollow Stem Auger techniques. Auger boreholes will be advanced using a 4-inch auger. Split-spoon soil samples will be collected during boring every five feet. Soil samples will be documented on the well installation log form (Attachment D-2) and will be described and classified according to the United Soil Classification System (USCS). The screen placement will be determined and adjusted in the field as work progresses based on soil samples collected and inferred groundwater elevations at each well location. The objective is to place the well screen within the permeable soils, if possible avoiding lenses of silt or confining layers. Geotechnical information will be logged by a geologist and documented on the well installation log (Attachment D-2). Once the auger has been drilled to the target elevation, the base of the auger will then be filled with bentonite and the well installation completed.

The new shallow wells will be constructed with 10-foot screens set approximately from an elevation of 10 feet Mean Lower Low Water (MLLW) to 0 feet MLLW, consistent with the previously installed shallow wells. The intermediate wells will be constructed with 10-foot screens set approximately from an elevation of 0 feet MLLW to -10 feet MLLW. The deep wells will be constructed with two 10-foot screens set approximately from an elevation of -40 feet MLLW to -60 feet MLLW, the same elevations as the bottom of the CDF.

All wells will be constructed of 2-inch diameter, flush-threaded, Schedule 40 PVC well casing and screen. Well screen assemblies will consist of 10-foot or 20-foot (deep wells) lengths of 0.020-inch (20-slot), flush-threaded, machine-slotted, Schedule 40 PVC set in a 10/20 sand or equivalent silica sand filter pack. The well design includes a 0.5-foot long flush-threaded, Schedule 40 PVC sump with a flush-threaded end cap. A 2-inch diameter PVC slip cap will cover the casing.

The sand filter pack will be installed by pouring sand into the space between the well casing and auger as the auger is withdrawn. A weighted tape will be used to monitor filter pack placement and depth during installation. The sand filter pack will extend three feet above the top of the screened interval. A minimum 2-foot thick seal of hydrated bentonite chips will be installed in the annular space immediately above the sand filter pack and hydrated with potable water if installed above the water table. The remainder of the annular space will be sealed with bentonite grout or hydrated bentonite chips to within one foot of the ground surface.

The new monitoring wells will be secured with either above-ground or flush to ground locking steel protective monuments to minimize the potential for surface water entering the monument.

Well development will be completed by continuous pumping at a steady rate using a peristaltic pump or other non-dedicated pumping equipment as needed. Wells will be developed using the described methodologies or equivalents at least 48 hours following well installation. Well development equipment will be decontaminated by pumping clean water through the pump and washing to the satisfaction of the on-site field technician. Well development will be terminated when the variation in the turbidity NTU readings is less than 10%, or to the satisfaction of the field technician. Installed wells will be labeled with a permanent marker on the well casing if above-round completions are constructed or on the well cover if flush mount wells are constructed.

D.4 72-HOUR TIDAL STUDY AND SLUG TEST PROTOCOL

After completing the installation and purging of the new monitoring wells in the monitoring well network, the post-construction hydrogeologic conditions will be evaluated by completing a 72-hour tidal study and slug tests. Water levels in monitoring wells will be recorded using a combination of pressure transducers with internal data loggers and an electronic water level indicator. The data collection will include continuous (every 15 minutes) transducer-based water level measurements in wells MW-01 through MW-15, in the surface water swale between Simpson's clarifier tanks and the offset berm, and in the Middle Waterway. The data logger will be programmed to automatically convert pressure changes to water levels. If possible, a vented transducer will be used that internally corrects for fluctuations in atmospheric pressure.

The general procedure for conducting the 72-hour tidal study and recording water levels in monitoring wells is summarized below:

1. At each monitoring well, lower a pressure transducer into the well and securely fasten it to the top of the well casing for the duration of the monitoring period.
2. Set the transducers to record the height of the water column above the transducer at 15-minute intervals.
3. Make sure the pressure transducers are rated to a minimum 15 pounds per square inch (psi) range capable of measuring a water level change of 23 feet with a resolution of 0.01 foot.
4. Periodically perform depth-to-water level measurements to the nearest 0.01 foot with a manual electronic water level indicator at the top of the well casing. Perform the manual depth-to-water level measurements in each monitoring well four times during the monitoring period.
5. At the end of the monitoring period remove the pressure transducers and upload the water level data to a computer.

Similar procedures will be used to monitor surface water levels in the surface water swale between the Simpson clarifiers, in the offset berm, and in the Middle Waterway.

Slug tests will also be performed in all monitoring wells to identify the range of hydraulic conductivities present at and adjacent to the CDF. Slug tests will act to verify the hydraulic connection between the well and the surrounding aquifer and to estimate the aquifer's hydraulic conductivity within the constructed CDF. Slug tests can be performed prior to or following the 72-hour tidal study. The tests will be performed at a tidal stage as to minimize the interference of tidal fluctuations on the aquifer and the determination of the hydraulic conductivities.

Slug tests will be performed using a PVC slug rod, a down-hole pressure transducer as described above, and a water level indicator in general accordance with ASTM D 4044-96 (2000). The general procedure for conducting the slug tests in monitoring wells is summarized below:

1. At each monitoring well, measure the static depth of groundwater as described in Section D.6.1 before placing the pressure transducer near the bottom of the well.
2. After stabilization of the groundwater level (from the displacement of the transducer), lower the slug rod into the well until it is submerged in the water column.
3. Monitor the recovery of the perturbed water level until it has returned to within 95 percent of the initial head indicated by the transducer prior to the introduction of the slug rod.
4. Once the water level has re-equilibrated quickly remove the slug from the water column and monitor the groundwater level for recovery.
5. After the water level has recovered to within tolerance (95 percent), manually measure the depth to groundwater again, remove the transducer, and secure the well.

The slug test response data will be analyzed using the Bouwer and Rice method (Bouwer and Rice 1976, Bouwer 1989).

D.5 SURFACE WATER SAMPLING PROTOCOL

Surface water samples will be collected and submitted to the laboratory for analysis concurrently with baseline groundwater samples from the CDF monitoring. Samples will be collected at the northern end of the Middle/St. Paul Peninsula and Peninsula Habitat Area (i.e., North Beach Habitat Area) (Figure D-1) and analyzed for dissolved copper, lead, nickel, and zinc; total and dissolved mercury; and salinity (analytical methods are listed in the QAPP; Attachment D-1). The analyses to be performed for surface water sampling are summarized in Table D-1.

The seawater samples will be collected at high, slack tide using a peristaltic pump with disposable tubing or tubing that has been decontaminated. The sampler will lower the pump intake to a depth of approximately three feet below the water surface. The sample intake will also remain a minimum of three feet off the bottom. At no time will the pump intake be allowed to come into contact with sediment on the bottom or come close enough to disturb sediment and create turbidity. Seawater temperature (T), pH, electrical conductivity (EC), dissolved oxygen (DO), and turbidity will be measured at the time of sampling using a water quality instrument with a flow through cell. Caution will be taken to pump water at a rate as to avoid the development of air bubbles within the flow through cell and achieve parameter stability. If groundwater parameters do not stabilize, the pumping rate will be reduced as a corrective action.

Surface water samples collected for dissolved metals analysis will be filtered in the field using an in-line 0.45 µm filter. Flexible silicone tubing will be used to attach the filter to the peristaltic pump discharge tube. Approximately one liter of water will be flushed through the filter prior to sample collection. If the filter clogs, it will be replaced with a new filter. Surface water samples will be pumped through the filter into sample collection containers.

D.6 GROUNDWATER SAMPLING PROTOCOL

Groundwater samples will be collected from selected wells during baseline and performance monitoring. Following the completion of the tidal study and slug tests, selected wells to be sampled as part of the baseline monitoring program will be equipped with dedicated sampling pumps, with the pump intake placed at the approximate midpoint of the well screen. The use of an electronic submersible dedicated pump will allow for low flow rate sampling and the down-well equipment will be dedicated to a given well, so both samples and the well will be protected from disturbance and the danger of cross-well contamination. The pumps will be constructed and assembled by the manufacturer and installed according to manufacturer's specifications. A cycle controller will be used with the pumps for well sampling. If the installed wells are flush mount wells the pumps will be assembled with ceiling caps to prevent infiltration of surface water and the pump will be suspended in the well from the flush mount cap.

As dedicated pump systems are to be used, cross-contamination is not expected and the order of well sampling is not critical. Therefore, the order of well sampling is left to the discretion of field personnel.

At each well location, inspect the area surrounding the well. If a well monument is blocked contact Simpson for site access to move equipment or other objects obstructing access to the well location. Once the well is accessible, the following field sampling procedures will be completed. Note: The details of this protocol may be revised to account for provisions of the specific sampling equipment (i.e., equipment brand) selected for baseline and performance monitoring.

D.6.1 Measure Depth to Water

1. Open protective casing. Observe and note on field log the condition of monument/well.
2. Decontaminate well sounder by rinsing with deionized (DI) water.
3. Drop water level indicator into well and determine water level by means of LED or beeper. Measure mark on the probe to the nearest 0.01 foot using a tape measure. Record this value, with date and time, on the field log as the static depth to water.

D.6.2 Purge Well

1. Lower the dedicated pump system into the well and tighten the compression bolts with an allen wrench.
2. Connect the electrical port on the well seal to the controller (converter) with an extension cable. Connect the controller to a power source.
3. Begin purging the well. Because groundwater contamination is not anticipated, the purge water will be directly discharged to the ground.
4. Purge the well at low flow rates not to exceed 0.5 liter per minute (determined by measuring the time to fill a known volume). The purge rate can be increased to one liter per minute if the purge water is observed to be generally non-turbid (less than 50 NTU) and the purging creates less than 0.5 foot of drawdown in the well. Because water levels may fluctuate in the monitoring wells with the tide, the drawdown will be measured and compared against this criterion in the first five minutes of purging.
5. Adjust the pump controller to achieve acceptable purge rate.
6. During purging, measure field parameters (T, pH, EC, DO, and turbidity) in the purge water at 3- to 5-minute intervals. Record the time and parameter values and purge rate on the field log for each set of readings. If the field measurements for turbidity, DO, and EC are approximately stable (± 10%) for three consecutive readings, the groundwater sample will be collected. If DO is below 5 mg/L, three consecutive readings of ±1 mg/L will be considered stable. Should the turbidity readings be negative values, the measurement will be recorded as less than 1 (< 1). If the field parameter meter also measures salinity, it should be recorded, but it will not be a stabilization parameter. Depth to water will be measured and recorded during the first five minutes of purging, to calculate drawdown, as discussed above. Because these field parameters (particularly turbidity) may not reach these stringent stabilization criteria at a particular well, collection of each groundwater sample will be based on the field personnel's best professional judgment at the time of sampling. The last set of field parameters measured during purging will represent field parameters for the groundwater sample.
7. Record all field measurements and observations legibly on the field forms, as these forms (Attachment D-2) will be included as appendices in the monitoring reports.

The analyses to be performed for groundwater well sampling are summarized in Table D-1.

D.6.3 Bottle Labeling

Before or during well purging, label the bottles provided by the lab. The sample number format will be “well number—year/month/day of collection.” For example, a sample collected from well MW-01 on September 15, 2007, would be labeled MW-01-091507. A duplicate sample would be labeled MW-01-091507-B. A sample collected from the surface water sampling location SWM-01 on September 15, 2007, would be labeled SMW-01-091507. In this way, every water sample has a unique identifier, and the collection date is known from the sample number. Other information to include on bottle label is date, time, and initials of sampler.

D.6.4 Sample Collection

1. After purging the well and labeling the bottles, collect the groundwater sample by directly filling the lab-provided bottles from the pump discharge line (maintain same flow rate as purging). In this way, only dedicated materials are used in sampling, and there is no need for equipment decontamination (other than the water level indicator). The specific bottles to be filled for each chemical analysis will be communicated by the laboratory.
2. Filter the sample for dissolved metals analysis. Use flexible silicon tubing to attach filter to pump discharge tube. Let approximately one liter of water run through filter before the sample is collected. If filter clogs with sediment, replace with new filter. Dispose of filter after each well sampled.
3. Immediately place all labeled, filled bottles in coolers packed with blue ice.

D.6.5 Leaving the Well

1. Turn off controller and disconnect the power source.
2. Disconnect hose connecting the well to the controller.
3. If freezing weather is possible before the next sampling event perform antifreeze maintenance. **Warning:** Never operate cold-weather blow-out mechanism with pump controller attached to pump.
4. Return water discharge tube to its original hole for storage. Retain in a closed plastic bag within the well monument, the teflon tubing and other tubing which will not fit in the well casing. Close and secure monument.

D.7 POST SAMPLING PROCEDURES

A chain of custody form will be provided with the sample bottles supplied by the laboratory. The custody form must be filled out by the sampler, indicating chemical analyses to be performed, date of sample collection, matrix (water), number of bottles per sample, method of delivery, turnaround time, etc. as specified on the form. Reference on the chain of custody to a laboratory services work order will help ensure that project-specific requirements (e.g., analytical methods, sample quantitation limits, QA/QC requirements) are completed by the laboratory. The chain of custody form must accompany the samples at all times, documenting each change of possession.

The samples should be delivered to the laboratory as soon as possible following collection to ensure that analytical holding times are met.

D.8 VISUAL OBSERVATION OF CDF CONTAINMENT AND OFFSET BERMS AND CAP

During each quarterly groundwater monitoring event, visual observation of the CDF containment and offset berms and the CDF cap will be completed to observe the physical condition of the berms and cap. The areas that will be observed during these inspections are shown on Figure D-1. The inspections will document changes in the berm structures, integrity of the cap, and any evidence of release or contamination using field forms and photographs.

Observations will be performed of each component of the CDF (i.e., containment berm, offset berm, and cap) and documented in the field form presented in Attachment D-4. Field personnel should complete one of the attached field forms for each component of the CDF to document observations and to maintain consistency throughout successive monitoring events.

For observations of the containment berm, offset berm, and cap, the following field notes will be recorded:

- Location (i.e., containment berm, offset berm, or cap), date, time, and weather conditions;
- Personnel performing observations;
- Description of the observed surface including materials observed at the surface (i.e., habitat mix, rip rap, quarry spalls, gravel, sand, silt, etc.) and presence of objects or debris (logs, garbage, etc.). If objects or debris are observed on the surface, information concerning the location should be recorded on the diagram section of the field form;
- Description of location of the top of the berms and elevation of adjacent surface water; and
- Berm structural or cap integrity observations relative to the as-built baseline conditions including:
    - Areas of settlement;
    - Down-slope movement of berm materials (i.e., sloughing);
    - Areas of loss of cap material or penetration into the cap;
    - Evidence of through-berm / cap seepage; and
    - Indicators of potential contamination (i.e., sheen, discoloration, staining, odor, etc.).

Berm and cap conditions will also be documented with digital photographs. Digital photographs should be obtained using the following procedures:

- For each component, take a digital photograph that includes the entire area, with a stationary object to be used for location reference;

- Where multiple photographs are taken, provide adequate overlap of coverage (using stationary objects) to ensure complete photo documentation of the berms and cap; and
- Record the location(s) where photographs were taken on the field forms.

Digital photographs will be labeled with the date and time the photograph was taken.

If visible evidence of berm structural changes or cap integrity is observed, additional notes should be recorded (within the provided space on the field forms) for further evaluation. At a minimum, additional information should identify potential causes and extent of cap disturbance and should be clearly recorded on the diagram.

REFERENCES

Bouwer, H. 1989. Slug test-an update. Ground Water 27:15-20.

Bouwer, H. and M.R. Rice. 1976. A slug test determining the hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. Water Resources Research. 12: 423-428.

TABLES

Table D-1 – CDF Monitoring Sampling Event Analyses

Table D-2 – CDF Monitoring Field Equipment Checklist

FIGURES

Figure D-1 – Monitoring Well and Surface Water Sampling Location Plan

ATTACHMENTS

Attachment D-1 – Quality Assurance Project Plan for Groundwater and Surface Water Analysis

Attachment D-2 – Groundwater and Surface Water Sample Collection Form

Attachment D-3 – Well Installation Log

Attachment D-4 – CDF Berms and Cap Observation Form

Table D-1
CDF Monitoring Sampling Event Analyses

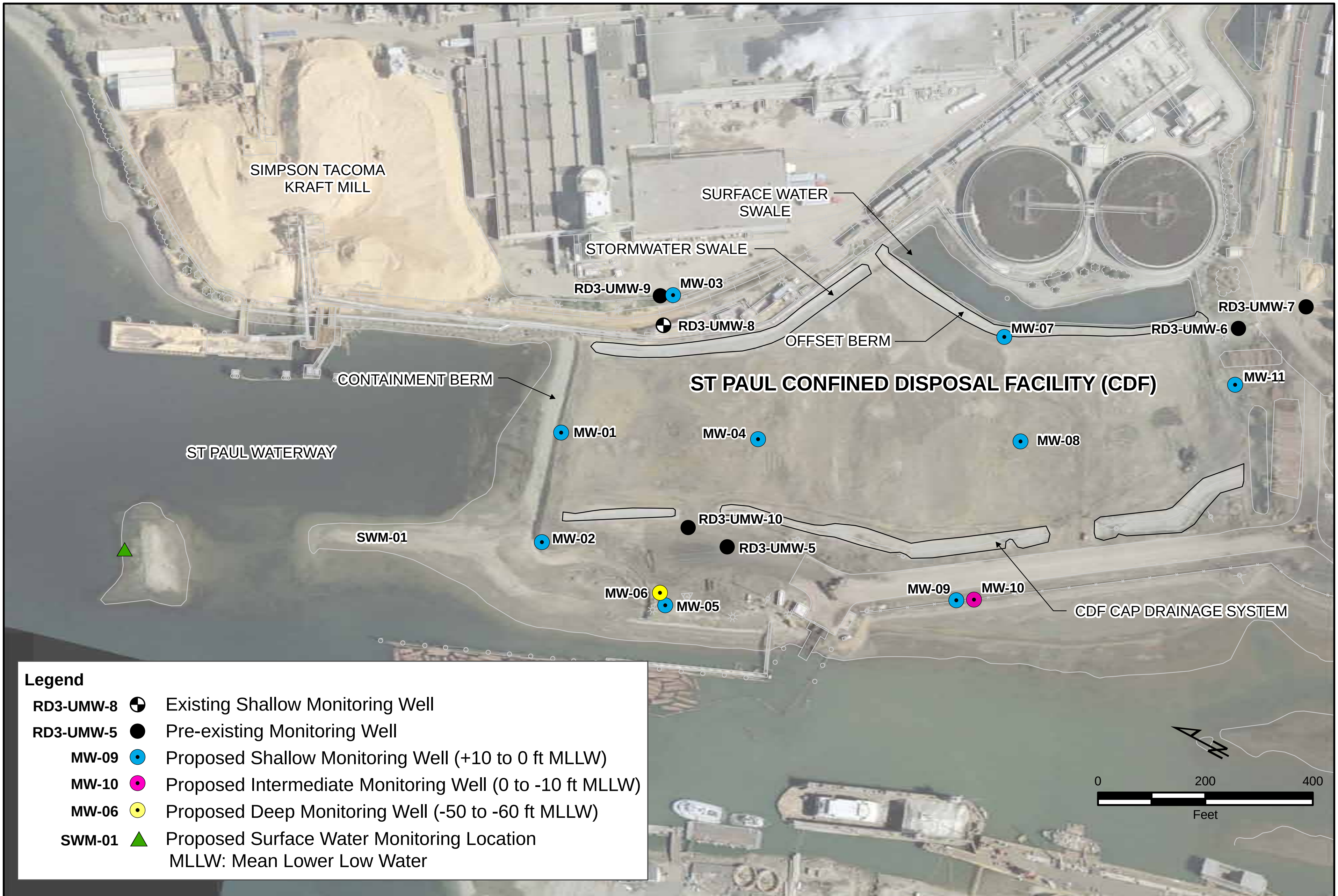
Sampling Event	Analyses Metals Dissolved Metals (Cu, Pb, Ni, Zn, Hg)	Total Metals (Hg)	Organics PAHs	Conventionals TSS	TOC	Salinity
Baseline Monitoring						
Groundwater Well Sampling						
Selected Monitoring Wells[1]	X	X	X	X	X	X
Field Duplicate	X	X	X	X	X	X
MS/MSD	X[2]	X[2]	X			
Surface Water Sampling						
Surface Water	X	X				X
Field Duplicate	X	X				X
Equipment Blank	X	X				
Compliance Monitoring						
Groundwater Well Sampling						
Selected Monitoring Wells[2]	TBD[3]	TBD[3]	TBD[3]	X	X	X
Field Duplicate	TBD[3]	TBD[3]	TBD[3]	X	X	X
MS/MSD	TBD[3]	TBD[3]	TBD[3]			

Notes:
1 Baseline sampling monitoring wells will be determined based on the results of the post-construction hydrogeologic evaluation and groundwater flow direction.
2 The laboratory will perform a laboratory duplicate and matrix spike for metals analyses.
3 Performance sampling monitoring wells and analtye list will be selected based on the results of the baseline monitoring program.

Table D-2
CDF Monitoring Field Equipment Checklist

72-Hour Tidal Study	
□	Key/tools necessary to access wells
□	Well sounder for water level measurements
□	Pressure transducer with internal data logger
□	Duck tape or materials to adhere transducer to well casing, etc.
Baseline Monitoring	
Groundwater Well Sampling	
□	Key/tools necessary to access wells
□	Air compressor with adequate gasoline
□	Controller for dedicated sampling pumps, 12-volt battery
□	Appropriate discharge tubing for each pump, with additional tubing for each well as needed, to accommodate the sampling pump tubing (likely stored inside the well monument/vault)
□	Well sounder for water level measurements
□	Field parameter probe(s) for measuring temperature (T), pH, electrical conductivity (EC), dissolved oxygen (DO), and turbidity, along with flow-through cell
□	Graduated container and stop watch for measuring well purging rate
□	Vehicle to haul equipment and supplies during sampling
□	Field forms and chain of custody forms
□	Plastic sheeting, garbage bags, and paper towels
□	0.45 micron filters (one per well, plus extras as contingency) to filter samples for dissolved metals analysis
□	Deionized (DI) water pump sprayer
□	Personal protective equipment as specified in the Health and Safety Plan (Appendix F)
□	Laboratory-supplied sample bottles
□	Blue ice and cooler
Surface Water Sampling	
□	Field parameter probe(s) for measuring temperature (T), pH, electrical conductivity (EC), dissolved oxygen (DO), and turbidity, along with flow-through cell
□	Peristalilc pump with battery
□	Appropriate discharge tubing for the pump and silicone tubing
□	0.45 micron filters (one per sample, plus extras as contingency) to filter samples for dissolved metals analysis
□	Vehicle to haul equipment and supplies during sampling
□	Field forms and chain of custody form

□	Garbage bags and paper towels
□	Personal protective equipment as specified in the Health and Safety Plan (Appendix F)
□	Laboratory-supplied sample bottles
□	Blue ice and cooler
Compliance Monitoring	
□	Key/tools necessary to access wells
□	Air compressor with adequate gasoline
□	Controller for dedicated sampling pumps, 12-volt battery
□	Appropriate discharge tubing for each pump, with additional tubing for each well as needed, to accommodate the sampling pump tubing (likely stored inside the well monument/vault)
□	Well sounder for water level measurements
□	Field parameter probe(s) for measuring temperature (T), pH, electrical conductivity (EC), dissolved oxygen (DO), and turbidity, along with flow-through cell
□	Graduated container and stop watch for measuring well purging rate
□	Vehicle to haul equipment and supplies during sampling
□	Field forms and chain of custody form
□	Plastic sheeting, garbage bags, and paper towels
□	0.45 micron filters (one per well, plus extras as contingency) to filter samples for dissolved metals analysis
□	Deionized (DI) water pump sprayer
□	Personal protective equipment as specified in the Health and Safety Plan (Appendix F)
□	Laboratory-supplied sample bottles
□	Blue ice and cooler



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**Thea Foss and Wheeler-Osgood Waterways
OMMP**

**Figure D-1
Monitoring Well and Surface
Water Sampling Location Plan**

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Attachment D-1

Quality Assurance Project Plan
for Groundwater and Surface Water Analysis

D-1.1 INTRODUCTION

The purpose of this Quality Assurance Project Plan (QAPP) is to give the objectives, organization, and functional activities, associated with groundwater and surface water monitoring for the St. Paul Confined Disposal Facility (CDF) as a component of the Thea Foss and Wheeler-Osgood Waterways Remediation Project. The CDF monitoring program was developed to assess the potential for impacts to the surface water via transport of contaminants in groundwater flowing from the CDF. A number of EPA documents were used as aids in preparing this document including EPA 1986, 1987, and 1989.

D-1.2 QUALITY ASSURANCE OBJECTIVE

The quality assurance (QA) objective for this project is to ensure that the data collected are of known and acceptable quality so that the goal of the CDF monitoring program can be achieved. The goal of CDF monitoring is long-term protection of surface water by demonstrating that groundwater quality adjacent to the CDF is not being adversely impacted.

The quality of the laboratory data is assessed by precision, accuracy, representativeness, comparability, and completeness (the "PARCC" parameters). Definitions of these parameters and the applicable quality control (QC) procedures are given below. Applicable quantitative goals for these data quality parameters, as well as method detection limits, are listed or referenced in Table D-1-1.

D-1.3 CONTRACT LABORATORY REQUIREMENTS

In completing chemical analyses for this project, the contract laboratory is expected to meet the following minimum requirements:

1. Adhere to the methods outlined in the QAPP, including methods referenced for each analytical procedure.
2. Deliver fax, hard copy, and electronic data as specified.
3. Meet reporting requirements for deliverables.
4. Meet turnaround times for deliverables.
5. Implement QA/QC procedures, including the QAPP data quality requirements, laboratory QA requirements, and performance evaluation testing requirements.
6. Allow laboratory and data audits to be performed, if deemed necessary.

D-1.4 CHEMICAL ANALYSES

Groundwater and surface water samples will be submitted for chemical analysis that will include a combination of the following:

- Metals (EPA Method 6020 [ICP-AES] for dissolved copper, lead, mercury, nickel, and zinc; EPA Method 7470A [CVAA] for total mercury);
- Total suspended solids (TSS) (EPA Method 160.2);
- Total organic carbon (TOC) (EPA Method 415.1);
- Salinity (per manufacturers specifications); and
- Polycyclic aromatic hydrocarbons (PAHs) (EPA Method 8270C).

Table D-1-1 presents the method of analysis and data quality objectives for the groundwater analyses.

D-1.4.1 Reporting Limits

The reporting limits for each analyte of interest are presented in the data quality objectives Table D-1-1. To achieve the required detection limits, some modifications to the methods may be necessary. Any modifications from the specified analytical methods will be provided by the laboratory at the time of establishing the laboratory contract, and EPA will be notified.

D-1.5 LABORATORY QUALITY ASSURANCE OBJECTIVES

D-1.5.1 Precision

Precision measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average values. Analytical precision is measured through matrix spike/matrix spike duplicate (MS/MSD) samples for organic analysis and through laboratory duplicate samples for inorganic analyses.

Analytical precision measurements will be carried out on project-specific samples at a minimum frequency of one per sampling event or one in twenty samples, whichever is more frequent per matrix analyzed, as practical. Laboratory precision will be evaluated against quantitative relative percent difference (RPD) performance criteria provided by the laboratory.

Field precision will be evaluated by the collection of blind field duplicates at a minimum frequency of one per laboratory analysis group or one in 20 samples. Field duplicate precision will be screened against a RPD of 50 percent for water samples. However, no data will be qualified based solely on field duplicate precision.

Precision measurements can be affected by the nearness of a chemical concentration to the method detection limit, where the percent error (expressed as RPD) increases. The equations used to express precision are as follows:

$$\text{RPD} = \frac{(C_1 - C_2) \times 100\%}{(C_1 + C_2)/2}$$

Where:

RPD = relative percent difference

C_1 = larger of the two observed values

C_2 = smaller of the two observed values

D-1.5.2 Accuracy

Accuracy is an expression of the degree to which a measured or computed value represents the true value. Field accuracy is controlled by adherence to sample collection procedures as outlined.

Analytical accuracy may be assessed by analyzing “spiked” samples with known standards (surrogates, laboratory control samples, and/or matrix spike) and measuring the percent recovery. Accuracy measurements on matrix spike samples will be carried out at a minimum frequency of one in 20 samples per matrix analyzed. Because MS/MSDs measure the effects of potential matrix interferences of a specific matrix, the laboratory will perform MS/MSDs only on samples from this investigation and not from other projects. Surrogate recoveries will be determined for every sample analyzed for organics.

Laboratory accuracy will be evaluated against quantitative matrix spike and surrogate spike recovery performance criteria provided by the laboratory. Accuracy can be expressed as a percentage of the true or reference value, or as a percent recovery in those analyses where reference materials are not available and spiked samples are analyzed. The equation used to express accuracy is as follows:

$$\%R = 100\% \times (S-U)/C_{sa}$$

Where:

%R = percent recovery

S = measured concentration in the spiked aliquot

U = measured concentration in the unspiked aliquot

C_{sa} = actual concentration of spike added

D-1.5.3 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent an environmental condition. For this program, the selected analytes have been identified as constituents of concern based on previous sampling investigations.

D-1.5.4 Comparability

Comparability expresses the confidence with which one data set can be evaluated in relation to another data set. For this study, comparability of data will be established through the use of standard analytical methodologies and reporting formats and of common traceable calibration and reference materials.

D-1.5.5 Completeness

Completeness is a measure of the amount of data that is determined to be valid in proportion to the amount of data collected. Completeness will be calculated as follows:

$$C = \frac{(\text{Number of acceptable data points}) \times 100}{(\text{Total number of data points})}$$

The data quality objective for completeness for all components of this project is 95 percent. Data that have been qualified as estimated because the quality control criteria were not met will be considered valid for the purpose of assessing completeness. Data that have been qualified as rejected will not be considered valid for the purpose of assessing completeness.

D-1.6 QUALITY CONTROL PROCEDURES

Sampling procedures for this investigation are described in detail in the CDF Monitoring Operations Manual for this project. Table D-1-1 presents the field sample preservation and holding time information.

D-1.6.1 Field Quality Control Procedures

Field sampling and documentation procedures are detailed in the CDF Monitoring Operations Manual. To control the quality of field samples, field duplicates will be collected at a frequency of 1 per 20 samples collected (minimum of one per sampling event). The QA/QC samples to be collected and analyzed for each sampling event are summarized in Table D-1-2. Although validation guidelines have not been established by EPA for field quality control samples, their analysis is useful in identifying possible problems resulting from sample collection or sample processing in the field. All field quality control samples will be documented in the field logbook and verified by the QA Manager, or designee.

D-1.6.2 Laboratory Quality Control Procedures

Laboratory Quality Control Criteria. Results of the quality control samples from each sample group will be reviewed by the analyst immediately after a sample group has been analyzed. The quality control sample results will then be evaluated to determine if control limits have been exceeded. If control limits are exceeded in the sample group, the Project QA Manager will be contacted immediately, and corrective action (e.g., method modifications followed by reprocessing the affected samples) will be initiated prior to processing a subsequent group of samples.

All primary chemical standards and standard solutions used in this project will be traceable to documented, reliable, commercial sources. Standards will be validated to determine their accuracy by comparison with an independent standard. Any impurities found in the standard will be documented.

The following sections summarize the procedures that will be used to assess data quality throughout sample analysis.

Initial and Continuing Calibration. Initial and continuing calibration will be performed in accordance with each analytical method requirements. Multipoint initial calibration will be performed on each instrument at the start of the project, after each major interruption to the analytical instrument, and when any ongoing calibration does not meet control criteria. Ongoing calibration will be performed daily for metals and organic analyses and with every sample batch for conventional parameters (when applicable) to track instrument performance.

Instrument blanks or continuing calibration blanks provide information on the stability of the baseline established. Continuing calibration blanks will be analyzed immediately following continuing calibration verification at a frequency of one continuing calibration blank for every 10 samples analyzed at the instrument for inorganic analyses and every 12 hours for organic analyses. If the ongoing calibration is out of control, the analysis must come to a halt until the source of the control failure is eliminated or reduced to meet control specifications. All project samples analyzed while instrument calibration was out of control will be reanalyzed.

Laboratory Duplicates. Analytical duplicates provide information on the precision of the analysis and are useful in assessing potential sample heterogeneity and matrix effects. Analytical duplicates are subsamples of the original sample that are prepared and analyzed as a separate sample. A minimum of one duplicate will be analyzed per sample group or for every 20 samples, whichever is more frequent.

Matrix Spikes and Matrix Spike Duplicates (MS/MSD). Analysis of matrix spike samples provides information on the extraction efficiency of the method on the sample matrix. By performing duplicate matrix spike analyses, information on the precision of the method is also provided for organic analyses. A minimum of one MS/MSD will be analyzed for every sample group or for every 20 samples, whichever is more frequent, when possible. MS/MSD analyses will be performed on project specific samples; QC analyses will not be performed using samples from different projects.

Surrogate Spikes. All project samples analyzed for organic compounds will be spiked with appropriate surrogate compounds as defined in the analytical methods. Surrogate recoveries will be reported by the laboratories; however, no sample result will be corrected for recovery using these values.

Method Blanks. Method blanks are analyzed to assess possible laboratory contamination at all stages of sample preparation and analysis. A minimum of one method blank will be analyzed for every extraction batch or for every 20 samples, whichever is more frequent.

D-1.7 SAMPLING DOCUMENTATION

Sample documentation is a critical aspect of environmental investigations. Sample possession and handling must be traceable from the time of sample collection through delivery to the laboratory. A sample log form and field logbook entries will be completed for each location occupied and each sample collected. Documentation procedures for sampling are provided in the CDF Monitoring Operations Manual.

D-1.7.1 Sample Handling

Sample collection and handling procedures are detailed in the Confined Disposal Facility Monitoring Operations Manual. To control the integrity of the samples during transit to the laboratory and during holding prior to analysis, established preservation and storage measures will be taken. Table D-1-1 presents container type, preservation, and maximum holding times for various chemical analyses of groundwater. Sample containers will be labeled with the client name, sample number, sampling date and time, required analyses, and initials of the individual processing the sample. The field technician will check all container labels, custody form entries, and logbook entries for completeness and accuracy at the end of each sampling day.

D-1.7.2 Sample Chain of Custody

Sample labeling and custody documentation will be performed as described in the CDF Monitoring Operations Manual. Custody procedures will be used for all samples at all stages in the sample collection, transfer, and delivery to the laboratory.

D-1.7.3 Sample Preservation

The requirements for preserving sample aliquots destined for each type of analysis for groundwater are listed in Table D-1-1. Immediately after the sample bottles are filled with groundwater they will be placed in the appropriate coolers with a sufficient number of ice packs (or crushed ice) to keep them at approximately 4 ± 2°C through the completion of that day's sampling and transport to the laboratory.

D-1.7.4 Sample Shipment

The lead field technician will be responsible for sample tracking and custody procedures in the field. The QA Coordinator will be responsible for final sample inventory and will maintain sample custody documentation. The field technician, or designee, will complete custody forms. At the end of each day, and prior to transfer, custody form entries will be made for all samples. Finally, information on the sample labels will be checked against sample logbook entries and custody forms, and samples will be recounted. All samples will be accompanied by custody forms; the forms will be signed at each point of transfer and will include sample numbers. All custody forms will be completed in indelible ink.

It is not expected that groundwater or surface water samples will require shipping, however, in the event that it is necessary the following steps will be taken. Prior to shipping, sample containers will be wrapped and securely packed inside the cooler with ice packs or crushed ice by the field technician. The original, signed custody forms will be transferred with the cooler. The cooler will be secured and appropriately sealed and labeled for shipping immediately.

Samples will be delivered to the laboratory under custody following completion of sampling activities.

D-1.7.5 Sample Receipt

The designated sample custodian at the laboratory will accept custody of the samples and verify that the chain of custody matches the samples received. A cooler receipt form will be filled out to document conditions of the cooler. The Project Manager at the laboratory will ensure that the custody forms are properly signed upon receipt of the samples and will note questions or observations concerning sample integrity on the custody forms. The laboratory will contact the Project QA Coordinator immediately if discrepancies are discovered between the custody forms and the sample shipment upon receipt. The laboratory Project Manager will specifically note any coolers that do not contain ice packs or are not sufficiently cold (4 ± 2°C) upon receipt.

D-1.8 DATA REDUCTION, VALIDATION, AND REPORTING

D-1.8.1 Data Reduction and Reporting

Initial data reduction, evaluation, and reporting at the laboratory will be carried out as described in the appropriate analytical protocols and the laboratory's QA Manual. Quality control data resulting from methods and procedures described in this document will also be reported.

The laboratory will be responsible for internal checks on data reporting and will correct errors identified during the quality assurance review. Close contact will be maintained between the Project QA Manager and the laboratory to resolve in a timely manner quality control problems that may arise. The analytical laboratory will be required, where applicable, to report the following:

- **Project Narrative.** This summary, in the form of a cover letter, will discuss problems, if any, encountered during any aspect of analysis. This summary should discuss, but not be limited to, quality control, sample shipment, sample storage, and analytical difficulties. Any problems encountered, actual or perceived, and their resolutions will be documented in as much detail as appropriate.
- **Chain of Custody Records.** Legible copies of the custody forms will be provided as part of the data package. This documentation will include the time of receipt and condition of each sample received by the laboratory.
- **Sample Results.** The data package will summarize the results for each sample analyzed. The summary will include the following information when applicable:
    - Field sample identification code and the corresponding laboratory identification code;
    - Sample matrix;
    - Date of sample extraction;
    - Date and time of analysis;
    - Reporting limits;
    - Analytical results with reporting units identified;
    - Data qualifiers and their definitions; and
    - A CD with the data.

- **Quality Assurance/Quality Control Summaries.** This section will contain the results of the laboratory QA/QC procedures. Each QA/QC sample analysis will be documented with the same information required for the sample results (see above). No recovery or blank corrections will be made by the laboratory. The required summaries are listed below; additional information may be requested.
- **Calibration Data Summary.** Report the concentrations of the initial calibration and daily calibration standards and the date and time of analysis. List the response factor, % RSD, percent difference, and retention time for each analyte as appropriate. Report results for standards to indicate instrument sensitivity.
- **Internal Standard Area Summary.** Report the stability of internal standard areas.
- **Method Blank Analysis.** Report the method blank analyses associated with each sample and the concentration of all compounds of interest identified in these blanks.
- **Surrogate Spike Recovery.** Report all surrogate spike recovery data for organic compounds. List the name and concentration of all compounds added, percent recoveries, and range of recoveries.
- **Matrix Spike Recovery.** Report all matrix spike recovery data for organic and metal compounds. List the name and concentration of all compounds added, percent recoveries, and range of recoveries. Report the RPD for all duplicate analyses.
- **Matrix Duplicate.** Report the RPD for all matrix duplicate analyses.
- **Relative Retention Time.** Report the relative retention time of each analyte detected in the samples for both primary and confirmational analyses.
- **Original Data.** Legible copies of the original data generated by the laboratory will include:
  - Weight and/or volume used for analysis;
  - Final dilution volumes or concentration factor for the sample;
  - Sample extraction, preparation, and cleanup logs;
  - Identification of the instrument used for analysis;
  - Instrument logs for all instruments used on days of calibration and analysis;
  - Reconstructed ion chromatograms for all samples, standards, blanks, calibrations, spikes, replicates, and reference materials;
  - Printouts and quantitation reports for each instrument used, including reports for all samples, standards, blanks, calibrations, spikes, replicates, and reference materials; and
  - Original data quantification reports for each sample.

D-1.8.2 Data Validation and Reporting

Once analysis is complete, a number of QC procedures will be followed to provide an accurate evaluation of the data quality. Specific procedures will be followed to assess data precision, accuracy, and completeness.

A data quality review of the analytical data will follow EPA National Functional Guidelines (EPA 1999 and 2002), in accordance with the QAPP limits. All chemical data will be reviewed with regard to the following, as appropriate to the particular analysis:

- Chain of custody/documentation;
- Holding times;
- Instrument calibration;
- Method blanks;
- Reporting limits;
- Surrogate recoveries;
- Matrix spike/matrix spike recoveries;
- Laboratory control sample recoveries; and
- Laboratory and field duplicate relative percent differences.

The results of the data quality review including text assigning qualifiers in accordance with the EPA National Functional Guidelines (EPA 1999 2002) and a tabular summary of qualifiers will be generated by the Data Validation Specialist and submitted to the Project QA Coordinator for final review and confirmation of the validity of the data. A quality assurance summary of the review will be generated by the Project QA Coordinator. This summary and copies of the complete review will be presented as an appendix to the monitoring reports.

D-1.9 LABORATORY AUDITS AND CORRECTIVE ACTIONS

Laboratory and field performance audits and corrective action procedures are described in this section.

D-1.9.1 Laboratory and Field Performance Audits

Laboratory and field performance audits consist of on-site reviews of quality assurance systems and equipment for sampling, calibration, and measurement. Laboratory audits will not be conducted as part of this study; however, all laboratory audit reports will be made available to the Project QA Coordinator upon request. The laboratory is required to have written procedures addressing internal QA/QC. The laboratory must ensure that personnel engaged in sampling and analysis tasks have appropriate training.

The laboratory will, as part of the audit process, provide for consultant's review, written details of any and all method modifications planned.

D-1.9.2 Corrective Action Procedures

Corrective Action for Field Sampling. The field technician will be responsible for correcting equipment malfunctions during the field sampling effort. The Project QA Coordinator will be responsible for resolving situations in the field that may result in noncompliance with the QAPP. All corrective measures will be immediately documented in the field logbook.

Corrective Action for Laboratory Analyses. The laboratory is required to comply with their Standard Operating Procedures (SOPs). The laboratory Project Manager will be responsible for ensuring that appropriate corrective actions are initiated as required for conformance with this

QAPP. All laboratory personnel will be responsible for reporting problems that may compromise the quality of the data.

If any quality control sample exceeds the project-specified control limits the analyst will identify and correct the anomaly before continuing with the sample analysis. The analyst will document the corrective action taken in a memorandum submitted to the Project QA Coordinator. A narrative describing the anomaly, the steps taken to identify and correct the anomaly and the treatment of the relevant sample batch (i.e., recalculation, reanalysis, and re-extraction) will be submitted with the data package.

REFERENCES

EPA. 1986. Superfund Remedial Design and Remedial Action Guidance, OSWER Directive 9355.0-4A. Office of Solid Waste and Emergency Response, Office of Emergency and Remedial Response. June 1986.

EPA. 1987. Data Quality Objectives for Remedial Response Activities. Development Processes. EPA/540/a-7/003.

EPA. 1989. Preparation Aids for the Development of RREL Quality Assurance Project Plans (Pocket Guide). Risk Reduction Engineering Laboratory, Cincinnati, Ohio. EPA/600/989087. October 1989.

EPA. 1994. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic and Organic Data Review. EPA/540/R-94/012. February 1994.

EPA. 1999 and 2002. EPA National Functional Guidelines

TABLES

Table D-1-1 – Data Quality Objectives for Groundwater and Surface Water Analyses

Table D-1-2 – QA/QC Sampling Summary

Table D-1-1
Data Quality Objectives for Groundwater and Surface Water Analyses

Parameter	Units	Reporting Limit Goal	Precision	Accuracy	Completeness	Reference	Sample Container	Container Type	Holding Time (a)	Preservative
Metals	µg/L	Cu: 1.75 Pb: 1.58 Hg: 0.05 Ni: 0.5 Zn: 2.04	+/- 25%	+/- 25%	95%	EPA Method 6010B for Cu, Pb, Ni, and Zn; EPA Method 7470A for Hg	1 liter	HDPE	28 days Hg, 6 months (all other metals)	cool/4°C/dark HNO3
PAHs	µg/L	0.01[b]	+/- 25%	+/- 25%	95%	EPA Method 8270C	1 liter amber	Glass amber	7 days/40 days	cool/4°C/dark
Total organic carbon	mg/L	1	+/- 20%	+/- 20%	95%	EPA Method 9060	250 milliliter	Glass amber	28 days	cool/4°C/dark H2SO4
Total suspended solids	mg/L	1	+/- 25%	NA	95%	EPA Method 160.2	1 liter	HDPE	7 days	NA
Salinity	ppt	0.5	+/- 25%	NA	95%	SM 2520			14 days	NA

Notes:
HDPE - High Density Polyethylene
NA - Not applicable.
[a] When two holding times are listed, the first holding time is until extraction, the second is until analysis.
[b] The reporting limit listed for PAHs is achieved using Selected Ion Monitoring (SIM) methodology.
* Actual analytical reporting limits for surface water or tidally influenced groundwater samples may be affected by interferences due to salinity.
If salinity interferences become evident in the initial round of monitoring, the laboratory Project Manager will notify the OMMP Project Proponent for analytical options.

Table D-1-2
QA/QC Sampling Summary

QA/QC Sample Type	Frequency/Number of Samples	Laboratory Analyses
Duplicate (Field or Laboratory)	One for groundwater and surface water samples at a 5% frequency	Same as original sample
Equipment Blank	One for non-dedicated surface water sampling equipment	Same as original sample
MS/MSD (Laboratory Only)	One additional sample collected per 20 groundwater and surface water samples	Same as original sample, collect triplicate volume

Attachment D-2

Groundwater and Surface Water Sample Collection Form

GROUNDWATER AND SURFACE WATER SAMPLE COLLECTION FORM

Date of Collection: ______________________________

Field Personnel: ______________________________

Purge Data (Not required for surface water collection, however, surface water field parameters must be recorded)

Well Condition: ______________________ Secure: ☐ Yes ☐ No Well Damage Description: ______________________________

____

Depth Sounder decontaminated Prior to Placement in Well: ☐ Yes ☐ No One Casing Volume (gal): ______________________

Depth of water (from top of well casing): ______________________ Well Casing Type/Diameter: ______________________

After 5 minutes of purging (from top of casing): ______________________

Begin purge (time): ______________________

End purge (time): ______________________

Gallons purged: ______________________

Purge water disposal method: ______________________

Volume of Schedule 40 PVC Pipe

Diameter	O.D.	I.D.	Volume (Gal/Linear Ft.)	Weight of Water (Lbs/Lineal Ft.)
1 ¼"	1.660"	1.380"	0.08	0.64
2"	2.375"	2.067"	0.17	1.45
3"	3.500"	3.068"	0.38	3.2
4"	4.500"	4.026"	0.66	5.51
6"	6.625"	6.065"	1.5	12.5

Time	Vol. Purged	pH	DO	Conductivity	Turbidity	Temp	Comments

Sampling Data

Sample No: ______________________ Location and Depth: ______________________

Date Collected (mo/dy/yr): ______________________ Time Collected: ____________ ☐ AM ☐ PM Weather: ______________________

Type: ☐ Ground Water ☐ Surface Water Other: ______________________ Sample: ☐ Filtered ☐ Unfiltered Other: ______________________

Sample Collected with: ☐ Bailer ☐ Pump Other: ______________________ Made of: ☐ Stainless Steel ☐ PVC ☐ Teflon Other: ______________________

Sample Decon Procedure: ______________________________

Sample Description (Color, Turbidity, Odor, Other): ______________________________

____

Sample Analyses

Analytes						Sample Containers		Preservatives	
TOC	☐	HG (diss/total)	☐	Filtered:	☐	Metals (filtered):	☐ (1) 1 L	Metals (filtered):	☐ HNO_3
Salinity	☐	PB (diss)	☐	Filtered:	☐	Hg (total):	☐ (1) 250mL	Hg (total):	☐ HNO_3
TSS	☐	CU (diss)	☐	Filtered:	☐	Conventionals:	☐ (1) 250mL	Conventionals:	☐ H_2SO_4
PAHs	☐	Zn (diss)	☐	Filtered:	☐	Other:	______________	Other:	______________

Additional Information

Types of Sample Containers:	Quantity:	Duplicate Sample Numbers:	Comments:

Signature: ______________________________ **Date:** ______________________

Attachment D-3

Well Installation Log

Well Installation Log

Thea Foss and Wheeler-Osgood Waterways OMMP

Location Sketch

Coordinates

N________ E________ Datum________

Obs. Well Install. ☐ Yes ☐ No If yes, see attached Sheet 2

Boring ________ Date ________ Sheet ____ of ____

Job ________ Job No. ________

Logged By ________ Weather ________

Drilled By ________

Drill Type/Method ☐ HSA, ☐ Geoprobe, other: ________

Sampling Method ☐ Splitspoon (hammer height ____, diameter ____) ☐ Shelby Tube, Other ____

Depth of Boring ________ ATD Water Level Depth(from top of PVC) ________

Ground Surface Elevation ________

SAMPLE ID	Blow Count	DEPTH From	DEPTH To	SAMPLE RECOVERY (FT)	Depth	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	Comments
					0			
					1			
					2			
					3			
					4			
					5			
					6			
					7			
					8			
					9			
					10			
					11			
					12			
					13			
					14			
					15			
					16			
					17			
					18			
					19			
					20			

Recovery

Subsample for Analysis

Driven Interval

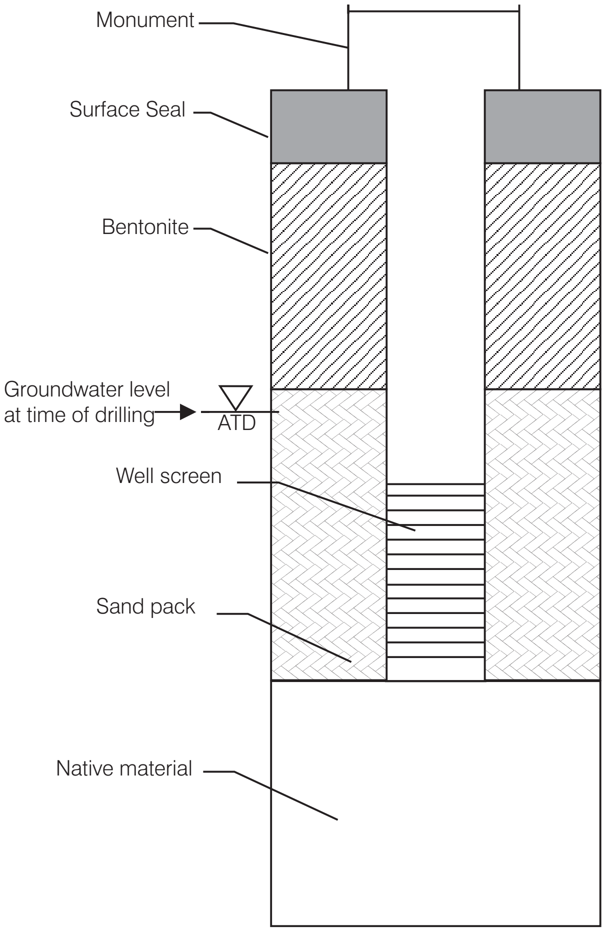
Groundwater Observed At Time of Drilling

Potentially Contaminated Soil

Well Installation Log

Boring____________________Date________________Sheet____of____

Logged By____



Monument type and height________________________

Depth and thickness of bentonite____________________

Depth and thickness of sand pack____________________

Screened interval______________________________

Additional Well Information

Well/Completion Type ☐ Flush mount, ☐ Above ground

If above ground - protective guard posts installed ☐ Yes ☐ No

Well material and diameter ____________________________

Type of sand pack ________________________________

Is screen prepacked ______________________________

Was well developed ☐ Yes ☐ No If yes, final turbidity______ NTU

Casing Depth__________________

Soil cuttings disposal method________________________

Attachment D-4

CDF Berms and Cap Observation Form

CDF BERMS AND CAP OBSERVATION FORM

Thea Foss and Wheeler-Osgood Waterways OMMP

Location: ______________________________

Date/Time: ______________________________

Weather: ______________________________

Field Personnel: ______________________________

Observation Notes:

1) Provide general sketch of observations of berm or cap
2) Draw diagram so that observation area fills diagram box
3) Note type of material(s) at surface (i.e., habitat mix, rip rap, quarry spalls, gravel, sand, silt, etc.)
4) Note presence and location of objects or debris (i.e., logs, garbage, etc.)
5) Delineate extent of berm or cap integrity issues, if present
6) Delineate presence of seeps or possible contamination (i.e., sheen, discoloration, staining, etc.), if present
7) Note approximate location of water surface and top of bank, if appropriate (i.e., berms)
8) Label photo locations and photo direction
9) Label north arrow

Additional Notes: (For any berm structure or cap integrity issues observed, describe potential causes and extent of issue)

____

____

____

Appendix E

Habitat Mitigation Area Monitoring Operations Manual

E.1 INTRODUCTION

As mitigation for effects of the remediation project on aquatic habitat, the City has constructed habitat sites within the Middle Waterway Tideflat, adjacent to the St. Paul/Middle Waterway peninsula, on the Puyallup River, and along Hylebos Creek. Additionally, the City constructed four enhancement areas within the Thea Foss Waterway. The purpose of this manual is to provide direction and procedures to be used to evaluate the success and development of the habitat sites as determined by biological performance standards. For a detailed description of the mitigation and enhancement sites, objectives, and Performance Standards, see Section 6.0 of the OMMP.

A schedule of habitat monitoring activities is presented in Tables E-2 and E-3 and listed below:

- Qualitative ground survey;
- Photo documentation;
- Invertebrate monitoring;
- Quantitative vegetation monitoring;
- Elevation monitoring;
- Water surface elevation monitoring;
- Brackish marsh salinity monitoring; and
- Juvenile salmonid monitoring.

This manual is organized into the following sections:

- Preparation for Habitat Mitigation Area Monitoring;
- Biological Habitat Monitoring Procedures; and
- Monitoring Event Completion Procedures.

Appendix F presents the project-specific Health and Safety Plan. The Health and Safety Plan must be reviewed prior to performing field monitoring activities. A copy of this Habitat Mitigation Area Monitoring Operations Manual must be available in the field when performing all monitoring activities.

E.2 PREPARATION FOR SAMPLING

E.2.1 Review and Understand this Manual

This manual contains discreet monitoring instructions for each mitigation site. In preparation for field activities, all personnel involved in the data collection, analysis, or reporting should review this manual carefully to ensure an organized mobilization for fieldwork is implemented. If any questions arise, the City's Project Manager should be contacted.

E.2.2 Contact Appropriate People for Site Access

The habitat mitigation and enhancement areas that will be monitored using the methods outlined in this manual are owned or operated by five separate entities. Property owners/operators will be contacted by the Project Manager at least 45 days prior to the beginning of habitat monitoring activities in the required areas. After schedules are established and site access has been arranged, EPA will be notified of the planned monitoring activities and schedules prior to initiation of the work.

Property Owner contact information for Habitat Site Monitoring is presented in Table E-1.

E.2.3 Contact Contractors

The monitoring methods described in this manual are intended to be conducted by City personnel with the following exceptions:

- Survey Activities – If City surveyors are not available, a contractor may be contacted to complete survey activities;
- Juvenile Salmonid Monitoring – This activity will be performed by a qualified field biologist; and
- Invertebrate Monitoring – This activity will be performed in coordination with a qualified field biologist.

The Project Manager will be responsible for arranging for these contracted services.

E.2.4 Organize Field Supplies

Field supplies should be organized prior to each monitoring event. Field supplies are described by monitoring activity below and summarized in Table E-4.

E.2.4.1 Qualitative Ground Surveys

The primary field supplies for each site are:

- Habitat Mitigation Area Monitoring Operations Manual;
- Copy of the appropriate Qualitative Ground Survey form;
- Map of the sites including planted areas and physical features (e.g., goose grids) for making spatial notes as appropriate;

- Digital camera;
- One field survey tape, at least 100 feet in length;
- For monitoring Years 1-10, bring a photocopy of the previous year's completed Qualitative Ground Survey field form;
- Probe for evaluating presence of habitat mix at North Beach, and
- Tide table.

Additional field supplies may include the following, depending on the field representative's familiarity with the site:

- Field guides for vegetation and wildlife (e.g., Pojar and MacKinnon 2004, Sibley 2003); and
- Munsell soils guide.

E.2.4.2 Photo Points

The field supplies for each site are:

- Habitat Mitigation Area Monitoring Operations Manual;
- Digital camera;
- Copy of the appropriate Qualitative Ground Survey field form, which includes photo points (photo points are to be done in conjunction with qualitative ground surveys according to the monitoring schedule);
- Map of the site showing the location of photo points:
    - For Year 1+: Copies of previous year's photo points in order to replicate the field of view for each image.
- Watch; and
- Tide table.

E.2.4.3 Invertebrate Monitoring

The field supplies for each site are:

- Map of the site showing the location of photo points;
- Three clear rigid plastic totes of the same size, with at least a 6-foot length of fishing line or similar material secured to one corner near the lip;
- Unscented, uncolored biodegradable soap (e.g., Planet brand dishwashing liquid);
- Mesh sieve with maximum 0.5 mm mesh size;
- Two 5-gallon buckets;

- Digital camera; and
- White fabric or paper board larger than tote area.

E.2.4.4 Quantitative Vegetation Monitoring

The field supplies for each site include:

- Habitat Mitigation Area Monitoring Operations Manual;
- Copies of the Quantitative Vegetation Monitoring data sheet (enough for each vegetation stratum at each site);
- A 0.25-m^2 quadrat for each field representative (marsh, riparian ground cover);
- A 10-foot diameter circular quadrat (5-foot length of rope) for each field representative (forested wetland, riparian shrub, and tree vegetation);
- dGPS unit;
- Field guides for upland and aquatic vegetation (e.g., Pojar and MacKinnon 2004);
- Copies of previous year's completed Quantitative Vegetation Monitoring data sheets;
- Digital camera;
- Field survey tapes, 150 feet in length;
- Map of the site showing planted areas and physical features which includes the pre-determined transect end-points and/or grid corners and sample locations:
    - For Year 1+: Map with pre-determined sampling locations and transect end points, spare coated rebar or lathe and mallet for replacing missing field markings; and
    - For all years: List (distance on transect/location on grid) of pre-determined sampling locations for each vegetation stratum.
- Watch; and
- Tide table.

E.2.4.5 Elevation Monitoring

The field supplies for each site include:

- Habitat Mitigation Area Monitoring Operations Manual;
- Copy of the Elevation Monitoring data sheet;
- Digital camera;
- Map of the site showing planted areas and physical features which includes the pre-determined location of each elevation monitoring location;
- Watch; and
- Tide table.

E.2.4.6 Hylebos Creek Water Surface Elevation Monitoring

The field supplies needed are:

- Habitat Mitigation Area Monitoring Operations Manual; and
- Hydrostatic pressure water level sensor with attached data logger.

E.2.4.7 Brackish Marsh Salinity Monitoring

Brackish marsh monitoring occurs only at the Middle Waterway Tideflat site. Field supplies include:

- Habitat Mitigation Area Monitoring Operations Manual;
- Map of the site showing marked sampling locations, elevation contours, and planted areas;
- Copy of the current version of the City of Tacoma's "STANDARD OPERATING PROCEDURE: Middle Waterway Sediment Salinity, Collection and Analysis of Interstitial Water" (SOP);
- Materials outlined in SOP, which include:
    - 500 ml jars, 1-gallon freezer bags or equivalent;
    - Ice chest/ice for transporting samples;
    - Spot light or lantern for night sampling;
    - Small shovel, post hole digger, sediment sampler or equivalent;
    - Chain of custody forms, pens, labels, etc. for note taking; and
    - Tape measures.
- Watch; and
- Tide table.

E.2.4.8 Juvenile Salmonid Observations

The primary field supplies for each site include:

- Habitat Mitigation Area Monitoring Operations Manual;
- Copy of the Juvenile Salmonid Observations data sheet;
- Map of the site showing elevation contours, planted areas, and physical features on which to make spatial notes (e.g., observation points, school locations);
- Polarized sunglasses;
- Watch; and
- Tide table.

Depending on the familiarity of the biologist with juvenile salmonids and other fishes, additional field guides may be appropriate. Binoculars or a spotting scope may be helpful, but are not necessary.

E.3 HABITAT MONITORING PROCEDURES

E.3.1 General Approach and Monitoring Schedule

The habitat monitoring approach consists of eight monitoring components. For each site, one or a combination of several procedures will be conducted for each monitoring effort. See Table E-2 for the activities to be performed at each habitat location, and Table E-3 for an overview of the monitoring schedule.

E.3.2 Pre-Monitoring Procedures and Point Installation Activities

Site construction and plantings for each habitat area will be completed in 2006 (Year 0). Before habitat monitoring activities are initiated, limited preliminary monitoring and point installation activities should be completed. The baseline elevation surveys should document as-built conditions and the locations of permanent transects and photo points. The procedures to be used for the elevation surveys are described in Table E-5. Note that these Pre-Monitoring Procedures apply to the entire monitoring program and should not be confused with field preparation for each monitoring event.

E.3.3 Monitoring Procedures

The sections below describe the specific methods for each sampling protocol. Unless specifically stated otherwise, sampling is to occur in mid- to late summer (according to the monitoring schedule presented Table E-3).

E.3.3.1 Qualitative Ground Survey

At each site, field personnel conducting all monitoring activities will make a number of qualitative observations of site dynamics, including physical changes (erosion), vegetation, prey, and wildlife in addition to the quantitative monitoring described in subsequent sections.

Upon arrival at each mitigation site complete the heading on the appropriate field form, including date, monitoring year, site being surveyed, staff present, and weather conditions. Record overall site health and notes within the vegetation or intertidal zones, paying attention to your location on-site. Illustrate notations of unusual or notable observations on the field map.

For each row within the Qualitative Ground Survey field form (Attachment E-2), note site characteristics, indicating any changes from previous year's observations; record observations or evidence of all wildlife species including mammals, avifauna, and macro-invertebrates.

At sites with goose exclusion grids, check the grids for damage, accumulating woody debris, garbage, or other potential problems. After vegetation is established (i.e., plants have survived and grown subsequent to planting and are less susceptible to damage from floating debris or goose feeding), goose exclusion grids may no longer be required. At this time, notify the City Project Manager that goose exclusion grids can be removed.

E.3.3.2 Photo Documentation

Photo documentation of the mitigation/enhancement areas requires establishment of set photo points within each site. The precise photo point locations will be carefully considered in the field to ensure complete coverage of site conditions. The photo points will be marked with permanent stakes (wood or rebar) and surveyed in Year 0 (Pre-Monitoring Procedures). All mitigation sites will be photographed at low tide (maximum water elevation 0 feet Mean Lower Low Water (MLLW), except the Hylebos Creek site where the maximum water elevation for photography is 2 feet NGVD 29 (8.78 feet MLLW). In addition, a second set of photos (where accessible) will be taken at the Hylebos Creek site when the water elevation is at approximately 6 feet NGVD 29 (12.78 feet MLLW).

Photo points including defined viewpoints for each point are shown on Figures E-1 through E-8. Images will be taken to characterize the planted vegetation nearest the photo point. Include an overlap or a view of shoreline whenever possible, but note that it is not necessary for viewpoints to have overlapping fields of view. Take photographs at a standing height above ground level; for purposes of consistency, do not crouch. Complete the photo log located on the Qualitative Ground Survey field form for each picture. Starting in Year 1, previous photos from each photo point will be available in the field to the field technician to ensure that the same viewpoint is captured in successive sampling events.

E.3.3.3 Invertebrate Monitoring

Juvenile salmon prey presence at side channel habitats (Hylebos and PRSC) will be verified using insect fallout traps that will be deployed one day prior to Qualitative Ground Surveys. Traps will be deployed at photo points 1, 4, and 6 at the PRSC site and photo points 1, 2, and 4 at the Hylebos Creek site. In addition, visual observations for aquatic prey species will be noted.

For insect monitoring at each site, use the 5-gallon buckets to sieve water from the site to remove any insects already present from the sample. Secure one tote to each photo point with the fishing line. Apply an aliquot of biodegradable soap to the bottom of each tote and pour one inch of sieved water on top (soap will help to reduce surface water tension to improve trapping efficiency). Rub the bottom of the tote with your hands to dissolve soap into the water. Place the trap so that the line is perpendicular to the shoreline and as far downslope as possible from the rebar stake. Traps will float if they are not overfull.

Twenty-four hours after deploying traps, return to the site and collect them. Under “notes” on the qualitative ground survey form, record whether insects are present or absent in each trap. Place each trap on a flat surface on top of the white backing material and photograph to document insect presence.

E.3.3.4 Elevation Monitoring

As part of Year 0 monitoring, erosion/accretion monitoring stakes must be installed at the North Beach Habitat, Middle Waterway Tideflat Habitat, Puyallup River Side Channel (PRSC), and the Hylebos Creek Mitigation Site (see Section E.3.2 - Pre-Monitoring Procedures and Point Installation Activities). The graduated erosion/accretion monitoring stakes consist of permanent markers (36-inch coated rebar with a PVC sleeve) that will be driven two feet into the substrate. The PVC sleeve shall be 18 inches in length and will cover the top 18 inches of the rebar.

Markings at one-inch intervals shall be permanently etched into the PVC sleeve and overlaid in black bands with permanent ink, with the exception of the 6th band from the base of the PVC. That band will be red to indicate the original substrate location. The 12th band from the base of the PVC also shall be marked with "+6". During installation, drive the stake (using single hand sledge) until the base of the PVC is flush with the substrate. Then carefully drive the stake six more inches where the red band is flush with the substrate. Photograph each stake so the image clearly depicts the red band is flush with the substrate. Figure E-9 depicts a schematic of the elevation monitoring stake.

For Year 0, elevations will be surveyed using a total station EDM or similar survey equipment. The horizontal datum will be NAD 83/91 and the vertical datum will be NVGD 29. All survey points that are measured will include both coordinates and elevations. Graduated erosion/accretion stakes will be located with the substrate surface elevation at the base of each stake recorded.

In subsequent years, check each erosion/accretion stake visually to determine the position of the red band (i.e., original substrate elevation) relative to the current substrate elevation. Record the current measurement on the data sheet in the corresponding data blank. Record erosion as a negative (-X-inch) value and accretion as a positive (+X-inch) value, and photograph the stake to visually record the data point.

At the Hylebos Creek Mitigation Site, elevations along transects located at the approximate centerline of both channels will be surveyed annually for 10 years. The horizontal datum will be NAD 83/91 and the vertical datum will be NGVD 29. All survey points that are measured will include both coordinates and elevations. Centerline elevation surveys will be conducted using land-based surveying or electronic position system methods. Each survey transect will contain a minimum of 9 survey points including the established elevation monitoring points (i.e., E-1, E-2, E-4, E-5, and E-6 as shown on Figure E-8). In addition to the transect survey, as part of the qualitative ground survey, the City's field representative will conduct a visual inspection along and between the transect points noting special or unusual features on the Qualitative Ground Survey Inspection Form.

E.3.3.5 Hylebos Creek Water Surface Elevation Monitoring

This component of monitoring is scheduled for Years 0, 3, 5, 7, and 10. A general description of the effort follows.

Surface water elevation is being monitored during Year 0 to confirm water level using a hydrostatic pressure water level sensor attached to a data logger. The sensor was put in place on April 18, 2006, and remained in place through October 2006, in order to cover the majority of the anticipated salmon outmigration period and also the lower base flow and tidal extremes of early summer. The logger recorded water level during periods of inundation in 10-minute intervals. In monitoring Years 3, 5, 7, and 10, the logger will be in place during the low flow period (July-August).

E.3.3.6 Brackish Marsh Salinity Monitoring

Procedures for brackish marsh salinity monitoring are described in the City of Tacoma SOP. The field and laboratory procedures from the SOP have been summarized below. For laboratory procedures in particular, reference the current version of the SOP for source guidance.

Brackish marsh salinity monitoring will be implemented within the Middle Waterway Tideflat Habitat area only. The field effort for salinity monitoring will occur on a descending tide, approximately two hours after the tidal elevation has dropped below 11.5 feet MLLW. Sampling stations are shown in Figure E-6.

Interstitial pore water salinity of the brackish marsh soils will be measured prior to planting in Year 0 and monthly for three months following brackish marsh planting (Year 0) to ensure the salinity suitability for the intended plants. The interstitial water will be measured in late March or early April of Year 1 to ensure that the proper sediment salinities are maintained.

Pore water samples will be collected from the Middle Waterway Tideflat Habitat shoreline soils located between 11.5 feet MLLW and 12.5 feet MLLW. Sampling stations located within the irrigated area are marked with rebar and painted green with orange flags indicating the sample station. These sampling stations are labeled MWTF-BW1 through MWTF-BW6. Three control points (rebar painted yellow with orange flagging) are labeled MWTF-BMC1 through MWTF-BMC3 and located outside of the irrigated area.

Samples will be taken within a five-foot radius of the rebar marking each station unless pore water is not found, in which case samples will be taken within a 10-foot radius from the rebar. Sample depth should be between zero and 16 inches. A hole is dug and interstitial pore water is allowed to accumulate. A calibrated multi-metered probe is used to collect conductivity readings of the accumulated water. Conductivity readings are then converted to salinity measurements. Results shall then be submitted following normal lab procedures. In the event that in-field monitoring is unable to be completed, one gallon zip lock bags will be filled with soil and then taken back to the lab for analysis by multi-metered probe as described below. Sampling will begin approximately two hours following a descending tidal elevation of 11.5 feet MLLW. Sampling should not occur during active rainfall. Once sampling is complete analysis can begin immediately or samples can be stored for up to seven days at 4° C.

The irrigation duration and frequency may be adjusted depending on, but not limited to, field observations of soil and vegetation, pore water salinity monitoring results, and weather conditions.

In Year 0, if less than 50%, of the results meet the salinity threshold of 10 ppt (1%) adjustment of the irrigation system may be needed if plants appear to be stressed, and sampling will continue weekly as tides allow (i.e., higher than 11.5 feet MLLW) until the threshold is met.

The following items will be recorded when sampling:

- Weather conditions;
- Station location, date, time;

- Distance and direction from the rebar (marking the sample station) to the location of the sample location;
- Distance from the rebar (marking the sample station) to the water's edge;
- Distance from the location of sample collection to water's edge;
- Approximate tide elevation; and
- Conductivity and temperature.

Laboratory Salinity Procedures (Optional)

If in-field sampling is unable to be completed as described above, the following laboratory procedures will be followed.

1. Retrieve samples from storage and make sure all samples match the chain of custody.
2. Decant off the overlying water from the sample to be processed and retain in clean beaker. If this provides adequate volume to make salinity measurements skip to Step 4.
   - Distribute equal portions of the sediment sample into each of the four 500 ml jars.
3. Place the 500 ml jars in the centrifuge.
   - Centrifuge the beakers for 15 minutes at 2000 rpm, or until the overlying water contains no visible suspended solids. Decant and save overlying liquid fraction for salinity determination, discard sediment fraction.
   - If initial centrifuging of the four 500 ml jars does not produce enough liquid for salinity determination, refill jars from one-gallon zip lock bag being careful to balance the jars and repeat Step 3.
4. Calibrate salinity meter following the manufacturer's directions. Determine salinity using a multi-meter probe or approved equal.
5. Record salinity for each station and submit data following normal lab procedures.

E.3.3.7 Quantitative Vegetation Monitoring

Quantitative and semi-quantitative data will be recorded and used to evaluate the establishment and development of planted riparian, marsh (brackish and salt), and forested wetland strata. Quantitative vegetation monitoring will not be used for the emergent marsh stratum at Hylebos Creek because this area is not included in the site and is not within the City's jurisdiction to modify for compliance with performance standards.

The specific metrics used will vary among strata, but generally include presence or absence of vegetation, measures of total percent cover for native and non-native naturalized species, density, and semi-quantitative notes on percent cover by individual species (including invasive species). For riparian and forested wetland strata, data will be recorded for vegetation within each sub-stratum (tree, shrub, groundcover/emergent) at each data point. Individual plants will be assigned to a sub-stratum based on growth habit of the species, not by size of the individual (e.g., a Douglas fir of any size is a tree; a Hooker's willow of any size is a shrub). Table E-6 describes the strata and sub-strata that are present at each site. Table E-7 describes the vegetation planted within each stratum and sub-stratum.

Transect and/or Grid Surveys

As part of the Year 1 Pre-Monitoring Procedures, vegetation monitoring transect end-points and grid corners (North Beach only) will be permanently marked in the field and surveyed. Sampling transects and/or grids will be established within each of the vegetation strata at the mitigation sites, with locations to be determined using ground-based reconnaissance after planting has been completed. Sampling areas will be defined using AutoCAD or other surveys that include planting areas, exclusion grids, and as-built elevations.

Sampling will occur in each vegetation stratum. Transects will be used to define potential sampling areas in each stratum. At each site, a total of 25 sample plots will be established in each vegetation stratum. To eliminate potential bias, sample locations will be established using a random number generator (Excel or other). For riparian and forested wetland strata, potential sample points must be spaced at a 10-foot interval in order to establish non-overlapping quadrats. For saltmarsh and brackish marsh, potential sample points should be spaced at 5-foot intervals. In order to test performance standards specific to weighted average percent cover in marsh areas, it is necessary that sample plots in the potential marsh areas include points both inside and outside of planted nodes.

At the North Beach site, only five of the eight planted nodes are defined as being within the potential marsh area (see Figure E-5). The remaining three nodes are being planted in more exposed areas on a pilot basis, and are not being monitored for performance standards. In each of these three pilot nodes, five additional marsh sample plots shall be established using a grid for each node.

Two different sizes of quadrats shall be used to reflect the patch size and variation of vegetation in different assemblage types. Marsh and emergent wetland vegetation sampling points will be defined using a 0.25 m^2 quadrat placed alongside the sample point at the upper left hand corner of the quadrat. For each riparian and forested wetland sampling point, two quadrats shall be used: a 0.25 m^2 quadrat for groundcover and emergent plants and a 10-foot diameter circular quadrat (or similar sized rectangular quadrat) for trees and shrubs.

To ensure consistency of observations between monitoring events, the Quantitative Vegetation Monitoring data sheet will be used for all monitoring events. For each sample point (and sub-stratum for riparian and forested wetland areas), the total percent cover of native or non-native naturalized species will be visually estimated by projecting the estimated canopy cover onto the ground surface and recorded using Daubenmire cover classes (0 to 5, 6 to 25, 26 to 50, 51 to 75, 76 to 95, and 96 to 100 percent) and cover class midpoint values (2.5, 15, 37.5, 62.5, 85, and 97.5 percent). Density shall be recorded as total shoot count with within the quadrat for native and non-native naturalized species. Semi-quantitative notes shall be made on the approximate percent cover for individual species, including invasives that are not included in total cover.

Area Extent Surveys

For potential marsh areas at North Beach and Middle Waterway Tideflat, the aerial cover and width of vegetated areas will be surveyed using a dGPS unit. At North Beach, the extent of vegetation at each of the three pilot nodes also will be surveyed.

Planted Species Information

For mitigation sites only, species planted in each stratum and sub-stratum are presented by site in Table E-7.

E.3.3.8 Juvenile Salmonid Monitoring

Before monitoring:

- Determine that weather conditions are conducive to reasonable visibility (e.g., calm, clear); and
- Consult tidal prediction tables to ensure water elevations will be appropriate for juvenile salmonid monitoring (very low slack tides can limit visibility).

The objective of this monitoring activity is to document juvenile salmonid presence within each mitigation site (i.e., North Beach Habitat, Middle Waterway Tideflat Habitat, Puyallup River Side Channel, and Hylebos Creek Mitigation Site) during the juvenile outmitigation period. A biologist will conduct observations over a four-hour period during each monitoring event. Two observation events will be scheduled at each mitigation site during the first and last weeks of May.

The biologist will select up to four different locations at each site where fish are likely to be observed. In order to maximize visibility of juvenile salmonids, recommended locations include shallow slopes below the water level and locations where the observer can look down the water from at least a few feet. At sites with obvious access points (i.e., Puyallup River Side Channel, Hylebos Creek Mitigation Site), some observation time should be spent near those points. Observations shall be made on days where conditions are conducive to reasonable visibility. Observation time toward four-hours may be accumulated over multiple days if visibility deteriorates to the point where a four-hour observation period cannot be completed in a single event. A minimum of one-hour of observation time must be completed during any single event toward the four-hour total.

To ensure consistency of observations between monitoring events, the Juvenile Salmonid Observations data sheet (Attachment E-5) will be used for all monitoring events. Notes shall include time of observation, approximate school size, approximately fork-length range (i.e., measurement from top of nose to fork in the caudal fin), location in water column (i.e., surface or subsurface), species present (as discernable), and notes on behavior. Locations may be made on the site map, but are not required for analysis. Care should be taken to avoid counting the same school multiple times, but there are no quantitative performance standards associated with this monitoring so it is not critical if a school is counted multiple times.

E.4 DATA ORGANIZATION AND ARCHIVING PROCEDURES

E.4.1 Monitoring Event Completion Procedures

To ensure transparency of the original data, a series of monitoring event completion procedures must be followed subsequent to completion of each monitoring activity.

E.4.1.1 Data Sheets and Field Forms

Original data sheets will be photocopied or scanned into digital format immediately upon return from monitoring activities. Photocopies will be used for data entry and analysis, and after digital data has been checked for Quality Control/Quality Assurance (see Attachment E-1), the original data sheets will be sent to the City for archiving in the project files. Photocopies will also be retained by the City.

E.4.1.2 Photos

Photo Points

A digital camera will be used for all photo points, and the contents will be downloaded upon completion of monitoring activities. The original files, with automated file names, will be kept in a folder called “original”; a second copy of the files re-named to reflect site and photo point will be kept in a second folder called “labeled”. No additional changes (e.g., file re-sizing, cropping, color adjustment) will be made to photo points. A CD with both sets of digital files will be sent to the City for archiving in the project files. Digital copies of the images will also be retained by the City.

Additional Photos

All additional photos (e.g., elevation stakes, insect traps) will be labeled and archived in the City project file similar to the method used for the pictures from the photo points.

E.4.2 Data Entry and Organization

Raw data will be entered into an appropriate spreadsheet (e.g., Excel) or database (e.g., Access) format to keep a digital record of every entry on the field data sheet. Raw data will then be subjected to 100% QA/QC review by another person to ensure accurate data entry. A separate Excel or Access file will be kept for the raw data for each monitoring event by protocol (e.g., vegetation sampling or juvenile salmonid observations).

The QA/QC’d raw digital data will be arranged into an EPA-approved format for Federal archiving, and will be arranged as necessary for data analyses.

Copies of the QA/QC’s raw digital data files and EPA-format files will be sent to the City for archiving in the project files and distribution to EPA. Copies will also be retained by the City.

The City project personnel conducting monitoring will be responsible for organizing the raw digital data into a format appropriate for analysis. Care should be taken to clearly label analysis spreadsheet contents so that the origin of data and method of analysis can be easily understood and repeated. Final copies of digital data analysis files will be sent to the City for archiving in the project files, and will be retained by the City.

Following the first year of data entry, organization, and analysis, persons conducting subsequent monitoring should attempt to follow similar organization procedures, naming conventions, and data arrangement in order to maintain consistency throughout the monitoring program.

E.5 ANALYSIS

E.5.1 Qualitative Ground Survey

There are no quantitative analyses associated with the qualitative ground surveys. Qualitative discussion should first focus on description of different site characteristics observed during the ground surveys, and then comparison with observations made in previous years that might indicate site trends.

Copies of qualitative ground survey data sheets shall be included as an appendix to the annual monitoring reports.

E.5.2 Photo Documentation

Photo Points

There are no quantitative analyses associated with photo points. The complete set of labeled photo points for each year should be presented in the same order as an appendix to the monitoring report. Labels should include site name, photo point, general direction of view, date, time, and tide level. For example, "Photo 1. Middle Waterway Tideflat, PP1A, facing west. Photo taken July 30, 2006 at 13:43, tide level -1.2 feet MLLW". Labels also may include additional notes pertinent to discussion in the report, e.g., "Note debris accumulation on goose grid", but this is not required. Discussion in the report should first focus on describing current conditions, and then address any changes or trends apparent with comparison from previous years' photo points.

E.5.3 Invertebrate Monitoring

There are no quantitative analyses associated with insect and other prey monitoring. Invertebrate presence or absence will be described in notes on the qualitative monitoring form. At least one photo of an insect trap from each location will be taken as outlined in Section E.3.3.3.

E.5.4 Elevation Monitoring

Elevation monitoring data will be analyzed for comparison against the elevation performance standards outlined in Section 6.0. Note that there are no performance standards for elevation monitoring at the Puyallup River Side Channel.

For monitoring Years 0, 1, 2, 3, 5, and 7, the analysis for each site will consist of calculating the average of the absolute value of change for each stake relative to the Year 0 0-inch baseline.

For monitoring Year 10, the analysis for each site will consist of calculating the average of the absolute value of change from Years 7 to 10. For comparison purposes, average change from Year 0 baseline also will be reported. Year 10 will be the last year for elevation monitoring.

Average change for each site will be reported in text and data will be presented for all sites in the table format shown in Table E-8. The example format shows the table that would be used in Year 5; during each year only those rows specific to years that have been monitored to date would be included in the report.

In addition, for Hylebos Creek, centerline transect elevations will be compared on a point-by-point basis with as-built elevations. The average change of all of the points will be calculated and that difference will be no greater than 0.2 feet.

E.5.5 Hylebos Creek Site Water Elevation Monitoring

This component of monitoring is scheduled for Years 0, 3, 5, 7, and 10. This monitoring is being conducted for informational purposes only. A general description of the effort follows.

The elevation of the data probe was surveyed to NGVD29 datum. Based on the recorded water depths and the surveyed elevation, surface water elevation within the habitat site can be calculated to determine the water level at anytime during monitoring. Water level data will be evaluated by a licensed Hydrogeologist to confirm that the elevation is greater than two feet at least 30% of the time. A similar procedure will be followed in subsequent monitoring years.

E.5.6 Quantitative Vegetation Monitoring

E.5.6.1 Vegetation Monitoring Analyses

Analyses for quantitative vegetation monitoring will vary according to site, stratum, and sub-stratum in order to address the performance standards for each site. Quantitative and semi-quantitative analyses are described below and summary of quantitative analyses by stratum and sub-stratum for each site is provided in Table E-9.

Quantitative analyses will include the following:

- **Percent Survival (PS).** This value applies only to forested wetland vegetation at Hylebos Creek. It will be calculated as one minus the number of failed plantings (shrub and tree) in the forested wetland area divided by the total number of plantings according to the planting plan for that stratum.
- **Total Percent Cover (TPC).** This value will be the average of the cover class mid-points (Daubenmire 1959) for each sub-stratum in riparian (North Beach, Middle Waterway Tideflat, PRSC) and forested wetland (Hylebos) strata. It also will be will be used to calculate salt marsh cover in the 15 additional quadrats sampled in the pilot nodes at North Beach, although there is no performance standard associated with that measure.
- **Area-Weighted Percent Cover (AWPC).** This metric applies only to the vegetation within the spatially defined “potential marsh areas” in the marsh strata at North Beach and Middle Waterway Tideflat. Use of this metric is intended to allow for

random sampling over the entire potential marsh area while correcting for the proportion of planted and unplanted (colonizing) area within it. This value will be calculated as follows:

$$Cover = \left[\left(\frac{\sum X_{planted}}{n_{planted}}\right)\times\left(\frac{Area_{planted}}{Area_{total}}\right)\right]+\left[\left(\frac{\sum X_{non-planted}}{n_{non-planted}}\right)\times\left(\frac{Area_{non-planted}}{Area_{total}}\right)\right]$$

Where:

$\frac{\sum X_{planted}}{n_{planted}}$ is the average percent cover in areas originally planted, calculated as the sum of percent cover measurements in planted area divided by the number of samples in that area;

$\frac{Area_{planted}}{Area_{total}}$ is the percent of the potential marsh area that was planted , calculated by area planted divided by total potential marsh area;

$\frac{\sum X_{non-planted}}{n_{non-planted}}$ is the average percent cover in areas colonizing (non-planted) areas calculated as the sum of percent cover measurements in non-planted area divided by the number of samples in that area; and

$\frac{Area_{non-planted}}{Area_{total}}$ is the average percent cover in areas originally planted, calculated by area that was not planted divided by total potential marsh area.

- **Percent of Potential Marsh Area with Some Vascular Marsh Vegetation (PPMV).** This metric applies only to the spatially defined “marsh areas” at North Beach and Middle Waterway Tideflat. It will be calculated as the percent of the 25 marsh (salt or brackish) quadrats in the marsh areas where any vascular native or non-native naturalized vegetation has been recorded. Quadrats in which only invasive vegetation has been recorded will be considered unvegetated for this metric, which applies only to native or non-native naturalized vegetation.

- **Density (D).** This metric applies only to the vegetation within the spatially defined “potential marsh areas” in the marsh strata at North Beach and Middle Waterway Tideflat. Number of marsh plants in each sample quadrat will be recorded. Because density performance standards apply only to vegetated areas within the planting nodes, density calculations will be made using only non-zero count samples from the planted areas. The density will be calculated as the average shoot count within vegetated, planted areas multiplied by four to account for the 0.25 m^2 sample quadrat.

Semi-quantitative metrics may include the following:

- **Percent Cover by Species.** For dominant species and all invasive species, notes will be made on percent cover. These will be used to describe the vegetation assemblage in each stratum or sub-stratum in a semi-quantitative manner. For the potential marsh area, semi-quantitative discussion of vegetation assemblage should distinguish whether it applies to planted, colonizing, or the overall marsh area.

- **Diversity.** Notes from vegetation sampling will include species present in each quadrat. This information will be used to discuss relative diversity of planted and colonizing vegetation at each site in a semi-quantitative manner.

E.5.6.2 Vegetation Monitoring Reporting

Results from vegetation monitoring should discussed in text and be summarized in tabular format (Table E-10). Data sheets for each quadrat will be included in an appendix to the annual monitoring report.

Discussion should initially focus on current results and how they compare to objectives and performance standards outlined in Section 6.0. Discussion should address the semi-quantitative metrics described in Section E.5.6.1. Additional discussion of trends and inter-annual or inter-site comparisons should follow. Inter-annual results should be shown in another table (Table E-11).

E.5.7 Brackish Marsh Salinity Monitoring

Salinity results for sampling and control sites will be reported for each monitoring event. These may be presented in tabular form and discussed in relation to objectives and performance standards which are outlined in Section 6.0. The report shall also include verification from City staff that the irrigation system is being maintained and is working properly.

E.5.8 Juvenile Salmonid Monitoring

Salmonid monitoring results will focus on the presence or absence of fish at each site during each year’s monitoring; inter-annual comparisons are not required. Additional discussion of numbers of fish, species (if discernable), and other characteristics or behaviors observed may be included for each site, but there should be no quantitative or semi-quantitative comparisons made between sites, as observations cannot be used to reliably quantify relative use.

A table will be used to summarize observations at each site (Table E-12).

E.6 REPORTING

Habitat monitoring reports will be completed at the end of each required monitoring event for inclusion in the overall OMMP Report and submittal to EPA. Habitat monitoring reports will compare that year’s results to previous years’ results. Annual reports will include appendices with copies of original data sheets for all monitoring activities. Copies of each report will be submitted to EPA, the Natural Resource Trustees, Simpson, and other members of the adaptive management team.

REFERENCES

Daubenmire, R.F. 1959. Canopy coverage method of vegetation analysis. Northwest Science 33:43-64.

Pojar, J. and A. MacKinnon. 2004. Plants of the Pacific Northwest Coast: Washington, Oregon, British Columbia & Alaska. Vancouver, BC: Lone Pine Publishing. (2004 revision, 1994 original is acceptable substitution)

Sibley, D.A. 2003. The Sibley field guide to birds of western North America. Alfred A. Knopf, New York.

TABLES

FIGURES

ATTACHMENTS

Table E-1
Contact Information for Habitat Site Monitoring

Habitat Site	Contact and Mailing Address	Notes
Mitigation Sites		
North Beach Habitat	Simpson Properties, 253-680-6813 or 253-680-6814 917 East 11th Street Tacoma, WA 98421	Pre-visit site training, hardhat, safety vest, and boots required for access to Simpson Properties. Contact 45 days in advance for training.
Middle Waterway Tideflat Habitat	Simpson Properties, 253-680-6813 or 253-680-6814 917 East 11th Street Tacoma, WA 98421	Pre-visit site training, hardhat, safety vest, and boots required for access to Simpson Properties. Contact 45 days in advance for training.
Puyallup River Side Channel (PRSC)	City of Tacoma Public Works, Mary Henley, 253-502-2113 Public Works Department 2210 Portland Avenue Tacoma, WA 98421-2711	Retrieve yellow gate key for levee access by vehicle, public access at E. 18th Street right of way off of Portland Ave.
Hylebos Creek Mitigation Site	City of Tacoma Public Works, Mary Henley, 253-502-2113. City to contact property owners Public Works Department 2210 Portland Avenue Tacoma, WA 98421-2711	Site Access on 4th Ave.
Enhancement Areas		
Johnny's Dock Habitat Enhancement	Johnny's Dock Restaurant, 253-627-3186 1900 East D Street Tacoma, WA 98421	Drop in at counter.
Head of Thea Foss Shoreline Habitat	Berg Scaffolding, 253-383-2035 2130 East D Street Tacoma, WA 98421	Drop in at office.
SR-509 Esplanade Riparian Habitat	Public Access East Dock Street under and adjacent to the SR-509 overpass	
Log Step Habitat Enhancement	Public Access 821 Dock Street Tacoma, WA 98402	

Table E-2
Habitat Monitoring Program Matrix

	North Beach	Middle Waterway Tideflat	PRSC	Hylebos Creek	Thea Foss Enhancement Areas
Qualitative Ground Survey	X	X	X	X	X
Photo Documentation	X	X	X	X	X
Quantitative Vegetation Monitoring	X	X	X	X	
Invertebrate Monitoring			X	X	
Elevation Monitoring	X	X	X	X	
Surface Water Elevation Sampling				X	
Brackish Marsh Salinity Monitoring		X			
Juvenile Salmonid Monitoring	X	X	X	X	

Table E-3
General Monitoring Schedule

	2006 - Year 0	2007 - Year 1	2008 - Year 2	2009 - Year 3	2010 - Year 4	2011 - Year 5	2012 - Year 6	2013 - Year 7	2014 - Year 8	2015 - Year 9	2016 - Year 10
Qualitative Ground Survey	X	X	X	X	X	X	X	X	X	X	X
Photo documentation	X	X	X		X			X			X
Quantitative Vegetation Monitoring		X	X		X			X			X
Invertebrate Monitoring		X		X							
Elevation Monitoring[1]	X	X	X	X		X		X			X
Surface Water Elevation Sampling	X			X		X		X			X
Brackish Marsh Salinity Monitoring	X	X									
Juvenile Salmonid Monitoring		X		X							

[1] Note that survey transects of the channels at Hylebos Creek will be performed annually while monitoring of elevation stakes at other locations will be performed on the schedule shown.

Table E-4
Biological Habitat Field Supplies

Item	Purpose	Qualitative Ground Surveys	Photo Points	Invertebrate Monitoring	Quantitative Vegetation Monitoring	Elevation Monitoring	Brackish Marsh Salinity Monitoring	Juvenile Salmonid Monitoring	Water Elevation Monitoring
Habitat Mitigation Area Monitoring Operations Manual	Reference field procedures.	X	X	X	X	X	X	X	
Data or survey forms (see Appendix E, 2.4 and 3.3 for appropriate forms and number of copies for each site)	Record qualitative and quantitative data for all monitoring activities.	X	X	X*	X	X		X	
Site maps (see Appendix E, 2.4 and 3.3 for appropriate site maps for each monitoring activity)	Provide site orientation (include planting areas, physical features, etc.), sampling locations; recording spatial notes during monitoring events.	X	X	X	X	X	X	X	
Camera	Record general site conditions, notable observations, and photo points as appropriate.	X	X	X	X	X			
Field survey tape, 100 or 300 ft (see Appendix E, 2.4 and 3.3 for appropriate length and number for each site)	Informing spatial notes, locating sample points along grids or transects.	X			X				
Copies of previous year's data forms (after initial monitoring event)	Reference level of detail and notable observations from previous years.	X			X				
Copies of previous year's photo points (after initial monitoring event)	Reference for exact field of view from previous years.		X						
Fallout traps (tethered rigid clear plastic bins, see Appendix E, Section 2.4.3 for description)	Sampling insect fallout into the side channel habitat sites.			X					

Item	Purpose	Qualitative Ground Surveys	Photo Points	Invertebrate Monitoring	Quantitative Vegetation Monitoring	Elevation Monitoring	Brackish Marsh Salinity Monitoring	Juvenile Salmonid Monitoring	Water Elevation Monitoring
Probe	Elevation of presence of habitat mix at North Beach.	X							
Unscented, uncolored biodegradable soap	Reducing surface tension in insect fallout traps.			X					
Mesh sieve with maximum 0.50 mm mesh size	Removing insects from fallout trap sampling water prior to setting traps.			X					
Two 5-gallon buckets	Sieving water for insect traps.			X					
White fabric or paperboard	Providing a white backdrop for photographing insect trap contents.								
Tide table, watch	Orientation relative to site bathymetry, timing of observations.	X	X		X	X	X	X	
Field guides for flora, fauna, and/or soils as appropriate	Reference as necessary to identify vegetation, fish and wildlife, or soils as necessary.	X			X			X	
Quadrats (0.25 m^2 PVC square, 5-ft length of rope) for each biologist	Define sample area for each sampling point.				X				
dGPS unit (North Beach, Middle Waterway Tideflat)	Record areal extent of saltmarsh vegetation.				X				
Spare coated rebar or wood lathe	Replace missing field markings.				X				
List of sampling points along transects or grids	Locate sampling locations using transect end points or grid corners and 150' field survey tapes.				X				
Copy of Salinity SOP (see Appendix E 2.4.7)	Reference detailed field methods for salinity monitoring.						X		

Item	Purpose	Qualitative Ground Surveys	Photo Points	Invertebrate Monitoring	Quantitative Vegetation Monitoring	Elevation Monitoring	Brackish Marsh Salinity Monitoring	Juvenile Salmonid Monitoring	Water Elevation Monitoring
Materials outlined in SOP (see Appendix E 2.4.5)	Conduct brackish marsh sampling.						X		
Polarized sunglasses	Enhance visibility during fish observations.							X	
Binoculars or spotting scope (optional)	Assist fish observations.							X	
Hydrostatic Pressure Water Level Sensor	Measure water level.								X

* Insect and other observable prey presence will be recorded under “notes” on Qualitative Ground Survey data sheets.

Table E-5
Pre-Monitoring Procedures and Point Installation Activities by Site

Pre-Monitoring Procedure/Point Installation Activity	North Beach	Middle Waterway Tideflat	PRSC	Hylebos Creek	Thea Foss Enhancement Areas
Baseline Elevation Surveys Baseline elevation surveys will document as-built conditions in AutoCAD for use in subsequent monitoring and reporting. Surveys should include site bathymetry, limits of planted areas, irrigation system location (Middle Waterway Tideflat), goose exclusion grids, physical features (e.g., large wood) as appropriate. Base files should include property lines and upland or in-water features when those features are available (e.g., adjacent buildings, marina structures). This must be completed as soon as possible post-planting during Year 0, prior to establishment of vegetation sampling transects and grids.	X	X	X	X	X
Establishment of Quantitative Vegetation Transects Using the baseline elevation surveys and ground-reconnaissance once plantings have been installed, exact locations of vegetation transect end-points and grid locations will be established and field marked. This must be done prior to the initial quantitative vegetation monitoring effort in Year 1. Depending on the results of the elevation surveys, potential marsh areas for North Beach and Middle Waterway Tideflat may be redefined at this time.	X	X	X	X	
Establishment of Salinity Sampling Points Six sampling station rebar will be installed between elevation +11.5 and +12.5 feet MLLW as well as three control points within same elevation.		X			
Marking of Photo Points Photo points will be field marked prior to Year 0 Qualitative Ground Surveys and reviewed in the field by City personnel. Photo points will be located roughly according to OMMP, with flexibility allowed for appropriate placement in-situ (Figures E-1 through E-8). Photo points will be surveyed during Year 0.	X	X	X	X	X
Determination of Vegetation Sampling Locations Prior to Year 1 vegetation sampling, all vegetation sampling points along transects and/or grids will be established and marked in AutoCAD as described in Section E.3.3.7.	X	X	X	X	
Installation of Elevation Monitoring Stakes Elevation stakes will be installed at each mitigation site during mid- to late-summer. Stakes will be installed and will be surveyed during Year 0.	X	X	X	X	

Table E-6
Quantitative Vegetation Monitoring Strata and Sub-Strata by Site

Site	Strata	Sub-Strata	Sample Size
North Beach	Riparian	Shrub	25
		Ground Cover	25
	Saltmarsh	n/a	25
	Saltmarsh, pilot area	n/a	15
Middle Waterway Tideflat	Riparian	Tree	25
		Shrub	25
		Ground Cover	25
	Brackish marsh	n/a	25
Puyallup River Side Channel	Riparian	Tree	25
		Shrub	25
		Ground Cover	25
Hylebos Creek	Forested Wetland	Tree and Shrub	25
		Ground Cover	25

Table E-7
Planted Vegetation at Each Mitigation Site by Stratum and Type

Stratum and Type	Scientific Name	Common Name	North Beach	Middle Waterway Tideflat	Puyallup River Side Channel	Hylebos Creek
Riparian, Tree	*Acer macrophyllum*	Big-leaf maple		X	X	
	Alnus rubra	Red alder		X	X	
	Pinus contorta	Shore pine		X	X	
	Populus balsamifera ssp. *trichocarpa*	Black cottonwood		X	X	
	Pseudotsuga menziesii	Douglas fir		X	X	
Shrub	*Holodiscus discolor*	Oceanspray	X	X	X	
	Ribes sanguineum	Red-flowering currant		X	X	
	Salix hookeriana	Hooker's willow	X	X	X	
	Salix sitchensis	Sitka willow		X	X	
Groundcover	*Calamagrostis canadensis*	Canada reed	X	X	X	
	Deschampsia cespitosa	Tufted hairgrass	X	X	X	
	Elymus glauca	Blue wildrye	X	X	X	
	Elymus mollis	American dunegrass	X			
	Festuca rubra var. *rubra*	Red fescue	X	X	X	
	Hordeum brachyantherum	Meadow barley	X	X	X	
	Trifolium repens	White clover	X	X	X	
Wetland Hydroseed	*Beckmannia syzigachne*	American sloughgrass			X	
	Deschampsia cespitosa	Tufted hairgrass			X	
	Elymus glauca	Blue wildrye			X	
	Festuca rubra var. *rubra*	Red fescue			X	
	Glyceria occidentalis	Western mannagrass			X	
Saltmarsh	*Distichlis spicata*	Saltgrass	X			
	Salicornia virginica	Pickleweed	X			
Brackish Marsh	*Carex lyngbyei*	Lyngby sedge		X		
	Schoenoplectus maritimus (formerly *Scirpus maritimus* var. *paludosus*)	Seacoast bulrush		X		
Forested Wetland, Tree	*Alnus rubra*	Red alder				X
	Fraxinus latifolia	Oregon ash				X

Stratum and Type	Scientific Name	Common Name	North Beach	Middle Waterway Tideflat	Puyallup River Side Channel	Hylebos Creek
	Malus fusca	Western crabapple				
	Populus balsamifera ssp. *trichocarpa*	Black cottonwood				X
	Thuja plicata	Western redcedar				X
Shrub	*Acer circinatum*	Vine maple				X
	Cornus stolonifera	Red-osier dogwood				X
	Corylus cornuta	Beaked hazelnut				X
	Lonicera involucrata	Black twinberry				X
	Physocarpus capitatus	Pacific ninebark				X
	Salix hookeriana	Hooker’s willow				X
	Salix sitchensis	Sitka willow				X
Ground Cover	*Bromis marginatus*	Mountain brome				X
	Deschampsia cespitosa	Tufted hairgrass				X
	Elymus glaucus	Blue wildrye				X
	Festuca idahoensis	Idaho fescue				X
	Festuca rubra var. rubra	Red fescue				X
Emergent Wetland	*Carex obnupta*	Slough sedge				X
	Carex stipata	Sawbeak sedge				X
	Glyceria grandis	Reed mannagrass				X
	Scirpus microcarpus	Small-fruited bulrush				X
	Scirpus acutus	Hardstem bulrush				X

Table E-8
Example Table for Reporting Elevation Monitoring Results

Site	Year	Stake 1	Stake 2	Stake 3	Stake 4	Stake 5	Stake 6	Average Change from Baseline	Average Change between Years
North Beach	1								n/a
	2								n/a
	3								n/a
	5								n/a
	7								n/a
	10								n/a
	Year 10 – Year 7							n/a	
MW Tideflat	1								n/a
	2								n/a
	3								n/a
	5								n/a
	7								n/a
	10								n/a
	Year 10 – Year 7							n/a	
PRSC	1								n/a
	2								n/a
	3								n/a
	5								n/a
	7								n/a
	10								n/a
	Year 10 – Year 7							n/a	
Hylebos Creek	1								n/a
	2								n/a
	3								n/a
	5								n/a
	7								n/a
	10								n/a
	Year 10 – Year 7							n/a	

Table E-9
Quantitative Vegetation Analyses by Site

Site	Strata	Sub-Strata	Metrics
North Beach	Riparian	Shrub	TPC
		Ground Cover	TPC
		All Combined	TPC
	Saltmarsh	n/a	AWPC, PPMV, D
	Saltmarsh, pilot area	n/a	TPC
Middle Waterway Tideflat	Riparian	Tree	TPC
		Shrub	TPC
		Ground Cover	TPC
		All Combined	TPC
	Brackish marsh	n/a	AWPC, PPMV, D
PRSC	Riparian	Tree	TPC
		Shrub	TPC
		Ground Cover	TPC
		All Combined	TPC
Hylebos Creek	Forested Wetland	Tree and Shrub	PS, TPC
		Ground Cover	TPC
		All Combined	TPC

TPC – Total Percent Cover
PS – Percent Survival
AWPC – Area-Weighted Percent Cover
PPMV – Percent of Potential Marsh with Some Vegetation
D - Density

Table E-10
Example Table for Reporting Quantitative Vegetation Results

Site	Strata	Sub-Strata	Metric	Result	Performance Standard	Performance Standard Met?
North Beach	Riparian	Shrub	TPC			
		Ground Cover	TPC			
		Total	TPC			
	Saltmarsh	n/a	AWPC			
			PPMV			
			D			
	Saltmarsh, pilot area	n/a	TPC			
Middle Waterway Tideflat	Riparian	Tree	TPC			
		Shrub	TPC			
		Ground Cover	TPC			
		Total	TPC			
	Brackish marsh	n/a	AWPC			
			PPMV			
			D			
PRSC	Riparian	Tree	TPC			
		Shrub	TPC			
		Ground Cover	TPC			
		Total	TPC			
Hylebos Creek	Forested Wetland	Tree and Shrub	PS			
			TPC			
		Total	TPC			

TPC – Total Percent Cover
PS – Percent Survival
AWPC – Area-Weighted Percent Cover
PPMV – Percent of Potential Marsh with Some Vegetation
D - Density

Table E-11
Example Table for Reporting Inter-Annual Quantitative Vegetation Results

Site	Strata	Sub-Strata	Metric	Year 1	Year 2	Year 4
North Beach	Riparian	Shrub	TPC			
		Ground Cover	TPC			
		Total	TPC			
	Saltmarsh	n/a	AWPC			
			PPMV			
			D			
	Saltmarsh, pilot area	n/a	TPC			
Middle Waterway Tideflat	Riparian	Tree	TPC			
		Shrub	TPC			
		Ground Cover	TPC			
		Total	TPC			
	Brackish marsh	n/a	AWPC			
			PPMV			
			D			
PRSC	Riparian	Tree	TPC			
		Shrub	TPC			
		Ground Cover	TPC			
		Total	TPC			
Hylebos Creek	Forested Wetland	Tree and Shrub	PS			
			TPC			
		Total	TPC			

TPC – Total Percent Cover
PS – Percent Survival
AWPC – Area-Weighted Percent Cover
PPMV – Percent of Potential Marsh with Some Vegetation
D - Density

Table E-12
Example Table for Reporting Salmonid Observations
(partially filled out for example only)

Site, Date	Observation Period	Observation Time	Approx. Fish	Approx. FL Range	Species
North Beach, 5/4/2007	13:00 to 17:00	14:23	25	30-40	ND
MW Tideflat, 5/5/2007	7:00 to 11:00	7:35	60	40-60	Chum, Chinook
PRSC, 5/6/207	8:00 to 12:00				
Hylebos, 5/7/2007	9:00 to 13:00				

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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure E-1
Head of Thea Foss Shoreline Habitat

DATE: 8/9/2006 2:52:28 PM
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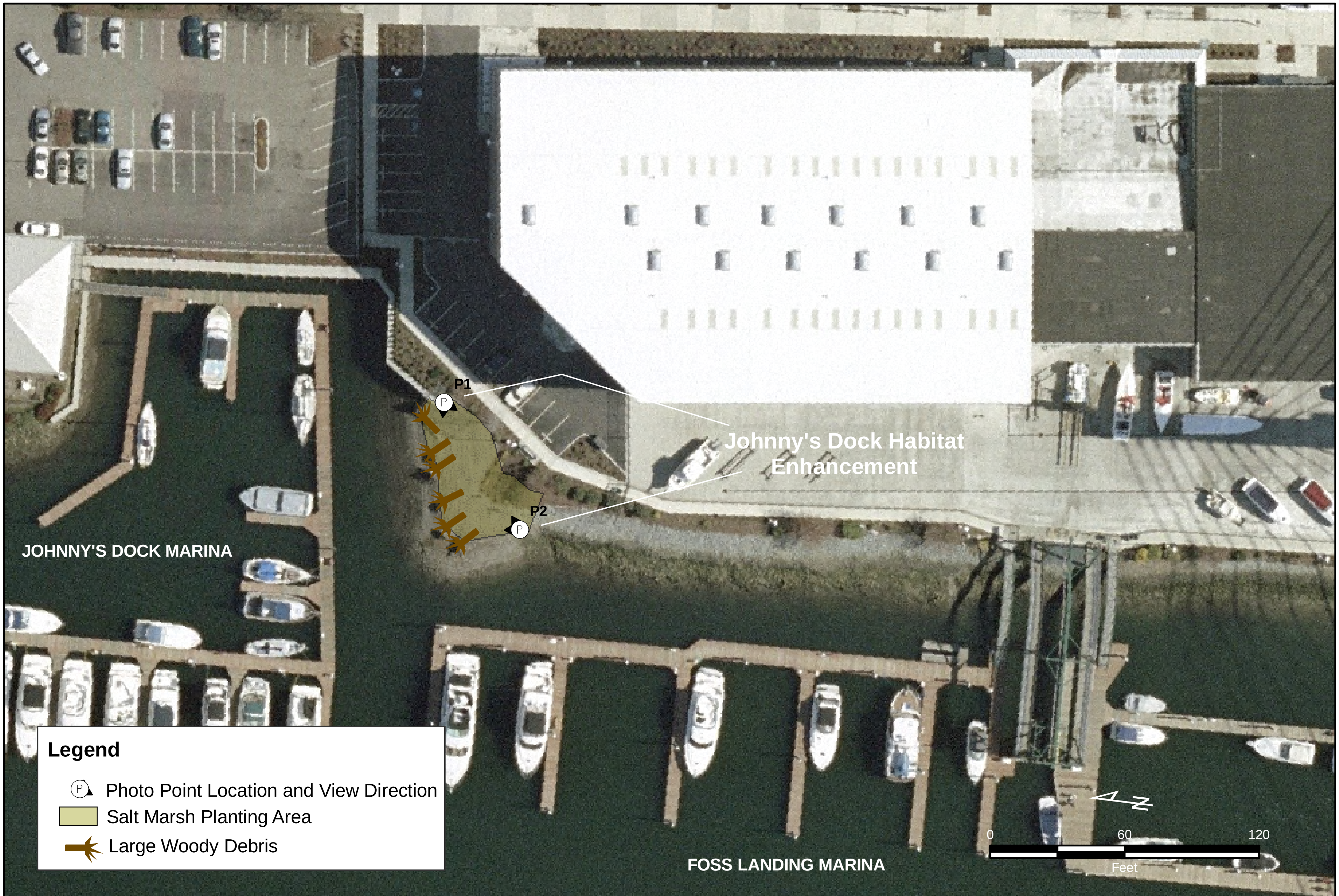

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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure E-2
Johnny's Dock Habitat Enhancement

DATE: 8/11/2006 12:49:19 PM
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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure E-3
SR 509 Esplanade Riparian Habitat

DATE: 8/9/2006 8:13:03 AM
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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure E-4
Log Step Habitat Enhancement

DATE: 8/14/2006 8:04:44 AM
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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure E-5
North Beach Habitat

DATE: 12/13/2006 3:18:17 PM
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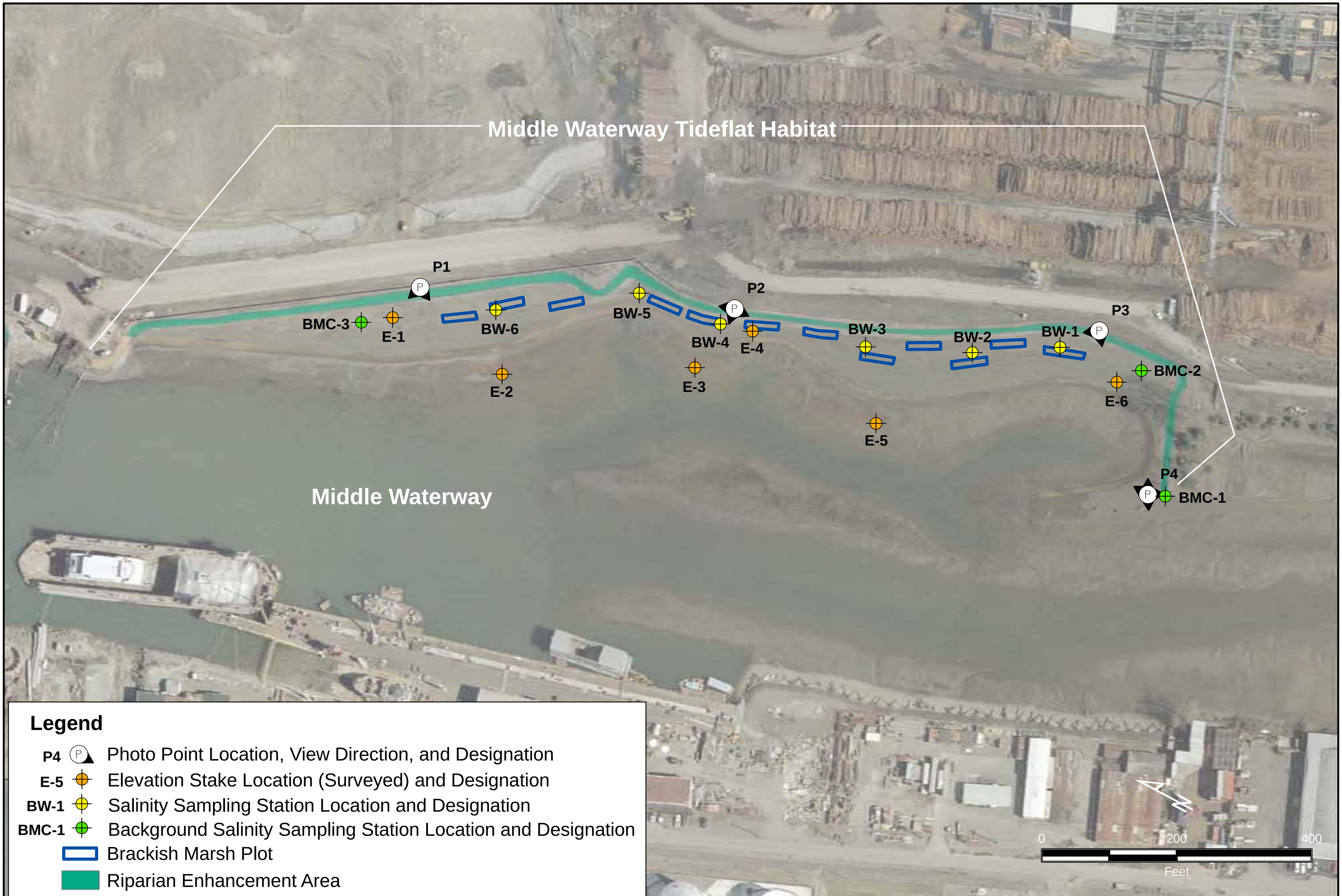

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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure E-6
Middle Waterway Tideflat Habitat

DATE: 12/13/2006 4:19:56 PM
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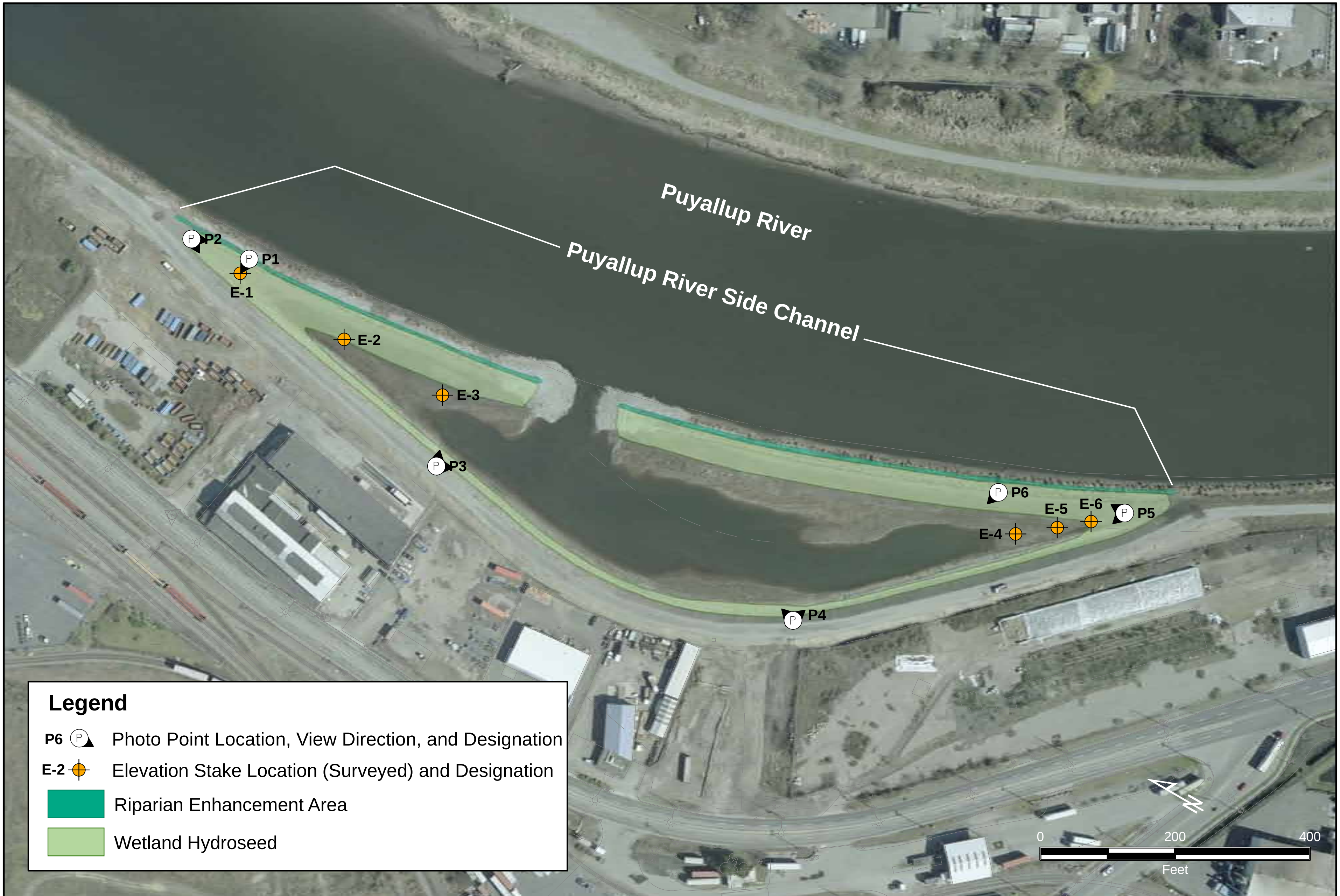

Legend

- P6 — Photo Point Location, View Direction, and Designation
- E-2 — Elevation Stake Location (Surveyed) and Designation
- Riparian Enhancement Area
- Wetland Hydroseed

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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure E-7
Puyallup River Side Channel

DATE: 12/13/2006 4:40:30 PM
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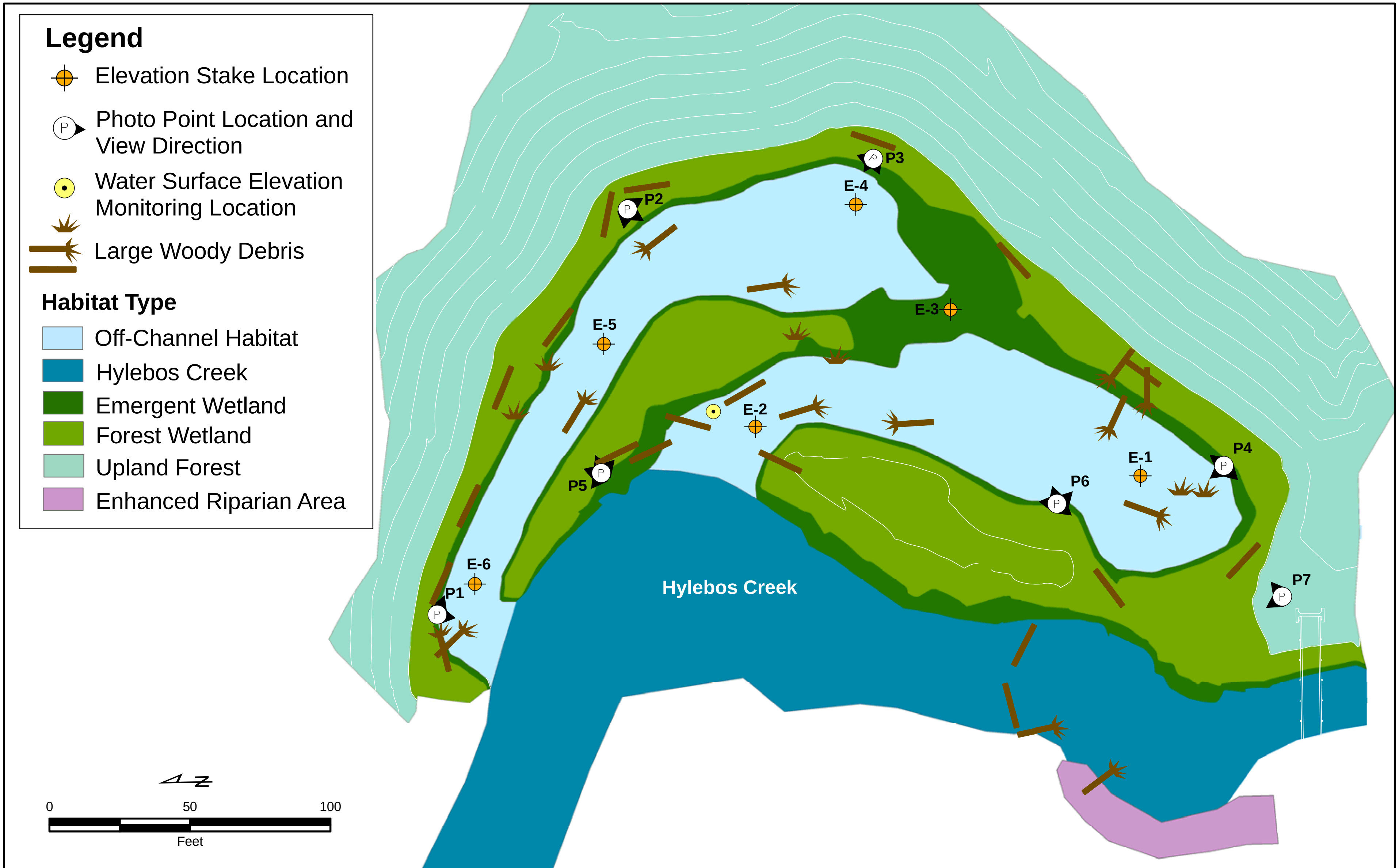

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Thea Foss and Wheeler-Osgood Waterways OMMP

Figure E-8
Hylebos Creek Mitigation Site

DATE: 12/18/2006 10:53:56 AM
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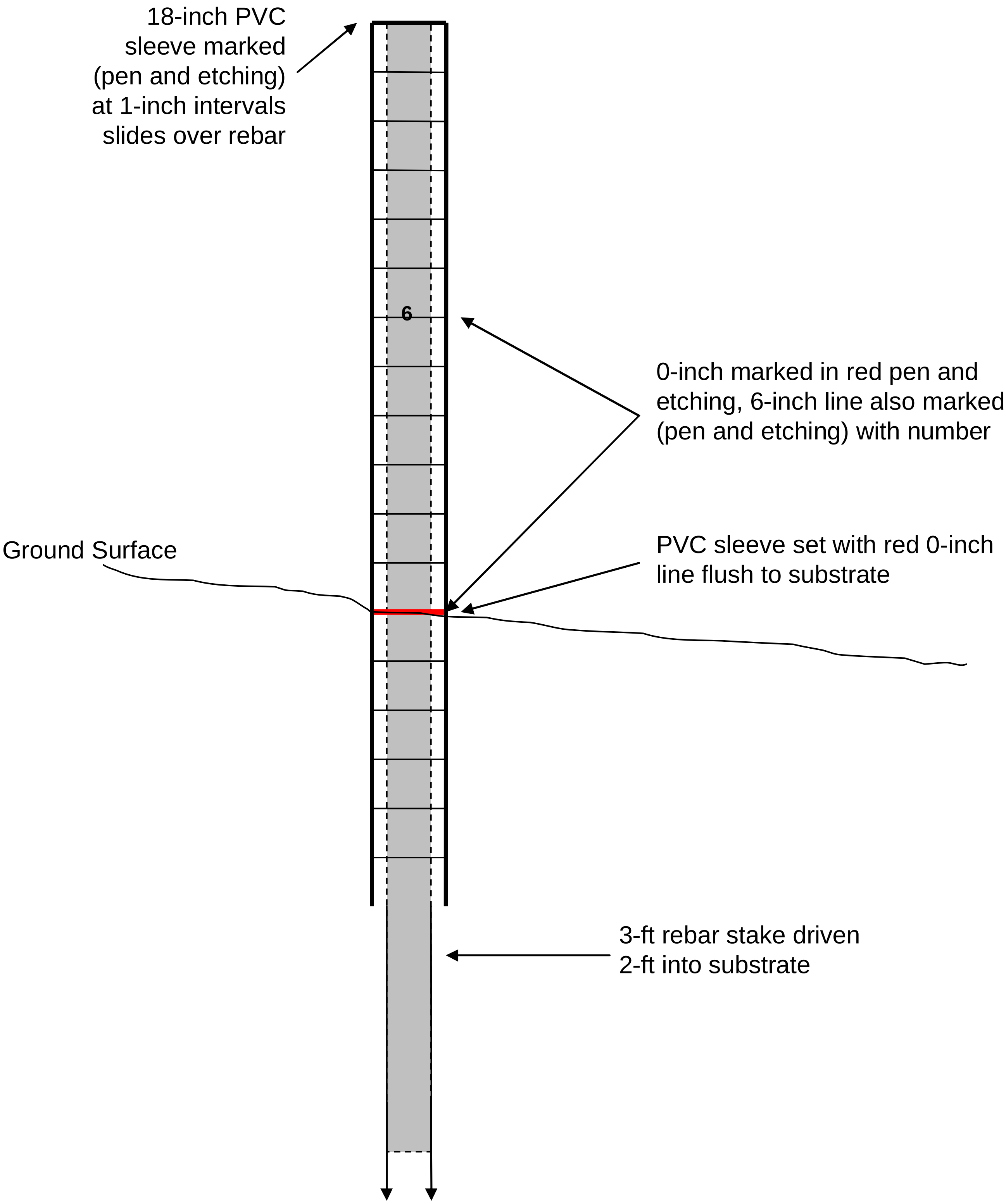

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Figure E-9
Schematic Diagram of an Elevation Monitoring Stake

F:\projects\KPFF Foss\Revised OMMP\Section 6.0 Habitat Materials and Appendix E\Appendix E Habitat Section Figures\Schematic for Elevation Monitoring Stake 080906.vsd

Attachment E-1

Quality Assurance Project Plan for Habitat Mitigation Area Monitoring

E-1.1 QUALITY ASSURANCE PROJECT PLAN

E-1.1.1 Personnel Responsible for Quality Control

Personnel	Responsibilities
EPA Project Manager	Oversee project performance to ensure compliance with Consent Decree.
City of Tacoma Project Manager	Oversee field team to ensure contract and/or manual compliance.
Field Manager	Oversee field efforts to ensure methods compliance. Implement necessary actions and adjustments to accomplish program objectives. Monitor field investigations. Coordinate data and sample tracking.

E-1.1.2 Quality Assurance Procedures

Qualitative Ground Surveys and Quantitative Vegetation Monitoring

Use of standardized field forms will ensure orderly data collection. The working copy of the original data should be reviewed by the field manager to ensure data is entered correctly. Any problems with the data forms noted at this point will be corrected directly on the working copy, with the reason, if not evident, for making any changes noted on the form. Errors will be lined out, dated and initialed.

Copies of original field forms and any referenced materials (e.g., photos) shall be archived in a central file at the City. All data also will be recorded in an electronic format approved by EPA for submission to that agency.

Corrected data should be entered into the database directly from field forms or photocopies of corrected field forms. Data files will be backed up after each step in data entry.

Photo Documentation

Use of the standardized field forms will ensure orderly data collection. Cameras should be downloaded directly into the computer and the files and renamed in a consistent site code format. File names should be reviewed by a second person to ensure no incorrect entries were made. Any problems with the data entry should be corrected at this point. Copies of all photographs shall be archived in their original media format (digital or film/print) in a central file at the City.

Elevation Monitoring

Use of standardized field forms will ensure orderly data collection. The working copy of the original data should be reviewed by the field manager to ensure data were entered in the correct location associated with each stake. After accompanying photographs are downloaded, each photograph should be reviewed to confirm an accurate reading of the stake.

Copies of original elevation field forms and photos shall be archived in a central file at the City. All data also will be recorded in an electronic format approved by EPA for submission to that agency.

Brackish Marsh Salinity Monitoring

Salinity monitoring will be performed at the Middle Waterway Tideflat Habitat only. Use of standardized laboratory forms will ensure orderly data management. The working copy of the original data should be reviewed by field personnel to ensure data were entered in the correct location. Any problems with the data forms noted at this point must be corrected directly on the working copy, with the reason, if not evident, for making any changes noted on the form. Errors will be lined out, dated and initialed.

Copies of original field forms and any referenced materials (e.g., photos) shall be archived in a central file at the City. Copies of the calibration record for the multi-meter should be stored with each year's salinity data. All data also will be recorded in an electronic format approved by EPA for submission to that agency.

Corrected data will be entered into the database directly from field forms or photocopies of corrected field forms. Data files will be backed up after each step in data entry.

E-1.1.3 Data Validation Procedures

As entered data are received, a hard copy will be produced for one hundred percent verification against the corrected copies of the field data forms. A record will be maintained of all errors identified during entry verification. For each correction, the original value, corrected value, reason for correction and the date will be recorded onto the hard copy of the data. As a precaution, a backup of the data file will be made before entering data corrections into the database.

Attachment E-2

Qualitative Ground Survey Forms

Qualitative Ground Survey, Mitigation Sites

Date: :____ Year: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Site (circle): North Beach Habitat (NBH), Middle Waterway Tideflat (MWT), Puyallup River Side Channel (PRSC), Hylebos Creek Habitat (HCH)

Staff Present:

Weather Conditions:

Overall health and vigor of plants: Excellent Fair Poor

Qualitative Observations:

	Riparian Area	Marsh Area	Comments
Erosion			
Sedimentation			
Wildlife			
Vegetation: Invasive			
Volunteer			
Survival (%)			
Animal Damage			
Disease			
Trash			
Vandalism			
Large Woody Debris			
Wrack or Organic Material			

* For the Hylebos Creek site, use "Riparian" column for forested wetland and "Marsh" column for emergent wetland. Include additional qualitative notes on high slope upland vegetation below

Wildlife Notes (Species observed, other evidence):

Insect Sampling Notes (Hylebos Creek and PRSC , Year 1 and 3 only):

Observable Insect Prey (e.g., amphipods, mycids, larvae):

Any indication of fish obstruction in the channels? ____

Soil/Sediment Quality: upland	aquatic areas
Odor:	
Sheen:	
Color:	
Texture:	

Presence/condition of habitat mix/fine-grained material at surface (North Beach – visual and probe – and PRSC – visual only):

Notes:

Photo Points (Circle Site): Year: 0, 1, 2, 4, 7, 10

North Beach	1A – W	1B – NW	2A – E	2B - N
2C – W	3A – E	3B – N	3C – NW	3D – S
4A – S	4B – SW	4C – NW	5A – S	5B – W
5C – N	5D – E	6 – W		
Middle Waterway Tideflat	1A – NW	1B – SW	2A – N	2B – W
2C – S	3A – N	3B – W	4A – S	4B – W
4C – N	4D – E			
Puyallup River Side Channel	1 – W	2A – S	2B – SW	3A – SE
3B – E	4A – NE	4B – SE	5A – N	5B – NE
6 – W				
Hylebos Creek	1A – E	1B – S	2A – SE	2B – SW
2C – W	3A – SW	3B – W	3C – NW	4A – NE
4B – N	4C – NW	5A – S	5B – W	5C – N
5D – E	6A – N	6B – NE	6C – SE	6D – S
7A – NE	7B – N			

Additional Notes/Photos:

Qualitative Ground Survey, Thea Foss Enhancement Sites

Date: :____ Year: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Site (circle): Johnny's Dock (JDH), Head of Thea Foss (HTF), SR509 Esplanade (509), Log Step Habitat (LSH)

Staff Present:

Weather Conditions:

Overall health and vigor of plants: Excellent Fair Poor

Qualitative Observations:

	Riparian Area	Marsh Area	Comments
Erosion			
Sedimentation			
Wildlife			
Vegetation			
Invasive			
Volunteer			
Survival (%)			
Animal Damage			
Disease			
Trash			
Vandalism			
Large Woody Debris			
Wrack or Organic Material			

Wildlife Notes (species observed, other evidence):

Soil/Sediment Quality: upland	aquatic areas
Odor:	
Sheen:	
Color:	
Texture:	

Notes:

Photo Points (Circle Site): Year: 0, 1, 2, 4, 7, 10

Johnny's Dock	1A – SW	1B – NW	2A – NW	2B – NE
Head of Thea Foss	1 – S	2 – N		
SR509 Esplanade	1 – S	2A – E	2B – S	3 – N
Log Step	1 – N			
Additional Photos				

Exclusion Grid Status (Johnny's Dock, Head of Thea, Log Step)

Vegetation Diversity Notes:

RIPARIAN

Planted Species

Volunteer Species

Invasive Species

MARSH

Planted Species

Volunteer Species

Invasive Species

MISCELLANEOUS ADDITIONAL NOTES:

Attachment E-3

Elevation Monitoring Forms

Elevation Monitoring

Monitoring Year: 1, 2, 3, 5, 7, 10

Date________________________________ Observer(s)____

Site (circle): North Beach, Middle Waterway, Puyallup River Side Channel, Hylebos Creek

Monitoring Point	1	2	3	4	5	6
Elevation Relative to Baseline (in)						

Notes:

Site (circle): North Beach, Middle Waterway, Puyallup River Side Channel, Hylebos Creek

Monitoring Point	1	2	3	4	5	6
Elevation Relative to Baseline (in)						

Notes:

Site (circle): North Beach, Middle Waterway, Puyallup River Side Channel, Hylebos Creek

Monitoring Point	1	2	3	4	5	6
Elevation Relative to Baseline (in)						

Notes:

Site (circle): North Beach, Middle Waterway, Puyallup River Side Channel, Hylebos Creek

Monitoring Point	1	2	3	4	5	6
Elevation Relative to Baseline (in)						

Notes:

Attachment E-4

Quantitative Vegetation Monitoring Forms

Quantitative Vegetation Monitoring, Riparian and Forested Wetland Strata

Site (circle): North Beach, Middle Waterway Tideflat, Puyallup River Side Channel, Hylebos Creek
Monitoring Year: 1, 2, 4, 7, 10
Date_________________________________ Observer(s)______________________________________

	Cover Class Midpoint				
Quadrat	**Tree**	**Shrub**	**Ground Cover**	**Total Cover***	**Notes (note if no native or naturalized non-native vegetation is present)**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

** Total cover is for all sub-strata combined, not the sum of cover for each sub-stratum.*

- Use reverse side for notes (use site map for additional spatial notes)
- If quadrats include pathways or sidewalks, or extend beyond planted areas (e.g., narrow riparian bands), the paths/sidewalks or area outside of planted area are not considered part of the sample.
- Cover class mid-point measurements are for all native or non-native naturalized vegetation; do not include invasives.
- Groundcover Vegetation Quadrats: .25 meter square
- Semi- quantitative notes to include species present and approximate cover for dominants; include invasive species in notes only, not in overall cover class for the quadrat

Daubenmire Scale for Percent Cover Measurements

Cover Class	**0 to 5**	**6 to 25**	**26 to 50**	**51 to 75**	**76 to 95**	**96 to 100**
Midpoint	2.5	15	37.5	62.5	85	97.5

Quantitative Vegetation Monitoring, Salt and Brackish Marsh

Site (circle): North Beach, Middle Waterway Tideflat
Monitoring Year: 1, 2, 4, 7, 10
Date_________________________________ Observer(s)____

Quadrat	Planted (yes, no)	Cover Class Midpoint	Notes (note if no native or naturalized non-native vegetation is present)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

- Use reverse side for notes (use site map for additional spatial notes)
- Cover class mid-point measurements are for all native or non-native naturalized vegetation; do not include invasives.
- Semi- quantitative notes to include species present and approximate cover for dominants; include invasive species in notes only, not in overall cover class for the quadrat
- Marsh Vegetation Quadrats: .25 meter square

Daubenmire Scale for Percent Cover Measurements

Cover Class	0 to 5	6 to 25	26 to 50	51 to 75	76 to 95	96 to 100
Midpoint	2.5	15	37.5	62.5	85	97.5

Quantitative Vegetation Monitoring, Marsh

Site: North Beach (pilot nodes, 5 quadrats each)
Monitoring Year: 1, 2, 4, 7, 10
Date________________________________   Observer(s)____

Quadrat	Planted (yes, no)	Cover Class Midpoint	Notes (note if no native or naturalized non-native vegetation is present)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

Additional Notes (use site map for additional spatial notes):

- Cover class mid-point measurements are for all native or non-native naturalized vegetation; do not include invasives.
- Marsh Vegetation Quadrats: .25 meter square
- Semi- quantitative notes to include species present and approximate cover for dominants; include invasive species in notes only, not in overall cover class for the quadrat

Daubenmire Scale for Percent Cover Measurements

Cover Class	0 to 5	6 to 25	26 to 50	51 to 75	76 to 95	96 to 100
Midpoint	2.5	15	37.5	62.5	85	97.5

Attachment E-5

Juvenile Salmonid Observations Form

Juvenile Salmonid Observations

Site (circle): North Beach, Middle Waterway, Puyallup River Side Channel, Hylebos Creek

Monitoring Year: 1, 3

Date________________________________ Observer(s)_____________________________________

Weather ________________________ Visibility (depth and distance from shore) ________________________

Time Observations Begin ________________ Tide ________________
Time Observations End ________________ Tide ________________

Time	Approx. School Size	Approx. FL (10 mm bins)	Depth in water column (.5 ft bins)	Species present (if discernable)	Notes (e.g., behavior, direction of movement)

Observations to be conducted over 4-hr period
General notes, including location(s) from which observations were made (use site map for additional spatial notes):

Appendix F

Health and Safety Plan

Emergency Contact Information

Site Location	Thea Foss, Wheeler-Osgood, Middle, and St. Paul Waterways, and the Puyallup River Side Channel and Hylebos Creek Mitigation Sites Tacoma, WA
Nearest Hospital	Tacoma General Hospital 315 Martin Luther King Jr. Way Tacoma, WA 98405-4234 253-403-1000 The location of the hospital is depicted in Figure F-1.
Emergency Responders	Police Department 911 Fire Department 911 Ambulance 911 U.S. Coast Guard Emergency 206-217-6000 General Information 206-220-7021 UHF Channel 16 National Response Center 800-424-8802 EPA 800-424-4372
Emergency Contacts	City of Tacoma Public Works Department Mary Henley 253-502-2113 Chris Getchell 253-502-2130
In an emergency, call for help as soon as possible	Give the following information: • Where you are (address, cross streets, or landmarks) • Phone number you are calling from • What happened – type of injury, accident • How many persons need help • What is being done for the victim(s) • You hang up last – let whomever you called hang up first

F.1 SITE HEALTH AND SAFETY PLAN SUMMARY

Site Name: Thea Foss and Wheeler-Osgood Waterways Remediation Project

Location: Tacoma, WA

Proposed Dates of Activities: 2006-2016

Type of Facility: Multiple use waterways: shipyards, lumber mill, stormwater outfalls, storage facilities, marinas, and parks.

Land Use of Area Surrounding Facility: Industrial, commercial, residential, and city parks.

Site Activities: Site inspections and collection of intertidal and subtidal sediment samples using van Veen grab samplers and vibracore. Collection of groundwater samples and hydrogeologic information.

Potential Site Contaminants: Arsenic, cadmium, copper, mercury, lead, zinc, total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), hydrogen sulfide, tributyltin (TBT), phthalates, and DDT.

Routes of Entry: Skin contact with sediment or water; and incidental ingestion of sediment or water.

Administrative and Engineering Controls: Limit number of people to those required for conducting sampling. Note, however, that EPA, Corps, Ecology, Trustee, or agency consultant personnel may be present during sampling. Their presence will not be limited as an administrative control. Stand upwind if hydrogen sulfide suspected.

Protective Measures: Safety glasses, gloves, hard hats, life vests, work boots, and protective clothing as specified in this plan.

Monitoring Equipment: Hydrogen sulfide badges or hydrogen sulfide monitor during sediment quality monitoring.

F.2 INTRODUCTION

F.2.1 Purpose and Regulatory Compliance

This site-specific Health and Safety Plan (HSP) addresses procedures to minimize the risk of chemical exposures, physical accidents to on-site workers, and environmental contamination. The HSP covers each of the 11 required plan elements as specified in 29 CFR 1910.120 or equivalent Washington State Department of Labor and Industries regulations. Table F-1 lists the sections of this plan which apply to each of these required elements. This site-specific plan meets all applicable regulatory requirements.

F.2.2 Distribution and Approval

This HSP will be made available to all field personnel and subcontractors involved in field work on this project. For subcontractors, this HSP represents minimum safety procedures and subcontractors are responsible for their own safety while present on site or conducting work for this project. Subcontractor work may involve safety and health procedures not addressed in the HSP. By signing the documentation form provided with this plan (Table F-3), project workers also certify their approval and agreement to comply with the plan.

F.2.3 Chain of Command

The chain of command for health and safety on this project involves the following individuals:

Project Manager and Project H&S Manager - Mary Henley. The Project Manager has overall responsibility for the successful outcome of the project. The Project Manager may delegate this authority and responsibility to the Field H&S (Health & Safety) Manager. The Project H&S Manager has overall responsibility for health and safety on this project. This individual ensures that everyone working on this project understands this HSP.

Field H&S Manager – Christopher L. Getchell. The Field H&S Manager is responsible for implementing the HSP in the field. This individual also observes subcontractors to verify that they are following these procedures, at a minimum. The Field H&S Manger will also assure that proper protective equipment is available and used in the correct manner, decontamination activities are carried out properly, and that employees have knowledge of the local emergency medical system should it be necessary.

F.2.4 Site Work Activities

The following work tasks will be accomplished:

- Collection of sediment samples by van Veen grab sampler, and potentially by coring;
- Habitat assessment;
- Groundwater level data collection (tidal study);
- Sampling groundwater monitoring wells;
- Decontamination of equipment; and
- Bathymetric survey and surveying of sampling locations.

These field site activities are described below.

F.2.5 Site Description

The Thea Foss, Wheeler-Osgood, Middle, and St. Paul Waterways are multi-purpose waterways located in the Port of Tacoma, adjacent to Commencement Bay. Properties operating along the waterway include shipyards, lumber mill, fuel terminals, marinas, residential buildings, parking lots, city parks, former foundries, and boatyards. The Puyallup River Side Channel is located along the Puyallup River adjacent to industrial and vacant land parcels. The

Hylebos Creek Mitigation Site is located on Hylebos Creek within a residential area and adjacent to unimproved properties and additional habitat enhancement areas.

F.3 HAZARD EVALUATION AND CONTROL MEASURES

This section discusses the toxicity of chemicals of concern, potential exposure routes, symptoms of heat stress and hypothermia, and other physical hazards. Table F-2 – Activity Hazard Analysis lists the potential hazards associated with each site activity and the recommended site control to be used to minimize each potential hazard.

F.3.1 Toxicity of Chemicals of Concern

Based on previous site information and knowledge of the types of activities conducted at this location, the following chemicals may be present at this site: arsenic, cadmium, copper, mercury, lead, and zinc, heavy metals, PAHs, PCBs, hydrogen sulfide and phthalates. Human health hazards of these chemicals are discussed below. This information covers potential toxic effects which might occur if relatively significant acute and/or chronic exposure were to happen. This information does not mean that such effects will occur from the planned site activities. In general, the chemicals which may be encountered at this site are not expected to be present at concentrations which could produce significant exposures. The types of planned work activities and use of monitoring procedures and protective measures will limit potential exposures at this site.

These standards are presented using the following abbreviations:

PEL Permissible exposure limit.

C Ceiling limit.

TWA Time-weighted average exposure limit for any 8-hour work shift.

STEL Short-term exposure limit expressed as a 15-minute time-weighted average and not to be exceeded at any time during a work day.

Arsenic (As) - Arsenic is toxic by inhalation and ingestion of dusts and fumes or by inhalation of arsine gas. Trivalent arsenic compounds are the most toxic to humans, with significant corrosive effects on the skin, eyes, and mucous membranes. Dermatitis also frequently occurs, and skin sensitization and contact dermatitis may result from arsenic trioxide or pentoxide. Trivalent arsenic interacts with a number of sulfhydryl proteins and enzymes, altering their normal biological function. Ingestion of arsenic can result in fever, anorexia, cardiac abnormalities, and neurological damage. Liver injury can accompany chronic exposure. Skin and inhalation exposure to arsenic has been associated with cancer in humans, particularly among workers in the arsenical-pesticide industry or copper smelters. The U.S. EPA currently classifies arsenic as a Class A, or confirmed, human carcinogen. Arsine is a highly toxic gaseous arsenical, causing nausea, vomiting, and hemolysis. The current State of Washington PEL-TWA for organic arsenic is 0.2 mg/m^3 and inorganic arsenic is 0.01 mg/m^3.

Cadmium (Cd) - Cadmium is toxic via inhalation or ingestion of fumes or dust. Fumes are contacted normally during exposure to heated metals (plating operations, welding, etc.). Acute effects resulting from such exposures include respiratory distress and irritation which may culminate in chronic emphysema. Chronic exposure to fumes or dust may also result in emphysema and kidney damage. These effects may be potentiated by smoking. Cadmium is considered to be a probable human carcinogen, and is currently classified as a Class B1, or probable, human carcinogen via the inhalation route. The current state PEL-TWA for all cadmium compounds is 0.005 mg/m^3.

Copper (Cu) - Copper exposure can occur via inhalation of dust or fume, ingestion, or skin and eye contact. Copper salts can act as skin irritants, causing itching and dermatitis. Eye contact can result in severe damage, including corneal damage. Contact with metallic copper can result in skin thickening, but is not associated with dermatitis in industrial settings. Fumes and dusts can irritate the respiratory tract and result in metal fume fever in severe exposures. Ingestion can result in irritation, but industrial exposure seldom results in damage because copper salts normally induce vomiting. Extensive exposure can damage the lungs, kidneys, skin, and liver. The current state PEL-TWA for copper as dust and mists is 1.0 mg/m^3, while the PEL for copper as fume is 0.1 mg/m^3.

Mercury (Hg) - The health effects of mercury exposure are dependent on the chemical form of mercury involved. Elemental mercury is toxic by inhalation, skin absorption, eye, and skin contact. Symptoms of exposure include coughing, chest pains, headache, fatigue, salivation, weight loss, and skin and eye irritation. The primary target organ of elemental mercury is the central nervous system, resulting in damage to sensory systems. The state PEL-TWA for exposure to mercury vapor is 0.05 mg/m^3.

Inorganic mercury compounds are toxic by inhalation, ingestion, and skin and eye contact. Acute poisoning results in lung damage. Chronic poisoning typically produces four classical symptoms: gingivitis, salivation, increased irritability, and muscular tremors. Delirium and other psychological abnormalities can also result from chronic exposures. Inorganic mercurials also have a corrosive effect on the alimentary tract, and kidney damage can result from exposure. The current State PEL-C limit for inorganic mercury is 0.1 mg/m^3.

Organomercury compounds include the methyl mercuries and aryl mercuries, many of which are used as herbicides or pesticides. Methyl mercury is toxic by inhalation, resulting in central nervous system damage manifested in tremors and sensory disturbances. Infants exposed to high methyl mercury before birth can exhibit severe central nervous system damage. The current state PEL-TWA for organo-alkyl compounds as Hg is 0.01 mg/m^3 with a STEL of 0.03 mg/m^3, and the PEL-C for aryl mercury compounds as Hg is 0.1 mg/m^3.

Lead (Pb) - Inorganic lead exposure can occur via inhalation of dusts or metal fumes, ingestion of dusts, and skin and eye contact. The principal target organs of lead toxicity include the nervous system, kidneys, blood, gastrointestinal tract, and reproductive systems. Generalized symptoms of lead exposure include decreased physical fitness, fatigue, sleep disturbances, headaches, bone and muscle pain, constipation, abdominal pain, and decreased appetite. More severe exposure can result in anemia, severe gastrointestinal disturbance, a “lead-line” on the gums, neurological symptoms, convulsions, and death.

Neurological effects are among the most severe of inorganic lead's toxic effects and vary depending on the age of individual exposed. Effects observed in adults occur primarily in the peripheral nervous system, resulting in nerve destruction and degeneration. Wrist-drop and foot-drop are two characteristic manifestations of this toxicity.

The U.S. EPA also currently lists inorganic lead as a Group B2 probable human carcinogen via the oral route. This conclusion is based on feeding studies conducted in laboratory animals. The current state PEL-TWA for inorganic lead is 0.05 mg/m^3. Occupational exposure to lead is also specifically regulated under WAC 296-62-07521, with an action level established at 0.03 mg/m^3 that triggers air monitoring and other requirements.

Zinc (Zn) - Zinc compounds can be hazardous by inhalation of dust and fumes, ingestion, and skin and eye contact. Zinc chloride is corrosive to skin and mucous membranes, and sensitization can occur resulting in dermatitis. Eye contact can produce inflammation and corneal ulceration. Ingestion can result in corrosive damage to the digestive tract. The current State PEL-TWA for exposure to zinc chloride fume is 1 mg/m^3. Zinc chromate exhibits potential carcinogenic effects and is currently limited with a State PEL-TWA of 0.05 mg/m^3. Zinc oxide is toxic via inhalation of fumes and dusts and may cause dermatitis. The current PEL-TWA for zinc oxide is 10 mg/m^3 as total dust and 5 mg/m^3 as the respirable fraction.

Total Petroleum Hydrocarbon (TPH) - TPH is a generic term based on analytical test procedures for the range of hydrocarbon materials from gasoline through heavier fuel oils. These materials typically consist of n-paraffins, isoparaffins, naphthenes, and aromatics in the boiling point range from approximately 50 to 250°C. Based on materials such as gasoline and fuel oils, TPH can be expected to typically act as a central nervous system depressant, resulting in slurred speech and mental confusion. Higher doses can result in unconsciousness and possibly death from respiratory failure. Skin contact can result in irritation, dermatitis, and defatting. Liver and kidney damage can also result following acute or chronic exposure. No PEL has been established for TPH. For comparison, the state PEL-TWA for gasoline is 300 ppm, with 500 ppm as a 15-minute STEL.

Polycyclic Aromatic Hydrocarbons (PAHs) - Exposure to PAHs can occur via inhalation of vapors, ingestion, and skin and eye contact. Skin contact can result in reddening or corrosion. Ingestion can cause nausea, vomiting, blood pressure fall, abdominal pain, convulsions, and coma. Damage to the central nervous system can also occur. The U.S. Department of Health and Human Services (1989) has classified 15 PAHs compounds as having sufficient evidence for carcinogenicity, while the U.S. EPA (1990) has classified at least five of the identified PAHs as human carcinogens. There are no currently assigned PEL-TWA for PAHs, but the closely related material coal tar is listed as coal tar pitch volatiles with a State PEL-TWA of 0.2 mg/m^3.

Polychlorinated Biphenyls (PCBs) - PCBs is a generic term for a range of polychlorinated biphenyl compounds used commercially in heat transfer media and in the chemical/coatings industry. PCBs have been marketed commercially under the trade names Askarel® and Aroclor®, with a designation referring to the percent weight of chlorine. Prolonged skin contact with PCBs may cause acne-like symptoms, known as chloracne. Irritation to eyes, nose and throat may also occur. Acute and chronic exposure can cause liver damage, and symptoms of edema, jaundice, anorexia, nausea, abdominal pains, and fatigue. If pregnant women accidentally ingest PCBs, stillbirth or infant skin and eye problems may occur. PCBs are a suspect carcinogen. The U.S. EPA currently classifies PCBs as a Class B2, or probable, human carcinogen. The state PEL-TWA for PCBs with 54 percent chlorine content is 0.5 mg/m^3, while the PEL-TWA for PCBs with 42 percent chlorine is 1 mg/m^3. Skin exposure may contribute significantly to uptake of these chemicals, and therefore all skin exposure should be strictly avoided.

Hydrogen Sulfide - Hydrogen sulfide is a gas which is toxic via inhalation, ingestion, and skin and eye contact. Inhalation can result in respiratory irritation, rhinitis, and edema of the lungs. Eye irritation results from exposure to hydrogen sulfide, and symptoms include photophobia and lacrimation. Subacute exposures to hydrogen sulfide may result in headache, dizziness, staggering gate, and agitation. Tremors, weakness, nausea, and diarrhea may also occur, but recovery is usually complete from such exposures. Acute exposure at higher concentrations may result in immediate coma, and death can follow rapidly as a consequence of respiratory failure. The mode of toxic action involved in this reaction is believed to be inhibition of the respiratory enzyme cytochrome oxidase, which effectively disrupts the process of respiration. The current state PEL-TWA for hydrogen sulfide is 10 ppm, with an STEL of 15 ppm.

Tributyltin (TBT) - Tributyltin (TBT, organotin) is a man-made chemical used in marine antifouling paints and occurs in a solid or liquid state. In pure form (DOT guidelines) organotins are poisonous and may be fatal if inhaled, swallowed, or absorbed through skin. Contact to the pure material may cause burns to the skin and eyes. Generalized symptoms of exposure are skin and eye irritation. The toxicity of organotin compounds is the result of their lipid solubility allowing penetration into the brain and central nervous system.

For sediment sampling, however, possible contact with TBT will be diluted. According to the U.S. Food and Drug Administration (USFDA), the symptoms of acute tin toxicity from ingestion to humans are “nausea, abdominal cramping, diarrhea, and vomiting.” These symptoms have often followed consumption of canned fruit juices and salmon containing 650 to 1,400 ppm tin. Because of low intestinal absorption of tin (a breakdown product of organotins), the acute toxic symptoms are probably caused primarily by local irritation of the gastrointestinal tract. The current state PEL-TWA for organotin compounds, as tin, is 0.1 mg/m^3 (skin contact).

Phthalates - Phthalates are a common additive to plastic products to make the material softer or more flexible. Phthalates are found in a wide variety of plastic products, including polyvinyl chloride products, building materials, food containers, medical equipment, adhesives, inks, pesticides, and cosmetics. Phthalates may affect the body if inhaled or ingested. In exposures to very large quantities, some phthalates have been shown to cause liver damage in lab animals and have been rated as potential human carcinogens. Human exposure to low levels of phthalates has not been found to cause serious health effects. The state PEL-TWA for diethyl phthalate is 5 mg/m^3.

DDT - DDT (dichlorodiphenyltrichloroethane, or 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane) is a chlorinated insecticide which was widely used in the United States until banned by the EPA in 1972. This action was motivated primarily by evidence demonstrating DDT's widespread distribution and persistence in the environment, its strong tendency to bioaccumulate in mammalian adipose tissue, and by a series of ecological studies which suggested reduced reproductive success among certain wild bird species when exposed to DDT and its metabolites. The principal mode of insecticidal action for DDT is believed to involve disruption of the normal sodium and potassium ion currents in motor and sensory nerves, such that repetitive and uncontrolled firing occurs. DDT can be toxic to humans by inhalation, ingestion, and eye and dermal contact, although DDT is reported to be poorly absorbed through the skin. Symptoms of DDT poisoning include tingling of the mouth and facial area, apprehension, irritability, dizziness, tremor, and convulsions. Symptoms may occur several hours after exposure. DDT exposure can also result in liver injury. The chemical metabolites of DDT designated as DDE (dichlorodiphenylethylene dichloride) and DDD (dichlorodiphenyldichloroethane), also share some of its toxic properties and tendency toward bioaccumulation. The EPA currently classifies DDT, DDD, and DDE as Class B2, or probable, human carcinogens. The current state PEL-TWA for DDT is 1.0 mg/m^3.

F.3.2 Potential Exposure Routes

Inhalation. Exposure via this route could occur if volatile chemicals were present and became airborne during site activities, especially upon exposure to open air, warm temperatures and sunlight. However, this is not likely to occur.

Skin Contact. Exposure via this route could occur if contaminated sediment or water contacts the skin or clothing. Protective clothing and decontamination activities specified in this plan will minimize the potential for skin contact with the contaminants.

Ingestion. Exposure via this route could occur if individuals eat, drink or perform other hand-to-mouth water contact in the contaminated (exclusion) zones. Decontamination procedures established in this plan will minimize the inadvertent ingestion of contaminants.

F.3.3 Air Monitoring

Badges specific to hydrogen sulfide will be worn daily by sediment sampling personnel or a direct-read hydrogen sulfide monitor will be used. If measurements indicate exposure to above 10 ppm over an 8-hour period, or over 15 ppm over any 15-minute period, subject work will cease pending re-evaluation of the exposure potential and development of additional engineering, administrative, and/or respiratory protection measures.

If the presence of hydrogen sulfide is detected by olfactory senses, the hydrogen sulfide badges or monitor will be monitored closely. If hydrogen sulfide odor is noted but badges or monitors do not indicate hazardous levels, engineering controls such as standing upwind or letting the odor dissipate before sample processing will be utilized as necessary. If the badges or monitors indicate hazardous levels, stop work and leave the area immediately. All results will be recorded in the field notes, at the end of each day. Badges are to be changed daily during sediment sampling or the hydrogen sulfide monitor is to be calibrated at the beginning and end of each day on site.

F.3.4 Heat and Cold Stress

Heat Stress. Use of impermeable clothing reduces the cooling ability of the body to evaporation reduction. This may lead to heat stress. If such conditions occur during site activities, appropriate work-rest cycles will be maintained and drink water or electrolyte-rich (Gatorade® or equivalent) to minimize heat stress effects. If ambient temperatures exceed 85° F, monitoring of employee pulse rates may be conducted at the discretion of the field H&S manager.

Each employee will check his or her own pulse rate at the beginning of each break period. Take the pulse at the wrist for 6 seconds and multiply by 10. If the pulse rate exceeds 110 beats per minute, then reduce the length of the next work period by one third.

Example: After a one-hour work period at 85 degrees, a worker has a pulse rate of 120 beats per minute. The worker must therefore shorten the next work period by one third, resulting in a work period of 40 minutes until the next break.

Hypothermia. Hypothermia can result from abnormal cooling of the core body temperature. It is caused by exposure to a cold environment and wind-chill as well as wetness or water immersion can play a significant role. The following section discusses signs and symptoms as well as treatment for hypothermia. However, these conditions are not anticipated for these sampling activities.

Signs of Hypothermia. Typical warning signs of hypothermia include fatigue, weakness, lack of coordination, apathy and drowsiness. A confused state is a key symptom of hypothermia. Shivering and pallor are usually absent and the face may appear puffy and pink. Body temperatures below 90° F require immediate treatment to restore temperature to normal.

Treatment of Hypothermia. Current medical practice recommends slow rewarming as treatment for hypothermia, followed by professional medical care. This can be accomplished by moving the person into a sheltered area and wrapping with blankets in a warm room. In emergency situations where body temperature falls below 90° F and heated shelter is not available, use a sleeping bag, blankets and/or body heat from another individual to help restore normal body temperature.

F.3.5 Other Physical Hazards

Trips/Falls. As with all field work sites, caution will be exercised to prevent slips on rain slick or uneven surfaces, stepping on sharp objects, etc. Work will not be performed on elevated platforms without fall protections.

As with any offshore work, there is a possibility of falling overboard. When possible, personnel will stand well in from the edges of the deck. Personal flotation devices will be worn at all times when on the vessel. At least one person trained in First Aid and CPR will be on site at all times.

Sampling Vessel Machinery/Moving Parts. The sampling vessel will be equipped with various winches, motors, booms and other machines. These present a general physical hazard from moving parts.

Personnel will stand clear of machinery at all times unless specific instructions are given by the vessel skipper or other person in authority. Safety toe rubber boots will be worn at all times when on the vessel and hardhats will be worn when overhead hazards are present. When possible, appropriate guards will be in place during equipment use.

Traffic. Groundwater sampling and the tidal study activities will be completed in areas of potentially heavy traffic on and around the St. Paul Waterway CDF. Personnel will wear a ANSI approved, class 2 vest and use traffic cones around the immediate work area, and will be alert to potential traffic hazards (e.g., blind corners).

Confined Spaces. Confined space entry is not anticipated for this project.

Noise. Noise is not anticipated as a problem on this project.

F.3.6 Sediment Sampling

All sediment sampling activities conducted from barges and boats will be conducted using basic principles of water safety.

- Use Coast Guard-approved life jackets for all off-shore activities;
- Avoid leaning over the edge of boat. If work must be conducted over edge, secure workers with lifeline;
- Avoid sampling on stormy days or when seas are high;
- Use caution when transferring from land to sea. Make sure barges and boats are firmly secured to dock or pier before boarding or disembarking; and
- Wear hard hats and appropriate personal protective equipment in exclusion areas.

F.3.7 Groundwater Sampling

All groundwater sampling activities will be conducted under the assumption that the media is contaminated and appropriate personal protective equipment (Modified Level D) will be required.

F.4 PROTECTIVE EQUIPMENT

Work for this project will be conducted in Level D and modified Level D. Levels A, B and C are not anticipated for this project. Administrative controls (standing upwind or ceasing work) will be used if excessive levels of hydrogen sulfide are encountered.

F.4.1 Level D Activities

Workers performing site activities where skin contact with highly contaminated materials is possible but not expected will wear regular work clothes, eye protection, hard hats, optional inner gloves and required nitrile outer gloves (whenever handling samples), and chemical-resistant safety boots and/or chemical-resistant boot covers. Off-shore activities require use of a Coast Guard-approved life jacket. Also, use rain suits on windy, rainy days to prevent hypothermia. Also, polyethylene-coated or uncoated tyvek will be worn in exclusion areas when contaminated sediments are present.

Workers performing site activities in the designated support zone (i.e., wheelhouse) where skin contact with contaminated materials is unlikely will wear regular work clothes, safety boots and hard hat. Life jackets will be worn if workers are on board the vessel. Hard hats must be worn when overhead hazards exist.

F.4.2 Modified Level D Activities

Workers performing site activities where skin contact with free product or heavily contaminated materials is possible will wear chemical-resistant gloves (nitrile, neoprene or other appropriate outer gloves, nitrile inner gloves) and Tyvek® or other chemical-resistant suites (i.e., polycoated if high splash potential to contaminate liquids) or rain gear. Make sure the protective clothing and gloves are suitable for the types of chemicals which may be encountered on site. Use face shields or goggles as necessary to avoid splashes in the eyes or face.

A summary of Modified Level D protection includes the following:

- Hard hats, if overhead hazard exists;
- Rain gear or uncoated Tyvek®;
- Eye protection (as necessary);
- Safety toe, chemical resistant boots;
- Nitrile inner gloves (optional); and
- Nitrile, neoprene or equivalent outer gloves.

F.5 SAFETY EQUIPMENT LIST

The following Safety Equipment must be available on site:

- First aid kit;
- Eye wash kit;
- Mobile telephone;
- Safety-toe and/or chemical-resistant safety boots;
- Chemical-resistant inner and nitrile outer gloves;
- Safety glasses;
- Life jackets (off-shore);
- Hard hat (when overhead hazards are present); and
- Fire extinguishers.

F.6 WORK ZONES

If migration of chemicals from the work is a possibility, or as otherwise required by regulations or specifications, site control will be maintained by establishing clearly identified work zones. These will include the exclusion zone, contaminant reduction zone and support zone, as discussed below and shown on Figure F-2. Figure F-2 shows the deck layout plan for a typical sampling boat.

F.6.1 Exclusion Zone

Exclusion zones will be established around each hazardous waste activity location. Only persons with appropriate training and authorization from the Field H&S Manager will enter this perimeter while work is being conducted there. Barrier tapes and warning signs will be used as necessary to establish the zone boundary. Warning signs will be posted in plain view of approach. On boats or barges such areas will be designated around contaminated sample handling locations.

F.6.2 Contamination Reduction Zone

A contamination reduction zone will be established just outside each temporary exclusion zone to decontaminate equipment and personnel as discussed below. This zone will be clearly delineated from the exclusion zone and support zone using the means noted above. Care will be taken to prevent the spread of contamination from this area. Separate buckets will be filled with spent decontamination fluids on a daily basis. The buckets, after labeling, will be moved to central storage location(s) pending disposal decisions.

F.6.3 Support Zone

A support zone will be established outside the contamination reduction area to stage clean equipment, don protective clothing, take rest breaks, etc. This zone will be clearly delineated from the contaminant reduction zone using the means noted above.

F.7 MINIMIZATION OF CONTAMINATION

To make the work zone procedure function effectively, the amount of equipment and number of personnel allowed in contaminated areas must be minimized. In addition, the amounts of sediment collected should not exceed what is needed for laboratory analysis and record samples. Do not perform any practice that increases the probability of hand-to-mouth transfer of contaminated materials. Use plastic drop cloths and equipment covers where appropriate. Eating, drinking, chewing gum, smoking or using smokeless tobacco are forbidden in the exclusion zone.

F.8 DECONTAMINATION

Decontamination is necessary to limit the migration of contaminants from the work zone(s) on the vessel into the surrounding environment. Figure F-3 presents a layout for conducting decontamination within the site zones previously discussed.

Equipment and personnel decontamination are discussed in the following sections and the following types of equipment will be available to perform these activities:

- Boot and glove wash bucket and rinse bucket;
- Scrub brushes - long handled;
- Spray rinse applicator;
- Plastic garbage bags; and
- Alkaline decontamination solution.

Detergent-bearing liquid wastes from decontamination of personnel protection will be stored in 5 gallon containers for later disposal to sanitary sewer drains.

F.8.1 Equipment Decontamination

Proper decon procedures will be employed to ensure that contaminated materials do not contact individuals and are not spread from the site. These procedures will also ensure that contaminated materials generated during site operations and during decontamination are managed appropriately.

All non-disposable equipment will be decontaminated in the contamination reduction zone.

F.8.2 Personnel Decontamination

Personnel working in exclusion zones will perform the appropriate decontamination in the contamination reduction zone prior to taking rest breaks, drinking liquids, etc. They will also decontaminate fully before eating lunch or leaving the site. The following describes the procedures for full decon activities:

1. In the contamination reduction zone, wash and rinse outer gloves and boots in portable buckets.
2. Remove outer gloves and protective suit and deposit in labeled container for disposable clothing.
3. Remove work boots without touching exposed surfaces, and put on street shoes. Put boots in individual plastic bag for later reuse.
4. Remove work boots without touching exposed surfaces, and put on street shoes. Put boots in individual plastic bag for later reuse.
5. Immediately wash hands and face using clean water and soap.
6. Shower as soon after work shift as possible.

F.9 DISPOSAL OF CONTAMINATED MATERIALS

All disposable sampling equipment and personal protective equipment (PPE) will be placed inside of a 10 mil polyethylene bag or other appropriate containers. Disposable supplies will be removed from the site and disposed of accordingly.

Decontamination liquids generated during site decon procedures will be collected and stored in 5 gallon carboys for future disposal into sanitary sewer drains or other appropriate method.

F.10 SITE SECURITY AND CONTROL

Site security and control will be the responsibility of the Field H&S Manager. Significant security problems are not anticipated when sampling is conducted on the marine vessel. Land based operations will be conducted on the shorelines of the waterways, on private properties, and at the end of a dead end street, and public access/security are not likely to be an issue of concern. If security issues are identified during the sampling period, notify the Project Manager and a response plan will be developed.

F.11 SPILL PLAN

Sources of bulk chemicals subject to spillage are not expected to be encountered in this project. Accordingly, a spill containment plan is not required for this project.

F.12 EMERGENCY RESPONSE PLAN

The Emergency Response Plan outlines the steps necessary for appropriate response to emergency situations. The following paragraphs summarize the key Emergency Response Plan procedures for this project. City of Tacoma personnel and subcontractors will be responsible for identifying an emergency situation, notifying the appropriate personnel or agency, evacuating the hazardous area, and attempting to control only very small hazards that could present an emergency situation. Personnel will not be responsible for handling the emergency.

F.12.1 Plan Content and Review

The principal hazards addressed by the Emergency Response Plan include the following: fire or explosion, medical emergencies, uncontrolled contaminant release, and situations such as the presence of chemicals above exposure guidelines or inadequate protective equipment for the hazards present. However, in order to help anticipate potential emergency situations, field personnel shall always exercise caution and look for signs of potentially hazardous situations, including the following as examples:

- Visible or odorous chemical contaminants;
- Drums or other containers;
- General physical hazards (i.e., traffic, moving equipment, sharp or hot surfaces, slippery or uneven surfaces, etc.);
- Live electrical wires or equipment; and
- Underwater cables.

These and other potential problems should be anticipated and steps taken to avert problems before they occur.

The Emergency Response Plan shall be reviewed and rehearsed, as necessary, during the on-site health and safety briefing. This ensures that all personnel will know what their duties shall be if an actual emergency occurs.

F.12.2 Plan Implementation

The Field H&S Manager shall act as the lead individual in the event of an emergency situation and evaluate the situation. He/she will determine the need to implement the emergency procedures, in concert with other resource personnel including City of Tacoma and contractor personnel and the Project Manager. Other on-site field personnel will assist the manager as required during the emergency.

In the event that the Emergency Response Plan is implemented, the Field H&S Manager or designee is responsible for alerting all personnel at the affected area by use of a signal device (such as a hand-held air horn) or visual or shouted instructions, as appropriate.

Emergency evacuation routes and safe assembly areas shall be identified and discussed in the on-site health and safety briefing, as appropriate. The buddy-system will be employed during evacuation to ensure safe escape, and the Field H&S Manager shall be responsible for roll-call to account for all personnel.

F.12.3 Emergency Response Contacts

Site personnel must know whom to notify in the event of Emergency Response Plan implementation. The following information will be readily available at the site in a location known to all workers.

- Emergency Telephone Numbers: see list at the beginning of this plan;
- Route to Nearest Hospital: see list and route map at the beginning of this plan;
- Site Descriptions: see the description at the beginning of this plan; and
- If a significant environmental release of contaminants occurs, the federal, state, and local agencies noted in this plan must be notified within 24 hours. Contact the Project Manager as soon as possible and he/she will be responsible for notifying agencies listed on page F-1. If the release to the environment includes navigable waters also notify the National Response Center.

In the event of an emergency situation requiring implementation of the Emergency Response Plan (fire or explosion, serious injury, tank leak or other material spill, presence of chemicals above exposure guidelines, inadequate personnel protection equipment for the hazards present, etc.), cease all work immediately. Offer whatever assistance is required, but do not enter work areas without proper protective equipment. Workers not needed for immediate assistance will decontaminate per normal procedures (if possible) and leave the work area, pending approval by the Field H&S Manager for re-start of work. The following general emergency response safety procedures should be followed.

F.12.4 Fires

City of Tacoma personnel will attempt to control only <u>very small, incipient stage</u> fires and only if trained to do so. If a large fire occurs or an explosion appears likely, evacuate the area (i.e., leave the vessel) immediately. If a fire occurs which cannot be controlled with a 10-pound ABC fire extinguisher, then immediate intervention by the local fire department or other appropriate agency is imperative. Use the following steps for evacuation:

- If time allows, contact local fire department or U.S. Coast Guard (phone numbers listed on page F-1) for immediate intervention and rescue;
- Jump into the water with life jackets and floatation devices and swim away from vessel;
- Perform head-count to ensure that all project personnel have evacuated safely; and
- Inform Project Manager of the situation.

F.12.5 Medical Emergencies

Contact the agency listed in the site-specific plan if a medical emergency occurs. If a worker needs to leave the site to seek medical attention, the vessel will return to shore and another worker will accompany the patient to the hospital. When in doubt about the severity of an accident or exposure, always seek medical attention as a conservative approach. Notify the Project Manager of the outcome of the medical evaluation as soon as possible. For minor cuts and bruises, an on-board first aid kit will be available.

- If a worker is seriously injured or becomes ill or unconscious, immediately request assistance from the emergency contact sources noted on page F-1.
- In the event that a seriously injured person is also heavily contaminated, use clean plastic sheeting to prevent contamination of the inside of the emergency vehicle. Less severely injured individuals may also have their protective clothing carefully removed or cut off before transport to the hospital. If it is deemed appropriate to transport the victim to the hospital, follow the route map on Figure F-1.
- The City of Tacoma Fire Station located below the 11th Street bridge on the east side of the Thea Foss Waterway is designated as a landfall for the sampling vessel to meet emergency vehicles (see Figure F-1).

F.12.6 Plan Documentation and Review

The Field H&S Manager will notify the Project Manager as soon as possible after the emergency situation has been stabilized. The Project Manager will notify the appropriate regulatory agencies, if applicable. If an individual is injured, the Field H&S Manager or designee will file a detailed Accident Report within 24 hours.

The Project Manager and the Field H&S Manager will critique the emergency response action following the event. The results of the critique will be used in follow-up training exercises to improve the Emergency Response Plan.

F.13 TRAINING REQUIREMENTS

City of Tacoma employees, subcontractors, EPA personnel, and EPA contractor personnel who perform site work must understand potential health and safety hazards and if potentially exposed to hazardous substances, health hazards, or safety hazards will have completed at least 24 hours of off-site initial hazardous materials health and safety training or will possess equivalent training by past experience. (Note that 40-hour training is required for workers spending 30 days or more per year on hazardous waste sites or for those required to wear respiratory protection.) They will also have a minimum of three days of actual field experience under the direct supervision of a trained supervisor. All employees will have in their possession evidence of completing this training. Employees will also complete annual refresher, supervisor, and other training as required by applicable regulations.

Mary Henley, the designated Site Health and Safety Manager, has completed 24-hour initial health and safety, 8-hour refresher, current first-aid, and CPR training courses.

Prior to the start of each work day, the Field H&S Manager or designee will review applicable health and safety issues with all employees and subcontractors working on the site, as appropriate. These briefings will also review the work to be accomplished, with an opportunity for questions to be asked.

F.14 REPORTING, REPORTS, AND DOCUMENTATION

The Field Health and Safety report (Figure F-4) will be completed weekly by the Field H&S Manager or designated individual. In the event that accidents or injuries occur during site work, the Project Manager will be informed. City of Tacoma staff and subcontractors on this site will sign the Record of H&S Communication document (Table F-3), which will be kept on site during work activities and recorded in the project files.

F.15 MEDICAL SURVEILLANCE

All City personnel are given a pre-employment medical exam. Additional medical surveillance will be performed as necessary. In particular, if there is an exposure above the permissible exposure limit, then additional medical monitoring will be instituted in conformance with the policies of the City of Tacoma.

TABLES

FIGURES

Table F-1
Required Health and Safety Plan Elements

Required Plan Element	Section
Confined Space entry	F.3.5 Other Physical Hazards
Decontamination	F.8 Decontamination
Emergency response plan	F.12 Emergency Response Plan
Medical surveillance	F.15 Medical Surveillance
Names of key personnel	F.2.3 Chain of Command
Personal protective equipment	F.4 Protective Equipment and F.5 Safety Equipment List
Safety and hazard analysis	F.3 Hazard Evaluation and Control Measures
Site Control	F.6 Exclusion Areas and F.10 Site Security
Spill Containment	F.11 Spill Containment
Training	F.13 Training Requirements

Table F-2
Activity Hazard Analysis

Activity	Hazard	Control
Surveying sampling locations	Slipping on wet or oily surfaces.	Wear appropriate slip-resistant boots.
	Skin or clothing contamination from surficial contamination.	Avoid touching or stepping on surfaces with visibly contaminated soils, puddles or stains. Appropriate PPE will be worn. Follow heat stress precautions in Section F.3.4.
	Tripping on uneven surfaces.	Walk carefully and don't take chances.
Decontamination of equipment	Inhalation or eye contact with airborne mists or vapors.	Wear safety glasses and respirators if necessary.
	Skin contact with contaminated liquids.	Wear modified Level D personal protections (PPE). Tape openings in garment. Follow heat stress precautions in Section F.3.4.
	Accidental ingestion of contaminants.	Decontaminate clothing and skin prior to eating, drinking, smoking or other hand to mouth contacts.
Sediment sampling from vessels	Skin contact with contaminated sediments.	Wear disposal protective clothing (tyvek), eye protection (as necessary) and chemical-resistant gloves.
	Falling off boat.	Wear Coast Guard-approved life jackets when boat is away from shore. Have at least two people aboard boat at all times when sampling.
	Stormy weather.	Do not launch boat in adverse weather conditions. Check weather forecasts to avoid being caught in a storm or squall.
Operating vessel and location control equipment (from cabin area)	None anticipated.	Wear Level D PPE and monitor sampling activities for signs of potential hazards.
Sampling handling, packaging and processing	Skin contact with contaminated sediments.	Wear modified Level D PPE.
Sediment sampling by hand along banks	Skin contact with contaminated sediments.	Wear modified Level D PPE, or at minimum chemical-resistant safety boots, and nitrile inner gloves.
	Tripping or falling over equipment or uneven surfaces.	Walk carefully, don't take chances, organize and store equipment properly.

Table F-3
Record of Health and Safety Communication

PROJECT NAME: Thea Foss Waterway

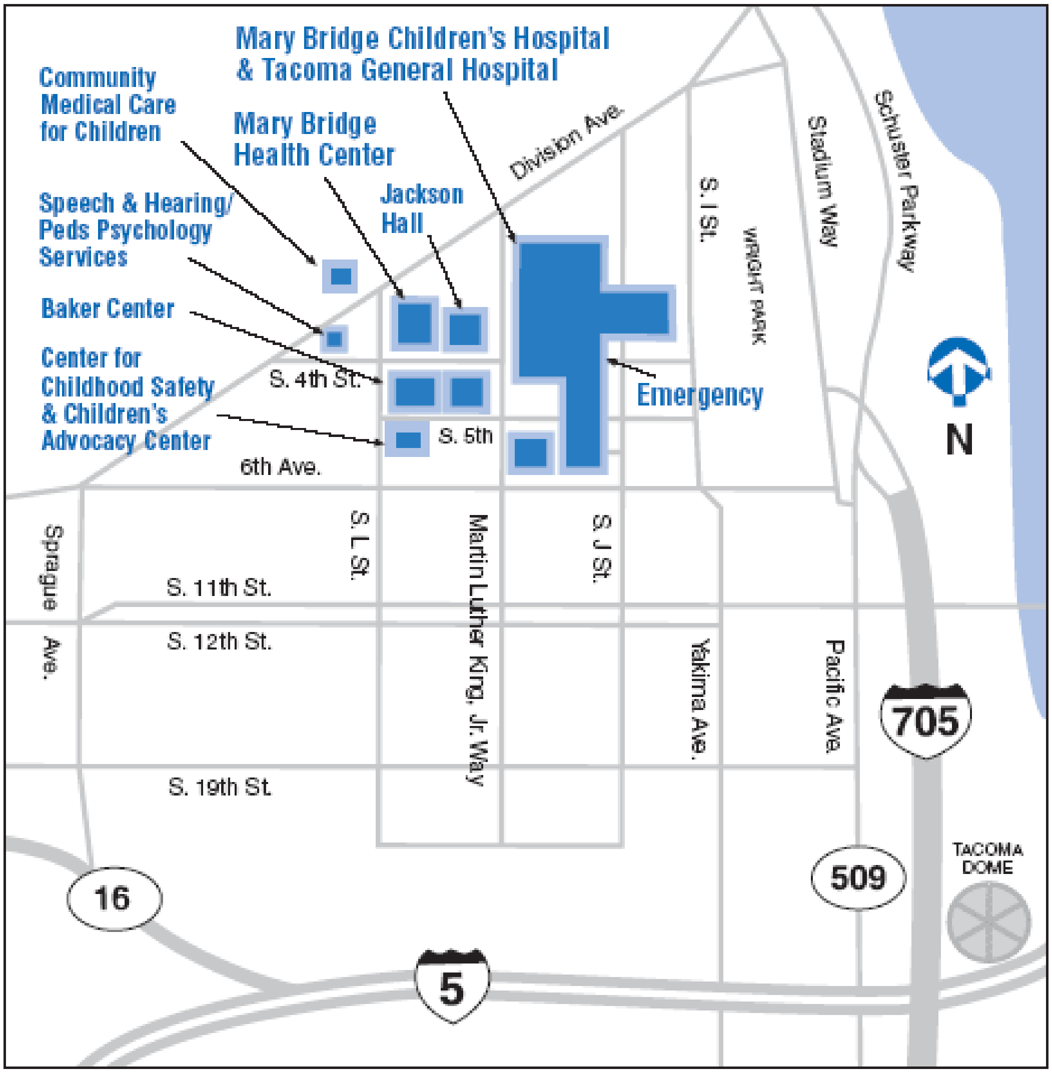
PPE REQUIREMENTS (check all that apply):

_X_ Safety glasses	**_X_ Gloves (specify)**	Nitrile
_X_ Safety boots	**_X_ Clothing (specify)**	Tyvek/Raingear
_X_ Hard hat	**___ Respirator (specify)**	
	___ Other (specify)	

The following personnel have reviewed a copy of the Site-specific Health and Safety Plan. By signing below, these personnel indicate that they have read the plan, including all referenced information, and that they understand the requirements which are detailed for this project.

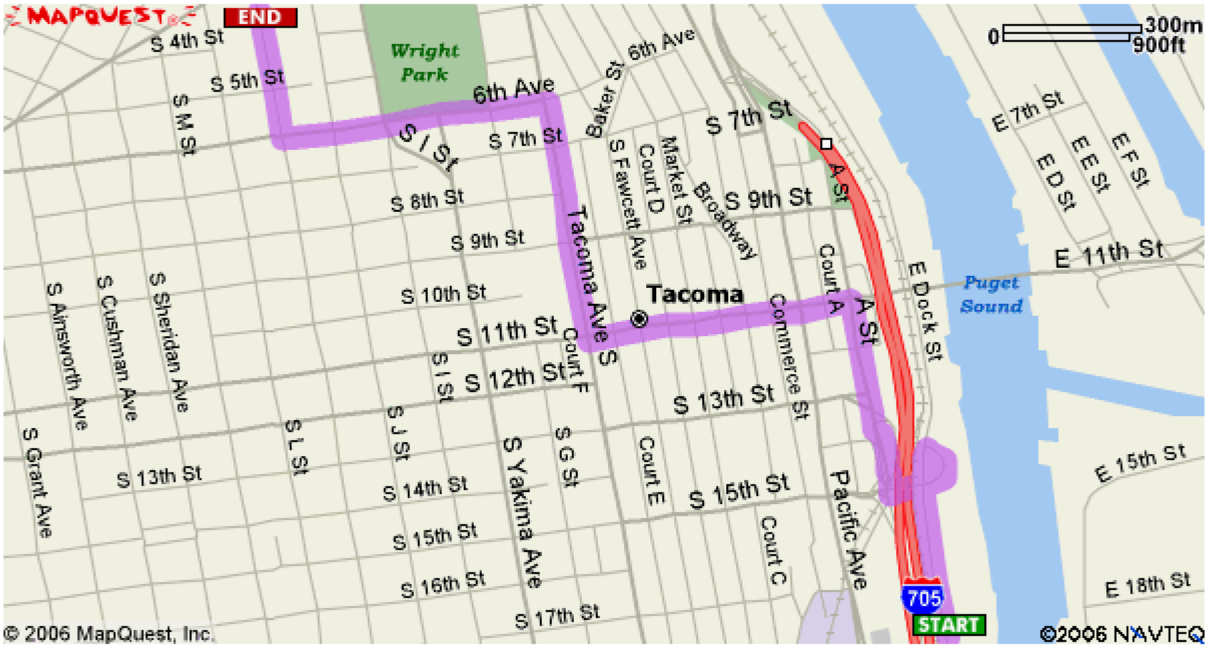
PRINTED NAME	SIGNATURE	PROJECT DUTIES	DATE

Figure F-1
Hospital Location and Directions



From I-5, take the City Center exit onto I-705. Follow directions to Schuster Parkway, exiting on Stadium Way. Turn right onto Stadium Way. Follow approximately 1/2 mile, turning left onto Division Avenue. Continue on Division for five blocks. Turn left on Martin Luther King Jr. Way.

West Side of Thea Foss Waterway
(i.e., Dock Street Marina - 1817 Dock Street)



Go north on E. Dock St. toward S. 15th St. Turn right onto S. 15th St. Turn right onto A St. Turn left onto S. 11th St. Turn right onto Tacoma Ave. S. Turn left onto 6th Ave. Turn right onto Martin Luther King Jr. Way.

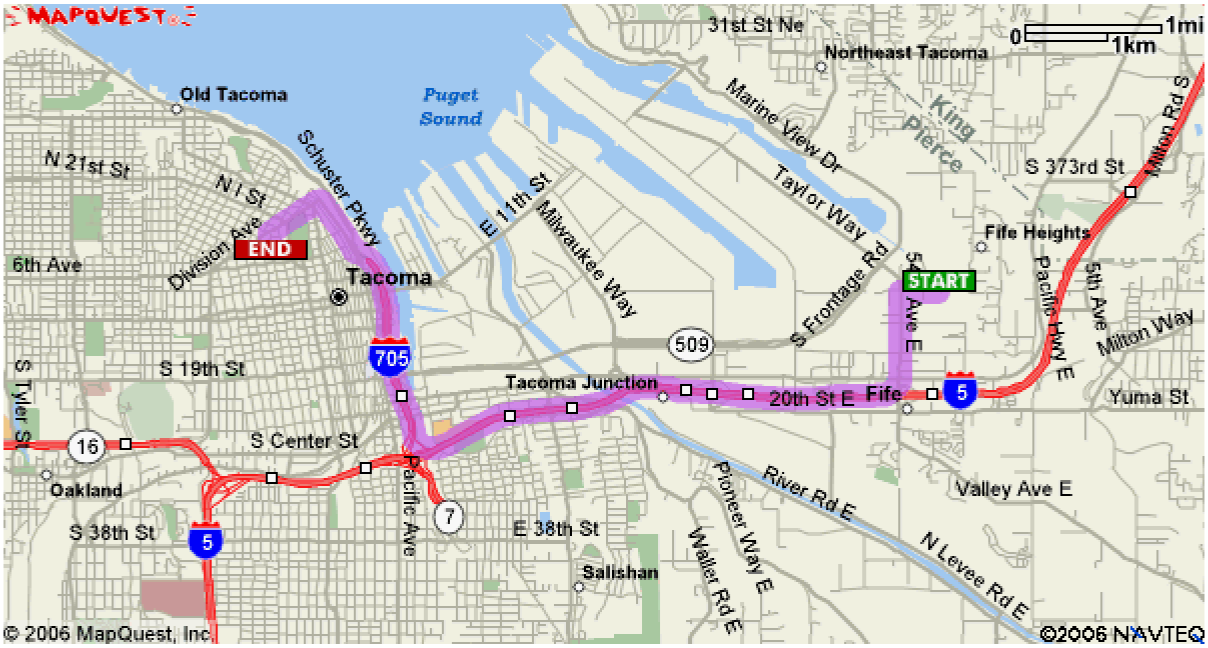
East Side of Thea Foss Waterway
(i.e., Fire Station 18 – 302 E. 11th Street)

Start out going east on E. 11th St. toward E. D St. Make a u-turn at E F St. onto E 11th St. Turn right onto Tacoma Ave. S. Turn left onto 6th Ave. Turn right onto Martin Luther King Jr. Way.

St. Paul / Middle Waterways and Simpson Tacoma Kraft Vicinity
(i.e., Simpson Tacoma Kraft – 917 E. 11th Street)

Start out going west on E. 11th St. Turn right onto Tacoma Ave. S. Turn left onto 6th Ave. Turn right onto Martin Luther King Jr. Way.

Hylebos Creek Mitigation Site
(adjacent to 5904 4th St. East, Fife)



Start out going west on 4th St. E. toward 58th Ave. E. Turn left onto 54th Ave. E. Merge onto I-5 South toward Tacoma. Merge onto I-705 North via Exit 133 toward City Center. Take the Stadium Way exit on the left. Turn right onto Stadium Way S. Turn left onto Division Ave. Turn left onto Martin Luther King Jr. Way.

Figure F-2
Sampling Boat Layout

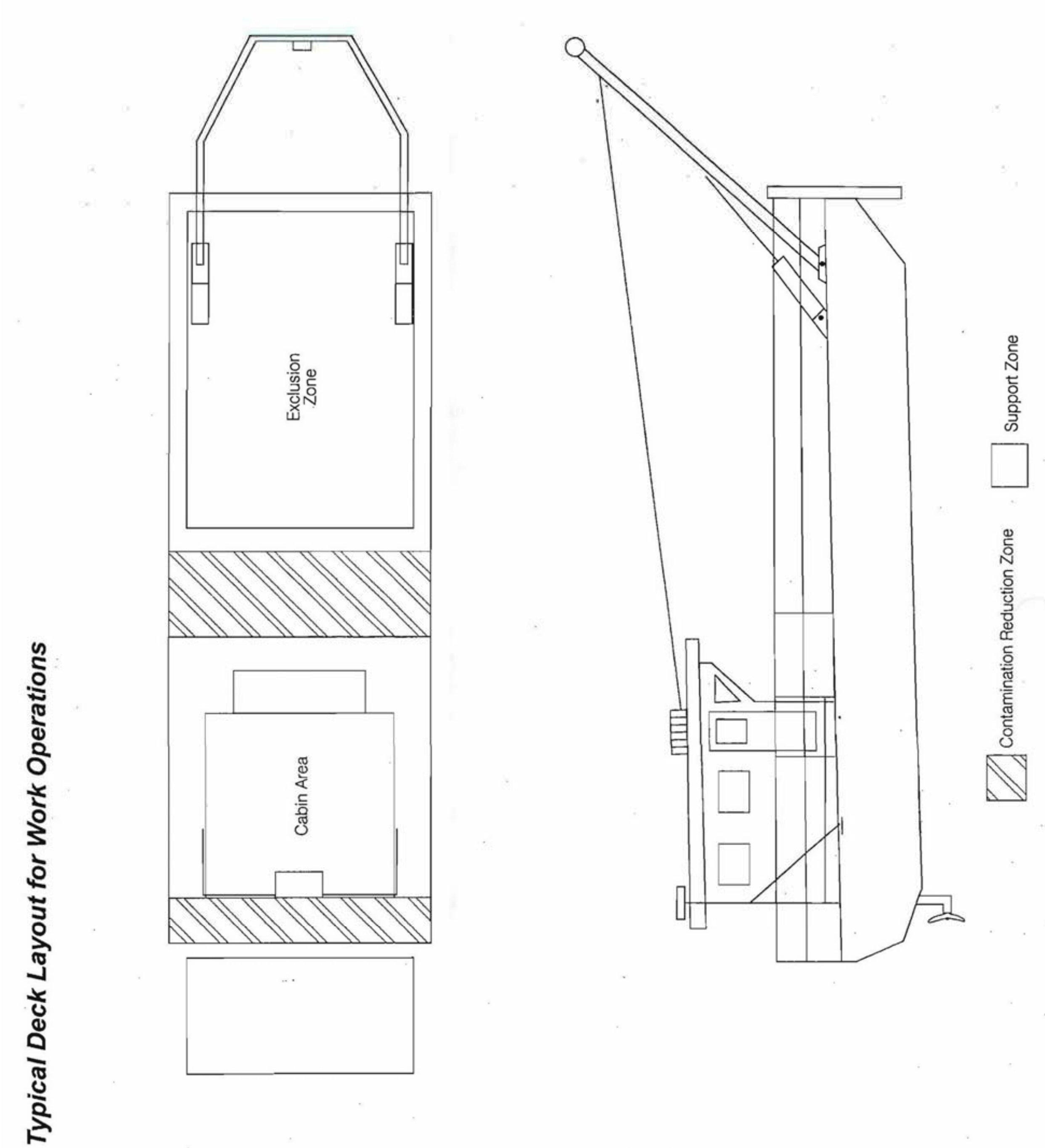


Figure F-3
Decontamination Layout

EXCLUSION ZONE

"HOT LINE"

	1	**Wash and Rinse Gloves and Boots**
	2	**Remove and Dispose Disposable Clothing (except inner gloves, if worn)**
Clean and Rinse	3	**Remove Respirator (if worn)**
Plastic Bag for Transport	4	**Remove Boots**
	5	**Remove Inner Gloves (if worn)**

CONTAMINATION CONTROL LINE

SUPPORT ZONE

Figure F-4
Health and Safety Report

Job No.___________________

Date______________________

S M T W Th F S

Arrival Time:_______________

Departure Time:____________

Job____

Location____

Client____

Field Representative___________________________Project Manager________________________

Field H&S Manager____________________________Project H&S Manager____________________

Names of personnel on site____

Site Activities____

Potential Hazards____

Hazard Control Used____

Protective Measures Taken_______________________________________

Comments or Observations_______________________________________

Sketch position of equipment relative to exploration

Indicate monitoring point(s) and prevailing wind direction

Exploration No.____________

Air Monitoring Log

Meter Number 1, Type____________Calibrated________________Checked_________________

Meter Number 2, Type____________Calibrated________________Checked_________________

Background Reading: Meter 1________________________Meter 2________________________

Time	Meter 1	Meter 2	Comments

Appendix G

Institutional Controls Plan

THEA FOSS AND WHEELER-OSGOOD WATERWAYS REMEDIATION PROJECT

INSTITUTIONAL CONTROLS PLAN

SEPTEMBER 2006





Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY

Prepared by:

CITY OF TACOMA

CITY OF TACOMA INSTITUTIONAL CONTROLS PLAN FOR THE THEA FOSS AND WHEELER-OSGOOD WATERWAYS REMEDIATION PROJECT

TABLE OF CONTENTS

EXHIBITS

CITY OF TACOMA INSTITUTIONAL CONTROLS PLAN FOR THE THEA FOSS AND WHEELER-OSGOOD WATERWAYS REMEDIATION PROJECT

I. INTRODUCTION

The City of Tacoma ("City") has completed remedial actions within the Thea Foss and Wheeler-Osgood Waterways ("Waterways"), beginning at the mouth of the Thea Foss Waterway to a point just north of the State Route 509 "cable stay" bridge, known as Waterway Station 70+10.[1] This Institutional Controls Plan ("Plan") is submitted in accordance with Section IX of the City's Consent Decree with the United States which was entered by the federal District Court for the Western District of Washington on May 9, 2003, under the case title *United States v. Atlantic Richfield Company, et al*., Civil Action No. CO3-5117 RJB ("Consent Decree"). The Consent Decree was negotiated and entered pursuant to the Comprehensive Environmental Response, Compensation and Liability Act ("CERCLA"), 42 U.S.C. §9601 et seq.

At the direction of the Environmental Protection Agency ("EPA"), the City has coordinated the development of this Plan with Puget Sound Energy, Advance Ross Sub Company, and PacifiCorp (hereinafter "the Utilities"). The Utilities completed remedial actions at the head of the Waterway south of Waterway Station 70+10 under a separate consent decree with the United States. The City also coordinated the development of this Plan with the Washington State Department of Natural Resources ("DNR"), which is responsible for managing state-owned aquatic lands within the Thea Foss Waterway under Revised Code of Washington, Title 79. DNR executed a separate consent decree with the United States to resolve its liability for sediment contamination in the Thea Foss Waterway.

In accordance with Section IX of the Consent Decree, the objective of this Plan is to ensure that contamination capped in the Waterways and in the Confined Aquatic Disposal Facility within the St. Paul Waterway, and contamination which is otherwise left in place in the Waterways remains contained and/or undisturbed for the purpose of:

[1] The area of the Thea Foss and Wheeler-Osgood Waterways where the City completed its sediment cleanup work under its Consent Decree with the United States is further delineated by separate "sub" work areas known as Remedial Action Areas 1 – 22. The Utilities completed sediment cleanup actions south of Waterway Station 70+10, in Remedial Areas 23 and 24.

i) reducing the potential exposure of marine organisms to contaminated sediments disposed of and confined in aquatic disposal sites or confined by capping; and

ii) reducing the potential exposure of marine organisms to contaminated sediments left in place in the Thea Foss and Wheeler-Osgood Waterways.

EPA has defined institutional controls as "non-engineered instruments, such as administrative and/or legal controls, that help minimize the potential for human exposure to contamination and/or protect the remedy by limiting land and/or resource use (e.g., easement, fish advisory, local permit)."[2]

The effectiveness of the City's Plan is dependent upon a variety of controls. Taken together, these controls will help to ensure both the short and long-term protection of human health and the environment at the Waterways cleanup site, ("Site"). These controls include easements and restrictive covenants, building, shoreline and wetland permits, federal, state and local permits and public outreach tools, among others. The elements of the City's Plan are discussed below.

II. ELEMENTS OF THE CITY'S PLAN

A. Protection Through Site Use Restrictions

Among other things, the effectiveness of the City's Plan is dependent upon having adjacent property owners along the Waterways and others refrain from activities that may interfere with or adversely affect the implementation, integrity, or protectiveness of the remedial measures and/or habitat improvements constructed pursuant to the Consent Decree. This group falls into seven categories: (1) parties who signed the Consent Decree as funding parties, (i.e., "Settling Defendants"); (2) parties that did not sign the Consent Decree, (i.e., "non-settling parties"); (3) Washington State Department of Transportation; (4) DNR; (5) Simpson Tacoma Land Company, Simpson Tacoma Kraft Company and Simpson Timber Company, (collectively "Simpson"); (6) owners of properties on which all or a portion of a habitat improvement was constructed; and (7) the general public who use and enjoy the Waterways.

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[2] See, *Institutional Controls: A Citizen's Guide to Understanding Institutional Controls at Superfund, Brownfields, Federal Facilities, Underground Storage Tank, and Resource Conservation and Recovery Act Cleanups*, OSWER 9355.0-98, EPA – 540-R-04-003, February 2005, at page 7.

A.1. Settling Defendants

The vast majority of properties with sediment caps located in or around the remedial action area are owned or controlled by parties who have signed the Consent Decree with the EPA and have therefore agreed under the Consent Decree to refrain from using their property in any manner that would interfere with or adversely affect the integrity or protectiveness of the remedial measures undertaken on such property. These parties are termed "Owner Settling Defendants" under the Consent Decree, and are identified in Appendix F to the Consent Decree. Exhibit A to this Plan shows the location of properties adjacent to the Thea Foss and Wheeler-Osgood Waterways owned by settling parties. Section IX, Paragraph 25.b of the Consent Decree requires that all Settling Defendants shall:

> "…refrain from using the Site, or such other property, in any manner that would interfere with or adversely affect the integrity or protectiveness of the remedial measures to be implemented pursuant to this Consent Decree or the Utilities Consent Decree …."

(See, Section IX, Paragraph 26.b of the Advance Ross Sub Company, PacifiCorp, and Puget Sound Energy Consent Decree for companion language.) This requirement is binding upon the Settling Defendants and their heirs, successors and assigns.

Pursuant to Section IX, Paragraph 25.c, EPA will request Owner Settling Defendants to execute and record in the Auditor's Office of Pierce County, State of Washington, a restrictive covenant authorized by the Model Toxics Control Act ("MTCA") at Chapter 70.105D RCW, and that complies with the form and content contained in WAC 173-340-440(9) for implementation of institutional controls that are required to ensure continued protection of human health and the environment or the integrity of the remedial actions and habitat mitigation work performed under the Consent Decree. (See, Section IX, Paragraph 27.c of the Utilities Consent Decree for companion language.) An example of the proposed model restrictive covenant which EPA will request Owner Settling Defendants to execute and record is attached as Exhibit B. The restrictive covenant will "run with the land" and become binding upon subsequent property owners. To assure the restrictive covenants executed and recorded by Owner Settling Defendants "run with the land", they must (1) comply with RCW 64.04.010; (2) "touch and concern the land"; (3) express an intent for the restrictive covenant to run with the land and bind future owners; and (4) be recorded with the Pierce County Auditor's Office. Restrictive covenants which are executed and recorded will burden only that portion of the property directly adjacent to the remedial action or habitat area where the remedial action work could potentially be disturbed, and will not affect the entire parcel. Each restrictive covenant will include a legal description of the entire parcel, along with a map showing geographically the area of the parcel that is burdened by the restrictive covenant. The City will produce a map of its cleanup area within the Waterway area and propose uplands boundaries which will delineate where restrictive covenants should apply.

The City will coordinate with EPA in its effort to assure that restrictive covenants are executed and recorded by Owner Settling Defendants by providing information, when requested, to such defendants regarding the nature and scope of remedial actions and habitat mitigation work undertaken on their property; and by providing them maps depicting the location of remedial actions and habitat mitigation on their property for attachment to the restrictive covenant they execute and record.

A.2. Non-Settling Parties

As shown in Exhibit A, the only non-settling parties that the City is aware of that currently own property adjacent to the Waterways within the City's work area where contamination was either capped or left in place on a portion of the property are the Foss Waterway Development Authority and Foss Landing LLC.

A.2.1. <u>Foss Waterway Development Authority</u>

At EPA's request, and in accordance with Section IX, Paragraph 28.c, of the Consent Decree, the City will use best efforts to ensure that the FWDA execute and record in the County Auditor's Office of Pierce County a restrictive covenant on any portion of property it owns along the Waterways where remedial actions or habitat mitigation work has been completed by the City under its Consent Decree. Property currently owned by the FWDA along the Waterways where remedial actions and/or habitat mitigation work has been completed is described in Exhibit A.

A.2.2. <u>Foss Landing LLC</u>

At EPA's request, and in accordance with Section IX, Paragraph 28.c, of the Consent Decree, the City will use best efforts to ensure that Foss Landing execute and record in the County

Auditor's Office of Pierce County a restrictive covenant on that portion of the property it owns along the Waterways and within the City's work area where remedial actions or habitat mitigation work has been completed by the City. The Utilities also completed a portion of their sediment cleanup work on Foss Landing's property. If requested by EPA under the Utilities' Consent Decree, the Utilities may also be required to use best efforts to ensure that Foss Landing executes and records a restrictive covenant on that portion of Foss Landing's property within the Utilities' work area. The City will seek to coordinate with the Utilities in efforts to ensure Foss Landing executes and record restrictive covenants on their property.

A.3. Washington State Department of Transportation

The City will coordinate with the Washington State Department of Transportation ("WSDOT") to assure that maintenance of the Eleventh Street Bridge and the SR 509 Bridge[3] are undertaken in a manner that protects the remedial actions within the Waterways. The City will provide WSDOT with a copy of this Plan.

A.4. Washington State Department of Natural Resources

The City and the Utilities (as performing parties in the Waterways) entered into a Settlement Agreement with DNR on August 21, 2003. Paragraph 5 of this Agreement includes the following language:

> "a. Existing Leases: For State-owned aquatic lands already under lease at the time this Agreement is executed, DNR will use its best efforts to assist the Performing Parties in (i) securing access to those leased areas for the purpose of implementing work requirements under the Performing Parties' consent decrees and statements of work, and (ii) implementing institutional controls that the Performing Parties are required to implement under their consent decrees and statements of work.
>
> b. New Leases: DNR shall provide the Performing Parties advance notice of DNR's intent to lease State-owned aquatic lands that lie within the Performing Parties' respective work areas and shall use its best efforts to provide such notice 30 days in advance of DNR issuing such a lease. Such notice will include a description of the area to be leased and the

[3] The Eleventh Street Bridge is located within the City's work area. The SR 509 Bridge is not, but maintenance or other activities associated with the SR 509 Bridge could potentially affect remedial actions or habitat mitigation in the City's work area.

proposed activities for that lease area. For any lease DNR issues in the Performing Parties' work areas, DNR will ensure that the lessees take the property subject to the work requirements in the Performing Parties consent decrees, statements of work, and the institutional controls that may be required by EPA as part of the remedy. DNR will exercise utmost care in its leasing activities to minimize the risk that its lessees could cause or contribute to recontamination of the Waterways or failure of the EPA remedy."

In addition to DNR notifying the City (and the Utilities) of new state-owned aquatic land leases within the Waterways, Section 3, Paragraph (d) of DNR's Institutional Controls Plan states that DNR will also provide the City thirty (30) days notice of any proposed easements, rights-of-entry, or use authorizations within the City's work area.

Also, through their Foss Waterway aquatic lands leases, and through their consent decree with EPA, DNR is primarily responsible for ensuring that their tenants refrain from taking actions that will interfere with, or cause damage to cleanup actions undertaken on state-owned aquatic lands. The City will cooperate with EPA and DNR as necessary to provide information related to any required institutional controls that must be communicated to their lessees. This may include the posting of signs restricting anchoring in near shore capped areas as further discussed below.

DNR's Institutional Controls Plan is attached as Exhibit C. The Utilities' Institutional Controls Plan is attached as Exhibit D.

A.5. Simpson/St. Paul Disposal Facility

The City entered into a Memorandum of Agreement (MOA) with Simpson to construct the Confined Disposal Facility (CDF) within the St. Paul Waterway, which Simpson owns. The purpose of the CDF is to contain the majority of contaminated sediments dredged during the Thea Foss and Wheeler-Osgood Waterways Remediation Project ("the Remediation Project"). Pursuant to the CDF MOA, Simpson recorded an Easement for Access, Maintenance, and Inspection of Confined Disposal Facility and Habitat ("Easement") on August 30, 2003, with the Pierce County Auditor (Pierce County Auditor Recording No. 200308200715) which, among other things, grants the City access to the property and imposes certain future site use restrictions. These site use restrictions are found at Paragraphs 13 through 19 of the

Easement, which are attached as Exhibit E. Easement language applicable to development at the CDF site as well as the associated habitat areas is included below.

Paragraph 1.5 of the CDF MOA reads as follows:

> "Recorded Restrictions. The Easement area in Attachment 7 includes: (a) a restriction for institutional controls, so that the use and development of the land on which the CDF is located is not inconsistent with the effectiveness and maintenance of the CDF; and (b) a restriction so that land on which the habitat mitigation/restoration portions of the Thea Foss Cleanup Project will be implemented will be reserved for habitat in perpetuity. Simpson will work with the City to respond to any reasonable request by EPA to modify recorded restrictions as may be necessary to protect human health and the environment."

The easement mentioned in this paragraph, and included in the CDF MOA includes additional language that restricts future use of the affected properties to those activities that will not affect the effectiveness of the CDF, or the associated habitat areas. Specifically, Paragraphs 14 and 15 of the Easement read as follows:

> 14. Restrictions on the Use of the Easement Area. The Parties shall not construct facilities on the St. Paul CDF in a manner that causes a release of hazardous substances to the environment.
>
> 15. Excavation of CDF and Development in Swale Adjacent to Clarifiers. Grantors shall not excavate the CDF cover and/or cap below +12 MLLW without the consent of Grantee. "Excavation" for purposes of this Paragraph 15 does not include the installation of piles or utilities. As long as the clarifier tanks are located at the southeasterly end of the St. Paul CDF, Grantors shall not place buildings in the swale between the clarifiers and St. Paul CDF without the consent of Grantee, and Grantors shall consult with Grantee prior to placing any structures other than utilities in this swale. Nothing in this Paragraph 15 shall affect Grantors' responsibility to obtain any City land use approvals or building permits that may be required."

Two habitat mitigation areas were constructed by the City on Simpson's property under the Consent Decree. These areas are known as the North Beach Habitat Area located at the peninsula between the St. Paul and Middle Waterways, and the Middle Waterway Tideflat

Habitat area. Institutional controls for these habitat mitigation areas are addressed under Paragraph 13 of the CDF MOA, which states as follows:

> "13. <u>Habitat in Perpetuity</u>. The Habitat Improvements may not be disturbed in any manner that would impair or interfere with the integrity of the restored or enhanced habitat unless such disturbance is necessary to (i) maintain habitat value in perpetuity; (ii) reduce a threat to human health or the environment; or (iii) allow for facilities in St. Paul and Middle Waterways, including but not limited to piers or pier improvements, as may be approved by government agencies with jurisdiction. A map of these two areas along with project descriptions is included as Exhibit ___. Also, a portion of the North Beach Habitat area which extends into Commencement Bay is covered by DNR Aquatic Land Use Authorization No. 22-074977. This Use Authorization, which is recorded with the Pierce County Auditor's Office, allows the City to use a portion of state-owned aquatic lands as necessary to implement the work required under the Consent Decree for a period of thirty (30) years. Section 6.3 of the Use Authorization restricts activities that will result in "mechanical or chemical disturbance of on-site habitat mitigation", among other things.

In addition, DNR's Institutional Controls Plan covers the North Beach Habitat area off the St. Paul Waterway. DNR has also removed the Middle Waterway Tideflat Habitat area from leasing. DNR's efforts further reduce potential impacts to these habitat restoration areas.

A.6. Other Properties with Habitat Mitigation Improvements

A.6.1. <u>Puyallup River Side Channel</u>

The Puyallup River Side Channel habitat mitigation project ("PRSC") was originally included within the Simpson CDF MOA, but was removed when Simpson conveyed the PRSC site in fee simple to the City in July 2004 for construction of the project. In November 2005, after the project was completed, the City conveyed ownership of the set back levee improvement to the Corps of Engineers ("Corps") along with a perpetual easement so they can operate and maintain the levee. The remainder of the property on which the PRSC project is constructed is under the City's ownership. The documents executed between the City and Corps are not intended to address controls to assure the PRSC maintains habitat value, nor are the property conveyance documents executed by the City and Simpson. The City's Operations, Maintenance, and Monitoring Plan ("OMMP") for the Foss Waterway Cleanup project requires the City to monitor the PRSC site to ensure that the habitat area is achieving the performance objectives. The City will execute and record a restrictive covenant for the City-owned PRSC property. Public access to the PRSC project site from the upland side is restricted by a 6-foot high chain link fence with locking gates and a fire ditch, which will be further restricted by a vehicle barrier.

A.6.2. Hylebos Creek Mitigation Site

The majority of the Hylebos Creek Mitigation Site is constructed on land owned by the City. The City's OMMP for the Foss Waterway Cleanup project requires the City to monitor the Hylebos Creek site to ensure that the habitat area is achieving the performance objectives. The City will prepare a restrictive covenant for the City-owned portion of the project area and file it with the Pierce County Auditor's Office.

The remainder of the project was constructed on three residential properties pursuant to three Grant Deed of Conservation Easements ("Conservation Easements") which have been recorded under Pierce County Auditor Recording Nos. 200508101174 & 20060405746 – Bunker; 200508120617 – Rouse; and 200508180917 – Murphy. Each of the Conservation Easements is perpetual, and runs with the land to bind future successors. The Conservation Easements require, among other things, access for the City to construct, inspect, repair and monitor the habitat mitigation project, and access for EPA to oversee the City's work and monitor the habitat mitigation project. The property owners to whom the conservation easements apply are restricted from using their property in a manner inconsistent with the purpose of the easements.

A.6.3. Foss Waterway Habitat Enhancement Areas

Habitat enhancement work was completed at several areas along the Foss Waterway. Those areas are located near Foss Landing Marina (formerly Pick's Cove Marina) (Johnny's Dock Habitat Enhancement), the old steam plant property near the Foss Waterway Marina (Log Step Habitat Enhancement), under the SR 509 Bridge on the western shoreline of the head of the waterway (SR 509 Esplanade Riparian Habitat), and along the eastern shoreline of the head of the Foss Waterway (Head of the Thea Foss Shoreline Habitat). The City owns the esplanade property under the SR 509 Bridge and will record a restrictive covenant on that portion of the property where remedial actions and/or habitat mitigation work has been undertaken. Other habitat areas located within the Foss Waterway will be protected by the Restrictive Covenants recorded for the property on which they are located, as required by the Consent Decree.

A.7 General Public

The City will place signs at marina and upland locations to notify the general public about the cleanup project and the need to avoid activities that could interfere with completed remedial actions and/or or habitat mitigation work, as further described in Section F below.

B. Protection Through Notice to Successors-In-Title

In accordance with Section V, Paragraph 9.a of the Consent Decree, the City recorded eleven EPA-approved Notice to Successors-in-Title with the Pierce County Auditor's Office relating to parcels it owns adjacent to the Foss Waterway. In the event any of these parcels are ever sold, subsequent owners will be on notice that Consent Decree restrictions apply to their use of the property. The City recorded these Notice to Successors-in-Title with the Pierce County Auditor's Office on June 26, 2003, under Pierce County Auditor Recording Nos. 200306260368 through 200306260378.

EPA also received confirmation that each Settling Defendant recorded Notice to Successors-in-Title with the Pierce County Auditor's Office.

C. Notice To Owner Settling Defendants

Within thirty (30) days of receiving EPA's Certification of Completion of Remedial Action Construction under Section XIV, Paragraph 50 of the Consent Decree, the City will send out a notice to those persons identified as Owner Settling Defendants in Appendix F to the Consent Decree to inform them that construction of the cleanup has been completed and to remind them to refrain from any actions that would adversely affect the protectiveness of the remedy. A copy of this Plan will be included in the notice.

D. Future Development

To the extent authorized by applicable federal, state and local law, the City will ensure that future development in and adjacent to areas of the Waterways where remedial actions and habitat mitigation work has been completed is undertaken in a manner that protects the remedy, as described below in this Section.

D.1. Future Building, Shoreline and Wetland Permits

D.1.1. Informational Handout

Persons seeking a building, shoreline and/or wetlands permit for development adjacent to the Thea Foss and Wheeler-Osgood Waterways will receive a City-prepared handout that provides general information about remedial actions and habitat improvements constructed within these Waterways. The handout will also identify potential limitations and/or restrictions that could apply during their development project. The City will provide EPA, DNR and the Utilities a draft handout for review and comment within thirty (30) days of receiving EPA's Certification of Completion of Remedial Action Construction under Section XIV, Paragraph 50 of the Consent Decree.

D.1.2. Permitting

The City will ensure that institutional controls are factored into permit decisions by the Public Works Department Building and Land Use Services Division (BLUS). This division is responsible for all building and land use permitting and inspection within the City, including implementing the City's Critical Area Ordinance (Tacoma Municipal Code "TMC" 13.11) and Shoreline Master Program (TMC 13.10) along the Thea Foss and Wheeler-Osgood Waterways, among other places. BLUS is also responsible for ensuring that its permit decisions are in compliance with its Environmental Code, (TMC 13.12), which adopts by reference those sections of Chapter 197-11 WAC (the State Environmental Policy Act rules), which are listed at TMC 13.12.004.

BLUS, and the Environmental Services Science and Engineering Division which is responsible for monitoring the Thea Foss and Wheeler-Osgood Waterways Remediation Project for the City, will take the following steps to ensure that institutional controls are factored into the review and authorization of shoreline, building and wetland permits for development proposals on the Waterways:

D.1.2.1. Provide copies of the City's, the Utilities', and DNR's Institutional Control Plans to the City's Land Use Administrator, and the Division Manager of BLUS, along with a map showing the areas within the Thea Foss and Wheeler-Osgood Waterways where institutional controls apply.

D.1.2.2. Provide training on applicable institutional controls to staff within BLUS responsible for reviewing plans, inspecting projects, issuing permits and enforcing the Tacoma Municipal Code for all building, shoreline and critical areas development projects located along the Thea Foss and Wheeler-Osgood Waterways, and near habitat mitigation areas constructed under the Consent Decree. This training will help ensure that projects proposed along the Thea Foss and Wheeler-Osgood Waterways, or mitigation areas, or other areas where a portion of the Consent Decree remedy was constructed are "flagged" by BLUS staff for follow-up for consistency with this Plan.

D.1.2.3. Provide notice to EPA, DNR and Ecology, and other affected agencies with regulatory jurisdiction when permit applications are received by the City concerning development which may affect portions of the Thea Foss and Wheeler-Osgood Waterways where remedial actions and habitat mitigation work has been completed for comment and, when authorized by state or federal law, imposition of separate state or federal permit conditions, as further described in Section D.1.3. below.

D.1.2.4. Add a data layer to the City's govME website showing: (1) a color map of the Thea Foss and Wheeler-Osgood Waterways which depicts areas that have been dredged, dredged and capped, areas left for natural recovery, areas where no cleanup action was taken, and areas where habitat mitigation work has been undertaken; (2) a color map of the St. Paul Waterway showing the Confined Aquatic Disposal Facility and associated habitat mitigation areas including the North Beach Habitat area, the Middle Waterway Tideflat Habitat area, the Hylebos Creek Mitigation Site and the Puyallup River Side Channel; and (3) a folder group that can be accessed by site users on the map pages titled "Foss Superfund". This folder group will include a brief discussion about the Thea Foss and Wheeler-Osgood Waterways cleanup and the purpose of institutional controls, and provide the site user with an option to download the Institutional Controls Plan prepared by the City, the Utilities, and DNR, as well as all restrictive covenants filed on properties adjacent to the Waterways. The govME website provides on-line access to building, zoning, shoreline and environmental permitting records and related information for City staff and the public. The govME website can be accessed at http://govme.cityoftacoma.org.

D.1.3. Shoreline Master Program – Administration

The City's Shoreline Master Program set forth in TMC 13.10, adopts by reference the sections of Chapter 173-27 WAC (Shoreline Management – Permits and Enforcement) listed in TMC 13.10.005[4]. TMC 13.10 authorizes the City to approve and monitor development and other activities within fourteen shoreline districts throughout the City. The Thea Foss and Wheeler-Osgood Waterways are part of the City's S-8 Shoreline District, which includes all of the Thea Foss Waterway, and Wheeler-Osgood Waterway between the west line of Dock Street, and east line of "D" Street, and 200 feet landward of the ordinary high water mark of the waterways.[5] (See, TMC 13.10.110 B.) TMC 13.10.110 D., describes the uses and development activities subject to permitting by the City in the S-8 Shoreline District.

Certain shoreline uses or developments are exempt from shoreline permitting under WAC 173-27-040, including uses and developments valued at less than five thousand dollars[6] and normal maintenance and repair of docks and structures, among others. When an exempt activity involves "in-water" work that is also subject to permitting by a federal agency, the City issues a letter of exemption and forwards a copy to the Department of Ecology ("Ecology") for coordination with the federal agency with jurisdiction to issue the permit for the activity. (See, WAC 173-27-050.)

When a shoreline permit application concerns development or other activity over which a federal, state, or other local agency exercises jurisdiction, the City is required to notify such agencies under WAC 173-27-110(6).[7] These agencies may impose their own conditions on the development or activity using their separate permit or approval processes. The City conditions

[4] The City also has a Critical Areas Preservation code at TMC 13.11. As of the date of this Plan (September 2006) TMC 13.11 applies to wetlands created to compensate when wetlands are lost due to development, but not to habitat mitigation projects which may involve creation of wetlands as part of a Superfund obligation to compensate for loss of aquatic habitat.

[5] The Thea Foss and Wheeler-Osgood Waterways are shorelines of statewide significance under TMC 13.10.030.55.f, as are other marine shorelines within the City. This designation mandates a hierarchy of use preferences compared to other shorelines. These use preferences are set forth in RCW 90.58.020. See also, *Washington Real Property Desk Book*, Volume VI, Chapter 93, at page 93-14.

[6] See, RCW 90.58.030 (e).

[7] Notification is required within fourteen days after the City has determined the application is complete. WAC 173-27-110 (2).

permit decisions under its Shoreline Master Program upon the approvals of other federal, state or local agencies (or Indian Tribes) with jurisdiction over the activity. Ecology, EPA, the Army Corps of Engineers, Washington State Fish and Wildlife and DNR are among the federal and state agencies that would typically be given notice when the City receives an application for a shoreline permit along the Thea Foss and Wheeler-Osgood Waterways.[8] Depending on the nature of the activity other agencies could be contacted as well. Ecology is the coordinating agency for the state with regard to permits issued by the Army Corps of Engineers. (See, WAC 173-27-050.) The City will also notify the Utilities when a shoreline permit application is received which concerns a proposed development or activity within their work area, and/or along the uplands adjacent to their work area. In an effort to process shoreline permit applications in a timely manner, agencies or persons notified of the permit application will be given a set time period within which to respond to the City.

D.1.4. Piling Installation and Removal

Piling installation is subject to regulation under the City's Shoreline Master Program. Permit applications for this type of work within those portions of the Waterways where remedial actions and/or habitat mitigation work has been completed will be forwarded to EPA and DNR (and the Utilities if proposed for their work area) for review. Applications for this type of work which are not proposed for completed remedial action areas within the Thea Foss Waterway, but which are proposed to be undertaken on state-owned aquatic lands will be forwarded to DNR for review. The City will condition its shoreline permit decision, or shoreline exemption decision for such work on the approval of EPA, DNR and any other federal, state, or local agency exercising jurisdiction over the proposed activity. The City will also notify the Utilities when a shoreline permit application for pile installation within or adjacent to their work area is received.

Driving piling in the waterways is considered "development" under WAC 173-27-030(6), and requires a shoreline permit. The City's Shoreline Management regulations require new piling in the waterways to be constructed of materials other than treated wood. (See, TMC 13.10.175.B.14.a.(9).) This is consistent with the City's understanding of DNR's approach, which is to prohibit the installation of creosote piling on state-owned aquatic lands, and require the use of steel or concrete piling instead.

[8] Review under the City's Environmental Code (TMC 13.12) is required for shoreline development proposals which can add an additional layer of notice.

Piling removal work is not regulated under the City's Shoreline Master Program.[9] However, such work is subject to a demolition permit issued by non-shoreline staff within BLUS. When applications for piling removal work within the Thea Foss Waterway are received, BLUS staff will refer to the govME website and require that piling located where a cap has been placed, or in close proximity to where a cap has been placed, be cut off at the mudline, rather than pulled.

D.1.5. Dredging or Excavating

Dredging or excavating in the Waterways may result in the impairment or interference with the sediment cap and habitat mix, thus interfering with the remedy by creating potential pathways for contaminants to rise to surface sediments. Therefore, in addition to any City shoreline permitting restrictions that may be placed on such activity, persons seeking to dredge or excavate within the Waterways in areas where a sediment cap or habitat mix has been placed will be required to satisfy conditions EPA may impose on such work. Such persons will also be required to obtain any applicable §404 permit approvals from the Army Corps of Engineers. When applicable, the §404 process will provide additional controls to prevent disturbance of the sediment cap and habitat mix areas. The City will forward any shoreline permit applications involving dredging and/or excavation to EPA, DNR and the Army Corps of Engineers for review. The City will also notify the Utilities when a shoreline permit application is received that concerns excavation and dredging within or adjacent to their work area.

D.2. Development at the CDF

As mentioned above, the MOA that the City has entered into with Simpson includes Easement language that restricts future use of the affected properties to those activities that will not reduce the effectiveness of the CDF or the associated habitat areas. The City will continue to coordinate with Simpson both through the MOA as well as through the building permit process to ensure the long-term integrity of the CDF and associated habitat areas.

[9] The Washington Court has held that removal of a structure is not a "development" under RCW 90.58.030(3)(d) or "substantial development" under RCW 90.58.030(3)(e) of the Shoreline Management Act of 1971. (See, *Cowiche Canyon Conservancy v. Bosley*, 118 Wn. 2d 801, 815 (1992.))

E. Navigational Maps, Anchorage Restrictions and Signage

E.1. Navigational Chart Update

The City has contacted the National Oceanic and Atmospheric Administration (NOAA) – Marine Chart Division – to request that NOAA update its navigational charts to reflect changed bathymetric conditions within the Thea Foss Waterway and in the associated habitat areas. The City will continue to work with NOAA representatives as they undertake a major update of NOAA's navigational charts for Commencement Bay, including the Thea Foss Waterway. Based on discussions with NOAA, updated navigational chart information is not expected to be compiled by NOAA field teams until spring 2007, and may not be reflected in NOAA's updated chart for Commencement Bay for another twelve (12) months thereafter. In the interim, the City will request NOAA to update its navigational charts for Commencement Bay to reflect elevation changes in and around the North Beach Habitat Area.

The City, in coordination with the Utilities and DNR will request NOAA and the United States Coast Guard ("USCG"), Thirteenth District in Seattle, to publish chart updates in a Local Notice to Mariners. The City will also request that NOAA update its Coast Pilot publication with the same information.

E.2. Regulated Navigation Area – Anchorage Restrictions

Within sixty (60) days of receiving EPA's Certification of Completion of Remedial Action Construction under Section XIV, Paragraph 50 of the Consent Decree, the City will, in coordination with the Utilities and DNR, place a request with the USCG for a rulemaking in accordance with 33 C.F.R. Part 165 to establish a Regulated Navigation Area ("RNA") which prohibits anchorage (and other activities including barge "spudding" which could disturb sediment cap or habitat mix material) south of the Eleventh Street Bridge in those portions of the Thea Foss Waterway where remedial actions have been undertaken.[10]

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[10] Although the City is authorized to regulate some aspects of anchorage under RCW 35.22, it has neither the resources, nor authority under the Tacoma Municipal Code to undertake this activity. Tacoma Municipal Code, Chapter 4.22 does authorize the City to regulate the period of anchorage, but does not prohibit anchorage. If an RNA is established by the USCG, the City will propose an amendment to Chapter 4.22 referencing the RNA.

Once the RNA is published in the Federal Register, the City, in coordination with the Utilities and DNR, will request NOAA and the USCG -Thirteenth District in Seattle, to publish notice of the RNA in a Local Notice to Mariners. The City will also request NOAA to update its Coast Pilot publication with same information.

F. Signage

F.1. Waterway Signs for Boaters

In coordination with the Utilities and DNR, the City will place signs on marina docks throughout the Thea Foss Waterway to notify mariners about prohibited activities relating to vessel speed, anchorage or other activities which could disturb the protective cap or habitat mix placed in the Thea Foss and Wheeler-Osgood Waterways. DNR has committed to cooperating with the City and Utilities in the placement of signs in Section 3 d) iv)(1)(d)(2) of its Institutional Controls Plan, and in their proposed restrictive covenant. This requirement will apply to all new lessees, and to current lessees with lease re-openers for restrictive covenants.

The City and Utilities' model restrictive covenant proposed for the Waterways requires persons recording restrictive covenants on their property to allow placement and maintenance of visual aids on their property to the extent such placement does not unreasonably interfere with their use and enjoyment of their property. The City will maintain any signs it places. Signs will be designed in accordance with the standards set forth in TMC 13.10.175.A.4.

F.2. Upland Signs for the Public

In addition to the signs described above in Section F.1., the City, in coordination with the Utilities, will place signs on selected upland locations to inform the public about the Thea Foss and Wheeler-Osgood Waterways Project and the need to limit or avoid any disturbance of the intertidal and offshore areas of the Waterways which could interfere with completed remedial actions and/or habitat mitigation work. Signs will take the form of educational displays, prominently visible to the general public. The City will maintain these signs to ensure that they remain in place and readable during the monitoring period. The City will coordinate with the Utilities regarding the content and design of information signs to assure consistency. Signs will be designed in accordance with the standards set forth in TMC 13.10.175.A.4.

G. Coordination with Tacoma Police Department Marine Unit

The City will notify the Marine Unit of the Tacoma Police Department about the institutional controls related to vessel traffic in the Waterways and emphasize that enforcement of the vessel speed limit in the Waterways, which is currently 5 miles per hour under TMC 4.10.130, will help prevent "prop wash" which could disturb the integrity of the sediment cap.

H. Shellfish Harvesting

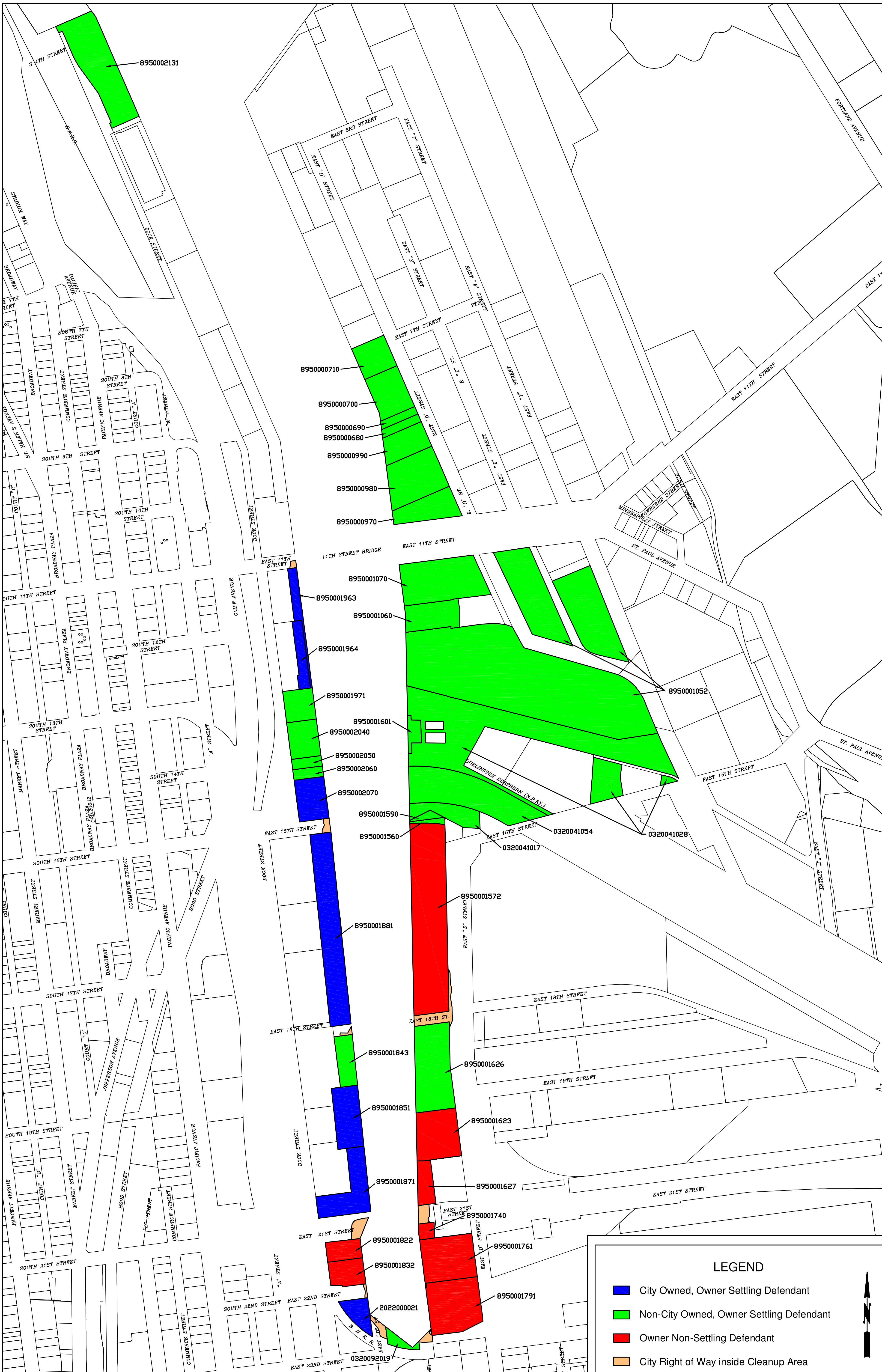
The Tacoma-Pierce County Health Department (TPCHD) is responsible for the placement and maintenance of multi-lingual signage in the waterway that warn the public about the danger of consuming shellfish harvested from this area. The City will continue coordination with TPCHD to ensure that these signs remain in place and are in good, readable condition as long as they are necessary. The City has received verbal approval from the TPCHD to include additional information on such signs prohibiting shell fishing techniques that will dig into, or disturb the sediment cap and/or habitat mix in the Waterways. As an alternative, the City may decide to develop a separate sign to be placed adjacent to the TPCHD sign which prohibits shell fishing techniques that will dig up, or stir the sediment cap and/or habitat mix in the Waterways. The City has contacted representatives of the Puyallup Tribe of Indians ("Puyallup Tribe") about these restrictions and there is no indication the Puyallup Tribe has harvested shellfish in the Waterways in recent history, and, given the status of the Waterways, there is no indication the Puyallup Tribe will use the Waterways for such purposes in the future. However, the City will forward a copy of this Plan to the Puyallup Tribe with a request that if they decide to exercise a Treaty Right to harvest shellfish in the Waterways, that it contact the City in advance to discuss the activity.

I. SCHEDULE

The projected schedule for implementing the tasks identified in this Plan is attached as Exhibit F. This schedule is a projection, and actual completion dates could vary depending upon emergent circumstances, and/or the cooperation and availability of persons outside of the City's Public Works Department – Science and Engineering Division to coordinate completion of the tasks identified in the schedule in Exhibit F.

Exhibit A

Location of “Owner Settling Defendant” and “Non-Settling Parties” Properties



CITY OF TACOMA
DEPARTMENT OF PUBLIC WORKS
Exhibit A. Thea Foss and Wheeler-Osgood Properties

DATE 9/28/2006
DRAWN LIH
SHEET 1 OF 1

Exhibit B

Model Restrictive Covenant

When Recorded, Return To:

Kelly Cole
Office of Regional Counsel
U.S. EPA, Region 10
1200 Sixth Ave. ORC-158
Seattle, WA 98101

State of Washington
Department of Ecology
Toxics Cleanup Program
Southwest Regional Office
PO Box 47600
Olympia, WA 98504-7600

Document Title:	**Restrictive Covenant**
Grantor:	**CITY OF TACOMA**
Grantee:	**WA DEPARTMENT OF ECOLOGY**
Legal Description:	
Additional Legal Description:	**SEE ATTACHMENT 1 FOR FULL LEGAL DESCRIPTION**
Assessor's Tax Parcel Number:	

RESTRICTIVE COVENANT

This Restrictive Covenant is made this ____ day of January, 2007, pursuant to RCW 43.21A.440 and RCW 70.105D.030(1)(f), (g) and (j), by ________ and its successors and assigns ("Grantor"), and the State of Washington, Department of Ecology, and its successors and assigns ("Grantee" but hereafter "Ecology") for the benefit of the United States Environmental Protection Agency, its successors and assigns, ("EPA").

The restrictions imposed by this covenant are consistent with those required by WAC 340-440(8) and (9) under the Model Toxics Control Act ("MTCA").

A portion of the property referenced above is subject to this Restrictive Covenant because Remedial Action and habitat mitigation work has been undertaken on the property pursuant to the Comprehensive Environmental Response, Compensation and Liability Act ("CERCLA"), 42 U.S.C. § 9601, et. seq., under a Consent Decree entered on May 9, 2003, titled *United States v. Atlantic Richfield Company, et al.*, in the United States District Court for the Western District of Washington, Civil Action No. C03-5117 RJB, ("Consent Decree"). The objective of the Remedial Action undertaken on the property is to protect human health and the environment. The objective of the habitat mitigation work is to mitigate impacts to the aquatic environment caused by remedial actions undertaken pursuant to the Consent Decree.

The Consent Decree is part of an integrated settlement that includes two other consent decrees. One is between EPA and Puget Sound Energy, Advance Ross Sub Company and PacifiCorp ("Utilities"), and was entered by the federal District Court on May 9, 2003. The other consent decree is between EPA and the State of Washington, Department of Natural Resources, which was entered by the federal District Court on December 17, 2003.

Grantor is the fee owner of real property (hereafter "Property") that is subject to this Restrictive Covenant, which is legally described in Attachment 1. The Property subject to this Restrictive Covenant is the portion of Tax Parcel No. _______ located at _______, Tacoma, in Pierce County, Washington, which is generally depicted by the cross-hatched area on the map attached as Attachment 2. Grantor, as holder of legal title, does hereby declare that is has authority to enter into this Restrictive Covenant.

This Restrictive Covenant is required because Remedial Action capped and/or left residual contamination in place. The purpose of this Restrictive Covenant is to reduce potential exposure of marine organisms to contaminated sediments confined by capping, and to reduce potential exposure of marine organisms to contaminated sediments left in place in the Thea Foss and Wheeler-Osgood Waterways. The purpose of this Restrictive Covenant is also to protect habitat mitigation work undertaken on the Property.

Grantor makes the following declarations as to limitations, restrictions, and uses on the Property. Furthermore, it is the intent of Grantor that such declarations shall constitute covenants that run with the land, as provided by law, and be binding on all parties and all persons claiming under them, including all current and future owners of any portion of or interest in the Property.

<u>Section 1.</u> The Remedial Action undertaken on the Property includes a cap (i.e., placement of capping material over contaminated sediment).

Section 2. Grantor shall not conduct, or allow to be conducted any activity on the Property that may result in the release or exposure to the environment of the hazardous substances contained by the Remedial Action, or that may create a new exposure pathway, unless the proponent of the activity obtains the prior written authorization from EPA and secures all necessary local, state, and federal permits and approvals for the activity in question. Activities prohibited unless otherwise approved include, but are not limited to:

2.1 Any activity that alters, modifies, or removes the Remedial Action undertaken on the Property.

2.2 Piling removal and installation.

2.3 Dredging and excavation.

2.4 Harvest of shellfish embedded in aquatic lands.

2.5 Anchoring

Section 3. Any other activity on the Property that may interfere with the Remedial Action, Operation and Maintenance, monitoring, or other measures necessary to assure the integrity of the cleanup action and continued protection of human health and the environment is prohibited without prior notice to and approval by EPA.

Section 4. Grantor shall not conduct, or allow to be conducted any activity on the Property including, but not limited to those activities referenced in subsections 2.2 through 2.5 above, that may interfere with the Habitat Mitigation Areas, or operation, maintenance and monitoring of such areas on the Property unless the proponent of the activity obtains the prior written authorization from EPA and secures all necessary local, state, and federal permits and approvals for the activity in question. The Habitat Mitigation Areas on the Property are generally depicted in the map attached as Attachment 3.

Section 5. Grantor shall give thirty (30) days advance written notice to EPA and Ecology of Grantor's intent to convey any interest in the Property. No conveyance of title, easement, lease or other interest in the Property shall be consummated by Grantor without adequate and complete provision for the continued compliance with all required institutional controls, including this Restrictive Covenant.

Section 6. Grantor shall notify EPA and Ecology and obtain approval from EPA before any use of the Property that is inconsistent with the terms of the Restrictive Covenant, or the Consent Decree.

Section 7. Grantor shall allow authorized representatives of EPA and Ecology the right to enter the Property at reasonable times for the purpose of evaluating compliance with the Consent Decree and other required plans, including the right to undertake Operation and Maintenance activities required under the Consent Decree, which includes gathering samples on the Property, and to confirm compliance with this Restrictive Covenant.

Section 8. Grantor shall restrict leases of the Property to uses and activities consistent with this Restrictive Covenant and shall notify all lessees of the restrictions on the use of the Property. Grantor shall include a copy of this Restrictive Covenant in any instrument conveying any interest in any portion of the Property, including conveyance of title, a lease, a license, an easement or other use authorizations.

Section 9. Within ten (10) days of the date this Restrictive Covenant is fully executed, Grantor shall record this Restrictive Covenant with the Auditor's Office, Pierce County, State of Washington. Conformed copies of such recordings shall be forwarded to EPA, Region 10, Office of Regional Counsel at 1200 Sixth Avenue, ORC-158, Seattle, Washington 98101, and Department of Ecology, Toxics Cleanup Program, Southwest Regional Office, PO Box 47600, Olympia, WA 98504-7600. Grantor shall include a copy of this Restrictive Covenant in any instrument conveying any interest in any portion of the Property.

Section 10. If requested by EPA, Grantor shall allow, at no cost, the placement and maintenance of signs on the Property regarding prohibited activities, vessel size and speed, and Waterway navigational buoys, markers and visual aids, to the extent such activities do not unreasonably interfere with the public's use and enjoyment of the Property.

Section 11. Grantor reserves the right to record an instrument that provides that this Restrictive Covenant shall no longer limit the use of the Property or be of any further force or effect. However, such an instrument may be recorded only if EPA concurs.

Section 12. Grantor hereby confirms that this Restrictive Covenant is enforceable at law by EPA and Ecology.

Section 13. The parties that must be notified by the terms of this Restrictive Covenant are:

Environmental Protection Agency
Office of Environmental Cleanup
1200 Sixth Avenue, ECL-111
Seattle, WA 98101

State of Washington
Department of Ecology
Toxics Cleanup Program
Southwest Regional Office
PO Box 47600
Olympia, WA 98504-7600

Puget Sound Energy – Thea Foss Waterway Cleanup
c/o Loren Dunn
Riddell Williams
1001 Fourth Avenue
Suite 4500
Seattle, WA 98154-1192

PacifiCorp – Thea Foss Waterway Cleanup
c/o Richard Gleason
Stoel Rives
900 SW Fifth Avenue
Suite 2600
Portland, OR 97204

If a proposed activity is within state-owned aquatic lands, then notice shall also be provided to:

State of Washington
Department of Natural Resources
Aquatic Resources Program
1111 Washington St. SE
PO Box 47027
Olympia, WA 98504-7027

CITY OF TACOMA

____
By: Eric Anderson
Its: City Manager

Approved as to Form:

____
Assistant City Attorney

STATE OF WASHINGTON)

COUNTY OF PIERCE)

On this ______ day of January, 2007, Eric Anderson personally appeared before me and on oath acknowledged that he was authorized to sign this instrument as the City Manager for the City of Tacoma, and further acknowledged that his signature was a free and voluntary act on behalf of the City of Tacoma, for the uses and purposes therein mentioned.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year first above written.

____
Notary Public in and for the State of
Washington, residing at _______________.
My appointment expires_______________.

ATTACHMENT 1

(Legal description)

ATTACHMENT 2

(Map Depicting Area of Property Affected by Restrictive Covenant)

ATTACHMENT 3

(Map showing Habitat Mitigation Area)

Exhibit C

DNR Institutional Controls Plan

Exhibit C

The Department of Natural Resources' Institutional Controls Plan will be provided under separate cover upon completion.

Exhibit D

Utilities' Institutional Controls Plan

Exhibit D

The Utilities' Institutional Controls Plan will be provided under separate cover upon completion.

Exhibit E

Simpson Easement (Paragraphs 13 through 19)

EXHIBIT E

200308200715 38 PGS
08-20-2003 03:04pm $56.00
PIERCE COUNTY, WASHINGTON

After Recording Return To:
Simpson Tacoma Land Company
Simpson Tacoma Kraft Company, LLC
Simpson Timber Company
1301 Fifth Avenue, Suite 2800
Seattle, Washington 98101
Attn: Joseph R. Breed

COPY

EASEMENT FOR ACCESS, MAINTENANCE, AND
INSPECTION OF CONFINED DISPOSAL FACILITY AND HABITAT

Grantors: Simpson Tacoma Land Company
Simpson Tacoma Kraft Company, LLC
Simpson Timber Company

Grantee: City of Tacoma

Legal Description:

Abbreviated Form: Portions of Section 33, Township 21 North, Range 3 East and Section 4, Township 20 North, Range 3 East of the Willamette Meridian and a portion of the Map of Tacoma Tidelands, as surveyed and platted by Tideland Appraisers for Pierce County, according to Plat filed September 14, 1985 (portions of Blocks 17, 18, and 19 of the Tacoma Tidelands), in the City of Tacoma, County of Pierce, State of Washington.

Additional legal on Exhibit A to document

Assessor's Tax Parcel ID#: R8950000480, R8950000490, R8950000528, R8950000530, R8950000531, R8950000563, R8950000564, R8950000565, R8950000566, R8950000404

EXCISE TAX EXEMPT DATE 8-20-03
Pierce County

By ______________ Auth. Sig

PROPERTY RESTRICTIONS

13. Habitat in Perpetuity. The Habitat Improvements may not be disturbed in any manner that would impair or interfere with the integrity of the restored or enhanced habitat unless such disturbance is necessary to (i) maintain habitat value in perpetuity; (ii) reduce a threat to human health or the environment; or (iii) allow for facilities in St. Paul and Middle Waterways, including but not limited to piers or pier improvements, as may be approved by government agencies with jurisdiction.

14. Restrictions on the Use of the Easement Area. The Parties shall not construct facilities on the St. Paul CDF in a manner that causes a release of hazardous substances to the environment.

15. Excavation of CDF and Development in Swale Adjacent to Clarifiers. Grantors shall not excavate the CDF cover and/or cap below +12 MLLW without the consent of Grantee. "Excavation" for purposes of this Paragraph 15 does not include the installation of piles or utilities. As long as the clarifier tanks are located at the southeasterly end of the St. Paul CDF, Grantors shall not place buildings in the swale between the clarifiers and St. Paul CDF without the consent of Grantee, and Grantors shall consult with Grantee prior to placing any structures other than utilities in this swale. Nothing in this Paragraph 15 shall affect Grantors' responsibility to obtain any City land use approvals or building permits that may be required.

16. Groundwater. No groundwater may be taken for drinking water or domestic purposes from the Property.

17. Access. Grantors shall provide access to authorized representatives of EPA and the State of Washington, their heirs, successors, and assigns, to enter the Easement Area at reasonable times and in a reasonable manner, as provided above in Section 3 of this Agreement, for the sole purpose of overseeing and evaluating the remedial action and confirming the effectiveness of the remedy contained in the Thea Foss Cleanup Plan and the associated Habitat Improvements, including to take samples and to inspect the remedial action; *provided that* EPA and the State of Washington or their representatives shall restore the property to the condition it was in before such samples were taken and shall otherwise indemnify and defend the Grantors against any and all claims or causes of

action for death or injuries to persons, or for loss or damage to property arising from or on account of the negligent acts or omissions in such sampling inspections.

18. Advance Notice of Conveyance. The appropriate Grantor shall give thirty (30) days written notice to Grantee and EPA in advance of any Closing of a sale or conveyance of any or all of the Property on which the Easement Area is located.

19. Lease Restrictions. Grantors shall restrict any leases to uses and activities consistent with the restrictive covenant in these Easements and notify all lessees of the restrictions on the use of the property. This provision may be satisfied by the inclusion into a lease of the restrictions and obligations under Sections 12 through 17 above.

Exhibit F

Schedule for Implementing ICP

EXHIBIT F

City's Projected[11] Schedule for IC Implementation

Site Use Restrictions

Maps: Provide maps to EPA showing remedial action and mitigation areas within Thea Foss and Wheeler-Osgood Waterways within ten (10) days of such request. (See, A.1, page 3.)

Restrictive Covenants – City Property: City records restrictive covenants on property it owns within thirty (30) days of EPA approving City's model restrictive covenants, or within thirty (30) days of receiving EPA's Certification of Completion of Remedial Action Construction ("Certification"), whichever is later. (See, A.1, page 3.)

Restrictive Covenants – Owner Settling Defendants: If requested, City provides information to Owner Settling Defendants regarding the nature and scope of remedial actions and habitat mitigation work undertaken on their property. Upon receiving notice from EPA that it has requested Owner Settling Defendants to record restrictive covenants on their property, the City will, within thirty (30) days of receiving such notice, provide Owner Settling Defendants with a map depicting the location of remedial actions and habitat mitigation on their property for attachment to the restrictive covenant they execute and record. (See, A.1, page 3.)

Restrictive Covenants – Non-Settling Property: City meets with non-settling parties regarding filing restrictive covenants on their property within thirty (30) days of receiving EPA's Certification of Completion of Remedial Action Construction, and use best efforts to secure filing of a restrictive covenant on such property within ninety (90) days of receiving EPA's Certification of Completion of Remedial Action Construction. (See, A.2, page 4.)

Institutional Controls Plan to WSDOT: City will provide WSDOT a copy of its Institutional Controls Plan within thirty (30) days of EPA's approval of such plan. (See, A.3, page 5.)

Notice to Owner Settling Defendants

City provides the Owner Settling Defendants identified in Appendix F of the Consent Decree notice that EPA has provided the City its Certification of Completion of Remedial Action Construction. The notice will be made within thirty (30) days of receiving EPA's Certification and will include a copy of the City's Institutional Controls Plan. (See, C, page 10.)

Future Development

Informational Handout: City distributes a final informational handout for distribution by the City's Building and Land Use Division within thirty (30) days of receiving comments from EPA, DNR and the Utilities. The City will prepare a draft handout for review by EPA, DNR and the Utilities within thirty (30) days of receiving EPA's Certification of Completion of Remedial Action Construction. (See, D.1.1, page 11.)

[11] This schedule is a projection, actual completion dates could vary depending upon on emergent circumstances, and/or the cooperation and availability of persons outside of the City's Public Works Department - Science and Engineering Division to coordinate completion of the tasks identified in this schedule.

EXHIBIT F

Additional BLUS Training: Will be completed within forty-five (45) days of receiving EPA's approval of the City's Institutional Controls Plan. (See, D.1.2, page 11.) Institutional Control Plans prepared by the City, DNR and the Utilities will be provided to BLUS within thirty (30) days of approval of such plans.

govME Website: Identify and load additional documents on govME website within forty five (45) days of EPA's approval of such documents. (See, D.1.2, at page 11.)

Navigational Maps/Restrictions/Signage

Navigational Maps: Within thirty (30) days of receiving EPA's Certification of Completion of Remedial Action Construction, request NOAA to update its Commencement Bay navigational chart to show North Beach Habitat Area. The City will monitor NOAA's progress on the major update of its navigational chart for Commencement Bay. (See, E.1., page 16.) The City will request the U.S. Coast Guard to publish a Local Notice to Mariners to alert mariners to chart updates within thirty (30) days of such updates. (See, E.1., page 16.)

Regulated Navigation Area: Within sixty (60) days of receiving EPA's Certification of Completion of Remedial Action Construction, request the U.S. Coast Guard to establish a Regulated Navigation Area to restrict anchorage and other activities that could harm or disturb remedial actions in the Thea Foss Waterway.

Signage: Within one hundred and twenty (120) days of receiving EPA's Certification of Completion of Remedial Action Construction, prepare and place signage on docks and upland areas, including signs warning about shellfish harvesting techniques. (See, F.1, at page 17, F.2 at page 17, and H at page 18.)

Install Vehicle Barrier at PRSC

The City will install a vehicle barrier in the City right-of-way abutting the PRSC project site within sixty (60) days of receiving EPA's approval of the City's Institutional Controls Plan. (See, A.6.1, at page 8.)

Coordination with Tacoma Police Marine Unit

Within thirty (30) days of receiving EPA's approval of the City's Institutional Controls Plan, notify, and if requested provide training to the Tacoma Police Marine Unit on institutional controls related to vessel traffic. (See, G., at page 18.)