Port Angeles Harbor
Sediment Characterization Study
Port Angeles, WA

Sampling and Analysis Plan

FINAL

Prepared for

Washington State Department of Ecology
Toxics Cleanup Program
300 Desmond Drive
Lacey, Washington 98504

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List of Acronyms

Be7	beryllium-7
CDD	chlorinated dibenzo-p-dioxin
CDF	chlorinated dibenzofuran
CFR	Code of Federal Regulations
cm	centimeter
Cs137	cesium-137
COC	chain of custody
COPC	chemical of potential concern
CRI	Color Rendering Index
CSL	Contaminant Screening Level
CSO	combined sewer outfall
CWA	Clean Water Act
DGPS	Differential Global Positioning System
Dpm	disintegrations per minute
DQO	data quality objective
ECOLOGY	Washington State Department of Ecology
EDD	electronic data deliverable
E & E	Ecology & Environment, Inc.
EIM	Environmental Information Management System
EPA	United States Environmental Protection Agency
ERA	ecological risk assessment
ERL	Effects Range Low
ERM	Effects Range Median
ESI	Expanded Site Investigation
ft	feet
FM	field manager
GCMS	gas chromatography mass spectroscopy
GPM	Government Project Manager
HARBOR	Port Angeles Harbor
HASP	Health and Safety Plan
HCID	hydrocarbon identification
Hg	mercury
HHRA	human health risk assessment
HPAH	high molecular weight polycyclic aromatic hydrocarbon
HxCB	hexachlorobiphenyl
HxCDD	hexachlorodibenzo-p-dioxin
HxCDF	hexachlorodibenzofuran
HpCB	heptachlorobiphenyl
HpCDD	heptachlorodibenzo-p-dioxin
HpCDF	heptachlorodibenzofuran
ICP	inductively-coupled plasma
ICS	interference check standard

IDW	investigative-derived waste
In	inch
km	kilometer
LCS/LCSD	laboratory control sample/laboratory control sample duplicate
LEKT	Lower Elwha Klallam Tribe
LPAH	low molecular weight polycyclic aromatic hydrocarbon
m	meter
m^2	square meters
MDL	method detection limit
MLLW	Mean Lower Low Water
MRI	Marine Remedial Investigation
MSMP	Marine Sediment Monitoring Program
MS/MSD	matrix spike/matrix spike duplicate
MTCA	Model Toxics Control Act
NAD 83	North American Datum of 1983
NELAP	National Environmental Laboratory Accreditation Program
NOAA	National Oceanic and Atmospheric Administration
NWTPH	northwest total petroleum hydrocarbon
OC	organic carbon
OCDD	octachlorodibenzo-p-dioxin
OCDF	octachlorodibenzofuran
oz	ounce
PAH	polycyclic aromatic hydrocarbon
PARCC	precision, accuracy, representativeness, completeness, and comparability
Pb210	lead-210
PBT	Persistent, Bioaccumulative, and Toxic Chemical
PCB	polychlorinated biphenyl
PE	performance evaluation
PeCB	pentachlorobiphenyl
PeCDD	pentachlorodibenzo-p-dioxin
PeCDF	pentachlorodibenzofuran
PLP	Potential Liable Party
PM	project manager
PQL	Practical Quantitation Limit
PPE	personal protective equipment
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RI/FS	Remedial Investigation/Feasibility Study
RL	Reporting Limit
RPD	relative percent differences
SAP	Sampling and Analysis Plan
SEDQUAL	sediment quality (database)
SIR	Sediment Investigation Report
SMS	Sediment Management Standards
SOPs	Standard Operating Procedures

SQS	Sediment Quality Standard
SVOC	semi-volatile organic compound
SMARM	Sediment Management Annual Review Meeting
TBT	tributyltin
TCDD	tetrachlorodibenzo-p-dioxin
TCDF	tetrachlorodibenzofuran
TDL	target detection limit
TeCB	tetrachlorobiphenyl
TEF	toxic equivalent factors
TEQ	total toxic equivalent concentration
TOC	total organic carbon
TPH	total petroleum hydrocarbons
USCS	Unified Soil Classification System
UST	underground storage tank
UV	ultraviolet
WAAS	Wide Area Augmentation System
WAC	(State of) Washington Administration Code
WHO	World Health Organization

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1.0 Introduction

Port Angeles Harbor (Harbor), Washington has been identified as a priority environmental cleanup and restoration project by the Washington State Department of Ecology (Ecology) as part of the Puget Sound Initiative. Ecology's Toxics Cleanup Program has identified the Harbor for focused source control actions, sediment cleanup, and restoration efforts. The effort to clean up and restore the Harbor requires characterizing the marine sediment's relationship to potential current and historic contaminant sources. Ecology has tasked Ecology and Environment, Inc., (E & E) with conducting a sediment investigation, focusing on the marine environments and associated terrestrial and aquatic source areas. The purpose of this Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) is to outline how this field investigation will be implemented. This document provides the following per requirements of the Washington State Model Toxics Control Act (MTCA) Chapter 173-340 Washington Administrative Code (WAC) (Ecology 2001) and tasks outlined in the Work Plan between E & E and Ecology (E & E 2008a):

- Study objectives and design
- Overview of field methods
- Overview of QA/QC measures for field and laboratory activities
- Data analysis and reporting

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2.0 Background

2.1 Harbor Description

The City of Port Angeles is located on the northern coast of the Olympic Peninsula in Clallam County. The city contains 26 miles (42 km) of marine shoreline, including Ediz Hook, a 2.5-mile-long sand spit (Figure 2-1). The Harbor is bounded to the west and south by the City of Port Angeles and to the north by Ediz Hook. The Harbor is considered a deep-water port, with depths greater than 90 feet (27.4 m) near the eastern end of Ediz Hook. Intertidal shorelines exist in the southeastern portion of the Harbor, as well as along the eastern shoreline of Ediz Hook. The marine waters of Port Angeles Harbor are currently listed as impaired by the State of Washington under Section 303(d) of the Clean Water Act (CWA) due to low dissolved oxygen levels (EPA 2004).

Port Angeles Harbor has many commercial and industrial facilities along its shoreline. Over the past century, the Harbor has been used by a number of industries including saw mills and plywood manufacturing, pulp and paper production, marine shipping/transport, boat building and refurbishing, petroleum bulk fuel facilities, marinas, and commercial fishing. Since the early 1900s, pulp and paper mills have comprised a dominant portion of Port Angeles' industrial sector. Treated and untreated mill process effluents were commonly discharged into the Harbor, and wood product sources throughout the Harbor have been identified as significant sources of chemicals of potential concern (COPCs) in marine sediments. Petroleum storage and transport businesses have historically operated and currently conduct business along the Port Angeles waterfront. Spills and leaks from petroleum facilities and tankers, as well as from facilities with leaking underground storage tanks (UST), have introduced COPCs into the Harbor. Marinas, shipping industries, and docks and piling infrastructure all have a variety of potentially associated COPCs. Historically and currently, the Harbor has received discharges from Combined Sewer Outfalls (CSO), deepwater effluent outfalls, septic systems in various stages of maintenance outside the city limits, non-point source runoff from stormwater, and surface water discharge from creeks with varying degrees of residential and commercial land-use influences. All these discharges may contribute COPCs to the Harbor. Refer to the *Port Angeles Harbor Summary of Existing Information and Identification of Data Gaps Report* (E & E 2008b) for a more detailed description of the Harbor.

2.2 Previous Investigations

Environmental investigations throughout the Harbor have indicated that chemicals of concern generated by industrial and urban activities exist within the marine sediments and biota of the Harbor and may pose a risk to the environment as some levels exceed the Washington State Sediment Management Standards (SMS) Chapter 173-204 WAC (Ecology 1995) and other established thresholds of environmental concern (EPA 1998, Long & Morgan 1991, Long et al. 1995) (Figures 2-2 and 2-3). Prior investigations conducted in the Harbor over the past 15 years include:

- EPA Dioxin and Furan Concentrations in Puget Sound Crabs (EPA 1991)

- EPA Expanded Site Investigation (ESI) of Rayonier Mill (E & E 1998 and 1999)
- Ecology Marine Sediment Monitoring Program (MSMP) (Ecology 1998a and b)
- Ecology Port Angeles Harbor Wood Waste Study (SAIC 1999)
- Rayonier Log Pond Survey for Remedial Investigations (Foster Wheeler 2001)
- Washington State Department of Transportation Port Angeles Graving Dock (GeoEngineers 2003)
- Remedial Investigation and Phase 2 Addendum for the Marine Environment near the Former Rayonier Mill Site (Malcolm Pirnie 2007a and b)
- Ecological Risk Assessment for the Marine Environment near the Former Rayonier Mill Site (Malcolm Pirnie 2006)
- Washington Department of Health Consultation: Rayonier Mill Site Exposure Investigation (WDOH 2005)

These studies are discussed in detail in the *Port Angeles Harbor Summary of Existing Information and Identification of Data Gaps Report* (E & E 2008b).

2.3 Study Objectives and Scope

This SAP addresses two separate but related components of the Port Angeles Harbor sediment investigation: a harbor-wide investigation intended to address the area-wide conditions in the harbor, and a focused investigation in and around the former Rayonier Mill to supplement previous data collected for the Rayonier Marine Remedial Investigations. The study objectives and scope for both components are addressed in the following subsections.

2.3.1 Harbor-wide Investigation

The goal of the harbor-wide investigation is to conduct a multi-faceted marine sediment investigation of Port Angeles Harbor to characterize the nature of sediment chemical contamination, identify potential sources of this contamination, map the presence of wood waste, and determine the potential uptake of chemical contaminants in marine biota. The specific objectives of the harbor-wide investigation are to:

1. Characterize sediment quality and conditions at locations throughout the Harbor.
2. Fill data gaps in existing knowledge, as identified in the Port Angeles Harbor Summary of Existing Information and Data Gaps Report (E & E 2008b).
3. Identify terrestrial and aquatic sources of chemical contaminants, wood waste, and wood-waste-related degradation products.

4. Evaluate human health and ecological risk from Harbor sediments. For further information on the Risk Assessment, refer to the Human Health and Ecological Risk Assessment Work Plan for Port Angeles Harbor Marine Environment, which is in Appendix D.

5. Evaluate bottom currents and sediment transport in the Harbor. See Appendix E and F for detailed information on field implementation of these studies.

Data generated by this study will be used to support risk-based environmental decisions for the Harbor. Specifically, the intent of the study is to generate data that identifies chemicals of concern that may drive system impacts and the likely sources of those chemicals. The study is not intended to be a Remedial Investigation/Feasibility Study (RI/FS). However, the data provided will allow potential liable parties (PLPs) to continue with the cleanup process.

The study area was determined based on prior Harbor investigations and discussions with Ecology personnel to ensure spatial coverage of potential sediment contamination areas within the Harbor. The scope of this SAP/QAPP is geographically limited to the aquatic areas of Port Angeles Harbor, including associated subtidal and intertidal nearshore areas, and areas within Dungeness Bay from which reference samples will be collected (Figure 2-1). Three bays near Port Angeles Harbor were evaluated to determine suitability as a reference for the Harbor: Sequim, Freshwater, and Dungeness. A reference site for a sediment study should reflect the test site in all aspects with the exception of the presence of chemical contaminants. Based on careful review and analysis of available data from all three Bays, the physical, geomorphological, and chemical concentration characteristics of Dungeness Bay make it the most appropriate reference site for Port Angeles Harbor. Dungeness Bay was also determined to be appropriate to serve as background for Port Angeles Harbor per MTCA definitions (WAC 173-340-200).

2.3.2 Rayonier Area Investigation

The goal of the Rayonier Area Investigation is to supplement existing data and information collected in previous Marine Remedial Investigation (MRI) studies at the site (Malcolm Pirnie 2007a and b). The planned Rayonier area investigation was developed based on comments provided to Rayonier by Ecology in a letter dated January 9, 2008. The specific objectives of the Rayonier area investigation are:

1. Further delineate the horizontal and vertical distribution of mill-related contaminants in marine sediments around the former mill;

2. Characterize the depth of wood waste and debris around the Mill Dock and the Log Pond areas; and

3. Characterize the presence of mill-related contaminants at and near the mouth of Ennis Creek.

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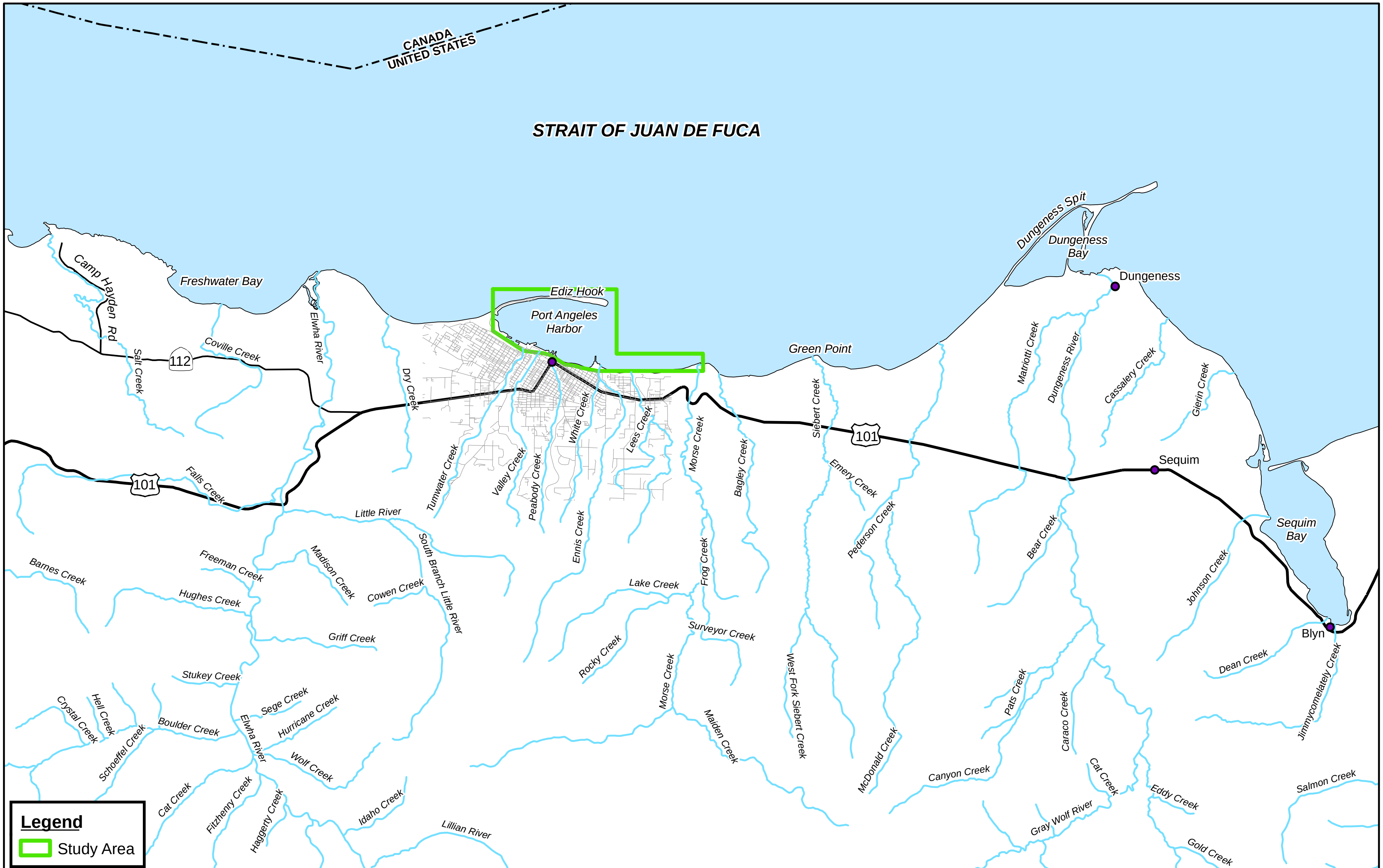

N
W
E
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Miles

Scale 1:224,000

Figure 2-1

Port Angeles Harbor, Washington

Project Vicinity Map

source: ecology & environment, inc., 3/10/2008 ...\port_angeles_sta\figure 2-1 project vicinity map.mxd

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N W E S

0 500 1,000 2,000 3,000 4,000 5,000 6,000
Feet

Scale 1:24,000

Figure 2-2

Port Angeles Harbor, Washington

Harbor-wide Historical Sample Locations Summary of Samples that Exceed SMS or NOAA Sediment Criteria

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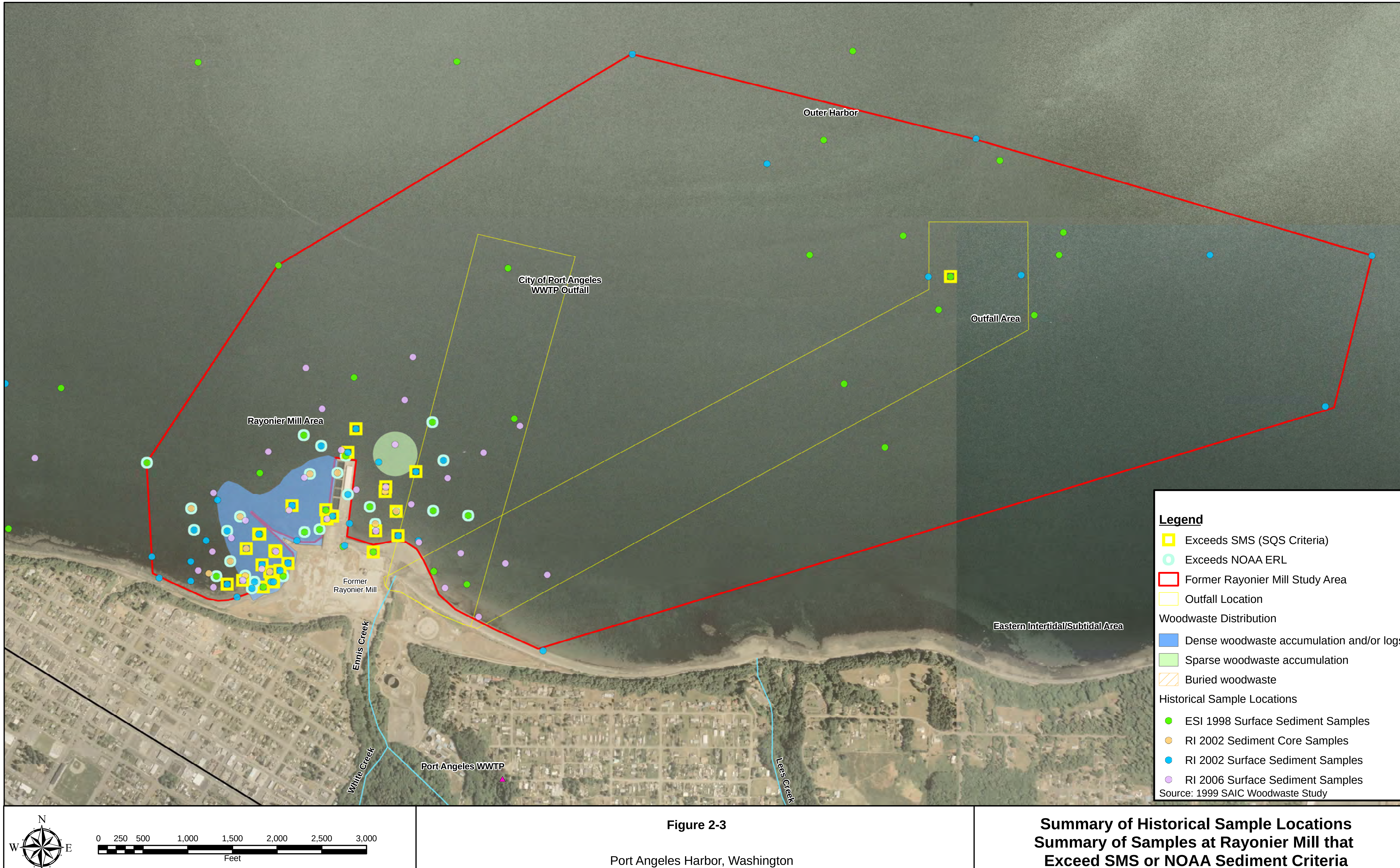

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Figure 2-3

Port Angeles Harbor, Washington

Summary of Historical Sample Locations
Summary of Samples at Rayonier Mill that Exceed SMS or NOAA Sediment Criteria

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3.0 Project Management

3.1 Project Team and Responsibilities

Implementation of this work plan will be conducted by E & E and its subcontractors at the direction of Ecology. The following sections describe the key roles and responsibilities of the project team.

3.1.1 Project Planning and Coordination

Cynthia Erickson, from Ecology's Toxic Cleanup Program, will serve as the Government Project Manager (GPM) and will oversee the overall project coordination, supply government-furnished data and services, provide review comments on the report, and coordinate with E & E to perform SAP tasks.

William Richards will serve as E & E's project manager (PM) and will have overall responsibility for executing the approved SAP/QAPP, ensuring the proper collection and analysis of field samples, and reporting analytical results.

3.1.2 Sample Collection

Eric White will serve as field team manager (FM) and will be responsible for the collection and processing of sediment and tissue samples in accordance with the SAP/QAPP, coordination of field laboratory work, and transport of samples to the analytical laboratories for analysis and testing. The FM will coordinate with the proposed sampling vessel operators for this project and will ensure accurate station positioning and reporting.

3.1.3 Laboratory Sample Preparation and Analysis

Under the direction of Eric White, E & E personnel will be responsible for the visual description of sediment grab samples, sample processing, and delivery of samples to the analytical laboratory. Established protocols in this SAP/QAPP for decontamination, sample preservation, holding times, and chain-of-custody documentation will be observed.

3.1.4 QA/QC Management

David Ikeda, E & E chemist, will serve as laboratory coordinator and perform quality assurance oversight for the laboratory programs. He will be responsible for subcontracting state-certified laboratories and ensuring that laboratory procedures meet the required analytical quality control limits. He will oversee QA/QC data validation of the analytical chemistry results.

Blythe Mackey, E & E biologist, will provide QA/QC data validation of the bioassay results.

3.1.5 Health and Safety Manager

Mark Longtine will serve as the designated E & E Health and Safety Manager. He will ensure that all personnel are properly trained, are fully aware of potential site hazards, conduct all work in a safe manner, wear appropriate personal protective clothing (PPE), and abide by the conditions set forth in the site-specific Health and Safety Plan (HASP) in Appendix A.

3.1.6 Subcontractor Support

The E & E project team will also consist of the following subcontractors to support the data collection activities and laboratory analytical services:

1) SAP/QAPP Development and Review

Avocet Consulting
Dr. Teresa Michelsen
2103 Harrison Avenue NW, #2502
Olympia, WA 98502
Phone: (253) 222-1441
teresa@avocetconsulting.com

2) Current Study & Sediment Transport Analysis

Evans Hamilton, Inc.
Carol Coomes
4608 Union Bay Place NE
Seattle, WA 98105
Phone: (206) 526-5622
Fax: (206) 526-5633
carol@evanshamilton.com

Herrera Environmental Consultants
Dr. Jeff Parsons
2200 Sixth Ave, Suite 1100
Seattle, WA 98121
Phone: 206-441-9080
Fax: 206-441-9108
jparsons@herrerainc.com

GeoSea Consulting Ltd.
Dr. Patrick McLaren
7236 Peden Lane
Brentwood Bay, British Columbia V8M1C5
Phone: 250-652-1334
Fax: 250-652-1395

3) Biological Testing

NewFields Northwest, LLC
Brian Hester
P.O. Box 216
4729 NE View Drive
Port Gamble, WA 98364
Phone: (360) 297-6060
Fax: (360) 297-7268
bhester@newfields.com

4) Analytical Chemistry

Test America Laboratories, Inc.
Terri Torres
5755 8th Street East
Tacoma, WA 98424
Phone: (253) 922-2310 ext. 114
Fax: (253) 922-5047
Terri.Torres@testamericainc.com

5) General/Physical Chemistry

Analytical Resources, Inc.
Sue Dunihoo
4611 South 134th Place; Suite 100
Tukwila, WA 98168-3240
Phone: (206) 695-6207
Fax: (206) 621-7523
Sue@arilabs.com

6) Sampling Vessels

Research Support Services (RSS).
Eric Parker
8010 NE Lovgren Road
Bainbridge Island, WA 98110
Phone: (206) 550-5202

Northwest Underwater Construction
Jesse Hutton
800 NE Tenny Road, Suite 110-111
Vancouver, WA 98685
Phone: (360) 993-5581

7) Dioxin/Furan Congener Analysis

Axys Analytical Services, Ltd.
Angelica Whetung

2045 Mills Road
Sidney BC V8L 3S8
Canada
Phone: (250) 655-5800
Fax: (250) 655-5811
awhetung@axys.com

8) Radioisotope Dating

Test America Richland
Jodie Carnes
2800 George Washington Way
Richland, WA 99354
Phone: (509) 375-3131
jodie.carnes@testamericainc.com

3.2 Schedule

The tentative schedule for the proposed field activities and deliverables submittal is as follows:

Task	Time After Notice to Proceed
Analytical laboratory subcontract acquisition	Week 0 – 2
Sampling vessel & operator subcontract acquisition	Week 0 – 2
Field planning	Week 0 – 3
Field mobilization and sampling	Week 3 (1 day)
Field sampling	Week 3 – 6
Field demobilization	Week 6 (1 day)
Sample analysis	Week 4 – 12 (8 weeks)
Data validation	Week 12 – 15 (3 weeks)
Reporting	Week 15 – 22 (8 weeks)
Draft report submittal to Ecology	Week 22
Final report submittal to Ecology	Week 30

4.0 Study Design

This section describes the study design for each component of the Port Angeles Harbor Sediment Investigation. The study area has been divided into Areas of Concern (Figure 4-1). These were delineated according to:

- Their identification as areas having potential sources of COPCs due to current and historic shoreline use/operations; for each of these areas, there may be
  - Prior data indicating areas where COPCs exist in sediment or biota, and some locations are known to exceed SMS and other threshold criteria, and/or
  - A lack of necessary data on potential sediment contamination associated with known or potential sources
- Their identification as areas where there is a potential increased risk of human health exposure to sediment and/or biota

Specific sample locations within Areas of Concern are chosen to characterize nearshore source areas with suspected sediment contaminants, and to determine the general distribution of potential contaminants from nearshore areas out into the Harbor. Proposed sampling locations within identified Areas of Concern are presented in Figure 4-2 and Table 4-1 for the Harbor-wide Investigation, and Figure 4-2a and Table 4-2 for the Rayonier Area Investigation. The stated study objectives will be achieved through collection and analysis of several types of sediment and tissue data, including surface and subsurface sediment chemistry, sediment toxicity, and biota tissue chemical residue.

Table 4-1 Harbor-wide Areas of Concern

Area of Concern	Field ID	Location	Potential Sources of Interest
Ediz Hook Point	EH	Eastern and southeastern point of Ediz Hook	Coast Guard UST remediation, fuel spills
Fish Pen Area	FP	The marine areas around and at the commercial fish pens along Ediz Hook	Fish pens, boat docks
Barge Area	BA	Mid-western edge of Harbor where large barges are temporary moored	Frequent barge traffic and mooring
Inner Ediz Hook Area	IE	The remainder of Ediz Hook's southern shore	Decaying docks, creosote pilings, BP Bulk Fuel Facility, Nippon Paper Mill, current log booming areas
Lagoon Area	LA	The lagoon west of the western edge of the Harbor.	Former log booming area, proximity to Nippon processes
Inner Harbor Area	IH	The western edge of Port Angeles Harbor, north of Terminal 7	M&R Timber lumber and wood chips facility, former Fibreboard Mill, wood chips transfer area, historic ship building facility, historic log booming areas, former CSO outfalls

Table 4-1 Harbor-wide Areas of Concern

Area of Concern	Field ID	Location	Potential Sources of Interest
Port Angeles Marina	MA	Large marina directly east of the Inner Harbor Area	Boat marina, boat yard, current log booming areas
Boat Launch & Standard Oil Area	BL	Area to the west and northeast of Terminal 3	Terminals 1 & 3 for large vessels & shipping activity, bulk fuel facility, Tumwater Creek outfall
K-Ply/Valley Creek	KP	Area between Terminal 1 and Terminal 4	K-Ply Mill, Valley Creek outfall, historic log booming areas, decaying metal dock, Terminal 4 boat dock
Landing Pier (Ferry Terminal)	FT	Area east of Terminal 4 and area around Terminal 2 (the Ferry terminal)	Ferry Terminal, Landing Pier, vessel docking, City Walking Pier, Peabody Creek outfall, current CSOs
Red Lion Inn	RL	Nearshore areas in front of the Red Lion Inn	This is a highly used public beach area
City of Port Angeles WWTP Outfall	WW	At the location of the City's WWTP deepwater outfall	Wastewater treatment effluent outfall
Outer Harbor	OH	Southeast of the end of Ediz Hook (north of outfalls)	Chosen in order to initially delineate where Harbor sediments become more like background sediments in the Strait
Eastern Intertidal/Subtidal Shore	EI	Subtidal/intertidal nearshore between Ennis Creek and Morse Creek	Mouths of Lees and Morse creeks
Reference Samples	RF	Dungeness Bay	Reference and Background

Table 4-2 Rayonier Area Investigation Areas of Concern

Area of Concern	Field ID	Location	Potential Sources of Interest
Log Pond	LP	Rayonier's Log Pond	Former log storage pond
Mill Dock	MD	West and northwest of Rayonier's Mill Dock Area	Former dock for Mill operations
East of Mill Dock	ED	East and Northeast of Rayonier's Mill Dock	Directly east and adjacent to Mill Dock
Nearshore Outfalls	CO	Former nearshore outfall locations along Rayonier's shoreline	Former effluent outfalls for Rayonier operations
Deep Outfall	DO	Along and at the end of the Rayonier Mill Effluent Outfall pipeline.	Former deepwater outfall for Rayonier operations
Ennis Creek	EC	At the mouth of Ennis Creek	Outfall of Ennis Creek, receives Rayonier stormwater runoff, site of oil leak
East of Ennis Creek	EE	Intertidal areas directly east of Ennis Creek	Adjacent to Ennis Creek and Rayonier operations

4.1 Harbor-wide Investigation Study Design

The study has a non-random sampling design, and applies a tiered laboratory analysis approach to characterize sediment conditions in the Harbor. Samples will be collected at locations with potential and/or known point and non-point sources of chemical contaminants, and areas selected to characterize potential boundary conditions. The first tier of analysis will characterize sediment conditions via bioassay toxicity results, biota tissue concentrations, and sediment chemical parameters requiring immediate analysis due to short sample holding times. In general, sediment samples for chemical analyses that do not have short holding times will be archived for possible later analysis. However, at select locations where chemical data is known to be needed, the sediment samples will be analyzed and not archived. Bioaccumulative chemicals in the tissue of organisms will also be analyzed in the first tier of analysis. The second tier of analysis will involve analytical testing of archived sediment samples to further characterize the distribution of COPCs in sediments based on biological effects as determined by sediment toxicity bioassays or chemical SQS exceedences. Bioassay results, initial sediment chemistry results, biota tissue concentrations, and relevant data collected during previous investigations will be used to indicate the need for analysis of archived sediment samples.

4.1.1 Surface Sediment Samples

Representative surface (0 to 10 centimeters (cm) deep) sediment samples will be collected at locations within each Area of Concern. Surface sediment will be collected at sampling locations throughout the harbor and from reference/background locations (Figures 4-3 to 4-5). A sample from each location will be homogenized and submitted to the laboratory for chemical analysis or archiving. Sediments will initially be analyzed for conventional parameters necessary to interpret bioassay results and for short holding time chemical parameters (i.e. mercury, tributyltin (TBT), and total petroleum hydrocarbons (TPH)). Sediment samples from select locations will not be archived, but analyzed for the full suite of chemical parameters to characterize sections of the Harbor known to require characterization, and to support the HHRA/ERA for bioaccumulative compounds. These locations include the mouths of creeks, the central Harbor, the boundary of the outer Harbor, the lagoon, the eastern intertidal areas, and the reference/background area. The remaining sediment samples will be archived for further testing pending review of multiple lines of evidence: bioassay and biota tissue concentration results, chemical results from the first round of analysis, and relevant historical data collected within the Harbor (Figure 4-3). A portion of the sediment from selected sampling locations will be collected for bioassay testing (see Section 4.1.3).

Chemical analysis of surface sediment samples include the SMS analyte list and sediment conventional parameters (TOC, grain size, total solids, and sulfides). In addition, chlorinated pesticides, NWTPH-HCID, TBT, dioxin/furan congeners, and wood resin compounds will be analyzed in areas where these compounds may occur based on potential current and historical contaminant sources.

The chemical analyte list, analytical methods, target detection limits, and comparative criteria are discussed in Section 6.0.

4.1.2 Subsurface Sediment Cores

Subsurface sediment cores will be collected to determine:

- The vertical distribution of potential chemical contamination in suspected depositional areas. Areas of net deposition, including the mouths of creeks and other areas within the study area, are expected to have accumulations of sediments that may have buried contaminants discharged historically into the Harbor;

- General evaluation of sedimentation rates and depth of mixing in the sediment layers at select sections of the Harbor using radioisotope dating;

- The vertical distribution of wood-waste debris in areas of known or suspected wood-waste accumulation.

Core sampling locations will be co-located with selected surface sediment locations. Analysis protocols of the subsurface sediment samples will follow those in Section 4.1.1; that is, some samples will be analyzed immediately for full suite chemistry or only for sediment conventionals and short-holding-time analytes. Cores will be either 4 feet (ft) or 12 ft in depth from the surface depending on the station sampling objective (Figures 4-4 and 4-6). Cores collected in depositional areas and those collected to determine sedimentation rates will be advanced to 4 ft below the surface. If continuous wood-waste is encountered in 4 ft cores, then those cores shall be advanced as far as practicable, up to 12 ft, to reach native sediments for sample collection. In documented wood-waste accumulation areas, the core sampler will advance up to 12 ft in depth to determine the vertical extent of wood debris. The core collection and evaluation will include a physical description of the stratigraphy (Appendix B), as well as the collection of sediment composite samples for possible chemical analysis. Archeological monitoring will be conducted on all cores located in water less than 50 ft in depth in accordance with the methodology described in Appendix G. The chemical analyte list, analytical methods, target detection limits, and comparative criteria are discussed in Section 6.0.

4.1.2.1 Depositional Area Cores

The subsurface sediment cores collected from depositional areas will be divided into depth intervals for analysis (Figure 4-6). The cores will be 4 ft long and sectioned into vertical horizons as follows: 1) 6 inches (in) to 1 ft, 2) 1 to 2 ft, 3) 2 to 3 ft, and 4) 3 to 4 ft. The core surface layer of 0-6 in will not be analyzed because the co-located surface grab sample will be immediately analysed for sediment conventionals and, as noted in Table 4-3, the appropriate sediment COPCs. Based on sampler judgment of sediment conditions within the core, two of the four core intervals will be selected for analysis as shown in Table 4-3 for the full suite of COPCs appropriate for the particular location. Criteria to be used by the sampling crew to determine sediment intervals for laboratory analysis are described in Section 5.3.2.

4.1.2.2 Radioisotope Dating Cores

Two 4-ft cores, one in the western section and one in the southeastern section of the Harbor, will be collected for radioisotope dating using a gravity or piston corer sampling device (Figure 4-6). These core samples will be analyzed for beryllium-7 (Be-7), lead-210 (Pb-210), and cesium-137

(Cs-137) (Figure 4-6). These cores will be finely divided into sections as described in Section 5.3.3. Sedimentation rate will be determined using the Pb-210 results. The Cs-137 results will be used to verify the dates determined for the sedimentation rate. Be-7 results will be used to estimate the depth of mixing in sediment layers.

4.1.2.3 Wood-waste Cores

Subsurface cores will be advanced as far as possible, to a maximum depth of 12 ft, to attempt to define the depth of the wood waste and characterize the underlying native sediment. The subsurface sediment cores will be divided into discrete intervals for compositing based on field sampler judgment, down to the lowest vertical extent of wood-waste debris. A minimum 1-ft interval will be collected where substantial sediment is present among the wood debris for chemical analysis. One sample will be collected from sediment within the wood-waste column portion of each core, if present. If encountered, the upper 1 ft of native sediment beneath a well defined wood-waste horizon will be combined into one sample for analysis. If a well defined wood waste horizon is not present, then the interval will be collected from the the zone immediately below the lowest observed wood waste. Both core aliqouts will be analyzed for sediment conventionals and the full suite of select COPCs (Table 4-3). Visual observations and descriptions of wood waste encountered within the core will be made in the field as cores are sectioned into samples. Description will include, at a minimum, color, odor (if present), measurement of accumulation and degree of decomposition of wood waste, presence and enumeration of biota, and wood-waste type. Wood-waste type will generally follow descriptions used in the Port Angeles Harbor Wood Waste Study (SAIC 1999), and are noted on the field form in Appendix B.

4.1.3 Sediment Toxicity Bioassays

Bioassays will be conducted to identify locations of acute and chronic toxicity of Harbor sediments to sensitive test organisms. These short-term toxicity indicators will enable the detection of sediment impairment in key areas, and provide initial weight of evidence data needed per SMS criteria for future cleanup and restoration activity. Samples will be collected from the Areas of Concern (Figures 4-4, 4-5, and 4-7) based on identification of potential sources and the need to spatially characterize the Harbor. Toxicity tests to be conducted include amphipod mortality, juvenile polychaete growth, and larvae development bioassays. To ensure data comparability, standard EPA test species were chosen based on toxicity testing conducted in previous Harbor and Puget Sound investigations. It is acknowledged that all the test species are not necessarily sensitive to the full suite of Harbor COPCs. For instance, polychaetes and amphipods are not affected by PCBs and dioxins due to their unique physiology. However, bivalve and echinoderm larvae do not have this restriction and have been shown to be highly sensitive to most contaminants (Pers comm. Brian Hester, May 28, 2008). Details on the toxicity testing methodology are provided in Section 6.2.

As mentioned previously, confirmed toxicity in the bioassays will be used to help determine when and where chemistry for archived sediments will be analyzed. Archived sediment samples specifically chosen for analysis may include both the sediment sample co-located with the bioassay and sediment collected from adjacent sample locations further out into the Harbor.

4.1.4 Tissue Samples

Tissue from species of macroalgae (kelp and/or eelgrass), shellfish (clams), and fish (lingcod) will be analyzed for potential tissue residues of bioaccumulative compounds found in sediments. Clam tissue samples will be comprised of either horse clams (*Tresus spp*.) or geoducks (*Panopea spp*.), whichever is present, and will be collected from intertidal/subtidal areas within the Harbor and reference locations within Dungeness Bay (Figures 4-4, 4-5, and 4-8). Kelp (*Order Laminariales*) and/or eelgrass (*Zostera spp*.), and lingcod (*Ophiodon verrucosa*) will be collected from intertidal and subtidal areas of the Harbor, depending on the target species. These particular species were chosen for several reasons: 1) they represent and span various levels of the marine food web, 2) they are long-lived, 3) they are likely ecological receptors of bioaccumulative sediment contaminants, and 4) for clams and lingcod, they are likely consumed by humans. Further, macroalgae were chosen to sample as there are few data on contaminant levels in this very important food item for waterfowl and some mammals. Lingcod is a top-level predator species with fidelic territorial hunting grounds that spends its life cycle in association with benthic sediments. They are prey for higher level predators and may be sources of bio-magnification of contaminants to those receptors. Therefore, lingcod can provide a direct measure of bioaccumulative risk from contaminants. Lingcod and each of the other species are good receptors on which to model direct and indirect human health and ecological risk (see Appendix D).

Lingcod samples will consist of two whole fish and two fillet samples. Clams and macroalgae will be composited whole for analysis. For clams, whole body tissue will include visceral cavity material, meat, gut ball, as well as the siphon/mantle. Tissue samples will be analyzed for SVOCs, chlorinated pesticides, metals, dioxin/furans compounds, and coplanar dioxin-like polychlorinated biphenyl (PCB) congeners. The chemical analyte list, analytical methods, target detection limits, and comparative criteria are discussed in Section 6.0.

A summary of each sample location, including analytes and rationale for each data type to be collected, is given in Tables 4-3 and 4-4. The data collection methods are described in Section 5.0.

Table 4-3 Sample Location Summary for Harbor-wide Study

Sample ID[1]	Description	TOC Grain Size	SVOC	Resin Compound	Pesticide	PCB[2]	Dioxin/ Furan	NWTPH-HCID	Organotin	Metal	Hg	Sulfide/ Ammonia	Bioassay
Ediz Hook Point													
EH01A	Surface	X	A					X		A	X		
EH02A	Surface	X	A					X		A	X	X	X
EH03A	Surface	X	A					X		A	X		
EH04A	Surface	X	A							A	X		
Fish Pen Area													
FP01A	Surface	X	A		A	A	A	X		A	X	X	X
FP02A	Surface	X	A		A	A	A	X		A	X		
FP03A	Surface	X	A		A	A	A	X		A	X		
Barge Area													
BA01A	Surface	X	A					X		A	X	X	X
BA02A	Surface	X	A					X		A	X		
Inner Hook Area													
IE01A	Surface	X	A	A		A	A	X		A	X	X	
IE01B	Subsurface	X	X	X		X	X	X		X	X	X	
IE01C	Subsurface	X	X	X		A	A	X		X	X	X	
IE02A	Surface	X	A	A		A	A			A	X	X	X
IE03A	Surface	X	A	A		A	A	X		A	X	X	X
IE04A	Surface	X	A	A		A	A	X		A	X	X	X
IE05A	Surface	X	A	A		A	A	X		A	X	X	
IE05B	Subsurface	X	X	X		X	X	X		X	X	X	
IE05C	Subsurface	X	X	X		A	A	X		X	X	X	
IE06A	Surface	X	A	A		A	A	X		A	X	X	X
IE07A	Surface	X	A	A		A	A	X		A	X	X	X
IE08A	Surface	X	A	A		A	A	X		A	X	X	
IE09A	Surface	X	A	A		A	A	X		A	X	X	X

Table 4-3 Sample Location Summary for Harbor-wide Study

Sample ID[1]	Description	TOC Grain Size	SVOC	Resin Compound	Pesticide	PCB[2]	Dioxin/ Furan	NWTPH-HCID	Organotin	Metal	Hg	Sulfide/ Ammonia	Bioassay
IE09B	Subsurface	X	X	X		X	X	X		X	X	X	
IE09C	Subsurface	X	X	X		A	A	X		X	X	X	
IE10A	Surface	X	A	A		A	A			A	X	X	
IE11A	Surface	X	A	A		A	A			A	X	X	
IE12A	Surface	X	A	A		A	A			A	X	X	
IE12B	Subsurface	X	X	X		X	X			X	X	X	
IE12C	Subsurface	X	X	X		A	A			X	X	X	
IE13A	Surface	X	A	A		A	A			A	X	X	
IE14A	Surface	X	A	A		A	A			A	X	X	X
IE14B	Subsurface	X	X	X		X	X			X	X	X	
IE14C	Subsurface	X	X	X		A	A			X	X	X	
IE15A	Surface	X	A	A		A	A			A	X	X	X
IE16A	Surface	X	A	A		A	A			A	X	X	
IE16B	Subsurface	X	X	X		X	X			X	X	X	
IE16C	Subsurface	X	X	X		A	A			X	X	X	
IE17TH	Clam Tissue		X			X	X			X	X		
IE18TH	Clam Tissue		X			X	X			X	X		
IE19TH	Clam Tissue		X			X	X			X	X		
IE20TH	Clam Tissue		X			X	X			X	X		
IE21TL	Fish Tissue		X			X	X			X	X		
IE22TL	Fish Tissue		X			X	X			X	X		
IE23TL	Fish Tissue		X			X	X			X	X		
IE24TL	Fish Tissue		X			X	X			X	X		
IE25TM	Macroalgae		X			X	X			X	X		
IE26TM	Macroalgae		X			X	X			X	X		

Table 4-3 Sample Location Summary for Harbor-wide Study

Sample ID[1]	Description	TOC Grain Size	SVOC	Resin Compound	Pesticide	PCB[2]	Dioxin/ Furan	NWTPH-HCID	Organotin	Metal	Hg	Sulfide/ Ammonia	Bioassay
Lagoon Area													
LA01A	Surface	X	X	X	X	X	X	X		X	X	X	
LA02A	Surface	X	A	A	A	A	A	X		A	X	X	X
LA02B	Subsurface	X	X	X	X	X	X	X		X	X	X	
LA02C	Subsurface	X	X	X	X	X	X	X		X	X	X	
LA03A	Surface	X	A	A	A	A	A	X		A	X	X	
Inner Harbor Area													
IH01A	Surface	X	A	A		A	A	X		A	X	X	X
IH02A	Surface	X	A	A		A	A	X		A	X	X	X
IH02B	Subsurface	X	X	X		X	X	X		X	X	X	
IH02C	Subsurface	X	X	X		X	X	X		X	X	X	
IH03A	Surface	X	A	A		A	A	X		A	X	X	X
IH04A	Surface	X	A	A		A	A	X		A	X	X	
IH05A	Surface	X	A	A		A	A	X		A	X	X	X
IH06A	Surface	X	A	A		A	A	X		A	X	X	X
IH06B	Subsurface	X	X	X		X	X	X		X	X	X	
IH06C	Subsurface	X	X	X		X	X	X		X	X	X	
Marina Area													
MA01A	Surface	X	A	A		A	A		X	A	X	X	X
MA02A	Surface	X	A	A		A	A	X	X	A	X	X	X
MA02B	Subsurface	X	X	X		X	X	X		X	X		
MA02C	Subsurface	X	X	X		X	X	X		X	X		
MA03A	Surface	X	A	A		A	A			A	X		
MA04A	Surface	X	A	A		A	A			A	X		
MA05A	Surface	X	A	A		A	A			A	X	X	X
MA06A	Surface	X	A	A		A	A			A	X	X	X

Table 4-3 Sample Location Summary for Harbor-wide Study

Sample ID[1]	Description	TOC Grain Size	SVOC	Resin Compound	Pesticide	PCB[2]	Dioxin/ Furan	NWTPH-HCID	Organotin	Metal	Hg	Sulfide/ Ammonia	Bioassay
MA06B	Subsurface	Radioisotope Dating Analysis											
Boat Launch Area													
BL01A	Surface	X	A		A	A	A	X	X	A	X	X	X
BL02A	Surface	X	X	X	X	X	X	X	X	X	X	X	X
BL02B	Subsurface	X	X	X	X	X	X			X	X	X	
BL02C	Subsurface	X	X	X	X	X	X			X	X	X	
BL03A	Surface	X	A	A		A	A	X	X	A	X	X	X
BL04A	Surface	X	A			A	A	X	X	A	X	X	X
BL05A	Surface	X	A	A		A	A			A	X		
BL06A	Surface	X	A			A	A			A	X	X	X
BL07A	Surface	X	A			A	A			A	X		
BL08A	Surface	X	A	A		A	A			A	X	X	
BL08B	Subsurface	X	X	X			X			X	X		
BL08C	Subsurface	X	X	X			X			X	X		
K-Ply/Valley Creek Area													
KP01A	Surface	X	A	A	A	A	X	X		A	X	X	X
KP02A	Surface	X	A	A	A	A	A	X	X	A	X	X	X
KP02B	Subsurface	X	X	X	X	X	X	X	X	X	X		
KP02C	Subsurface	X	X	X	A	A	A	X	X	X	X		
KP03A	Surface	X	X	X	X	X	X	X		X	X	X	X
KP03B	Subsurface	X	X	X	X	X	X	X		X	X		
KP03C	Subsurface	X	X	X	A	A	A	X		X	X		
KP04A	Surface	X	X	X	X	A	X			X	X		
KP05A	Surface	X	A	A	A	A	A		X	A	X	X	X
KP06A	Surface	X	A	A	A	A	A			A	X	X	X
KP07A	Surface	X	X	X	X	X	X		X	X	X		

Table 4-3 Sample Location Summary for Harbor-wide Study

Sample ID[1]	Description	TOC Grain Size	SVOC	Resin Compound	Pesticide	PCB[2]	Dioxin/ Furan	NWTPH-HCID	Organotin	Metal	Hg	Sulfide/ Ammonia	Bioassay
KP07B	Subsurface	X	X	X	X	X	X			X	X		
KP07C	Subsurface	X	X	X	A	A	A			X	X		
KP08A	Surface	X	A	A	A	X	A		X	A	X		
KP08B	Subsurface	X	X	X	X	X	X			X	X	X	
KP08C	Subsurface	X	X	X	A	A	A			X	X	X	
Landing Pier (Ferry Terminal) Area													
FT01A	Surface	X	X	A	X	X	X	X		X	X	X	X
FT02A	Surface	X	X	A	X	X		X		X	X		
FT03A	Surface	X	X	A	X	X		X		X	X	X	X
FT04A	Surface	X	X	X	X	X	X	X		X	X	X	X
FT04B	Subsurface	X	X	A	X	X		X		X	X		
FT04C	Subsurface	X	X	A	X	X		X		X	X		
FT05A	Surface	X	A	A	A	A				A			
FT06A	Surface	X	A	A	A	A	A			A	X	X	X
FT06B	Subsurface	X	X	A		X				X	X		
FT06C	Subsurface	X	X	A		X				X	X		
FT07A	Surface	X	A	A	A	A				A			
FT08A	Surface	X	A	A	A	A				A			
FT09A	Surface	X	A	A	A	A				A			
FT10A	Surface	X	A	A	A	A	A			A			
FT11A	Surface	X	A	A	A	A				A	X	X	X
FT12A	Surface	X	A	A	A	A				A	X		
FT12B	Subsurface	X	X	A	X					X	X		
FT12C	Subsurface	X	X	A	X					X	X		
FT13A	Surface	X	X	X	X	X	X	X		X	X		

Table 4-3 Sample Location Summary for Harbor-wide Study

Sample ID[1]	Description	TOC Grain Size	SVOC	Resin Compound	Pesticide	PCB[2]	Dioxin/ Furan	NWTPH-HCID	Organotin	Metal	Hg	Sulfide/ Ammonia	Bioassay
Red Lion Inn													
RL01A	Surface	X	A		A	A	A	X		A	X	X	X
RL02A	Surface	X	A		A	A	A	X		A	X	X	X
RL03A	Surface	X	A		A	A	A			A	X		
RL03B	Subsurface	Radioisotope Dating Analysis											
RL04TG	Clam Tissue		X		X	X	X			X	X		
Eastern Intertidal/Subtidal Areas													
EI01A	Surface	X	X		X	X				X	X	X	
EI02A	Surface	X	X		X	X	X			X	X	X	X
EI02B	Subsurface	X	X		X	X	A			X	X	X	
EI02C	Subsurface	X	X		X	X	X			X	X	X	
EI03A	Surface	X	X		X	X				X	X	X	
EI04A	Surface	X	X		X	X	X			X	X	X	
EI04B	Subsurface	X	X		X	X	A			X	X	X	
EI04C	Subsurface	X	X		X	X	X			X	X	X	
EI05A	Surface	X	X		X	X				X	X	X	
EI06A	Surface	X	X		X	X				X	X	X	
EI07A	Surface	X	X		X	X	X			X	X	X	X
EI07B	Subsurface	X	X		X	X	A			X	X	X	
EI07C	Subsurface	X	X		X	X	X			X	X	X	
EI08TH	Clam Tissue		X		X	X	X			X	X		
Port Angeles Waste Water Treatment Plant Outfall													
WW01A	Surface	X	A		A		X	X		A	X	X	X
Outer Harbor Area													
OH01A	Surface	X	X	X		X	X	X		X	X	X	
OH02A	Surface	X	X	X		X	X	X		X	X	X	X

Table 4-3 Sample Location Summary for Harbor-wide Study

Sample ID[1]	Description	TOC Grain Size	SVOC	Resin Compound	Pesticide	PCB[2]	Dioxin/ Furan	NWTPH-HCID	Organotin	Metal	Hg	Sulfide/ Ammonia	Bioassay
OH03A	Surface	X	X	X		X	X	X		X	X	X	
Reference Samples (Dungeness Bay)													
RF01A	Surface	X	X	X	X	X	X	X	X	X	X	X	X
RF02A	Surface	X	X	X	X	X	X	X	X	X	X	X	X
RF03A	Surface	X	X	X	X	X	X	X	X	X	X	X	X
RF04TH	Clam Tissue		X		X	X	X			X	X		
RF05TH	Clam Tissue		X		X	X	X			X	X		
RF06TG	Clam Tissue		X		X	X	X			X	X		

1 Refer to Tables 5-1 and 6-1 through 6-3 for actual analytical methods, detection limits, and analyte list. Refer to Section 5.5 for sample ID convention. The tissue sample identification will be determined in the field, based on the actual clam species collected.

2 Tissue samples will be analyzed for the 12 coplaner dioxin-like PCB congeners.

Key:

X	=	analyzed
A	=	archived
B	=	Interval to be determined in field whether analyzed or archived
HCID	=	hydrocarbon identification
Hg	=	mercury
NWTPH	=	Northwest total petroleum hydrocarbon
PCB	=	polychlorinated biphenyl
Pesticide	=	chlorinated pesticides
Resin Compound	=	retene, guaiacol, chlorinated guaiacols, and resin acids
SVOCs	=	semivolatile organic compounds
TOC	=	total organic carbon

Table 4-4 Sample Rationale Summary for Harbor-wide Investigation

Sample ID[1]	Description	Sample Justification[2]
Ediz Hook Point		
EH01A	Surface	Characterization of surface sediments potentially impacted by historical fuel releases at U.S. Coast Guard station on Ediz Hook. Provide data for spatial distribution of contaminants in northeast part of Harbor.
EH02A	Surface	
EH03A	Surface	
EH04A	Surface	
Fish Pen Area		
FP01A	Surface	Characterization of surface sediments potentially impacted by fuel releases on Ediz Hook and from aquaculture (fish pen) operations.
FP02A	Surface	
FP03A	Surface	
Barge Area		
BA01A	Surface	Characterization of surface sediments potentially impacted by fuel releases from barge operations. Provide data for spatial distribution of contamination in central part of Harbor.
BA02A	Surface	
Inner Hook Area		
IE01A	Surface	Characterization of surface sediments potentially impacted by fuel releases from Ediz Hook, creosote-coated pilings, and submerged wood waste and debris.
IE01B,C	Subsurface	Vertical delineation of depth/thickness of wood waste and debris. Characterization of subsurface sediments potentially impacted by fuel releases from Ediz Hook and creosote-coated pilings.
IE02A	Surface	Characterization of surface sediments potentially impacted by fuel releases from Ediz Hook, creosote-coated pilings, and submerged wood waste and debris.
IE03A	Surface	
IE04A	Surface	
IE05A	Surface	
IE05B,C	Subsurface	Vertical delineation of depth/thickness of wood waste and debris. Characterization of subsurface sediments potentially impacted by fuel releases from Ediz Hook and creosote-coated pilings.
IE06A	Surface	Characterization of surface sediments potentially impacted by fuel releases from Ediz Hook, creosote-coated pilings, and submerged wood waste and debris.
IE07A	Surface	
IE08A	Surface	
IE09A	Surface	

Table 4-4 Sample Rationale Summary for Harbor-wide Investigation

Sample ID[1]	Description	Sample Justification[2]
IE09B,C	Subsurface	Vertical delineation of depth/thickness of wood waste and debris. Characterization of subsurface sediments potentially impacted by fuel releases from Ediz Hook and creosote-coated pilings.
IE10A	Surface	Characterization of surface sediments potentially impacted by fuel releases from Ediz Hook, creosote-coated pilings, and submerged wood waste and debris.
IE11A	Surface	
IE12A	Surface	
IE12B,C	Subsurface	Vertical delineation of depth/thickness of wood waste and debris. Characterization of subsurface sediments potentially impacted by fuel releases from Ediz Hook and creosote-coated pilings.
IE13A	Surface	Characterization of surface sediments potentially impacted by fuel releases from Ediz Hook, creosote-coated pilings, and submerged wood waste and debris. Provide data for spatial distribution of contamination in central part of Harbor.
IE14A	Surface	
IE14B,C	Subsurface	Vertical delineation of depth/thickness of wood waste and debris. Characterization of subsurface sediments potentially impacted by fuel releases from Ediz Hook and creosote-coated pilings.
IE15A	Surface	Characterization of surface sediments potentially impacted by fuel releases from Ediz Hook, creosote-coated pilings, and submerged wood waste and debris. Provide data for spatial distribution of contamination in central part of Harbor.
IE16A	Surface	
IE16B,C	Subsurface	Vertical delineation of depth/thickness of wood waste and debris. Characterization of subsurface sediments potentially impacted by fuel releases from Ediz Hook and creosote-coated pilings.
IE17TH	Clam Tissue	Characterization of potential uptake of contaminants from sediment to clam tissue. Provide tissue data for human health and ecological risk assessments.
IE18TH	Clam Tissue	
IE19TH	Clam Tissue	
IE20TH	Clam Tissue	
IE21TL	Fish Tissue	Characterization of potential uptake of contaminants from sediment to fish tissue. Provide tissue data for human health and ecological risk assessments.
IE22TL	Fish Tissue	
IE23TL	Fish Tissue	
IE24TL	Fish Tissue	
IE25TM	Macroalgae	Characterization of potential uptake of contaminants from sediment to macroalgae. Provide data for ecological risk assessment.
IE26TM	Macroalgae	
Lagoon Area		
LA01A	Surface	Characterization of surface sediments potentially impacted by wood waste and industrial/urban runoff.
LA02A	Surface	

Table 4-4 Sample Rationale Summary for Harbor-wide Investigation

Sample ID[1]	Description	Sample Justification[2]
LA02B,C	Subsurface	Vertical delineation of depth/thickness of wood waste and debris. Characterization of subsurface sediments potentially impacted by wood waste and industrial/urban runoff.
LA03A	Surface	Characterization of surface sediments potentially impacted by wood waste and industrial/urban runoff.
Inner Harbor Area		
IH01A	Surface	Characterization of surface sediments potentially impacted by wood waste, historical operations at paper and lumber facilities (Nippon, M&R Timber, Fibreboard), historical operations at ship building and dock facilities (Graving Dock), former combined sewer outfalls, and creosote-coated pilings.
IH02A	Surface	
IH02B,C	Subsurface	Vertical delineation of depth/thickness of wood waste and debris. Characterization of subsurface sediments potentially impacted by historical operations at paper and lumber facilities (Nippon, M&R Timber, Fibreboard), historical operations at ship building and dock facilities (Graving Dock), and former combined sewer outfalls.
IH03A	Surface	Characterization of surface sediments potentially impacted by wood waste, historical operations at the Graving Dock, M&R Timber and Fibreboard, former combined sewer outfalls, and creosote-coated pilings.
IH04A	Surface	
IH05A	Surface	Characterization of surface sediments potentially impacted by wood waste, historical operations at Fibreboard, former combined sewer outfalls, and creosote-coated pilings.
IH06A	Surface	
IH06B,C	Subsurface	Vertical delineation of depth/thickness of wood waste and debris. Characterization of subsurface sediments potentially impacted by historical operations at paper and lumber facilities (Nippon, M&R Timber, Fibreboard), historical operations at ship building and dock facilities (Graving Dock), and former combined sewer outfalls.
Marina Area		
MA01A	Surface	Characterization of surface sediments potentially impacted by fuel spills, boat refurbishing/maintenance activities, and wood waste.
MA02A	Surface	
MA02B,C	Subsurface	Characterization of subsurface sediments potentially impacted by fuel spills, boat refurbishing/maintenance activities, and wood waste.
MA03A	Surface	Characterization of surface sediments potentially impacted by fuel spills, boat refurbishing/maintenance activities, and wood waste.
MA04A	Surface	
MA05A	Surface	
MA06A	Surface	Characterization of surface sediments potentially impacted by fuel spills, boat refurbishing/maintenance activities, and wood waste. Provide data for spatial distribution of contaminants in central part of Harbor.
MA06B	Subsurface	Characterization of sediment age/deposition rates in western part of Harbor.

Table 4-4 Sample Rationale Summary for Harbor-wide Investigation

Sample ID[1]	Description	Sample Justification[2]
Boat Launch Area		
BL01A	Surface	Characterization of surface sediments potentially impacted by fuel releases, urban runoff, boat operations, and outfall of Tumwater Creek.
BL02A	Surface	
BL02B,C	Subsurface	Characterization of subsurface sediments potentially impacted by fuel releases, urban runoff, boat operations, and outfall of Tumwater Creek.
BL03A	Surface	Characterization of surface sediments potentially impacted by fuel releases, urban runoff, boat operations, and historical marine vessel decommissioning.
BL04A	Surface	
BL05A	Surface	
BL06A	Surface	Characterization of surface sediments potentially impacted by fuel releases, urban runoff, and boat operations. Provide data for spatial distribution of contaminants in central part of Harbor.
BL07A	Surface	Characterization of surface sediments potentially impacted by fuel releases, urban runoff, boat operations, and historical marine vessel decommissioning.
BL08A	Surface	Characterization of surface sediments potentially impacted by fuel releases, urban runoff, and boat operations. Provide data for spatial distribution of contaminants in central part of Harbor.
BL08B,C	Subsurface	Characterization of surface sediments potentially impacted by fuel releases, urban runoff, and boat operations. Provide data for spatial distribution of contaminants in central part of Harbor.
K-Ply/Valley Creek Area		
KP01A	Surface	Characterization of surface sediments potentially impacted by fuel spills, creosote-coated pilings, urban runoff, Valley Creek outfall, and historical operations at K-Ply.
KP02A	Surface	
KP02B,C	Subsurface	Vertical delineation of depth/thickness of wood waste and debris. Characterization of subsurface sediments potentially impacted by fuel spills, creosote-coated pilings, urban runoff, Valley Creek outfall, and historical operations at K-Ply.
KP03A	Surface	Characterization of surface sediments potentially impacted by fuel spills, creosote-coated pilings, urban runoff, Valley Creek outfall, and historical operations at K-Ply.
KP03B,C	Subsurface	Characterization of subsurface sediments potentially impacted by fuel spills, creosote-coated pilings, urban runoff, Valley Creek outfall, and historical operations at K-Ply.
KP04A	Surface	Characterization of surface sediments potentially impacted by fuel spills, creosote-coated pilings, urban runoff, and historical operations at K-Ply.
KP05A	Surface	
KP06A	Surface	Characterization of surface sediments potentially impacted by fuel spills, urban runoff, and historical operations at K-Ply. Provide data for spatial distribution of contaminants in central part of Harbor.
KP07A	Surface	

Table 4-4 Sample Rationale Summary for Harbor-wide Investigation

Sample ID[1]	Description	Sample Justification[2]
KP07B,C	Subsurface	Characterization of subsurface sediments potentially impacted by fuel spills, creosote-coated pilings, urban runoff, Valley Creek outfall, and historical operations at K-Ply.
KP08A	Surface	Characterization of surface sediments potentially impacted by fuel spills, urban runoff, and historical operations at K-Ply. Provide data for spatial distribution of contaminants in central part of Harbor.
KP08B,C	Subsurface	Characterization of subsurface sediments potentially impacted by fuel spills, creosote-coated pilings, urban runoff, Valley Creek outfall, and historical operations at K-Ply.
Landing Pier (Ferry Terminal) Area		
FT01A	Surface	Characterization of surface sediments potentially impacted by fuel spills, marine vessel operations, urban runoff, and active combined sewer outfall #6.
FT02A	Surface	
FT03A	Surface	
FT04A	Surface	Characterization of surface sediments potentially impacted by urban runoff, Peabody Creek outfall, and active combined sewer outfalls #7 and 8.
FT04B,C	Subsurface	Characterization of subsurface sediments potentially impacted by urban runoff, Peabody Creek outfall, and active combined sewer outfalls.
FT05A	Surface	Characterization of surface sediments potentially impacted by fuel spills and marine vessel operations.
FT06A	Surface	
FT06B,C	Subsurface	Characterization of subsurface sediments potentially impacted by urban runoff, Peabody Creek outfall, and active combined sewer outfalls. Provide data for spatial distribution of contaminants in central part of Harbor.
FT07A	Surface	Characterization of surface sediments potentially impacted by fuel spills and marine vessel operations.
FT08A	Surface	Characterization of surface sediments potentially impacted by fuel spills, marine vessel operations, and urban runoff. Provide data for spatial distribution of contaminants in central part of Harbor.
FT09A	Surface	Characterization of surface sediments potentially impacted by fuel spills, marine vessel operations, urban runoff, and active combined sewer outfalls.
FT10A	Surface	
FT11A	Surface	
FT12A	Surface	Characterization of surface sediments potentially impacted by fuel spills, marine vessel operations, and urban runoff. Provide data for spatial extent of contaminants in central part of Harbor.
FT12B,C	Subsurface	Characterization of subsurface sediments potentially impacted by urban runoff, Peabody Creek outfall, and active combined sewer outfalls.
FT13A	Surface	Characterization of surface sediments potentially impacted by fuel spills, marine vessel operations, and urban runoff. Provide data for spatial extent of contaminants in central part of Harbor.

Table 4-4 Sample Rationale Summary for Harbor-wide Investigation

Sample ID[1]	Description	Sample Justification[2]
Red Lion Inn		
RL01A	Surface	Characterization of surface sediments potentially impacted by adjacent sources and urban runoff. May characterize surface sediments potentially impacted by active combined sewer outfall #10. Provide data for potential human health exposure to sediment contaminants as these samples (specifically RL01 and RL02) are intended to be collected in the intertidal zone near Hollywood Beach that is used heavily by the public.
RL02A	Surface	
RL03A	Surface	
RL03B	Subsurface	Characterization of sediment age/deposition rates in southeastern portion of Harbor.
RL04TG	Clam Tissue	Characterization of potential uptake of contaminants from sediment to clam tissue. Provide tissue data for human health and ecological risk assessments.
Eastern Intertidal/Subtidal Areas		
EI01A	Surface	Characterization of surface sediments potentially impacted by urban runoff. Provide data for human health and ecological risk assessments.
EI02A	Surface	
EI02B,C	Subsurface	Characterization of subsurface sediments potentially impacted by urban runoff.
EI03A	Surface	Characterization of surface sediments potentially impacted by urban runoff. Provide data for human health and ecological risk assessments.
EI04A	Surface	
EI04B,C	Subsurface	Characterization of subsurface sediments potentially impacted by urban runoff.
EI05A	Surface	Characterization of surface sediments potentially impacted by urban runoff. Provide data for human health and ecological risk assessments.
EI06A	Surface	Characterization of surface sediments potentially impacted by urban runoff. Provide data for human health and ecological risk assessments.
EI07A	Surface	
EI07B,C	Subsurface	Characterization of subsurface sediments potentially impacted by urban runoff.
EI08TH	Clam Tissue	Characterization of potential uptake of contaminants from sediment to clam tissue. Provide tissue data for human health and ecological risk assessments.
City of Port Angeles Waste Water Treatment Plant		
WW01A	Surface	Characterization of surface sediments potentially impacted by on-going waste water discharges from deep water outfall.
Outer Harbor Area		
OH01A	Surface	Provide data for spatial extent of contaminants in eastern part of Harbor.
OH02A	Surface	
OH03A	Surface	

Table 4-4 Sample Rationale Summary for Harbor-wide Investigation

Sample ID[1]	Description	Sample Justification[2]
Reference Samples (Dungeness Bay)		
RF01A	Surface	Quantification of reference surface sediment contaminant concentrations.
RF02A	Surface	
RF03A	Surface	
RF04TH	Clam Tissue	Quantification of reference tissue contaminant concentrations.
RF05TH	Clam Tissue	
RF06TG	Clam Tissue	

1 Refer to Section 5 for sample identification process to be used by the sampling team.

2 All samples will be analyzed for grain size and total organic carbon.

4.2 Rayonier Area Investigation Study Design

This section describes the study design for the former Rayonier Mill area. This portion of the study is intended to fill data gaps that remain following Rayonier MRI efforts conducted in 2002 and 2006, as documented in Ecology's letter to Rayonier dated January 9, 2008. Accordingly, the Rayonier Area Investigation study design is a focused plan to better define the horizontal and vertical extent of mill-related contaminants in Port Angeles Harbor. Sample stations and identification codes are presented in Figure 4-2a.

4.2.1 Surface Sediment Samples

Surface (0 to 10 cm deep) sediment samples will be collected at the log pond, the mill dock area, east of the mill dock area, at the former Rayonier outfalls, at and near the mouth of Ennis Creek, and in the former deepwater outfall area (Figure 4-9). Surface sediment samples will be analyzed for conventional parameters and sediment COPCs as identified in the MRI reports (Malcolm Pirnie 2007a and b). Additionally, PCBs and petroleum hydrocarbons will be analyzed in sediment samples collected at and near the mouth of Ennis Creek, the outfalls, and the mill dock area to characterize potential impacts from historical PCB and petroleum releases into Ennis Creek adjacent to the former mill. Sediment toxicity bioassays will also be run on selected samples in these areas and in the deepwater outfall area (see Section 4.2.3). Tables 4-5 and 4-6 summarize the sample analytical parameters and collection rationale.

4.2.2 Subsurface Sediment Cores

Subsurface sediment core samples will be collected at all surface sediment sample stations as identified in Figure 4-9. Cores collected to characterize the vertical distribution of contamination at Ennis Creek, east of Ennis Creek, outfalls, and east of Mill Dock will be 4 ft in length, while cores collected within the Log Pond and Mill Dock areas will be up to 12 ft in length depending on potential depth of refusal. For all cores, the surface layer of 0-6 in will not be analyzed; however, the co-located surface grab sample will be immediately analysed for the full suite of COPCs for the particular location. Subsurface sediment samples will be analyzed for conventional parameters and sediment COPCs as identified in the MRI reports (Malcolm Pirnie 2007a and b). PCBs and petroleum hydrocarbons will additionally be analyzed in samples collected at and near the mouth of Ennis Creek, the outfalls, and the mill dock area to characterize potential impacts from historical PCB and petroleum releases into Ennis Creek adjacent to the former mill. Archeological monitoring will be conducted on all cores located in water less than 50 ft in depth in accordance with the methodology described in Appendix G. Tables 4-5 and 4-6 summarize the sample analytical parameters and rationale for collection for the subsurface sediment and wood-waste samples.

4.2.2.1 Cores at or near Ennis Creek

The objective of collecting subsurface sediment samples at sample stations at Ennis Creek and east of Ennis Creek is to characterize the potential historical (buried) contaminants from mill operations and contributions over time to the Harbor from upstream sources along Ennis Creek. The 4-ft cores will be sectioned into vertical horizons as follows: 1) 6 in to 1 ft, 2) 1 to 2 ft, 3) 2 to 3 ft, and 4) 3 to 4 ft. Based on sampler judgment of sediment conditions observed within the core, two of the four core intervals will be selected for chemical analysis. Criteria to be used by the sampling crew to determine sediment intervals for laboratory analysis are described in Section 5.3.2.

4.2.2.2 Nearshore Outfalls

Subsurface sediment samples will be collected from the nearshore outfall locations to characterize potential buried mill-related contaminants that were discharged historically from the outfalls. The 4-ft cores will be sectioned into vertical horizons as follows: 1) 6 in to 1 ft, 2) 1 to 2 ft, 3) 2 to 3 ft, and 4) 3 to 4 ft. Based on sampler judgment of sediment conditions observed within the core, one of the four core intervals will be selected for chemical analysis.

4.2.2.3 Deepwater Outfalls

The objective of subsurface sediment sampling at locations in the former deepwater outfall area is to characterize potential buried mill-related contaminants from historical discharges from the deepwater outfall. The 4-ft cores will be sectioned into vertical horizons as follows: 1) 6 in to 1 ft, 2) 1 to 2 ft, 3) 2 to 3 ft, and 4) 3 to 4 ft. Each of the four intervals collected in this area will be analyzed, for a total of four samples per core location.

4.2.2.4 Log Pond and Mill Dock Cores

The objective of taking subsurface cores in the log pond and mill dock areas is to further delineate the vertical depth of wood waste in these areas. Cores will be advanced to the bottom of the wood waste as possible, or to a maximum depth of 12 ft. Two samples will be collected per core. One sample will be collected from the wood-waste column (based on sampler judgment), and one at the native sediment surface beneath the wood waste, if encountered. For wood-waste column samples, a minimum 1-ft interval will be collected where substantial sediment is present among the wood debris for chemical analysis. If encountered, the upper 1 ft of native sediment beneath the wood-waste will be composited into one sample and analyzed for sediment conventionals and COPCs. Visual observations and descriptions of wood waste encountered within the core will be made in the field as cores are sectioned into samples. Description is to include, at a minimum, color, odor (if present), measurement of accumulation and degree of decomposition of wood waste, presence and enumeration of biota, and wood-waste type. Wood-waste type will generally follow descriptions used in the Port Angeles Harbor Wood Waste Study (SAIC 1999), and are noted on the field form in Appendix B.

4.2.3 Sediment Toxicity Bioassays

Bioassays will be conducted to further identify locations of acute and chronic toxicity of sediments near the former mill site to sensitive test organisms. The following areas have been identified as needing further toxicity testing: the Mill Dock, east of the Mill Dock, nearshore outfalls, the deepwater outfall, and at the mouth of Ennis Creek. A total of fifteen bioassays will be conducted as depicted in Figure 4-9.

Bioassays will be performed using the same species and methodology as described in Section 4.1.3.

4.2.4 Tissue Samples

Bivalve tissue samples will be collected from a total of nine collection areas as illustrated in Figure 4-9. Tissue samples will comprise either horse clams or geoducks, whichever are present. Bivalves will be collected from intertidal areas adjacent to the log pond and at the mouth of Ennis Creek. Bivalves will also be collected from subtidal areas adjacent to the west side of the mill dock (Figure 4-9). Bivalves will be composited from each collection area.

The tissue samples will be analyzed for bioaccumulative contaminants of concern, including PCB congeners, PAHs, metals, and dioxins/furans. Samples collected from the mouth of Ennis Creek, east of Ennis Creek, at the nearshore outfalls, and from the log pond will also be analyzed for pesticides to characterize potential impacts from urban runoff to Harbor biota. Tables 4-5 and 4-6 summarize the sample analytical parameters and rationale for tissue sample collection.

A summary of each sample location, including analytes and rationale for each data type to be collected, is given in Tables 4-5 and 4-6. The data collection methods are described in Section 5.0.

Table 4-5 Sample Location Summary for Rayonier Area Investigation

Sample ID[1]	Description	TOC Grain Size	SVOC	Resin Compound	Pesticide	PCB[2]	Dioxin/ Furan	NWTPH-HCID	Organotin	Metal	Hg	Sulfide/ Ammonia	Bioassay
Log Pond													
LP01A	Surface	X	X	X			X			X	X	X	
LP01B	Subsurface	X	X	X								X	
LP01C	Subsurface	X	X	X			X			X	X	X	
LP02A	Surface	X	X	X			X			X	X	X	
LP02B	Subsurface	X	X	X								X	
LP02C	Subsurface	X	X	X			X			X	X	X	
LP03A	Surface	X	X	X			X			X	X	X	
LP03B	Subsurface	X	X	X								X	
LP03C	Subsurface	X	X	X			X			X	X	X	
LP04A	Surface	X	X	X			X			X	X	X	
LP04B	Subsurface	X	X	X								X	
LP04C	Subsurface	X	X	X			X			X	X	X	
LP05A	Surface	X	X	X			X			X	X	X	
LP05B	Subsurface	X	X	X								X	
LP05C	Subsurface	X	X	X			X			X	X	X	
LP06TH/G	Clam Tissue		X		X	X	X			X	X		
LP07TH/G	Clam Tissue		X		X	X	X			X	X		
LP08TH/G	Clam Tissue		X		X	X	X			X	X		
Mill Dock													
MD01A	Surface	X	X	X		X	X	X		X	X	X	X
MD01B	Subsurface	X	X	X		X	X	X				X	
MD01C	Subsurface	X	X	X		X	X	X		X	X	X	
MD02A	Surface	X	X	X		X	X	X		X	X	X	X
MD02B	Subsurface	X	X	X		X	X	X				X	

Table 4-5 Sample Location Summary for Rayonier Area Investigation

Sample ID[1]	Description	TOC Grain Size	SVOC	Resin Compound	Pesticide	PCB[2]	Dioxin/ Furan	NWTPH-HCID	Organotin	Metal	Hg	Sulfide/ Ammonia	Bioassay
MD02C	Subsurface	X	X	X		X	X	X		X	X	X	
MD03A	Surface	X	X	X		X	X	X		X	X	X	X
MD03B	Subsurface	X	X	X		X	X	X				X	
MD03C	Subsurface	X	X	X		X	X	X		X	X	X	
MD04A	Surface	X	X	X		X	X	X		X	X	X	
MD04B	Subsurface	X	X	X		X	X	X				X	
MD04C	Subsurface	X	X	X		X	X	X		X	X	X	
MD05A	Surface	X	X	X		X	X	X		X	X	X	
MD05B	Subsurface	X	X	X		X	X	X				X	
MD05C	Subsurface	X	X	X		X	X	X		X	X	X	
MD06TH/G	Clam Tissue		X			X	X			X	X		
MD07TH/G	Clam Tissue		X			X	X			X	X		
MD08TH/G	Clam Tissue		X			X	X			X	X		
East of Mill Dock													
ED01A	Surface	X	X			X	X	X		X	X	X	
ED01B	Subsurface	X	X			X	X	X		X	X		
ED01C	Subsurface	X	X			X	X	X		X	X		
ED02A	Surface	X	X			X	X	X		X	X	X	
ED02B	Subsurface	X	X			X	X	X		X	X		
ED02C	Subsurface	X	X			X	X	X		X	X		
ED03A	Surface	X	X			X	X	X		X	X	X	X
ED03B	Subsurface	X	X			X	X	X		X	X		
ED03C	Subsurface	X	X			X	X	X		X	X		
ED04A	Surface	X	X			X	X	X		X	X	X	X
ED04B	Subsurface	X	X			X	X	X		X	X		
ED04C	Subsurface	X	X			X	X	X		X	X		

Table 4-5 Sample Location Summary for Rayonier Area Investigation

Sample ID[1]	Description	TOC Grain Size	SVOC	Resin Compound	Pesticide	PCB[2]	Dioxin/ Furan	NWTPH- HCID	Organotin	Metal	Hg	Sulfide/ Ammonia	Bioassay
ED05A	Surface	X	X			X	X	X		X	X	X	X
ED05B	Subsurface	X	X			X	X	X		X	X		
ED05C	Subsurface	X	X			X	X	X		X	X		
Outfalls													
CO01A	Surface	X	X	X	X	X	X	X		X	X	X	X
CO01B	Subsurface	X	X	X	X	X	X	X		X	X		
CO02A	Surface	X	X	X	X	X	X	X		X	X	X	X
CO02B	Subsurface	X	X	X	X	X	X	X		X	X		
CO03A	Surface	X	X	X	X	X	X	X		X	X	X	
CO03B	Subsurface	X	X	X	X	X	X	X		X	X		
CO04A	Surface	X	X	X	X	X	X	X		X	X	X	X
CO04B	Subsurface	X	X	X	X	X	X	X		X	X		
CO05A	Surface	X	X	X	X	X	X	X		X	X	X	
CO05B	Subsurface	X	X	X	X	X	X	X		X	X		
Deep Outfall													
DO01A	Surface	X	X	X			X			X	X	X	
DO01B	Subsurface	X	X	X						X	X	X	
DO01C	Subsurface	X	X	X			X			X	X	X	
DO01D	Subsurface	X	X	X						X	X	X	
DO01E	Subsurface	X	X	X			X			X	X	X	
DO02A	Surface	X	X	X			X			X	X	X	
DO02B	Subsurface	X	X	X						X	X	X	
DO02C	Subsurface	X	X	X			X			X	X	X	
DO02D	Subsurface	X	X	X						X	X	X	
DO02E	Subsurface	X	X	X			X			X	X	X	
DO03A	Surface	X	X	X			X			X	X	X	X

Table 4-5 Sample Location Summary for Rayonier Area Investigation

Sample ID[1]	Description	TOC Grain Size	SVOC	Resin Compound	Pesticide	PCB[2]	Dioxin/ Furan	NWTPH-HCID	Organotin	Metal	Hg	Sulfide/ Ammonia	Bioassay
DO03B	Subsurface	X	X	X						X	X	X	
DO03C	Subsurface	X	X	X			X			X	X	X	
DO03D	Subsurface	X	X	X						X	X	X	
DO03E	Subsurface	X	X	X			X			X	X	X	
DO04A	Surface	X	X	X			X			X	X	X	X
DO04B	Subsurface	X	X	X						X	X	X	
DO04C	Subsurface	X	X	X			X			X	X	X	
DO04D	Subsurface	X	X	X						X	X	X	
DO04E	Subsurface	X	X	X			X			X	X	X	
DO05A	Surface	X	X	X			X			X	X	X	X
DO05B	Subsurface	X	X	X						X	X	X	
DO05C	Subsurface	X	X	X			X			X	X	X	
DO05D	Subsurface	X	X	X						X	X	X	
DO05E	Subsurface	X	X	X			X			X	X	X	
Ennis Creek													
EC01A	Surface	X	X	X	X	X	X	X		X	X	X	X
EC01B	Subsurface	X	X			X	X	X		X	X		
EC01C	Subsurface	X	X	X	X	X	X	X		X	X	X	
EC02A	Surface	X	X	X	X	X	X	X		X	X	X	X
EC02B	Subsurface	X	X			X	X	X		X	X		
EC02C	Subsurface	X	X	X	X	X	X	X		X	X	X	
EC03A	Surface	X	X	X	X	X	X	X		X	X	X	
EC03B	Subsurface	X	X			X	X	X		X	X		
EC03C	Subsurface	X	X	X	X	X	X	X		X	X	X	
EC04A	Surface	X	X	X	X	X	X	X		X	X	X	X
EC04B	Subsurface	X	X			X	X	X		X	X		

Table 4-5 Sample Location Summary for Rayonier Area Investigation

Sample ID[1]	Description	TOC Grain Size	SVOC	Resin Compound	Pesticide	PCB[2]	Dioxin/ Furan	NWTPH-HCID	Organotin	Metal	Hg	Sulfide/ Ammonia	Bioassay
EC04C	Subsurface	X	X	X	X	X	X	X		X	X	X	
EC05A	Surface	X	X	X	X	X	X	X		X	X	X	
EC05B	Subsurface	X	X			X	X	X		X	X		
EC05C	Subsurface	X	X	X	X	X	X	X		X	X	X	
EC06TH/G	Clam Tissue		X		X	X	X			X	X		
EC07TH/G	Clam Tissue		X		X	X	X			X	X		
EC08TH/G	Clam Tissue		X		X	X	X			X	X		
East of Ennis Creek													
EE01A	Surface	X	X		X	X	X	X		X	X		
EE01B	Subsurface	X	X		X	X	X	X		X	X		
EE01C	Subsurface	X	X		X	X	X	X		X	X		
EE02A	Surface	X	X		X	X	X	X		X	X		
EE02B	Subsurface	X	X		X	X	X	X		X	X		
EE02C	Subsurface	X	X		X	X	X	X		X	X		
EE03A	Surface	X	X		X	X	X	X		X	X		
EE03B	Subsurface	X	X		X	X	X	X		X	X		
EE03C	Subsurface	X	X		X	X	X	X		X	X		
EE04A	Surface	X	X		X	X	X	X		X	X		
EE04B	Subsurface	X	X		X	X	X	X		X	X		
EE04C	Subsurface	X	X		X	X	X	X		X	X		
EE05A	Surface	X	X		X	X	X	X		X	X		
EE05B	Subsurface	X	X		X	X	X	X		X	X		

Table 4-5 Sample Location Summary for Rayonier Area Investigation

Sample ID[1]	Description	TOC Grain Size	SVOC	Resin Compound	Pesticide	PCB[2]	Dioxin/ Furan	NWTPH-HCID	Organotin	Metal	Hg	Sulfide/ Ammonia	Bioassay
EE05C	Subsurface	X	X		X	X	X	X		X	X		

[1] Refer to Tables 5-1 and 6-1 through 6-3 for actual analytical methods, detection limits, and analyte list. Refer to Section 5.5 for Sample ID convention. The tissue samples identification will be determined in the field, based on the actual clam species collected.

[2] Tissue samples will be analyzed for the 12 coplaner dioxin-like PCB congeners.

Key:

X	=	analyzed
HCID	=	hydrocarbon identification
Hg	=	mercury
NWTPH	=	Northwest total petroleum hydrocarbon
PCB	=	polychlorinated biphenyl compounds
Pesticide	=	chlorinated pesticides
Resin Compound	=	retene, guaiacol, chlorinated guaiacols, and resin acids
SVOCs	=	semivolatile organic compounds
TOC	=	total organic carbon

Table 4-6 Sample Rationale Summary for Rayonier Area Investigation

Sample ID[1]	Description	Sample Justification[2]
Log Pond		
LP01A	Surface	Characterization of surface sediment/wood waste potentially impacted by historical log rafting and mill waste water discharges. LP01 may characterize surface sediments potentially impacted by active CSO #10. For subsurface layers, delineation of depth/thickness and characterization of wood waste.
LP01B,C	Subsurface	
LP02A	Surface	
LP02B,C	Subsurface	
LP03A	Surface	
LP03B,C	Subsurface	
LP04A	Surface	
LP04B,C	Subsurface	
LP05A	Surface	
LP05B,C	Subsurface	
LP06TH/G	Clam Tissue	Characterization of potential uptake of contaminants from sediment to clam tissue. Provide tissue data for human health and ecological risk assessments.
LP07TH/G	Clam Tissue	
LP08TH/G	Clam Tissue	
Mill Dock		
MD01A	Surface	Characterization of surface sediments potentially impacted by wood waste, historical mill dock operations and mill waste water discharges. For subsurface layers, delineation of depth/thickness and characterization of wood waste.
MD01B,C	Subsurface	
MD02A	Surface	
MD02B,C	Subsurface	
MD03A	Surface	
MD03B,C	Subsurface	
MD04A	Surface	
MD04B,C	Subsurface	
MD05A	Surface	
MD05B,C	Subsurface	

Table 4-6 Sample Rationale Summary for Rayonier Area Investigation

Sample ID[1]	Description	Sample Justification[2]
MD06TH/G	Clam Tissue	Characterization of potential uptake of contaminants from sediment to clam tissue. Provide tissue data for human health and ecological risk assessments.
MD07TH/G	Clam Tissue	
MD08TH/G	Clam Tissue	
East of Mill Dock		
ED01A	Surface	Characterization of surface sediments potentially impacted by wood waste, historical mill dock operations and mill waste water discharges. For subsurface layers, delineation of depth/thickness and characterization of wood waste.
ED01B,C	Subsurface	
ED02A	Surface	
ED02B,C	Subsurface	
ED03A	Surface	
ED03B,C	Subsurface	
ED04A	Surface	
ED04B,C	Subsurface	
ED05A	Surface	
ED05B,C	Subsurface	
Outfalls		
CO01A	Surface	Characterization of surface and subsurface sediments potentially impacted by historical mill waste water discharges.
CO01B	Subsurface	
CO02A	Surface	
CO02B	Subsurface	
CO03A	Surface	
CO03B	Subsurface	
CO04A	Surface	
CO04B	Subsurface	
CO05A	Surface	
CO05B	Subsurface	

Table 4-6 Sample Rationale Summary for Rayonier Area Investigation

Sample ID[1]	Description	Sample Justification[2]
Deep Outfall		
DO01A	Surface	Characterization of surface and subsurface sediments potentially impacted by historical deep water outfall waste water discharges.
DO01B,C,D,E	Subsurface	
DO02A	Surface	
DO02B,C,D,E	Subsurface	
DO03A	Surface	
DO03B,C,D,E	Subsurface	
DO04A	Surface	
DO04B,C,D,E	Subsurface	
DO05A	Surface	
DO05B,C,D,E	Subsurface	
Ennis Creek		
EC01A	Surface	Characterization of surface and subsurface sediments potentially impacted by historical fuel and PCB releases from mill site into Ennis Creek, and urban runoff.
EC01B,C	Subsurface	
EC02A	Surface	
EC02B,C	Subsurface	
EC03A	Surface	
EC03B,C	Subsurface	
EC04A	Surface	
EC04B,C	Subsurface	
EC05A	Surface	
EC05B,C	Subsurface	
EC06TH/G	Clam Tissue	Characterization of potential uptake of contaminants from sediment to clam tissue. Provide tissue data for human health and ecological risk assessments.
EC07TH/G	Clam Tissue	
EC08TH/G	Clam Tissue	

Table 4-6 Sample Rationale Summary for Rayonier Area Investigation

Sample ID[1]	Description	Sample Justification[2]
East of Ennis Creek		
EE01A	Surface	Characterization of surface and subsurface sediments potentially impacted by historical fuel and PCB releases from mill site into Ennis Creek, and urban runoff.
EE01B,C	Subsurface	
EE02A	Surface	
EE02B,C	Subsurface	
EE03A	Surface	
EE03B,C	Subsurface	
EE04A	Surface	
EE04B,C	Subsurface	
EE05A	Surface	
EE05B,C	Subsurface	

[1] Refer to Section 5 for sample identification process to be used by the sampling team.

[2] All samples will be analyzed for grain size and total organic carbon.

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N
W E
S

0 495 990 1,980 2,970 3,960 4,950 5,940

Feet

Scale 1:24,000

Figure 4-1

Port Angeles Harbor, Washington

Areas of Concern with Historical and Proposed Sampling Locations in Port Angeles Harbor

source: ecology & environment, inc., 3/10/2008 ...\port_angeles_sta\fig 4-1 proposed sampling area.mxd

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N S W E

0 500 1,000 2,000 3,000 4,000 5,000 6,000

Feet

Scale 1:24,000

Figure 4-2

Port Angeles Harbor, Washington

Harbor-wide Proposed Sample Locations

source: ecology & environment, inc., 4/8/2008 ...\port_angeles_sta\fig4-2 proposed sample locs.mxd

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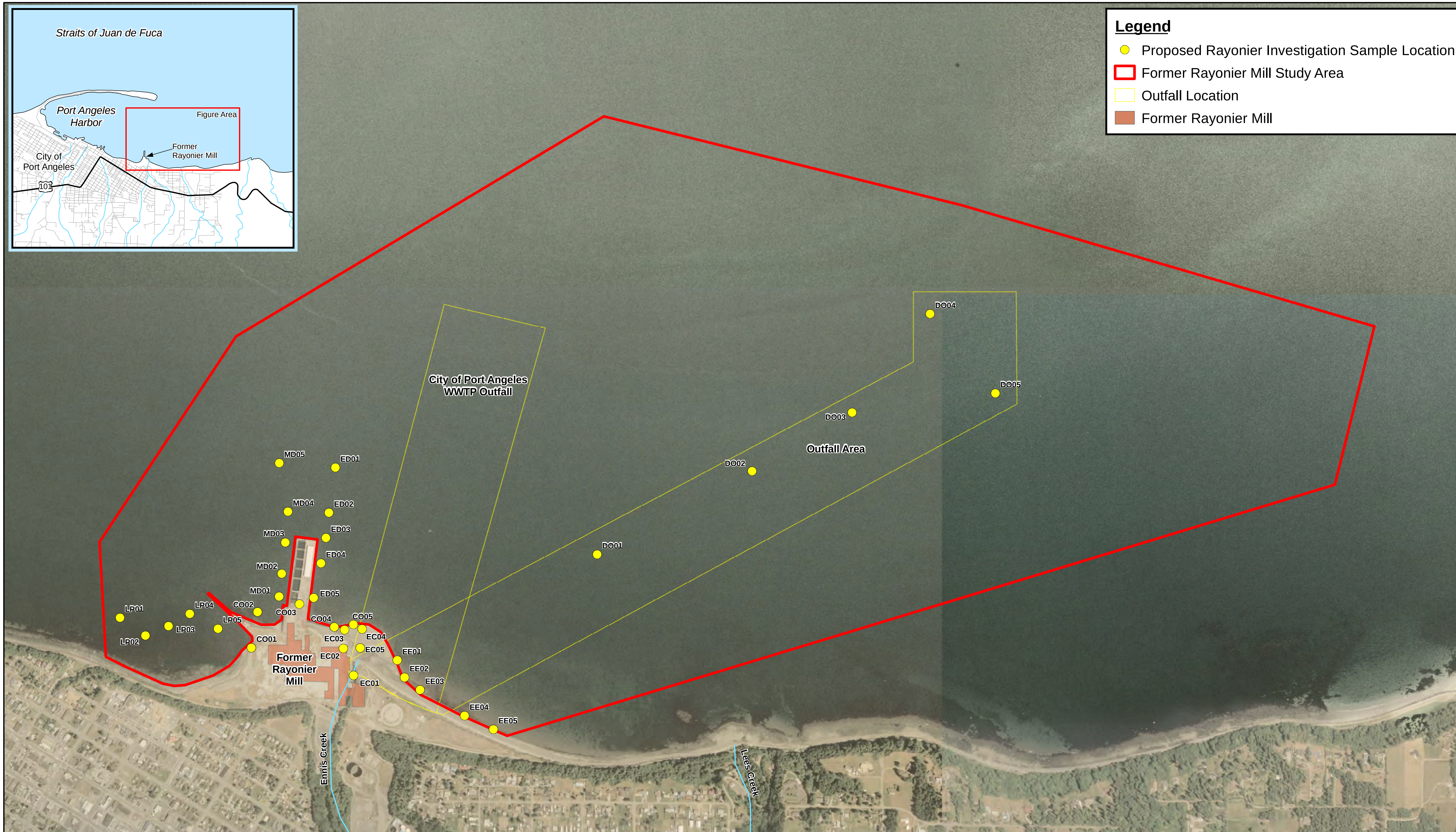

N
W E
S

0 250 500 1,000 1,500 2,000 2,500 3,000
Feet

Scale 1:12,000

Figure 4-2a

Port Angeles Harbor, Washington

Former Rayonier Mill Study Area and Proposed Sample Locations

source: ecology & environment, inc., 4/8/2008 ...\port_angeles_sta\fig 4-2a proposed sample locs-rayonier.mxd

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N W E S

0 500 1,000 2,000 3,000 4,000 5,000
Feet
Scale 1:18,000

Figure 4-3

Port Angeles Harbor, Washington

Harbor-wide Surface Sediment Chemistry Sample Locations

source: ecology & environment, inc., 3/10/2008 ...\port_angeles_sta\harbor_non-archived_chem_samples.mxd

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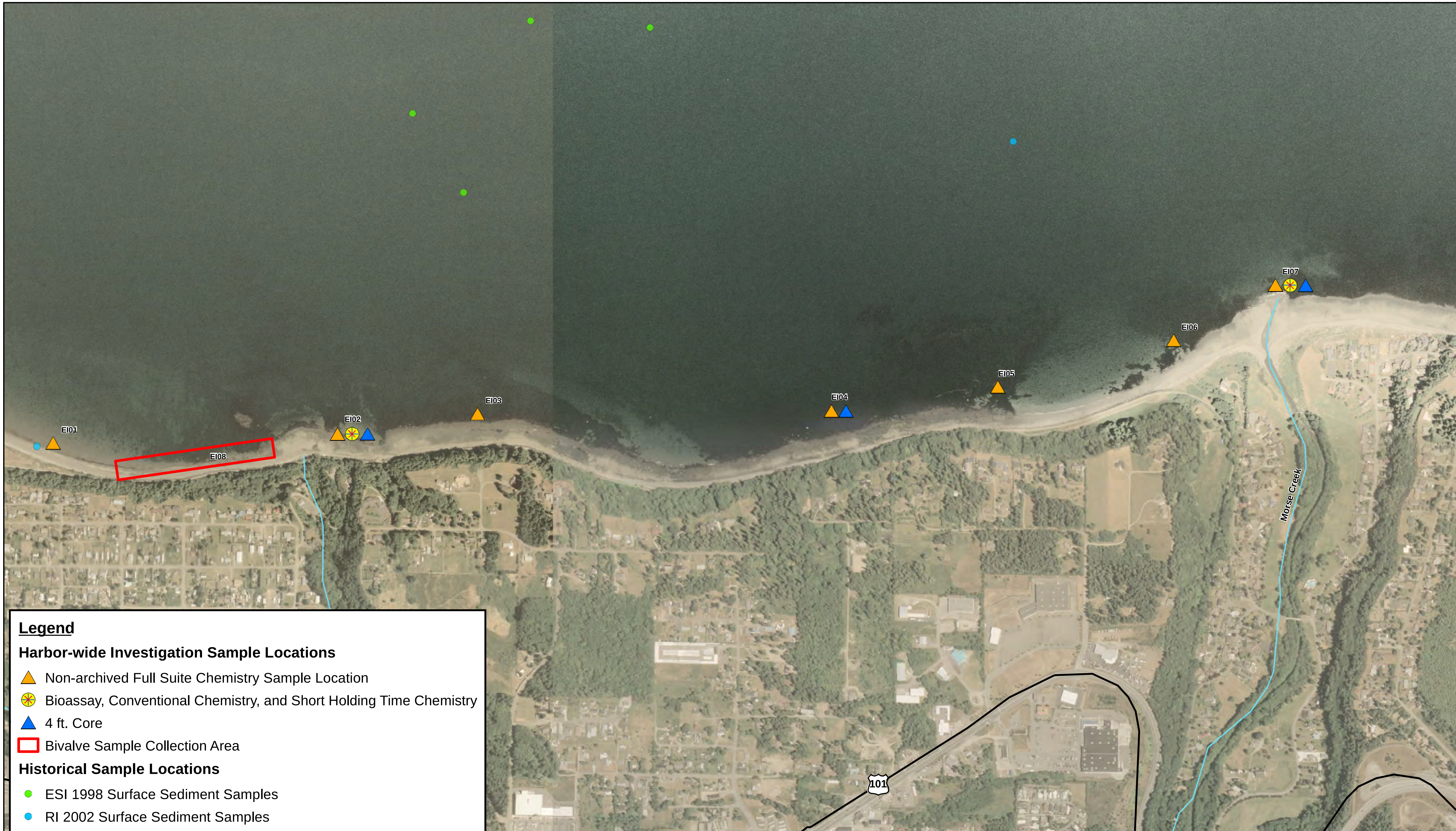

N W E S

0 250 500 1,000 1,500 2,000 2,500 3,000
Feet

Scale 1:10,000

Figure 4-4

Port Angeles Harbor, Washington

Eastern Intertidal/Subtidal Sample Locations

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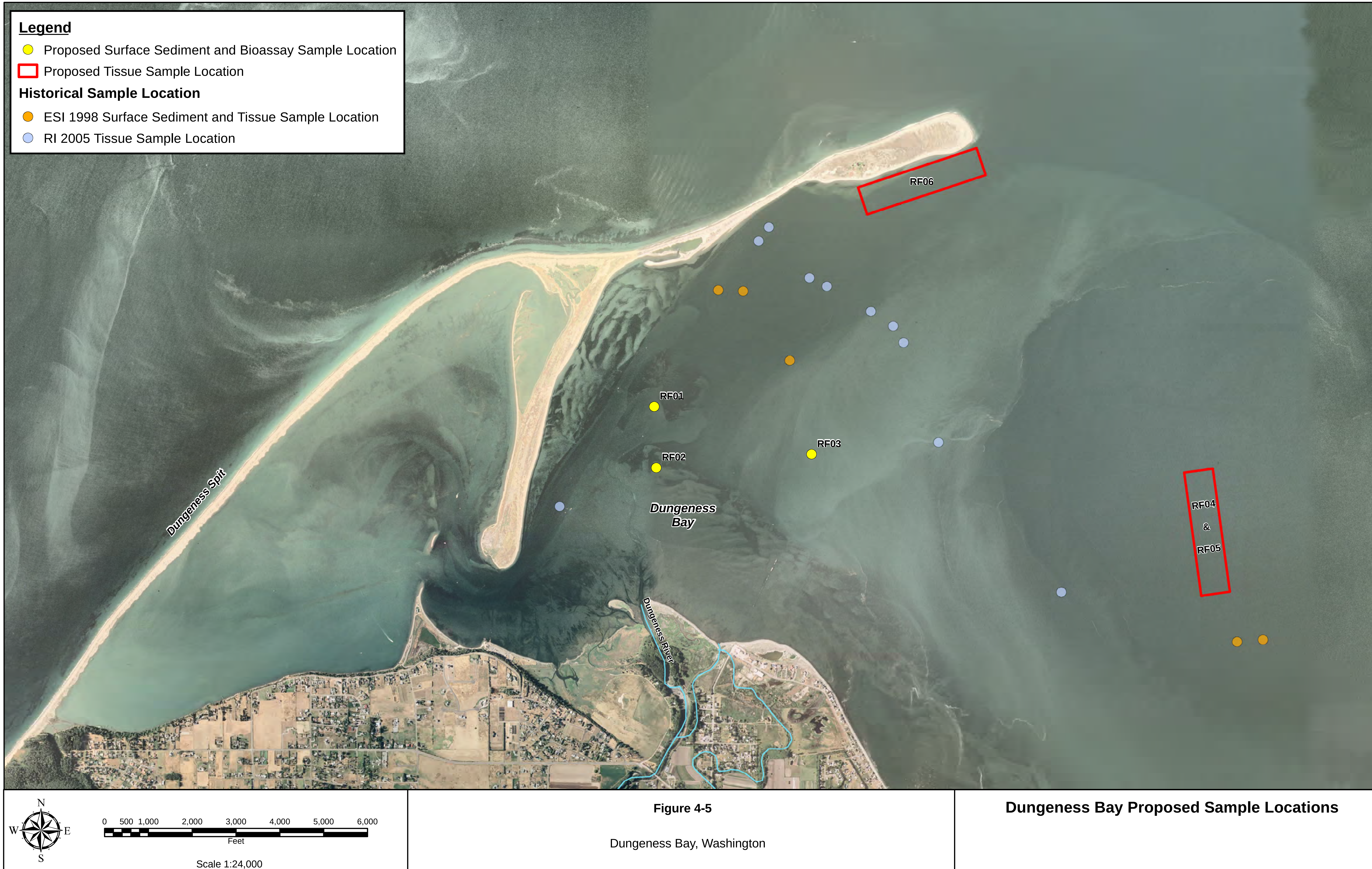

Figure 4-5

Dungeness Bay, Washington

Dungeness Bay Proposed Sample Locations

source: ecology & environment, inc., 4/8/2008 ...\port_angeles_sta\fig4-2 proposed sample locs.mxd

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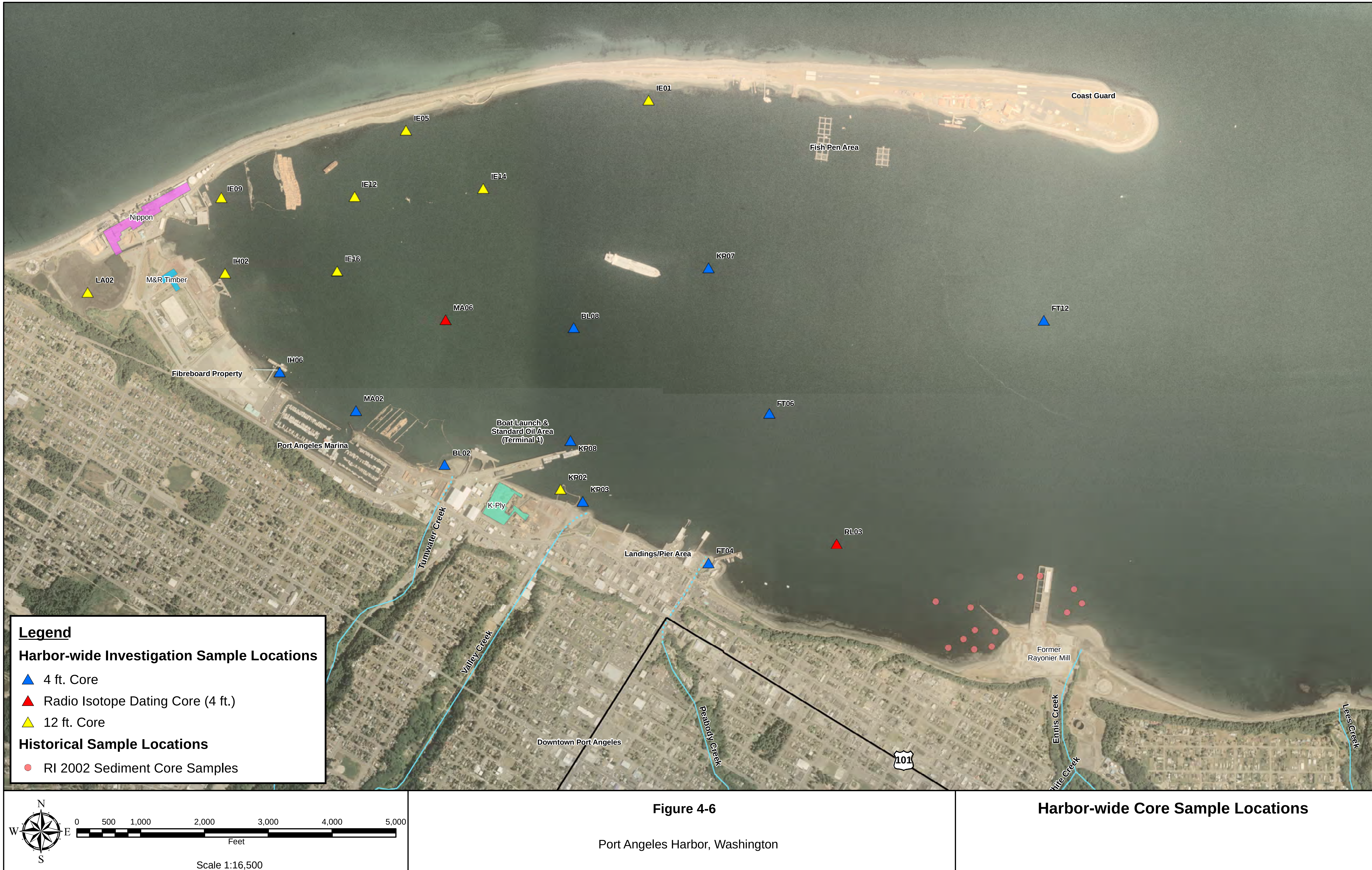

Figure 4-6

Port Angeles Harbor, Washington

Harbor-wide Core Sample Locations

source: ecology & environment, inc., 3/10/2008 ...\port_angeles_sta\harbor_core_samples.mxd

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N
W E
S

0 375 750 1,500 2,250 3,000 3,750 4,500 5,250
Feet

Scale 1:18,000

Figure 4-7

Port Angeles Harbor, Washington

Harbor-wide Sediment Bioassay and Initial Chemistry Sample Locations

source: ecology & environment, inc., 3/10/2008 ...\port_angeles_sta\fig 4-7 harbor_bioassay_initial_chem_samples.mxd

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Figure 4-8

Port Angeles Harbor, Washington

Harbor-wide Tissue Sample Locations

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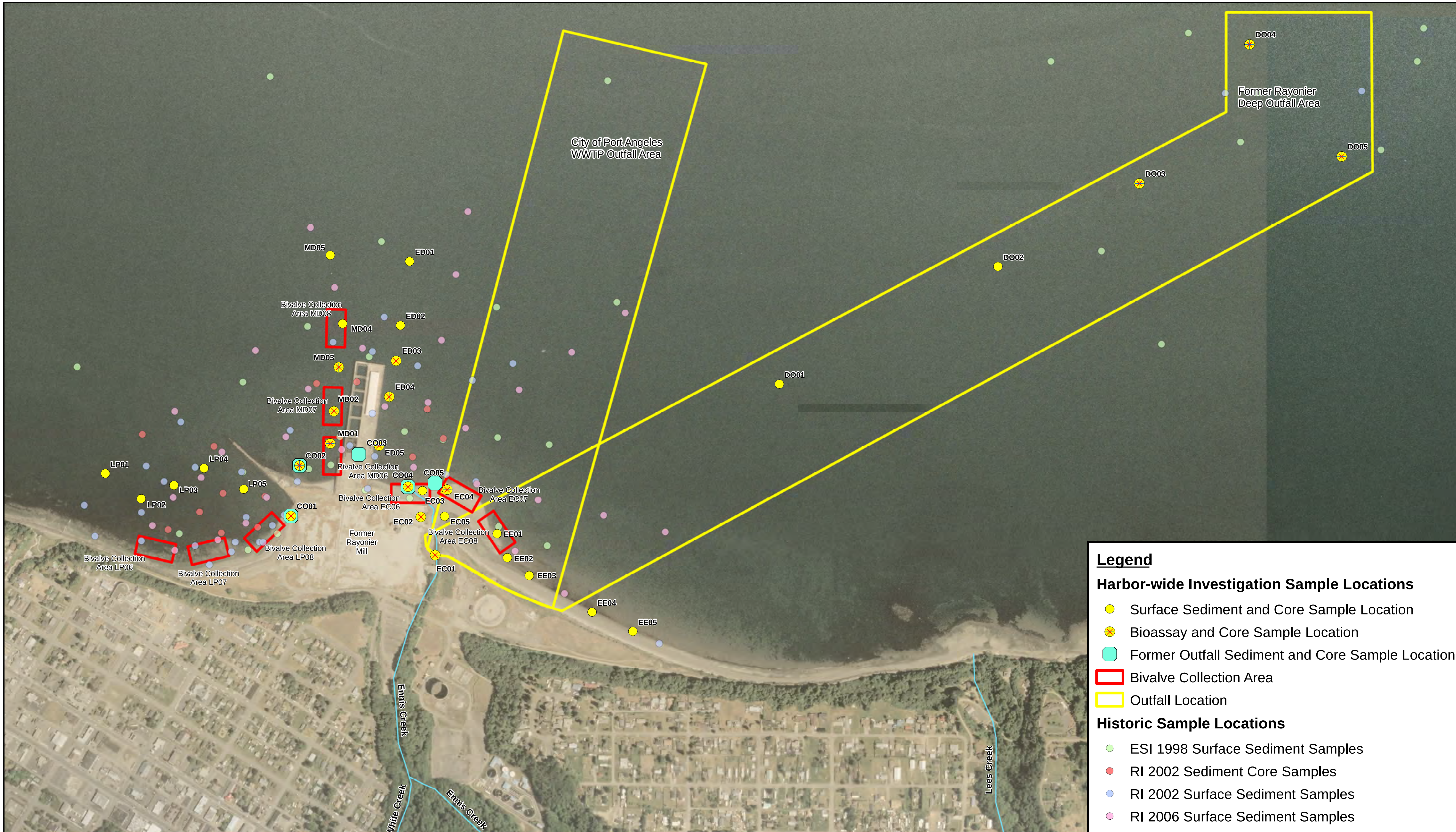

N S E W

0 250 500 1,000 1,500 2,000 2,500

Feet

Scale 1:8,500

Figure 4-9

Port Angeles Harbor, Washington

Rayonier Mill Area Sample Locations

source: ecology & environment, inc., 4/8/2008 ...\port_angeles_sta\historical samp locs - rayonier.mxd

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5.0 Sampling and Handling Methods

This section describes the methodology for positioning, sample collection, processing, identification, documentation, equipment decontamination, and investigation-derived waste handling for the field investigation. The laboratory methods for chemical analysis, toxicity testing, and radioisotope analysis are presented in Section 6.0.

5.1 Sampling Platforms

Two types of vessels will be used for the surface and subsurface sediment collection. A 32 ft x 10 ft shallow-draft landing craft will be used for grab sediment samples and a 24 to 28 ft research vessel for core collection. Tissue samples will be collected in cooperation with the Lower Elwha Klallam Tribe (LEKT). The Tribe will collect clam and fish tissue samples based on their local knowledge of the Harbor using divers for clam collections and to spear fish for lingcod. Either E & E or LEKT personnel will collect macroalgae tissue using hand harvesting methods. E & E personnel will accompany the LEKT during all tissue collection activities.

5.2 Station Positioning and Navigation

A differential global positioning system (DGPS) will be used for station positioning for all vessel sediment sampling stations. The vessels will have navigation equipment that provides accurate station positioning and assures that sample stations and water depths are accurately recorded. The DGPS receiver will be capable of surveying positions accurate to within 2 meters (m). For manually-collected samples, a hand-held GPS unit with Wide Area Augmentation System (WAAS) will be used to record the sampling station coordinates. Accuracy of the WAAS-enabled GPS unit will be within 3 m. Horizontal coordinates will be referenced to the Washington State Plane coordinate system under the North American Datum of 1983 (NAD 83). The vertical datum will be the mean lower low water (MLLW) datum. Vertical control measured by the vessel depth finder will be corrected for tidal influence after field activities are completed.

Before field work is initiated, a control check point such as a dock or piling will be established that can be accessed by the sampling vessel. At the beginning and end of each day, the check point will be surveyed from the vessel and compared to the known coordinates. The control check point position as recorded by the vessel should not differ by more than 2 meters from the land-surveyed coordinates.

For vessel-deployed sampling, the DGPS receiver will be placed above the sampling device deployment boom to accurately record the position of the sampling device. At surface sediment grab stations, once the sampling device has been deployed, the actual position will be recorded when the device reaches the sediment floor and the deployment cable is in a vertical position. At these locations, water depths will be measured directly by lead-line and converted to mudline elevations after correction for tide.

Coordinates of the proposed sampling stations will be programmed as waypoints into the vessel's navigation system and used to guide the vessel to the appropriate locations.

5.3 Sediment Sample Collection

Surface sediment samples will be collected at sampling locations throughout the Harbor, including the Rayonier Area and reference locations. These samples will undergo chemical analysis and toxicity testing. Table 5-1 lists the analytical and biological testing methods, specified holding times, and the sample container, volume, and preservation requirements. The following sections describe collection and processing of surface sediment samples. Detailed sample collection procedures are provided in the standard operating procedures (SOPs) provided in Appendix C.

5.3.1 Surface Sediment Samples

Surface sediment will be collected using either a stainless-steel pneumatic power grab device or a gravity driven dredge, such as a stainless-steel van Veen (modified 0.1 square meters (m^2)) (1.1 square feet (ft^2)), or similar grab device. If accessible during low tide events, surface sediment samples from intertidal areas may be collected directly with stainless-steel spoons and bowls. Up to three grab attempts will be made at each proposed sampling location to achieve the minimum sediment volume needed to perform all necessary analyses specific to each station. If, after three grabs, the minimum sediment volume has not been met, the station will be moved to a new location at the discretion of the field team leader. This new location will be chosen based on similar location characteristics and using best professional judgment. Up to three attempts to re-locate a station will be made. If it is not possible to obtain a successful sample from any of these three locations, the station will be abandoned and the E & E project manager and Ecology will be notified.

Surface sediment samples will be collected from the 0- to 10-cm (0- to 4-in) interval. As detailed above, it may require multiple grabs to obtain an adequate sample volume for all analyses. Compositing and homogenization of samples is described below. Samples will be collected as described in the SOP for surface sediment sampling (Appendix C). Samples will be carefully collected to ensure the following conditions are met, as required by Ecology (2008):

1) Make logbook and field form entries as necessary throughout the sampling process to ensure accurate and thorough record-keeping. (Field documentation is described in Section 5.7.)

2) Position the sampling vessel at the targeted sampling location.

3) Set the sampler jaws in the open position, place the sampler over the edge of the boat, and lower the sampler to the bottom.

4) Trip the sampler to collect the sample.

5) Record the location using the DGPS; measure and record the water depth.

6) Retrieve the sampler and place it securely in the sampling vessel.

7) Examine the sample for the following sample acceptance criteria; if criteria are not achieved, the sample will be rejected and another collection attempt will be made.

    - The sampler is not overfilled with sample in order to prevent the sediment surface from pressing against the top of the sampler.
    - The sample does not contain large foreign objects such as trash or debris. A sample that is rock/gravel fill will be rejected in favor of depositional material (sand/silt/clay).
    - Overlying water is present in the sampler (indicates minimal leakage).
    - The overlying water is not excessively turbid (indicates minimal sample disturbance).
    - The sediment surface is relatively flat (indicates minimum of disturbance or winnowing).
    - The desired penetration depth is achieved (several centimeters more than the targeted sample depth).

8) Siphon off any overlying surface water.

9) Collect samples for total sulfides analysis directly from the grab sampler and place the sediment aliquots in appropriate, pre-cleaned, labeled sample containers (Table 5.1).

10) Measure and collect the top 10 cm (4 in) with a stainless steel spoon, avoiding any sediment that is in contact with the inside surface of the grab sampler, then place the sediment into a stainless steel bowl and cover with aluminum foil.

11) Record the following observations of sediment sample characteristics on the field form (Appendix B); if more sample volume is required repeat steps 3 through 11.
    - Texture
    - Color
    - Biological organisms or structures (for example, shells)
    - Presence of debris (natural or anthropogenic objects)
      For wood debris, characterize using following categories:
        - Logs or large wood pieces
        - Small wood and/or bark chips (wood chips)
        - Very fine wood particles and/or fibers (wood pulp)
        - Trace to sparse wood pulp/chips mixed within the sediment column
        - Sparse, scattered wood pieces on top of the sediment surface
    - Presence of oily sheen or obvious contamination
    - Odor (for example, hydrogen sulfide or petroleum)

12) Wash excess sediment back into the water away from any areas remaining to be sampled.

13) Once sufficient sediment volume has been collected, homogenize the sample by mixing with a stainless steel spoon until a consistent color and texture are achieved. Place sample material in the appropriate, pre-cleaned, labeled sample containers, place in a cooler maintained at 4 ºC, and prepare for shipment to the analytical or biological laboratory as described in Section 5.6.

14) Confirm all relevant documentation has been completed, entries are accurate, and paperwork has been signed.

15) Decontaminate all sampling equipment as described in Section 5.8 before proceeding to the next sampling location.

A matrix spike/matrix spike duplicate (MS/MSD) sample will be collected randomly at the field supervisor's discretion. Aliquots of homogenized sediment will also be collected for toxicity testing at designated locations. The sample types collected from each location are presented in Table 5.1.

Manual sampling methods may be used at locations that are exposed during low tide conditions. The field crew will manually sample sediments by scooping and compositing sediment with stainless steel spoons and bowls. Surface sediment will be collected from the 0 to 10 cm (0 to 4 in) interval. Samples will be collected as described in the SOP for surface sediment sampling (Appendix C).

5.3.2 Subsurface Sediment Collection

Subsurface sediment samples will be collected at and co-located with selected surface sediment location. Core samples will preferably be collected using a 12 ft (3.7 m) vibracorer. As needed, an impact or gravity corer will be employed to facilitate successful sampling. In most cases, the cores will be advanced to a depth of 4 ft (1.2 m) or refusal. In some locations, the cores will be advanced to the maximum depth of 12 ft (3.7 m) to delineate the depth of wood debris. The core sample will be documented and sediment from the first 12 in (30 cm) below the wood debris will be collected for analysis.

Up to three attempts will be made at each proposed sampling location to achieve one successful core with the minimum sediment volume needed to perform all necessary analyses specific to each station. For any 4ft cores where wood waste is unexpectedly encountered, only one attempt will be made to collect a successful 4ft core. Thereafter, a 12ft core tube will be utilized and two more attempts made at that station to obtain a successful 12ft core. Each of the three core attempts will be made within the same general area as mapped on figures (for example, within the Rayonier log pond). If the three attempts are met with core refusal, the core sample will be deemed un-collectable and the station will be abandoned. If it is not possible to obtain a successful sample from a core sample location, the E & E project manager and Ecology will be notified.

The general procedure for collecting sediment cores is as follows:

1) Make logbook and field form entries as necessary throughout the sampling process to ensure accurate and thorough record-keeping. Field documentation is described in Section 5.7.

2) Position the sampling vessel at the targeted sampling location.

3) Record the location using the DGPS; measure and record the water depth.

4) Insert pre-cleaned acetate or lexan or stainless steel core tubes equipped with an "eggshell" core catcher to retain material in the core barrel for deployment.

5) Position the core-sampler vertically on the bottom and advance to a sampling depth of approximately 4 ft (1.2 m) or 12 ft (3.7 m) to include all targeted sampling intervals, or until refusal.

6) Once sampling is complete, extract the sampler and detach the core tube from the core apparatus. Examine the core sample at each end to verify that sufficient sediment was retained. Then inspect the condition and quantity of material within the core to determine acceptability. If sample acceptance criteria are not achieved, reject the sample and make another sample collection attempt.

   - To verify whether an acceptable core sample has been collected the following criteria must be met:
     a) target penetration depth or refusal was achieved;
     b) sediment recovery was at least 65% of the penetration depth;
     c) sample appears undisturbed and intact without any evidence of obstruction or blocking within the core tube or core catcher.

7) Archeological monitoring will be conducted on all cores located in water less than 50ft in depth in accordance with the methodology prescribed in Appendix G.

8) Determine the percent sediment recovery by dividing the length of material recovered in the core tube by the depth of core penetration below mudline. If the sample is deemed acceptable, siphon overlying water from the top of the core tube, and cap and seal each end of the tube with duct tape for storage until processing. The cores will be stored on ice until they are processed. Record the station number, station coordinates, date and time of collection, sediment description, sediment compaction, field crew, and weather conditions in the sediment coring log (Appendix B).

9) Record observations of sediment sample characteristics on the field form (Appendix B); if more sample volume is required repeat steps 4 through 13.

10) Process sediment cores onboard or at a predetermined location onshore, including cores for radioisotope dating. Sediment cores processed onshore will be labeled, capped, and stored in a stable position in a container packed with ice until processed. Cores will be processed as soon as possible and handled with extreme care in order to not mix sediment layers.

11) Confirm all relevant documentation has been completed, entries are accurate, and paperwork has been signed.

12) Wash excess sediment back into the water away from any remaining sample areas.

13) Decontaminate all sampling equipment as described in Section 5.8 before proceeding to the next sampling location.

A single acceptable sample for each subsurface interval will be collected. All sediment cores will be processed (extrusion, documentation, and sample collection for analysis) onboard or at a designated processing location. Disposable nitrile gloves will be worn for all handwork such as sectioning and extruding the core, sub-sampling, mixing samples, and filling sample containers. The gloves will be disposed of between sample composites to prevent cross contamination between samples. Sampling implements and processing equipment will be decontaminated prior to processing the sediment cores. Sediment cores will be processed in the same order as collected to minimize holding time. Each section comprising a core sample will be extruded onto a stainless steel tray using a core sample removal tool (a plunger-style device that pushes the sample through the core tube). Care will be taken to preserve the integrity of the core section strata by extruding in order from top (mudline) to bottom (native material). Once the sediment has been extruded, the sample material will be visually characterized immediately. The core will then be entered in the core log, with the following information and characteristics noted:

- Station number
- Date and time of collection
- Station coordinates
- Weather conditions
- Names of persons collecting and logging the sample
- Penetration depth
- Percent sediment recovery
- Physical soil description in accordance with the Unified Soil Classification System (USCS)
- Color
- Odor (for example, hydrogen sulfide or petroleum)
- Visual stratifications and lenses
- Vegetation and/or woody debris
  Characterize wood debris using the following categories:
  - Logs or large wood pieces
  - Small wood and/or bark chips (wood chips)
  - Very fine wood particles and/or fibers (wood pulp)
  - Trace to sparse wood pulp/chips mixed within the sediment column
  - Sparse, scattered wood pieces on top of the sediment surface
- Biological activity (for example detritus, shells, tubes, bioturbation, live or dead organisms)
- Presence of oil sheen or obvious contamination
- Any other distinguishing characteristics or features

Core intervals that are to be chosen for laboratory analysis based on in-field sampler judgment will use the following criteria to determine which interval(s) will be selected for analysis:

- Assess visual and odor conditions as potential indicators of contamination (for example, visible sheen or strong petroleum odor); select intervals exhibiting obvious signs of contaminant presence
- Assess visual stratifications and lenses; select intervals with higher percent fines

- If wood waste is present in core, select interval(s) directly below wood-waste horizon(s)
- If there is no distinction in the sediments based on the above conditions, then select the uppermost interval and the deepest interval

Representative aliquots of sediment will be collected from the prescribed or sampler selected intervals using decontaminated stainless steel spoons. Samples collected from each core will represent a minimum 1 ft (0.3 m) vertical interval, where possible. Sediment will be collected from the center of the core, where it has not been smeared by, or has come in contact with, the core tube. The volumes removed will be placed in a decontaminated stainless steel bowl or pan and mixed until homogenous in texture and color. After all the sample sediment is collected and homogenized, representative aliquots will be placed in the appropriate, pre-cleaned, labeled sample containers and prepared for shipment to the analytical laboratories.

5.3.3 Radioisotope Cores

Two subsurface cores will be submitted for sedimentation rate and surface mixed layer depth analysis. These cores will be obtained using a gravity corer and the appropriate sampling methods. Each core will be approximately 4 ft (1.2 m) in length, and will be subsampled as follows:

- Section the core in 2 cm (0.8 in) increments to 100 cm (39.4 in) and in 10 cm (3.9 in) increments for the remainder of the core.

- A full 125-ml container of wet sediment will be collected for each sample section, which should provide 100 grams (g) (3.5 ounces (oz)) of dry sediment.

5.4 Tissue Samples

Clam, macroalgae, and lingcod tissue samples will be collected and analyzed from the areas designated in the Inner Hook and Eastern Intertidal areas. Clams will also be collected from Dungeness Bay and near the Former Rayonier Mill. Every effort will be made to collect biota tissue prior to and/or in conjunction with sediment collections to ensure the attainment of co-located samples. The methods for collecting and processing the samples are as follows.

Clams and macroalgae collected for tissue residue analysis will be rinsed with site water following collection. All organisms collected for a composite sample will be included in the same polyethylene bag. All composite sample clams and macroalgae will be placed directly into pre-cleaned sample jars (one per species). Two composite tissue samples of macroalgae will be collected from two locations in the Inner Ediz Hook area. At least 4 lbs of macroalgae material is needed for a composite sample. Total weight and taxonomic identification of the macroalgae sample will be recorded. A minimum of five clams will be collected per composite clam tissue sample. The shell length and weight for each clam retained for analysis will be recorded in the biological sampling log. Clams will be shipped to the analytical laboratory where they will be shucked to collect the soft tissues once received. Tissue for clams will entail all visceral material including gut ball and meat, and the siphon/mantle. The tissue from each sample will be homogenized and analyzed. Processing of tissue will be conducted according to standard protocols (EPA 2000).

Four lingcod will be collected for tissue analysis in the Inner Hook area. Two samples will be whole fish, and the other two samples will consist of one fillet each from two different animals. Each fish will be weighed and measured in the field prior to shipment to laboratory. The samples will be placed in separate polyethylene bags and labeled.

Tissue samples will be immediately placed on ice in coolers in the field. If not submitted immediately (within 24 hr) to the analytical laboratory, the tissue samples will be frozen at -18 °C (PSEP 1997c). The analytical laboratory will fillet two of the fish and then weigh each fillet prior to processing.

5.5 Sample Identification, Containers, and Labels

Samples will be identified based on the sampling area, location, and sample depth. All samples collected during the investigation will be labeled clearly and legibly. Each sample will be labeled with a unique alphanumeric identification number that identifies characteristics of the sample as follows:

Sampling Area	Location Number	Sample Depth or Tissue Type
EH-	05-	X or XX

Where:

Sampling Area consists of two characters describing the sampling area (EH = Ediz Hook; FP = Fish Pen Area; BA = Barge Area; IE = Inner Ediz Hook Area; LA = Lagoon Area; IH = Inner Harbor Area; MA = Marina Area; BL = Boat Launch/Standard Oil Area; KP = K-Ply/Valley Creek Area; FT = Landing Pier/Ferry Terminal Area; RL = Red Lion Area 3; EI = Eastern Intertidal/Subtidal Area; WW = City of Port Angeles WWTP Outfall; OH = Outer Harbor Area; LP = Log Pond; MD = Mill Dock; ED = East of Mill Dock; CO = Rayonier Outfalls; DO = Rayonier Deep Outfall; EC = Ennis Creek; EE = East of Ennis Creek; and RF = Reference Area).

Location Number consists of two characters identifying the station location number (Figures 2-2 and 4-2).

Sample Depth consists of one character indicating depth interval as measured from the bottom of the grab. This character will vary depending on sediment type as follows:

Study Component	Sediment Type	Sample Intervals and Sample Depth Identifier
Harbor-wide & Rayonier	Surface sediment grab	0 to 10 cm = A
Harbor-wide & Rayonier	4 ft core	1st interval, chosen from among layers of core by field sampler, who will record depth in the field log book = B 2nd interval, chosen from among layers of core by field sampler, who will record depth in the field log book = C
Rayonier	4 ft core at nearshore outfalls	1-ft interval, chosen from among layers of core by field sampler, who will record depth in the field log book = B
Rayonier	4 ft core at deepwater	6 in to 1 ft = B

Study Component	Sediment Type	Sample Intervals and Sample Depth Identifier
	outfalls	1 ft to 2 ft = C 2 ft to 3 ft = D 3 ft to 4 ft = E
Harbor-wide & Rayonier	12 ft core	1st interval, chosen from among layers of core by field sampler, who will record depth in the field log book = B 0- to 1-ft interval of native sediment encountered directly beneath wood-waste debris= C

For example, the surface sediment sample collected from 0 to 10 cm from the Ediz Hook Area fifth sampling location would be labeled EH-05-A.

Tissue Type consists of samples collected for tissue analysis and will be denoted by the character "T" followed by a second character for biota type (H = horse clam; G = geoduck; M = macroalgae; L = lingcod). For example, the lingcod tissue sample collected from the second Inner Hook Area would be labeled IE-02-TL.

Sample aliquots submitted to the analytical laboratories will be placed in pre-cleaned sample containers and preserved as identified in Table 5-1. The procedure for sample storage and shipping is given in Section 5.6.

Sample labels will be made of self-adhering, waterproof material. An indelible pen will be used to fill out each label. Each sample label will contain the project name, sample identification number, date and time of collection, analyses, preservative (as applicable), and the initials of the person preparing the sample. Sample labels will be protected by packaging tape wrapped around the entire jar to prevent loss or damage of the labels during handling and storage.

5.6 Sample Storage and Delivery

An SOP for sample packing and shipment is provided in Appendix C. All samples will be stored in insulated coolers and preserved by cooling with ice or frozen gelpacks to a temperature of 4ºC. Maximum sample holding and extraction times will be strictly adhered to by field personnel and the analytical and testing laboratories. Archived samples will be frozen to halt the clock on prescribed extraction and holding times, as necessary. Jars for shipment to fixed laboratories will be prepared in the following manner:

- Package and ship samples in accordance with U.S. Department of Transportation regulations as specified in 49 Code of Federal Regulations (CFR) 173.6 and 49 CFR 173.24.
- Place sample containers in plastic zip-lock bubble-pack bags, or wrap in bubble pack and secure with packaging tape.
- Prepare an empty insulated cooler by placing three to four ice packs in a garbage bag at the bottom of the cooler. Place sample containers in a garbage bag and fill with the sample bottles. Add more bags of ice as needed to surround the bag containing the samples.

- Enclose chain of custody (COC) forms in a plastic bag and tape them to the inside lid of the cooler.
- Seal the cooler with strapping tape and a custody seal.

Samples for chemical analyses will be hand-couriered or shipped to the analytical laboratories as soon as possible after collection and in accordance with holding time requirements; samples will be accompanied by the COC record, which identifies the shipment contents. Samples held in custody by the field crew for a limited amount of time must be maintained in a secured location under sufficient cooling conditions to maintain sample integrity. The COC will be signed by the individual relinquishing samples to the onsite laboratory representative. When samples are received at the laboratory, the shipping container seal will be broken and the receiver will record condition of the samples. The field personnel will be responsible for:

- Packaging the samples;
- Signing the COC before placing it inside the cooler to be sealed;
- Applying a shipping label, a waybill, a custody seal, and strapping tape to the cooler;
- Shipping the samples in accordance with the maximum holding time allowed for the analyses to be performed;
- Notifying the laboratory of when the samples are shipped; and
- Confirming laboratory receipt of the samples in good condition.

Sediment samples to be archived will be frozen and stored by the laboratory for a minimum of six months from collection. All sediment samples, both for immediate and archived analysis, will be retained for a minimum of six months from the time they were received, using standard laboratory handling procedures. They may be removed from the laboratory prior to the end of the six-month period only at the direction of the E & E project manager.

5.7 Field Documentation

A complete record of field activities will be maintained. Documentation necessary to meet quality assurance (QA) objectives for this project includes field notes and field forms, sample container labels, and COC forms. An SOP for field documentation is provided in Appendix C. The field documentation will provide descriptions of all sampling activities and weather conditions and names of sampling personnel. Any necessary modifications to the SAP will be discussed with and approved by Ecology prior to field implementation. All modifications, decisions, and/or corrective actions to the study design and procedures identified in this SAP will be clearly documented in field notebooks.

5.7.1 Field Notebooks

Field logbooks will be kept on site during field operations. Daily activities will be recorded in a bound field logbook of water-resistant paper. Separate logbooks consisting of bound, paginated field forms will be kept for sediment core sampling, sediment grab sampling, tissue collection, and an inventory of sample containers (separate from the COC documentation). All entries will be made legibly in indelible ink and will be signed and dated. Information recorded will include the following:

- Date, time, place, and location of sampling;
- Onsite personnel and visitors;
- Daily safety discussion and any safety issues;
- Quality control samples (for example, field blanks);
- Field measurements and their units;
- Number of attempts at each sampling station;
- Observations about site and location (weather, current, odors, appearance, and so forth);
- Observations about the samples (DGPS locations, depth as recorded by vessel depth sounder, maximum penetration depth, comments);
- General sediment characteristics (texture, color, biota, odor, sheen, and so forth); and
- Equipment decontamination verification.
- Any approved change orders that required modifications and/or corrective actions to the SAP study design and procedures.

Field logbooks are intended to provide sufficient data and observations to enable participants to reconstruct events that occur during project field activities. Entries should be factual, detailed, and objective. Unless samplers are restricted by weather conditions, they should record all original data in field logbooks, on sample identification tags, on COC records, and on field forms in waterproof ink. If an error is made, the individual responsible may make corrections simply by crossing out the error and entering the correct information. The erroneous information will not be obliterated. All corrections will be initialed and dated. All documentation, including voided entries, will be maintained within project files.

5.7.2 Chain of Custody Procedures

Samples will be retained at all times in the field crew's custody until E & E personnel deliver or ship them to the appropriate laboratory. COC forms will be initiated at the time of sample collection to ensure that all collected samples are properly documented and traceable through storage, transport, and analysis. When all line items on the form are completed or when the samples are relinquished, the sample collection custodian will sign and date the form, list the time, and confirm the completeness of all descriptive information contained on the form. Each individual who subsequently assumes responsibility for the samples will sign and date the COC form. The field COC terminates when the laboratory receives the samples. The field sample custodian will retain a copy of the completed, signed COC form(s) for project files.

5.8 Equipment Decontamination Procedures

The vessel-deployed grab samplers, core samplers and inner core sleeves, compositing pans, and sampling utensils will be thoroughly decontaminated prior to use in accordance with Puget Sound Estuary Program (PSEP) protocols (PSEP 1997a-d). The equipment will be scrubbed and washed with non-phosphate detergent and in situ water, followed by a rinse with an appropriate solvent per PSEP protocols. A final rinse with distilled water also will be performed. If a noticeable oily sheen or petroleum odor is observed, sampling bowls and utensils used to process those samples will not be used for subsequent sample processing.

All handwork will be conducted with disposable nitrile gloves, which will be changed after handling each sample and between sampling stations to prevent cross-contamination.

5.9 Waste Disposal

Investigation-derived waste (IDW) expected to be generated by sampling activities during the Port Angeles Harbor sediment study include:

- Sediment sample material not submitted to the laboratories,
- Equipment decontamination fluids, and
- Disposable protective clothing and sampling supplies.

5.9.1 Sediment Sample/Sediment Core

The sediment will be processed either onboard the vessel or at an onshore processing station established for this investigation. To the extent practicable, excess sediment material will be returned to the site following completion of sample processing. Any sediment not returned to the site will be packed in sealable containers and disposed of properly.

5.9.2 Equipment Decontamination Fluids

Water-based decontamination fluids will be disposed of on site. Organic solvent fluids generated during equipment decontamination will be contained in sealable containers and disposed of properly following field activities.

5.9.3 Disposable Protective Clothing and Sampling Equipment

Used personal protective equipment (PPE) such as gloves and disposable supplies such as paper towels and packaging will be placed in plastic storage bags and disposed of as municipal waste. If PPE contains residual sediments, the PPE will be decontaminated using the procedures outlined in Section 5.3, and will be disposed of as non-hazardous waste. Waste material will be recycled as feasible (for example, cardboard and aluminum).

Table 5-1 Sample Analyses Summary

Matrix	Analytical Parameters/ Method	Sample Preservation[1]	Technical Holding Time[a]	Sample Container(s)
Sediment	SVOCs/SW-846 Method 8270D	Cool to 4°C +/- 2°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	Wood Resin/SW-846 Method 8270D	Cool to 4°C +/- 2°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	Chlorinated Guaiacols/NCASI CP-86.07	Cool to 4°C +/- 2°C	Extract within 30 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	Dioxin/Furans/EPA Method 1613B	Cool to 4°C +/- 2°C	Extract within 1 year of collection.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	Pesticides/SW-846 Method 8081B	Cool to 4°C +/- 2°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	PCBs as Aroclors/SW-846 Method 8082	Cool to 4°C +/- 2°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	NWTPH-HCID/Ecology NWTPH-HCID	Cool to 4°C +/- 2°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	TBT /(Krone, et al., 1989)	Cool to 4°C +/- 2°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	Metals/SW-846 Methods 6000/7000 Series	Cool to 4°C +/- 2°C	180 days from collection (28 days for mercury).	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	TOC/SW-846 9060 (Plumb)	Cool to 4°C +/- 2°C	28 days from collection.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	Grain Size/PSEP	Cool to 4°C +/- 2°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 16-oz wide-mouth glass jar with Teflon-lined lid.
	Percent Solids/ PSEP	Cool to 4°C +/- 2°C	14 days from collection.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	Sulfide/SW-846 9030	Cool to 4°C +/- 2°C	7 days from collection.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	Ammonia/PSEP	Cool to 4°C +/- 2°C	28 days from collection.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	Core Dating (beryllium 7, cesium 137, lead 210)[b]	Cool to 4°C +/- 2°C	Analyze cores as soon as possible.	4ft intact core segments in lexan or stainless steel barrel
	Sediment Toxicity (Bioassay)[c]	Cool to 4°C +/- 2°C	40 days from collection.	Three to four 64-oz wide-mouth glass jars with Teflon-lined lids.

Table 5-1 Sample Analyses Summary

Matrix	Analytical Parameters/ Method	Sample Preservation[1]	Technical Holding Time[a]	Sample Container(s)
Tissue	SVOCs/SW-846 Method 8270D	Cool to 4°C +/- 2°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	Dioxin/Furans/EPA Method 1613B	Cool to 4°C +/- 2°C	Extract within 1 year of collection.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	Pesticides/SW-846 Method 8081B	Cool to 4°C +/- 2°C	Extract within 14 days of collection; analyze within 40 days of extraction.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	PCB congeners/EPA Method 1668	Cool to 4°C +/- 2°C	Extract within 1 year of collection.	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	Metals/SW-846 Methods 6000/7000 Series	Cool to 4°C +/- 2°C	180 days from collection (28 days for mercury).	One 8-oz wide-mouth glass jar with Teflon-lined lid.
	Percent lipids/EPA	Cool to 4°C +/- 2°C	14 days from collection.	One 8-oz wide-mouth glass jar with Teflon-lined lid.

[1] Sediment samples to be archived will be frozen to -18 °C. All tissue samples in transit to laboratory or being held to extend holding times will be frozen to -18 °C (PSEP 1997c).

[a] Technical holding times have been established only for water matrices. Water technical holding times were applied to sediment and tissue samples when applicable; in some cases, recommended sediment holding times are listed. If tissue samples remain frozen, then that extends extraction holding time to 40 days per PSEP requirements (1997c).

[b] Samples will be analyzed by alpha and gamma spectroscopy.

[c] Bioassay consisting of three toxicity tests: amphipod mortality, larval development, and polychaete growth.

Key:

°C = degrees Celsius
Ecology = Washington Department of Ecology
HCID = hydrocarbon identification
NWTPH = northwest total petroleum hydrocarbon
oz = ounce
PCB = polychlorinated biphenyl
Pesticides = chlorinated pesticides
PSEP = Puget Sound Estuary Program Methods
SVOCs = semivolatile organic compounds
SW-846 = *Test Methods for Evaluating Solid Waste, Physical Chemical Methods*, 3rd edition, SW-846, 1986

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6.0 Laboratory Methods

All the chemical analytical procedures used in this program will be performed in accordance with the most current SMS and PSEP, and with Ecology's *Sediment Sampling and Analysis Plan Appendix* (Ecology 2008) documentation, as applicable. Analytes include metals, SVOCs (PAHs, phthalates, and phenols), polychlorinated dibenzo-p-dioxin compounds (dioxins), polychlorinated dibenzofuran compounds (furans), chlorinated pesticides, total PCBs (reported as summed Aroclor concentrations), PCB congeners, wood resin compounds, NWTPH-HCID, grain size, TOC, ammonia, and sulfides. In addition, two cores will be analyzed for Pb-210, Cs-137, and Be-7 radioisotope dating.

Each laboratory participating in this program will be National Environmental Laboratory Accreditation Program- (NELAP) and/or Ecology-certified to perform the analysis. Each laboratory analysis must conform to accepted standard methods and internal QA/QC. As needed or requested by Ecology, E & E will conduct on-site audits of analytical laboratories prior to initiation of sediment sampling to verify appropriate protocols are in place which will meet the analytical data quality objectives for this project.

6.1 Chemical Analyses

Chemical analysis will be conducted by laboratories subcontracted to E & E. The specific analyses and conventional parameters to be measured, sample preparation methods, analytical methods, target detection limits (TDLs), and SMS numeric criteria (SQS and CSL) are presented in Table 6-1. The TDLs listed are the laboratory reporting limits (RLs) and may be subject to modification due to elevated sample concentrations, heterogeneous samples (sediment), and potential matrix interferences that may preclude obtaining the desired quantification limit. Several organic compounds in the SMS criteria are normalized for organic carbon (OC) content. If the laboratory is unable to meet the OC-normalized SQS and CSL numeric values, the reasons for the deviation will also be reported.

Analytical laboratory reports will be accompanied by sufficient backup data and QC results to enable independent reviewers to evaluate the quality of the data results. Analytical data will be reported in the units specified in Tables 6-1, 6-2, and 6-3. Detection limits were carefully compared to Sediment Management Standards [SMS] (Chapter 173-204 WAC) Sediment Quality Standard (SQS) and Cleanup Screening Level (CSL) values. Since many SQS and CSL values are normalized to organic carbon (OC) content, a conservative assumption was made that the OC content in Port Angeles Harbor sediments was 1%. A brief review of published data suggests that the mean OC content in Port Angeles Harbor sediments is on the order of 3.5% or higher, which makes the 1% value a conservative estimate. Table 6-1 provides the sediment reporting limits for the organic compounds in ug/kg (dry weight) and SMS criteria in mg/kg OC.

The analytical laboratory deliverables will include the following:

- Case narrative (including any problems encountered, protocol modifications, and/or corrective actions taken);
- Sample analytical and QA/QC results with units;
- All protocols used during analyses;

- Any protocol deviations from the approved sampling plan;
- Surrogate recovery results;
- MS/MSD results;
- Laboratory duplicate/triplicate results;
- Blank results;
- Sample custody records (including original chain-of-custody forms); and
- Analytical results in Ecology's Environment Information Management (EIM) electronic format or equivalent.

Table 6-1 Sediment SMS Analyte List Summary

Analyte	Prep Method[1]	Analytical Method[2]	Sediment RL[3,4]	SQS	CSL
Conventional Parameters					
Total Solids (%)	---	PSEP	0.1	---	---
Total Organic Carbon (%)	---	PSEP	0.1	---	---
Total Sulfides (mg/kg)	---	PSEP	1	---	---
Ammonia (mg/kg)	---	PSEP	1	---	---
Grain Size	---	PSEP	---	---	---
Metals			**mg/kg**	**mg/kg**	
Arsenic	PSEP/3050B	6010B/6020	3	57	93
Cadmium	PSEP/3050B	6010B/6020	0.5	5.1	6.7
Chromium	PSEP/3050B	6010B/6020	1.3	260	270
Copper	PSEP/3050B	6010B/6020	1.0	390	390
Lead	PSEP/3050B	6010B/6020	1.5	450	530
Mercury	---	7471A	0.2	0.41	0.59
Silver	PSEP/3050B	6010B/6020	1.0	6.1	6.1
Zinc	PSEP/3050B	6010B/6020	2.5	410	960
Low Molecular Weight Polycyclic Aromatic Hydrocarbons (LPAH)			**µg/kg**	**mg/kg OC**	
Naphthalene	3540C/3550B	8270C	20	99	170
Acenaphthylene	3540C/3550B	8270C	20	66	66
Acenaphthene	3540C/3550B	8270C	20	16	57
Fluorene	3540C/3550B	8270C	20	23	79
Phenanthrene	3540C/3550B	8270C	20	100	480
Anthracene	3540C/3550B	8270C	20	220	1200
2-Methylnaphthalene	3540C/3550B	8270C	20	38	64
Total LPAH			20	370	780
High Molecular Weight Polycyclic Aromatic Hydrocarbons (HPAH)			**µg/kg**	**mg/kg OC**	
Fluoranthene	3540C/3550B	8270C	20	160	1200
Pyrene	3540C/3550B	8270C	20	1000	1400
Benzo(a)anthracene	3540C/3550B	8270C	20	110	270
Chrysene	3540C/3550B	8270C	20	110	460
Benzofluoranthenes, total	3540C/3550B	8270C	20	230	450

Table 6-1 Sediment SMS Analyte List Summary

Analyte	Prep Method[1]	Analytical Method[2]	Sediment RL[3,4]	SQS	CSL
Benzo(a)pyrene	3540C/3550B	8270C	20	99	210
Indeno(1,2,3-c,d)pyrene	3540C/3550B	8270C	20	34	88
Dibenzo(a,h)anthracene	3540C/3550B	8270C	20	12	33
Benzo(g,h,i)perylene	3540C/3550B	8270C	20	31	78
Total HPAH			20	960	5300
Chlorinated Benzenes			**µg/kg**	**mg/kg OC**	
1,2-Dichlorobenzene	3540C/3550B	8270C	20	2.3	2.3
1,4-Dichlorobenzene	3540C/3550B	8270C	20	3.1	9
1,2,4-Trichlorobenzene	3540C/3550B	8270C	20	0.81	1.8
Hexachlorobenzene	3540C/3550B	8270C	20	0.38	2.3
Phthalate Esters			**µg/kg**	**mg/kg OC**	
Dimethyl phthalate	3540C/3550B	8270C	20	53	53
Diethyl phthalate	3540C/3550B	8270C	20	61	110
Di-n-butyl phthalate	3540C/3550B	8270C	20	220	1700
Butyl benzyl phthalate	3540C/3550B	8270C	20	4.9	64
Bis(2-ethylhexyl)phthalate	3540C/3550B	8270C	20	47	78
Di-n-octyl phthalate	3540C/3550B	8270C	20	58	4500
Ionizable Organic Compounds			**µg/kg**	**µg/kg**	
Phenol	3540C/3550B	8270C	20	420	1200
2-Methylphenol	3540C/3550B	8270C	20	63	63
4-Methylphenol	3540C/3550B	8270C	20	670	670
2,4-Dimethylphenol	3540C/3550B	8270C	20	29	29
Pentachlorophenol	3540C/3550B	8270C	100	360	690
Benzyl alcohol	3540C/3550B	8270C	20	57	73
Benzoic acid	3540C/3550B	8270C	200	650	650
Miscellaneous Compounds			**µg/kg**	**mg/kg OC**	
Dibenzofuran	3540C/3550B	8270C	20	15	58
Hexachlorobutadiene	3540C/3550B	8270C	20	3.9	6.2
N-Nitrosodiphenylamine	3540C/3550B	8270C	20	11	11

Table 6-1 Sediment SMS Analyte List Summary

Analyte	Prep Method[1]	Analytical Method[2]	Sediment RL[3,4]	SQS	CSL
Total PCBs (as summed Aroclors)	3540C/3550B	8082	10	12	65

1. Recommended sample preparation methods are PSEP (1997a,b) and USEPA 3000 series (sample preparation methods from SW-846 (USEPA 1986))
2. Recommended sample cleanup methods are USEPA SW-846 Methods 3640A, 3660B, and 3665A. Alternative cleanup procedures are described in PSEP and SW-846.
3. RL, SQS, and CSL are on a dry weight basis.
4. RL is based on a value equal to one-third of the 1988 dry weight lowest apparent effects threshold (LAET) value (Barrick et al. 1988) except for the following chemicals: 1,2-dichlorobenzene, 1,2,4-trichlorobenzene, hexachlorobenzene, hexachlorabutadiene, n-nitrosodiphenylamine, 2-methylphenol, 2,4-dimethylphenol, and benzyl alcohol, for which the recommended MRL is equal to the full value of the 1988 dry weight LAET.

Key:

CSL = cleanup screening level
HPAH = high molecular weight polycyclic aromatic hydrocarbon compounds
LPAH = low molecular weight polycyclic aromatic hydrocarbon compounds
µg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram.
OC = organic carbon
PSEP = *Recommended Protocols for Measuring Metals in Puget Sound Water, Sediment and Tissue Samples*, Puget Sound Estuary Program, April 1997
RL = reporting limit
SQS = Sediment Quality Standards
SW-846 = *Test Methods for Evaluating Solid Waste, Physical Chemical Methods*, 3rd edition, USEPA, SW-846, 1986
USEPA = United States Environmental Protection Agency

Table 6-2 Sediment non-SMS Analyte List Summary		
Parameter	**Analysis Method**	**Sediment RL**
Metals (mg/kg dry weight)		
Antimony	SW 6010/6020	3
Nickel	SW 6010/6020	1
Aroclors (µg/kg dry weight)		
Aroclor 1016	SW 8082	10
Aroclor 1221	SW 8082	10
Aroclor 1232	SW 8082	10
Aroclor 1242	SW 8082	10
Aroclor 1248	SW 8082	10
Aroclor 1254	SW 8082	10
Aroclor 1260	SW 8082	10
Chlorinated Pesticides (µg/kg dry weight)		
Aldrin	SW 8081	1
gamma-BHC (Lindane)	SW 8081	1
Heptachlor	SW 8081	1
Hexachlorobenzene	SW 8081	1
alpha-Chlordane	SW 8081	1
4,4'-DDD	SW 8081	2
4,4'-DDE	SW 8081	2
4,4'-DDT	SW 8081	2
Dieldrin	SW 8081	2
Organotin Compounds (µg/kg dry weight)[1]		
Butyltin	Krone et al., 1989	4
Dibutyltin	Krone et al., 1989	6
Tributyltin	Krone et al., 1989	4
Wood Resin Compounds (µg/kg dry weight)		
Retene	SW 8270	20
Guaiacol	modified SW 8270	20
4-Chloroguaiacol	modified SW 8270	TBD
3,4-Dichloroguaiacol	modified SW 8270	TBD
4,5-Dichloroguaiacol	modified SW 8270	50
4,6-Dichloroguaiacol	modified SW 8270	TBD
3,4,5-Trichloroguaiacol	modified SW 8270	75
3,4,6-Trichloroguaiacol	modified SW 8270	TBD
4,5,6-Trichloroguaiacol	modified SW 8270	50
Tetrachloroguaiacol	modified SW 8270	75

Table 6-2 Sediment non-SMS Analyte List Summary

Parameter	Analysis Method	Sediment RL
Pimaric acid	modified SW 8270	100
Sandracopimaric acid	modified SW 8270	100
Isopimaric acid	modified SW 8270	100
Palustric acid	modified SW 8270	100
Dehydroabietic acid	modified SW 8270	100
Abietic acid	modified SW 8270	100
Neoabietic acid	modified SW 8270	100
9,10-Dichlorostearic acid	modified SW 8270	TBD
Oleic acid	modified SW 8270	100
Linolenic acid	modified SW 8270	100
1,2-Chlorodehydroabietic acid	modified SW 8270	100
1,4-Chlorodehydroabietic acid	modified SW 8270	100
Dichlorodehydroabietic acid	modified SW 8270	100
NWTPH-HCID (mg/kg dry weight)		
Gasoline	NWTPH-HCID	20
Diesel #2	NWTPH-HCID	50
Motor oil	NWTPH-HCID	100
PCDD/PCDF (ng/kg dry weight)		
2,3,7,8-TCDD	EPA 1613B	0.1
Total TCDD	EPA 1613B	0.1
1,2,3,7,8-PeCDD	EPA 1613B	0.5
Total PeCDD	EPA 1613B	0.5
1,2,3,4,7,8-HxCDD	EPA 1613B	0.5
1,2,3,6,7,8-HxCDD	EPA 1613B	0.5
1,2,3,7,8,9-HxCDD	EPA 1613B	0.5
Total HxCDD	EPA 1613B	0.5
1,2,3,4,6,7,8-HpCDD	EPA 1613B	0.5
Total HpCDD	EPA 1613B	0.5
OCDD	EPA 1613B	1.0
2,3,7,8-TCDF	EPA 1613B	0.1
Total TCDF	EPA 1613B	0.1
1,2,3,7,8-PeCDF	EPA 1613B	0.5
2,3,4,7,8-PeCDF	EPA 1613B	0.5
Total PeCDF	EPA 1613B	0.5
1,2,3,4,7,8-HxCDF	EPA 1613B	0.5
1,2,3,6,7,8-HxCDF	EPA 1613B	0.5
1,2,3,7,8,9-HxCDF	EPA 1613B	0.5

Table 6-2 Sediment non-SMS Analyte List Summary

Parameter	Analysis Method	Sediment RL
2,3,4,6,7,8-HxCDF	EPA 1613B	0.5
Total HxCDF	EPA 1613B	0.5
1,2,3,4,6,7,8-HpCDF	EPA 1613B	0.5
1,2,3,4,7,8,9-HpCDF	EPA 1613B	0.5
Total HpCDF	EPA 1613B	0.5
OCDF	EPA 1613B	1.0

Notes:

1. Krone et al., 1989. *A method for analysis of butyltin species and measurement of butyltin in sediment and English sole livers from Puget Sound.* Marine Environment Research, 27, 1-18.

Key:

CDD = chlorinated dibenzo-p-dioxin compounds
CDF = chlorinated dibenzofuran compounds.
EPA 1613B = *Method 1613 Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS*. U.S. Environmental Protection Agency, Office of Water, Engineering and Analysis Division. October 1994.
HCID = hydrocarbon identification
HxCDD = hexachlorodibenzo-p-dioxin
HxCDF = hexachlorodibenzofuran
HpCDD = heptachlorodibenzo-p-dioxin
HpCDF = heptachlorodibenzofuran
NWTPH = Northwest total petroleum hydrocarbon
OCDD = octachlorodibenzo-p-dioxin
OCDF = octachlorodibenzofuran
PeCDD = pentachlorodibenzo-p-dioxin
PeCDF = pentachlorodibenzofuran
RL = reporting limit
SW = *Test Methods for Evaluating Solid Waste, Physical Chemical Methods*, 3rd edition, USEPA, SW-846, 1986.
TBD = to be determined
TCDD = tetrachlorodibenzo-p-dioxin
TCDF = tetrachlorodibenzofuran

Table 6-3 Tissue Analyte List Summary

Parameter	Analysis Method	Tissue RL
Metals (mg/kg wet weight)		
Antimony	SW 6010/6020	3
Arsenic	SW 6010/6020	0.25
Cadmium	SW 6010/6020	0.5
Chromium	SW 6010/6020	1.3
Copper	SW 6010/6020	1
Lead	SW 6010/6020	1.5
Mercury	SW 7471	0.2
Nickel	SW 6010/6020	1
Silver	SW 6010/6020	1
Zinc	SW 6010/6020	2.5
Polycyclic Aromatic Hydrocarbons (PAH) (µg/kg wet weight)		
Naphthalene	SW 8270	20
Acenaphthylene	SW 8270	20
Acenaphthene	SW 8270	20
Fluorene	SW 8270	20
Phenanthrene	SW 8270	20
Anthracene	SW 8270	20
2-Methylnaphthalene	SW 8270	20
Fluoranthene	SW 8270	20
Pyrene	SW 8270	20
Benzo(a)anthracene	SW 8270	20
Chrysene	SW 8270	20
Benzofluoranthenes	SW 8270	20
Benzo(a)pyrene	SW 8270	20
Indeno(1,2,3-c,d)pyrene	SW 8270	20
Dibenzo(a,h)anthracene	SW 8270	20
Benzo(g,h,i)perylene	SW 8270	20
Chlorinated Benzenes (µg/kg wet weight)		
1,2-Dichlorobenzene	SW 8270	20
1,4-Dichlorobenzene	SW 8270	20
1,2,4-Trichlorobenzene	SW 8270	20
Hexachlorobenzene	SW 8270	20
Phthalate Esters (µg/kg wet weight)		
Dimethyl phthalate	SW 8270	20
Diethyl phthalate	SW 8270	20

Table 6-3 Tissue Analyte List Summary

Parameter	Analysis Method	Tissue RL
Di-n-butyl phthalate	SW 8270	20
Butyl benzyl phthalate	SW 8270	20
Bis(2-ethylhexyl)phthalate	SW 8270	20
Di-n-octyl phthalate	SW 8270	20
Ionizable Organic Compounds (µg/kg wet weight)		
Phenol	SW 8270	20
2-Methylphenol	SW 8270	20
4-Methylphenol	SW 8270	20
2,4-Dimethylphenol	SW 8270	20
Pentachlorophenol	SW 8270	100
Benzyl alcohol	SW 8270	20
Benzoic acid	SW 8270	200
Miscellaneous Compounds (µg/kg wet weight)		
Dibenzofuran	SW 8270	20
Hexachlorobutadiene	SW 8270	20
N-Nitrosodiphenylamine	SW 8270	20
Chlorinated Pesticides (µg/kg wet weight)		
Aldrin	SW 8081	1
gamma-BHC (Lindane)	SW 8081	1
Heptachlor	SW 8081	1
Hexachlorobenzene	SW 8081	1
alpha-Chlordane	SW 8081	1
4,4’-DDD	SW 8081	2
4,4’-DDE	SW 8081	2
4,4’-DDT	SW 8081	2
Dieldrin	SW 8081	2
Dioxin-like PCB congeners (ng/kg wet weight)		
3,3’,4,4’-TeCB (PCB-77)	EPA 1668	2
3,4,4’,5-TeCB (PCB-81)	EPA 1668	2
2,3,3’,4,4’-PeCB (PCB-105)	EPA 1668	2
2,3,4,4’,5-PeCB (PCB-114)	EPA 1668	2
2, 3’,4,4’,5-PeCB (PCB-118)	EPA 1668	2
2’,3,4,4’,5-PeCB (PCB-123)	EPA 1668	2
3,3’,4,4’,5-PeCB (PCB-126)	EPA 1668	2
2,3,3’,4,4’,5-HxCB (PCB-156)	EPA 1668	2
2,3,3’,4,4’,5’-HxCB (PCB-157)	EPA 1668	2
2,3’,4,4’,5,5’-HxCB (PCB-167)	EPA 1668	2

Table 6-3 Tissue Analyte List Summary

Parameter	Analysis Method	Tissue RL
3,3’,4,4’,5,5’-HxCB (PCB-169)	EPA 1668	2
2,3,3’,4,4’,5,5’-HPCB (PCB-189)	EPA 1668	2
PCDD/PCDF (ng/kg wet weight)		
2,3,7,8-TCDD	EPA 1613B	0.2
Total TCDD	EPA 1613B	0.2
1,2,3,7,8-PeCDD	EPA 1613B	1.0
Total PeCDD	EPA 1613B	1.0
1,2,3,4,7,8-HxCDD	EPA 1613B	1.0
1,2,3,6,7,8-HxCDD	EPA 1613B	1.0
1,2,3,7,8,9-HxCDD	EPA 1613B	1.0
Total HxCDD	EPA 1613B	1.0
1,2,3,4,6,7,8-HpCDD	EPA 1613B	1.0
Total HpCDD	EPA 1613B	1.0
OCDD	EPA 1613B	2.0
2,3,7,8-TCDF	EPA 1613B	0.2
Total TCDF	EPA 1613B	0.2
1,2,3,7,8-PeCDF	EPA 1613B	1.0
2,3,4,7,8-PeCDF	EPA 1613B	1.0
Total PeCDF	EPA 1613B	1.0
1,2,3,4,7,8-HxCDF	EPA 1613B	1.0
1,2,3,6,7,8-HxCDF	EPA 1613B	1.0
1,2,3,7,8,9-HxCDF	EPA 1613B	1.0
2,3,4,6,7,8-HxCDF	EPA 1613B	1.0
Total HxCDF	EPA 1613B	1.0
1,2,3,4,6,7,8-HpCDF	EPA 1613B	1.0
1,2,3,4,7,8,9-HpCDF	EPA 1613B	1.0
Total HpCDF	EPA 1613B	1.0
OCDF	EPA 1613B	2.0

Table 6-3 Tissue Analyte List Summary

Parameter	Analysis Method	Tissue RL

Key:

CDD	=	chlorinated dibenzo-p-dioxin compounds
CDF	=	chlorinated dibenzofuran compounds
EPA 1613B	=	*Method 1613 Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS*. USEPA, Office of Water, Engineering and Analysis Division. October 1994.
EPA 1668A	=	*Method 1668 Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by HRGC/HRMS*. U.S. Environmental Protection Agency, Office of Water, Engineering and Analysis Division. December 1999.
HCID	=	hydrocarbon Identification
HxCB	=	hexachlorobiphenyl
HxCDD	=	hexachlorodibenzo-p-dioxin
HxCDF	=	hexachlorodibenzofuran
HpCB	=	heptachlorobiphenyl
HpCDD	=	heptachlorodibenzo-p-dioxin
HpCDF	=	heptachlorodibenzofuran
NWTPH	=	Northwest total petroleum hydrocarbon
OCDD	=	octachlorodibenzo-p-dioxin
OCDF	=	octachlorodibenzofuran
PCB	=	polychlorinated biphenyl
PeCB	=	pentachlorobiphenyl
PeCDD	=	pentachlorodibenzo-p-dioxin
PeCDF	=	pentachlorodibenzofuran
RL	=	reporting limit
SW	=	*Test Methods for Evaluating Solid Waste, Physical Chemical Methods*, 3rd edition, USEPA, SW-846, 1986.
TBD	=	to be determined
TeCB	=	tetrachlorobiphenyl
TCDD	=	tetrachlorodibenzo-p-dioxin
TCDF	=	tetrachlorodibenzofuran

6.2 Bioassay Analyses

This section describes specific procedures for the suite of bioassays used for SMS biological analysis for the determination of acute and/or chronic toxicity within sediments. Sediment collected at specific locations will be submitted for bioassays. Test sediments must be matched with, and tests run with, appropriate control and reference sediments to account for background conditions and sediment grain-size effects on bioassay organisms. The sampling team will collect the identified reference sediments at the same time that other samples are collected. In the event one or more bioassays fail, these results will be used in conjunction with other lines of evidence to trigger the further analysis of archived sediment samples.

All sediment samples selected for bioassay analysis will be stored at 4°C with no headspace, or under a nitrogen atmosphere (nitrogen-purged headspace) until bioassays are run. All bioassays, including retests, will commence within 14 days from collection of the first grab sample of the sediment to be tested. The laboratory will maintain chain-of-custody procedures throughout biological testing. For bioassays conducted in intertidal areas influenced by freshwater (i.e.

mouth of Ennis Creek), the toxicity laboratory will adjust the sediment sample upon receipt, if necessary, to appropriate salinities for bioassay testing.

Bioassays will be initiated as soon as possible after the last sample (to define a batch) is received by the laboratory to maintain holding times. This includes obtaining test organisms and control/reference sediments in a timely manner. This approach will support the opportunity for any second-round (additional) bioassays within the allowable 14-day holding period, if such need arises.

Three bioassays (Table 6-4) including amphipod mortality, larval development, and juvenile polychaete growth will be conducted on each sample identified for biological testing. Multi-generational bioassays will not be conducted as a part of this study as long-term biological effects may be inferred from the biota tissue concentrations and associated ecological risk assessment, as practicable (Appendix D). It is acknowledged that bioassays conducted with specific species may not be applicable to determine potential effect to all invertebrates; however, this is not the goal of standard bioassays. The goal is to indicate potential toxicity within sediments to broad classes of organisms. All biological testing will be in strict compliance with Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments (PSEP 1995), with appropriate modifications as specified in the Sediment Management Annual Review Meeting (SMARM) process. General biological testing procedures and specific procedures for each sediment bioassay are summarized in the following sections.

Table 6-4 Bioassay Suite Summary

Bioassay Test	Test Organisms
10-day Amphipod Mortality Test – Acute test	*Eohaustorius estuarius*[2] *Rhepoxynius abronius* *Ampelisca abdita*
48-hour Larval Development Test[1] – Acute test	*Mytilus galloprovincialis*[3] *Dendraster excentricus*
20-day Juvenile Polychaete Growth Test – Chronic test	*Neanthes arenaceodentata*

1. Actual test length may vary based on larval development stage.
2. Species used depends on grain size and salinity (Ecology 2008).
3. *Mytilus* is preferred over *Dendraster,* depending on organism availability.

The specific QA/QC measures employed as part of the biological analyses are discussed in detail in Section 7.0.

6.2.1 Amphipod Mortality Bioassay

This test involves exposing *Rhepoxynius abronius, Ampelisca abdita,* or *Eohaustorius estuarius* to test sediment for 10 days and counting the surviving animals at the end of the exposure period (Ecology 2008). Daily emergence data and the number of amphipods failing to rebury at the end of the test will be recorded as well. The control sediment has a performance standard of 10% mortality. The reference sediment has a performance standard of 25% mean mortality.

E. estuarius is the preferred test organism for sediments with percent fines less than 60% in areas with interstitial salinity less than 25 ppt. *R. abronius* is the preferred amphipod species for sediments with percent fines less than 60% with interstitial salinity higher than 25 ppt. *A. abdita* is used for sediments of all salinities with percent fines greater than 60%. Based on historical grain size data from previous investigations, all three amphipod species may be used in the investigation.

No treatment for confounding factors will be performed on the sediment sample during the bioassay procedure. Ammonia reference toxicant tests may be conducted if elevated ammonia concentration is suspected in test sediments.

6.2.2 Larval Development Bioassay

This test monitors larval development of a suitable echinoderm or bivalve species (for example, *Dendraster excentricus* or *Mytilus galloprovincialus*) in the presence of test sediment. *M. galloprovincialis* is the preferred species, followed by *D. excentricus*, depending on organism availability and viability. However, both species are considered highly sensitive to a wide range of sediment contaminants, including those COPCs in the Harbor (Pers. Comm. with Brian Hester 2008). The sediment larval bioassay has a variable endpoint (not necessarily 48 hours) that is determined by the developmental stage of organisms in a sacrificial seawater control (PSEP 1995). At the end of the test, larvae from each test sediment exposure are examined to quantify abnormality and mortality. The seawater control has a performance standard of 70% mean normal survivorship. Initial and final counts for seawater control, reference sediment, and test sediment will be made on 10-ml (0.34 oz) aliquots.

No treatment for confounding factors will be performed on the sediment sample during the bioassay procedure. Ammonia reference toxicant tests may be conducted if elevated ammonia concentration is determined in test sediments.

6.2.3 Juvenile Polychaete Growth Bioassay

This sublethal, static-renewal toxicity test can be used to determine the relative toxicity of marine sediments using the juvenile polychaete *Neanthes arenaceodentata*. The test is conducted in accordance with the methods described by PSEP (1995) and modifications to the test approved by Ecology.

The toxicity test involves a 20-day exposure to sediments and monitoring the response of the organisms to test sediments as compared to their response in control (clean) and reference sediment. The test endpoint is mean individual growth (expressed as mg/individual/day).

The control sediment has a performance standard of 10% mortality. The reference sediment has a performance standard of 80% of the control growth. A target control growth performance guideline of greater than or equal to 0.72 mg/individual/day has also been established. The *N. arenaceodentata* negative control performance guideline is a target growth rate of greater than or equal to 0.72 mg/individual/day; the negative control performance standard is greater than 0.38 mg/individual/day (below which the test is considered a QA/QC failure). Use of worms smaller than 0.25 mg (dry weight) at the beginning of the test will also be considered a QA/QC failure.

6.2.4 Full-Spectrum Lighting

Under certain conditions, when PAHs are exposed to ultraviolet (UV) radiation of sufficient quality and quantity, photo-activation may occur (Kosian 1998). Photo-activation can result in increased acute and chronic toxicity (Arfsten 1996). Benthic and aquatic organisms exposed to selected PAHs and simultaneously to specific wavelengths and intensities of UV radiation may be at significantly greater risk to toxic effects than organisms exposed to the same PAHs absent the UV radiation (Ahrens 2002). When the following site conditions are encountered, bioassays will be performed in the presence of full-spectrum lighting that includes UV wavelengths of sufficient intensity to mimic conditions at the site (Ecology 2008):

1) Sediment depths are 12 ft (4 m) or less, including intertidal and shallow subtidal zones, AND

2) Any of the photo-activated PAHs listed in Table 6-5 are present or presumed present (Nagpal 1993).

Table 6-5 Photo-activated PAH Compounds

PAHs	PAHs
Anthracene	Benz[c]acridine
Acridine	Benzathrone
Phenazine	Benzo[a]pyrene
Fluoranthene	Benzo[e]pyrene
1H-benzo[a]fluorine	Perylene
1H-benzo[b]fluorine	Dibenz[a,h]acridine
Pyrene	Dibenz[a,h]anthracene
Benz[a]anthracene	Dibenz[a,j]anthracene
Benz[b]anthracene	Benzo[b]chrysene
Chrysene	Dibenz[a,c]phenazine
Benzo[k]fluoranthene	Benzo[b]triphenyline
Benz[a]acridine	Benzo[g,h,i]perylene

Based on historical data from previous sampling events in Port Angeles Harbor, bioassays in the nearshore environment in less than 12ft of water should be conducted using full-spectrum lighting.

Standard fluorescent laboratory lighting fixtures are not full spectrum and do not produce "natural" wavelengths and intensity of light, therefore the laboratory must use two light sources with different radiation characteristics. The full spectrum fluorescent lamp must include the following (Ecology 2008):

1) UV-B output (280 nm $< \lambda <$ 315 nm) photo-activating wavelengths;

2) UV-A output (315 nm $< \lambda <$ 400 nm); this may have an effect upon burial and feeding behavior.

3) Correct Color temperature: "warm" red to "cold" blue expressed in degrees Kelvin. Daylight at noon is typically estimated at 5,500 °K.

4) High Color Rendering Index (CRI): Color rendering is the degree to which a light source shows the true color of objects it illuminates. This is measured on a CRI rated from 0 to 100. A normal fluorescent lamp rates 54 on the CRI scale. High quality fluorescent lamps rate 90–98 on the same scale.

In addition to the lamp's quality, its proximity to the animal, its output intensity, and duration of use are also important. It is absolutely critical that nothing is placed between the envelope of the lamp tube and the recipient test organism or vessel. UV-B is greatly attenuated by glass, plastic, and ultra-fine mesh. The amount of UV-B received is also diminished with distance. It is recommended that UV-B tubes be no further than 12 in (30 cm) away from the organism or vessel (Ecology 2008).

The recommended lab conditions for full spectrum testing include:

- Light intensity: 50–100 foot candles;
- Light duration: 16:8 (light/dark);
- Lamp to water surface distance: not greater than 30 cm (12 inches); and
- UV wavelength range: 3–8% UV-B (280nm < λ < 315nm) (3–5% preferred); 20–35% UV-A (315nm < λ < 400nm).

6.2.5 Bioassay Interpretation

Test interpretations consist of endpoint comparisons to controls and reference on an absolute percentage basis as well as statistical comparison to reference. The SMS biological effects criteria are presented in Table 6-6.

Table 6-6 SMS Biological Effect Criteria

Biological Test[1]	Sediment Quality Standards	Cleanup Screening Levels
Amphipod Mortality	Sample fails bioassay if: The test sediment has a mean mortality significantly higher (t-test, P≤0.05) than the reference sediment, and the test sediment mean mortality is more than 25% greater, on an absolute basis, than the reference sediment mean mortality.	Sample fails bioassay if: The test sediment has a mean mortality significantly higher (t-test, P≤0.05) than the reference sediment, and the test sediment mean mortality is more than 30% greater, on an absolute basis, than the reference sediment mean mortality.
Larval Development	Sample fails bioassay if: The test sediment has a mean survivorship of normal larvae that is significantly less (t-test, P≤0.1) than the mean normal survivorship in the reference sediment, and the mean normal survivorship in the test sediment is less than 85% of the mean normal survivorship in the reference sediment.	Sample fails bioassay if: The test sediment has a mean survivorship of normal larvae that is significantly less (t-test, P≤0.1) than the mean normal survivorship in the reference sediment, and the mean normal survivorship in the test sediment is less than 70% of the mean normal survivorship in the reference sediment.
Juvenile Polychaete	Sample fails bioassay if:	Sample fails bioassay if:

Table 6-6 SMS Biological Effect Criteria

Biological Test[1]	Sediment Quality Standards	Cleanup Screening Levels
Growth	The mean individual growth rate of polychaetes in the test sediment is less than 70% of the mean individual growth rate of the polychaetes in the reference sediment, and the test sediment mean individual growth rate is statistically different (t-test, P $P \leq 0.05$) from the reference sediment mean individual growth rate.	The mean individual growth rate of polychaetes in the test sediment is less than 50% of the mean individual growth rate of the polychaetes in the reference sediment, and the test sediment mean individual growth rate is statistically different (t-test, P $P \leq 0.05$) from the reference sediment mean individual growth rate.

1. Sufficient sediment will be collected at all locations to conduct the suite of three laboratory bioassays: amphipod mortality, larval development, and juvenile polychaete growth.

6.3 Radioisotope Analyses

Laboratory analysis will consist of beryllium-7 (Be-7), lead-210 (Pb-210), and cesium-137 (Cs-137) radioisotope activity measurements. Percent dry weight and Pb-210 in disintegrations per minute per gram (dpm/g), Be-7 in dpm/g, and Cs-137 in dpm/g will be determined for each sample.

Analysis strategy will follow the procedures recommended by the analytical laboratory:

1. Follow a typical strategy for initial analysis of Pb-210:
   - 0-39-in (0-100-cm) Interval: Analyze every third 0.8 in (2 cm) section (17 samples).
   - 39-59-in (100-150-cm) Interval: Analyze every other section (3 samples).
   - Greater than 59 in (150 cm): Analyze if necessary.

2. Initially analyze the top section (0-0.8 in (0-2 cm)), fourth section (2-3 in (6-8 cm)) and seventh section (5-6 in (12-14 cm)) for Be-7. If Be-7 activity is detected at 6 in (14 cm), then continue analyzing every third section until activity is not detected.

3. Analyze every ninth 0.8-in (2-cm) section for Cs-137. If Cs-137 activity is detected at 22-23-in (56-58-cm) section, then continue analyzing every ninth section until activity is not detected.

A sedimentation rate will be calculated from the Pb-210 profile of the core. If there are gaps in the profile, additional samples will be analyzed to fill in the needed information. In addition, core intervals may be combined to achieve sufficient sample volume. Once the sedimentation rate has been calculated, sections that correspond to the approximate years 1950 to 1975 for Cs-137 will be analyzed to verify the sedimentation rate.

7.0 Quality Assurance Project Plan

The purpose of the project QA/QC is to provide confidence in the project data results through a system of quality control performance checks of data collection methods, laboratory analysis, data reporting, and appropriate corrective actions to achieve compliance with established performance and data quality criteria. This section presents the QA/QC procedures to ensure that the investigation data results are defensible and usable for their intended purpose.

7.1 Measurements of Data Quality

Data quality objectives (DQOs) are qualitative or quantitative statements derived from the planning process. The DQOs are used to clarify the study objectives and define the appropriate type of data to collect to support project decisions. Additional guidance on developing DQOs is found in *Guidance for the Data Quality Objective (DQO) Process,* EPA 600/R-96/005 (EPA 1996). Acceptance and performance criteria establish the quality and quantity of data needed to meet the project DQOs. General acceptance or performance criteria for the collection, evaluation, or use of environmental data for this investigation are outlined in Section 6, Laboratory Methods. Acceptance and performance criteria are often specified in terms of the precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters. Numerical acceptance criteria cannot be assigned to all PARCC parameters, but general performance goals are established for most data collection activities. Data assessment procedures throughout this SAP/QAPP outline the steps to be taken, the responsible individuals, and the implications if QA objectives are not met. PARCC parameters are briefly defined below.

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 value, usually stated in terms of standard deviation or coefficient of variation. It also may be measured as the relative percent difference (RPD) between two values. Precision includes the interrelated concepts of instrument or method detection limits and multiple field sample variance. Sources of this variance are sample heterogeneity, sampling error, and analytical error.

Accuracy measures the bias of the measurement system. Sources of this error are the sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analysis. Data interpretation and reporting may also be significant sources of error. Typically, analytical accuracy is assessed by analyzing spiked samples and may be stated in terms of percent recovery or the average (arithmetic mean) of the percent recovery. Blank samples are also analyzed to assess sampling and analytical bias (that is, sample contamination). Background measurements similarly assess measurement bias.

Representativeness expresses the degree to which data represent a characteristic of a population, a parameter variation at a sampling point, or an environmental condition. Representativeness is a qualitative parameter and is most concerned with proper design of the measurement program. Sample/measurement locations may be biased (judgmental) or unbiased (random or systematic). For unbiased schemes, the sampling must be designed not only to collect samples that represent conditions at a sample location, but also to select sample locations that represent the total area to be sampled.

Completeness for sample collection is defined as the percentage of specified samples listed in the SAP that were actually collected. Completeness shall be 95% for this project. Completeness for acceptable data is defined as the percentage of acceptable data out of the total amount of data generated. Acceptable data includes data that passed all QC criteria and also data that may not pass all the QC criteria but for which appropriate corrective actions were taken. Data acceptable for risk assessment shall be defined by the risk assessor.

Comparability is a qualitative parameter expressing the confidence with which one data set may be compared to another. Sample data should be comparable to other measurement data for similar samples and sample conditions. This goal is achieved through use of standard techniques to collect and analyze samples.

7.2 Quality Assurance and Quality Control for Chemistry Sediment Samples

Laboratory QA/QC samples will be used to evaluate the data precision, accuracy, representativeness, and comparability of the analytical results.

7.2.1 Laboratory QA/QC for Chemical Sediment Sample

Analytical performance is monitored through QC samples and spikes, such as laboratory method blanks, surrogate spikes, QC check samples, matrix spikes, matrix spike duplicates, and duplicate injections. All QC samples are applied on the basis of a laboratory batch. Two types of batches are used: the preparation batch and the run (analytical) batch. The preparation batch includes all samples processed as a unit during organic sample preparation, metals digestion, or wet chemistry preparation. Preparation batches do not exceed 20 samples excluding associated QC samples. The QC samples associated with sample preparation include method blanks, laboratory control samples (LCSs), matrix spikes, and matrix duplicates. The run batch is all samples analyzed together in the run sequence. The run sequence is typically defined by the analytical method. For some analyses, such as TOC, the run batch is equivalent to the preparation batch. The QC samples associated with the run sequence include calibration standards, instrument blanks, and reference standards.

Instances may arise where high sample concentrations, non-homogeneity of samples, or matrix interferences preclude achieving the detection limits or associated QC target criteria. In such instances, data will not be rejected *a priori* but will be examined on a case-by-case basis. The laboratory will report the reason for deviations from these detection limits or noncompliance with QC criteria in the case narrative.

7.2.1.1 Laboratory Method Blanks

A laboratory method blank is an analyte-free material processed in the same manner and at the same time as a project sample. Laboratory method blanks demonstrate a contamination-free environment in the laboratory. The goal is for method blanks to be free of contamination. Low-level contamination may be present, but must be less than the Practical Quantitation Limit (PQL) as defined by the method SOP. If the method blank concentration is greater than the PQL, the samples are reanalyzed. If contaminants are present in the method blank but not in project samples, no further action is required. All sources of contamination that are not common laboratory contaminants as defined in the method SOPs must be investigated as part of the corrective action process. Sample results must not be blank-subtracted unless specifically required by the analytical method.

7.2.1.2 Surrogate Standards

For certain organic methods, all samples, including the laboratory method blank and standards, are spiked with a set of specific surrogate standards to monitor the accuracy of the analytical determination. Surrogate spikes are added at the start of the laboratory preparation process. Surrogate recoveries must be within QC criteria for method blanks and LCSs to demonstrate acceptable method performance. If surrogate recoveries are outside QC criteria for method blanks or LCS samples, corrective action is required and the QC Manager should be notified. Surrogate recoveries in the samples indicate the method performance on the particular sample matrix. Surrogate recoveries that are outside QC criteria for a sample indicate a potential matrix effect. Matrix effects must be verified based on review of recoveries in the method blank or LCS, sample reanalysis, or evaluation of interfering compounds. Sample clean-up procedures required by the Ecology-approved SOPs must be implemented to alleviate potential matrix problems.

7.2.1.3 Laboratory Control Sample

An LCS consists of a method blank spiked with the target compounds of interest near the mid-point of the calibration range. The LCS is processed by the same sample preparation, standard addition, and analysis as the project samples. The recovery of target analytes in the LCS is an estimation of method accuracy.

The LCS recovery must be within the control limits to demonstrate acceptable method performance. If the LCS recovery values are outside QC criteria for the target analytes, recovery values are significantly low, or the compounds were not detected in the samples, then corrective action is required. After corrective action is complete, sample re-analysis is required for the failed parameters. For any deviations from the LCS control limits that can not be resolved by sample re-analysis within holding times, the QC Manager must be notified immediately. If critical samples are affected, the Project Manager may determine that re-sampling is required.

7.2.1.4 Matrix Spike Sample

A matrix spike (MS) sample consists of a project sample split into two parts and processed as two separate samples in a manner identical to that of the rest of the samples. In addition to the regular addition of monitoring standards (internal standards, surrogate), spiking analytes are added to the sample aliquot. Generally, all method target analytes, if compatible, are added. A subset of target analytes may be used if indicated in the method SOP and approved during review of the SOP. An MS must be prepared for every batch of 20 samples (or fewer) for a given matrix if sufficient sample allows. Field and trip blanks must not be chosen for spiking. The laboratory must analyze a site-specific MS for every batch that contains samples from the site, even if the batch contains samples from other sites.

MS recovery values are a measure of the performance of the method on the sample being analyzed. MS recovery values outside the control limits applied to the LCS indicate matrix effects. Sample clean-up procedures may be warranted for samples with severe matrix effects. The laboratory should notify the QC Manager of these instances to determine an appropriate corrective action.

7.2.1.5 Matrix Spike Duplicate Sample

The matrix spike duplicate (MSD) sample is commonly prepared in conjunction with the MS sample. The MSD is prepared from a separate portion of the client sample and processed with the same additions as are in the MS. The MSD is prepared for methods that do not typically show concentrations of target analytes above MDLs, such as organic methods. The RPD values between the recovery values in the MS and MSD measure the precision of the analytical method on the actual project samples. For this project, QC criteria for RPDs are 35 percent for sediments unless the laboratory provides additional statistical criteria.

7.2.1.6 Other Laboratory QC Samples

The laboratory analyzes other QC samples or standards, depending on the analytical method. Standard QC samples or standards are documented in the specific method SOP. Method-specific QC samples or standards include internal standard spikes for gas chromatography (GC)/mass spectrometry (MS) methods; post-digestion spikes and serial dilutions for metals analysis; and interference check samples (ICSs) for inductively-coupled plasma (ICP) analysis. Results of all associated QC should be reported.

7.2.1.7 Performance Evaluation Samples

As part of the laboratory approval process, the laboratory must maintain acceptable scores on its analyses of external performance evaluation (PE) samples provided annually by an outside certifying agency. For this project any PE failures for project target compounds must be reported to the QC Manager immediately.

7.3 Bioassay Testing QA/QC for Sediment Samples

The detailed SOPs for the bioassay tests proposed for this investigation will be provided by the selected biological laboratory upon request. This section summarizes the toxicity test QA/QC procedures to be implemented to ensure the test results are valid. Standard QA/QC procedures include use of negative controls, reference sediment samples, laboratory replicates, and daily water quality measurements. Close contact with the biological laboratory will be maintained prior to and during the testing period to resolve any QA/QC problems or testing methodology issues in a timely manner.

7.3.1 Negative Control

The negative control consists of clean, inert material tested in parallel with the test sediments under identical test conditions. The biological testing laboratory provides this clean material, which usually consists of sediment collected from the original location from which the test organisms were harvested. The test acceptability criteria are based on the results of the negative control. A test with at least 90% survival (70% mean normal survivorship for larval development) in negative control test chambers is considered acceptable.

All bioassays have performance standards for controls (see Section 6.2). If these standards are not met, retesting may be required.

7.3.2 Reference Sediment

Reference sediments, which closely match the grain size characteristics of the test sediments, will be run with each test batch for all three bioassays. The reference sediment is used for test comparisons and interpretations. The collection area will be determined based on test sample physical characteristics. All reference sediments will be analyzed for total solids, total organic carbon, bulk ammonia, bulk sulfides, and grain-size.

All bioassays have performance standards for reference sediments (see Section 6.2). If these standards are not met, retesting may be required.

7.3.3 Laboratory Replication

Five laboratory replicates of each test sediment, reference sediment, negative control, and elutriate concentration will be run for each respective bioassay. The replication of tests provides multiple observations of effects to test organisms so that statistical comparisons can be made between test and reference sediments.

7.3.4 Bioassay Water Quality

Water quality monitoring will be conducted for the amphipod, larval development, and juvenile polychaete growth bioassays. This monitoring will consist of daily measurements of salinity, temperature, pH, and dissolved oxygen (every third day for juvenile polychaete growth bioassay). Ammonia and sulfides will be determined at test initiation and termination, and interstitial salinity will be determined prior to the test setup. Monitoring will be conducted for all test and reference sediments and negative controls (including seawater controls). Parameter measurements must be within the limits specified for each bioassay as listed in Table 7-1. Measurements for each treatment will be made on contents of a separate chemistry beaker set up identically to the other replicates within the treatment group. In addition, interstitial ammonia measurements at test initiation and test termination will be conducted for the amphipod test.

Table 7-1 Water Quality Requirements for Bioassay Tests

Test (*Test Species*)	Temperature	Salinity	Dissolved Oxygen	pH[3]
Amphipod Mortality (*E. estuarius; R. abronius; A. abdita*)	15 ± 1 °C	Ambient[1]	NA[2]	---
Larval Development (*Mytilus sp.*)	16 ± 1 °C	28 ± 1 ppt	> 60% saturation	---
Larval Development (*D. excentricus*)	15 ± 1 °C	28 ± 1 ppt	> 60% saturation	---

Table 7-1 Water Quality Requirements for Bioassay Tests

Test (*Test Species*)	Temperature	Salinity	Dissolved Oxygen	pH[3]
Juvenile Polychaete Growth (*N. arenaceodentata*)	20 ± 1 °C	28 ± 2 ppt	NA[2]	---

1. Same as interstitial salinity of test sediment
2. Continuous aeration is required by the protocol, so the dissolved oxygen should not be a cause of concern
3. pH is monitored as a water quality parameter. There are generally no control limits for pH; however, measurements of pH may be useful in interpreting results (Ecology 2008).

7.4 Data Validation

At a minimum, all laboratory data will undergo a QA1 review (PTI 1989a). If requested by Ecology, the data will be reviewed following QA2 procedures (PTI 1989b). If data fail the review, the laboratory will be contacted and the data will be reanalyzed, qualified, or unqualified with an explanation. For each data type, the quality of the data will be summarized in validation memos. EIM data qualifiers, as listed in Subappendix E of Ecology's *Sediment Sampling and Analysis Plan Appendix*, will be used for all data review (Ecology 2008).

In addition, laboratory data packages will be provided for the chemistry and bioassay data to allow independent data verification and validation. The data packages will consist of the sample results followed by a cover letter describing procedures used and analytical problems encountered, qualifiers used, reconstructed ion chromatogram (for GC/MS), mass spectra of detected target compounds (for GC/MS), chromatograms, quantification reports, and calibration data summaries. Dilution volumes, sample sizes, percent moisture, and surrogate recoveries will be presented on each summary sheet with the analytical results. A similar package is also assembled for each quality control sample (for example, method blank).

The following types of data will be reviewed:

- Analytical laboratory summary reports including QC summary data for surrogates, method blanks, LCSs, and MS/MSD samples. Acceptance and performance criteria will be developed from the reported laboratory control limits even if those limits differ from the limits listed in the QAPP;

- Bioassay laboratory summary reports including QC summary data. Acceptance and performance criteria will be developed from the current laboratory control limits even if those limits differ from the limits listed in the QAPP;

- Calibration summary data will be checked to verify that all positive results for target compounds were generated under an acceptable calibration as defined by the analytical method;

- Field data such as sample identifications and sample dates will be checked against the laboratory report; and

- Any field data to be included in the final report will be checked for completeness and compliance with the QAPP.

Raw data files from the field and laboratory may not be reviewed unless there is a significant problem noted with the summary information.

Evaluation of Completeness

After project data are received back from the laboratory, the data will be validated. The QC Manager will verify that the laboratory information matches the field information and that the following items are included in the data package:

- Chain-of-custody forms;
- Case narrative describing any out-of-control events and summarizing analytical procedures;
- Data report forms;
- QA/QC summary forms;
- Calibration summary forms; and
- Chromatograms documenting any QC problems.

If the data package is incomplete, the QC Manager will contact the laboratory, which must provide all missing information within one day.

Evaluation of Compliance

The actual data validation will follow the procedures outlined below:

- Review the data to check field and laboratory QC data, to verify that holding times and acceptance and performance criteria were met, and to note any anomalous values;

- Review chromatograms, mass spectra, and other raw data if provided as backup information for any apparent QC anomalies;

- Ensure all analytical problems and corrections are reported in the case narrative and that appropriate laboratory qualifiers are added;

- For any problems identified, review concerns with the laboratory, obtain additional information if necessary, and check all related data to determine the extent of the error; and

- Apply data qualifiers to the analytical results to indicate potential limitations on data usability.

QC Managers will follow qualification guidelines in applicable QA1 or QA2 guidelines. If no QA1 or QA2 guidelines exist, then applicable USEPA National and Regional Data Review guidelines such as SMS criteria will be used.

Data Validation Reporting

The QC Manager will perform the following reporting functions:

- Alert the Project Manager of any QC problems, obvious anomalous values, or discrepancies between the field and laboratory data, and resolve any issues;

- Discuss QC problems in a data validation memo for each laboratory report. Send the memo and a copy of the data package to Project Manager;

- Review the laboratory electronic data deliverable (EDD) and electronic field data, enter the data qualifiers into the database, and prepare analytical data summary tables. There will be tables that summarize those samples and analytes for which detectable concentrations were exhibited as well as complete analytical summary tables. The tables will include field QC samples; and

- At the completion of all field and laboratory efforts for site, QC Manager will prepare a data review/validation memorandum summarizing planned versus actual field and laboratory activities and data usability concerns.

8.0 Data Analysis and Reporting

This section describes the data analysis and reporting requirements for the data collection activities described in this workplan.

8.1 Analysis of Surface Sediment Chemistry Data

Analysis of chemistry data will include comparison of the results to the SMS numeric criteria and other thresholds of concern (National Oceanic and Atmospheric Administration's Effects Range Low (ERL) and Effects Range Median (ERM)) (Long et al. 1991 and 1995). The concentration of dioxin/furan compounds and PCB congeners will be evaluated as a 2,3,7,8-TCDD total toxic equivalent concentration (TEQ) using toxic equivalency factors (TEFs) provided by the World Health Organization (WHO) for human, fish, and wildlife receptors (Van den Berg et al. 1998, 2006) and mandated for use by MTCA (173-340-708). The TEQ is the sum of the concentrations of individual congeners multiplied by their respective TEF values (potency relative to 2,3,7,8-TCDD). For congeners reported as non-detect in all samples in a given medium, the detection limit will be replaced with a value of zero. For congeners reported as non-detect that are detected in one or more samples within the dataset, the detection limit will be replaced with a value equal to one-half of the method detection limit. Further data treatment of chemical mixtures for risk assessment, including treatment of nondetect values, is discussed in Appendix D, Section 3.2.2.

The sediment chemistry data will be summarized and presented in tables indicating sediment locations and detected contaminants and any detection limits that exceed SQS and/or CSL numeric criteria, along with any data qualifiers assigned by the laboratory or during the data validation efforts. The locations with chemistry exceeding numeric criteria will be mapped. Where feasible, historical sediment data will be incorporated into the study findings as additional data points, as well as for comparative purposes.

8.2 Subsurface Sediment Chemistry

Analysis of chemistry data will include comparison of the results to the SMS numeric criteria and other thresholds of concern. The subsurface sediment chemistry data will be summarized and presented in tables indicating sediment locations and detected contaminants and any detection limits that exceed SQS and/or CSL numeric criteria, along with any data qualifiers assigned by the laboratory or during the data validation efforts. The locations with chemistry exceeding numeric criteria will be mapped. Again, where feasible, historical subsurface sediment chemistry data will be incorporated into the study findings as additional data points and for comparative purposes.

8.3 Radioisotope Dating

Sedimentation rate information including sediment age in years, year of deposition, sediment accumulation rate (cm/yr), and sedimentation rate ($g/cm^2/yr$) will be determined and reported. The sedimentation rate is normally derived from Pb-210 results; however, in some cases the Cs-

137 data may be used to determine the sedimentation rate and sediment ages. Cs-137 results are normally used to verify dates determined with sedimentation rates. Be-7 results will be used to estimate the mixed depth.

8.4 Fingerprinting Analysis of Sediment Data

A screening-level "fingerprinting" evaluation of TPH, PAH, and dioxin/furan sediment data will be conducted to provide a preliminary indication of the usefulness of the analytical data to differentiate between sources of contaminants. Three lines of forensic evidence will be qualitatively investigated: petroleum hydrocarbons (TPH), PAHs, and dioxin/furans (PCDD/PCDFs).

Petroleum hydrocarbons will be analyzed using the Total Petroleum Hydrocarbon (TPH) method NWTPH-HCID for Hydrocarbon Identification. NWTPH-HCID is a qualitative and semi-quantitative screening tool that will be used to confirm the presence and type of petroleum product in a sediment sample. Results are qualitatively reported as gasoline, diesel, or heavy oils. The method is most useful for elimination of the need for more detailed petroleum analyses where NWTPH-HCID results indicate TPH concentrations are below regulatory limits. The reporting limits for sediment are 20 mg/kg for gasoline, 50 mg/kg for #2 diesel, and 100 mg/kg for motor oil. Pattern matching with known reference product chromatograms is used to identify (i.e. "fingerprint") the type of hydrocarbon. A laboratory analyst will categorize the TPH based on chromatogram identification. E & E personnel will also visually evaluate the sample chromatograms to identify unique patterns, if any, associated with potential sources.

Both PAHs and PCDD/PCDFs have characteristic patterns and distributions in materials. For example, petroleum and wood combustion sources have different PAH analyte patterns, while wood industry and smelter activities generate different patterns of PCDD/PCDFs. The sediment data will be evaluated for relative analyte concentrations of PAHs and PCDD/PCDFs and compared to published data on the relative ratios in potential source materials. PAH and PCDD/PCDF analyte distribution in samples from potential source areas will also be visually evaluated to identify unique patterns, if any, associated with those sources.

While the analytical data should meet the data quality objectives necessary to provide qualitative screening for guidance regarding the utility of the data for source differentiation, given the limited number of samples at each potential source quantitative evaluation of the data on a statistically significant basis will likely not be possible.

8.5 Current and Sediment Transport Data

Information obtained from the Sediment Trend Analysis (Appendix E) and the Current Meter Study (Appendix F) will be prepared and included as part of the Sediment Investigation Report. The Sediment Trend Analysis results will discuss sediment trend statistics for all sample transects and provide a discussion of derived transport paths with known transport processes. GIS-based maps will be used to show patterns of sediment transport, sediment sources and sinks, areas of erosion, deposition, and dynamic equilibrium, the relationships between sediment transport and contaminant levels, and the presence/characterization of woodwaste.

Data from the current meter study will include a comprehensive discussion on the range of bottom and surface currents, wave and turbidity observed, interpretations of general circulation and wave patterns, correlation of currents to observed water levels at the NOAA tide gage in Port Angeles, correlation of wave activity to reported winds at local airports, and the correlation of the bed shear stress to sediment re-suspension events. Surface current discussions will be based on a review of previously generated data and surface modeling interpretations. Current movement differences between surface and bottom currents, if present, will be identified. The results will also include a listing of the physical processes potentially responsible for transport of existing sediment contaminants based on geomorphic observations. Both current meter and geomorphic assessment information will provide additional framework to interpret the results of the sediment trend analysis, and provide a more complete understanding of the physical processes influencing sediment contaminant transport in the Harbor.

8.6 Analysis of Biological Data

Analysis of biological data will include comparison to SMS biological effects criteria. The toxicity test data results will be summarized and presented in tables indicating sediment locations and test results that exceed SQS and/or CSL biological effects interpretive criteria, along with the results of statistical comparisons to reference sediment test results. The sampling locations with sediment toxicity exceeding the SMS criteria will be mapped to indicate any areas that may require cleanup or other remedial action. Historical bioassay data will be incorporated into the study findings as practicable.

8.7 Tissue Residue Chemistry

Analysis of tissue chemistry data will include comparison of the results to the surface and subsurface sediment results. Tissue samples will be analyzed for SVOCs, chlorinated pesticides, metals, dioxin/furans, and coplanar dioxin-like PCB congeners. The concentration of dioxin/furan compounds and PCB congeners will be normalized to the toxicity of 2,3,7,8-TCDD TEQ using TEFs (potency relative to 2,3,7,8-TCDD) appropriate for human, fish, and wildlife receptors as updated by the WHO in 2005 (Van den Berg et al. 2006). The WHO TEF values are the same as those required by MTCA. Non-detect values will be assessed as half of the method detection limit for data evaluation purposes. Historical tissue concentration data will be used as additional data points to the extent practicable. The tissue samples data results will be reported as an appendix to the sediment quality investigation.

8.8 Sediment Investigation Report

A written SIR documenting all activities associated with collection, transportation, chemical analyses, and biological testing of sediment samples will be prepared. The report will include recommendations for further action or investigation based on the results of this investigation. The chemical, biological, and QA/QC reports will be included as appendices. As a minimum, the following will be included in the Final Report:

- Description of sampling and analysis activities;

- Protocols used during sampling and testing and an explanation of any deviations from the sampling plan protocols or the approved workplan;
- Physical descriptions of samples;
- Methods used for station positioning, with sample collection locations reported in latitude and longitude to the nearest tenth of a second (NAD 83);
- Map showing actual locations of sampling stations and results of data comparisons to SMS criteria;
- Chain-of-custody records;
- Chemistry and biological testing results and laboratory reports;
- Fingerprinting analysis results;
- Current and sediment transport studies results and reports;
- Comparison of data results to interpretive criteria;
- Radioisotope results and interpretation;
- QA/QC summary; and
- Data validation reports.

8.9 Human Health and Ecological Risk Assessment

In addition, an HHRA and ERA report will include recommendations for further action or investigation based on the data results from this investigation (See Appendix D).

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Appendix A

Health and Safety Plan

ecology and environment, inc. (E & E)

SITE-SPECIFIC
HEALTH AND SAFETY PLAN

Project: Port Angeles Harbor Sediment Investigation

Project No. 002330.WD20.03

Project Location: Port Angeles, Washington

Proposed Field Activity Date(s): May 2008 – June 2008

Project Manager: William Richards

Prepared by: William Richards Date Prepared: April 7, 2008

Approved by: Joe Grojean Date Approved: April 11, 2008

1. INTRODUCTION

1.1 POLICY

It is E & E's policy to ensure the health and safety of its employees, the public, and the environment during the performance of work it conducts. This site-specific health and safety plan (SHASP) establishes the procedures and requirements to ensure the health and safety of E & E employees for the above-named project. E & E's overall safety and health program is described in *Corporate Health and Safety Program for Toxic and Hazardous Substances* (*CHSP*). After reading this plan, applicable E & E employees shall read and sign E & E's Site-Specific Health and Safety Plan Acceptance form (Attachment A). The addendum form in Attachment B is provided for documentation of amendments to this plan. The amendment(s) must be reviewed and approved.

This SHASP has been developed for the sole use of E & E employees and is not intended for use by firms not participating in E & E's training and health and safety programs. Subcontractors are responsible for developing and providing their own safety plans.

This SHASP has been prepared to meet the following applicable regulatory requirements and guidance:

Applicable Regulation(s)/Guidance
29 CFR 1910.120, Hazardous Waste Operations and Emergency Response (HAZWOPER)
WAC 296-843, Hazardous Waste Operations prepared by the Department of Labor and Industries, State of Washington
Other:

1.2 SCOPE OF WORK

Description of Work: Sediment sampling from boats, sediment sampling from beach access areas, vibracore sampling from boats, biological tissue collection, and sample preparation.

Equipment/Supplies:
Attachment C contains a checklist of equipment and supplies that will be needed for this work.

The following table contains a description for each numbered task:

Task Number	Task Description
1	Sediment sampling from boats, sediment sampling from beach access areas, vibracore sampling from boats
2	Field operations support (sample runner and gathering supplies) and onsite administrative support
3	Sample preparation and packaging for shipment

1.3 SITE DESCRIPTION

Site Map: A site map or sketch is attached at the end of this plan (as Attachment F).

Site History/Description (see project work plan for detailed description): Port Angeles Harbor has been the scene of decades of industrial activities associated with pulp and paper milling, other forest products industries, marine services, a Coast Guard station, aquaculture, and fuel storage. Potential contaminants in marine sediments include a wide range of organic and inorganic chemical contaminants and high organic-content wood waste.

Is the site currently in operation? X Yes No

Locations of Contaminants/Waste: Chemical contaminants have been documented in intertidal and subtidal sediments throughout the harbor. Contaminants are also released to the water column during bottom-disturbing events. Wood waste has been documented in subtidal areas, primarily in the western part of the harbor.

Types and Characteristics of Contaminants/Waste:

X Liquid	X Solid	Sludge	Gas/Vapor
Flammable/Ignitable	Volatile	Corrosive	Acutely Toxic
Explosive	Reactive	X Carcinogenic	Radioactive
Medical/Pathogenic	Other: ___		

2. ORGANIZATION AND RESPONSIBILITIES

E & E team personnel shall have on-site responsibilities as described in E & E's standard operating procedure (SOP) for site entry (*Hazardous Waste Site Entry and Egress*, ENV 3.2). The project team, including qualified alternates, is identified in the table below.

Name	**Site Role/Responsibility**
William Richards	E&E Project Manager
Eric White	E&E Field Team Manager
Mark Longtine	E&E **Site Safety Officer** and Lead Sampler
Jennifer Siu	Sampler/Sample Custodian
Jennifer Schmitz	Sampler/Sample Custodian

3. TRAINING

Prior to work, E & E team personnel shall have received training as indicated in the table below. As applicable, personnel shall have read the project work plan, sampling and analysis plan, and/or quality assurance project plan prior to project work.

Training	**Required**
40-Hour OSHA HAZWOPER Initial Training and Annual Refresher (29 CFR 1910.120 and WAC 296-843)	X
Annual First Aid/CPR	X
Hazard Communication (29 CFR 1910.1200)	X
40-Hour Radiation Protection Procedures and Investigative Methods	
8-Hour General Radiation Health and Safety	
Radiation Refresher	
DOT and Biannual Refresher	
Other:	

4. MEDICAL SURVEILLANCE

4.1 MEDICAL SURVEILLANCE PROGRAM

E & E field personnel actively shall participate in E & E's medical surveillance program as described in the *CHSP* and shall have received, within the past year, an appropriate physical examination and health rating.

E & E's health and safety record form will be maintained on site by each E & E employee for the duration of his or her work. E & E employees should inform the site safety officer (SSO) of any allergies, medical conditions, or similar situations that are relevant to the safe conduct of the work to which this SHASP applies.

Is there a concern for radiation at the site? Yes X No If no, skip to Section 5.

4.2 RADIATION EXPOSURE

4.2.1 External Dosimetry

Thermoluminescent Dosimeter (TLD) Badges: TLD badges are to be worn by all E & E field personnel on certain required sites.

Pocket Dosimeters: ______________________________

Other: ______________________________

4.2.2 Internal Dosimetry

Whole body count Bioassay Other

Requirements: ______________________________

4.2.3 Radiation Dose

Dose Limits: E & E's radiation dose limits are stated in the *CHSP*. Implementation of these dose limits may be designated on a site-specific basis.

Site-Specific Dose Limits: ______________________________

ALARA Policy: Radiation doses to E & E personnel shall be maintained as low as reasonably achievable (ALARA), taking into account the work objective, state of technology available, economics of improvements in dose reduction with respect to overall health and safety, and other societal and socioeconomic considerations.

5. SITE CONTROL

5.1 SITE LAYOUT AND WORK ZONES

Site Work Zones: Refer to the site map or sketch, attached at the end of this plan (as Attachment F, if available), for designated work zones.. The Command Post will be a City of Port Angeles boat house located on Ediz Hook Road near the Coast Guard Station.

Site Access Requirements and Special Considerations: The Port of Port Angeles and the Coast Guard will be notified of all vessel operations during sampling activities.

Illumination Requirements: Proper inside lighting. Outside activities will be performed during daylight hours only. .

Sanitary Facilities (e.g., toilet, shower, potable water): The boat house command post has sanitary facilities for the field team.

On-Site Communications: vessel air horn and marine band radio will be used for emergency communications; all field team members will be equipped with cellular telephones.

Other Site-Control Requirements: Fire extinguishers shall be provided so that the travel distance from any work area to the nearest extinguisher is less than 100 feet. When 5 gallons or more of a flammable or combustible liquid is being used, an extinguisher must be within 50 feet.

5.2 SAFE WORK PRACTICES

Daily Safety Meeting: A daily safety meeting will be conducted for all E & E personnel and will be documented on the Daily Safety Meeting Record form (Attachment D) or in the field logbook. The information and data obtained from applicable site characterization and analysis will be addressed in the safety meetings and also will be used to update this SHASP, as necessary.

Work Limitations: Work shall be limited to a maximum of 12 hours per day. If 12 consecutive days are worked, at least one day off shall be provided before work is resumed. Work will be conducted during daylight hours only unless prior approval is obtained and the illumination requirements in 29 CFR 1910.120(m) and WAC 296-800-290 are satisfied.

Weather Limitations: Work shall not be conducted during electrical storms. Work conducted in other inclement weather (e.g., high winds or heavy rains) will be approved by vessel operators, project management and the regional safety coordinator or designee. Vessel operators will have the authority to stop work if vessel operating conditions are deemed unsafe by the operator.

Other Work Limitations:

Buddy System: Field work will be conducted in pairs of team members according to the buddy system.

Line of Sight: Each field team member shall remain in the line of sight and within verbal communication with at least one other team member.

Eating, Drinking, and Smoking: Eating, drinking, smoking, and the use of tobacco products shall be prohibited in the exclusion and contamination reduction areas, at a minimum, and only shall be permitted in designated areas.

Contamination Avoidance: Field personnel shall avoid unnecessary contamination of personnel, equipment, and materials to the extent practicable.

Sample Handling: Protective gloves of a type designated in Section 7 will be worn when containerized samples are handled for labeling, packaging, transportation, and other purposes.

Vermiculite Handling: Vermiculite will not be used in packing and handling of samples.

Other Safe Work Practices: Only authorized personnel are permitted to operate marine vessels and sampling equipment. Personnel working in the vicinity of contaminated sediments will wear disposable coveralls or equal and exercise enhanced personal hygiene (for example, frequent hand washing prior to eating, drinking, and smoking; separation of work and street clothing/footwear).

6. HAZARD EVALUATION AND CONTROL

6.1 PHYSICAL HAZARD EVALUATION AND CONTROL

Potential physical hazards and their applicable control measures are described in the following table for each task.

Hazard	Task Number	Hazard Control Measures
Biological (flora, fauna, etc.	1, 2, 3	∃ Potential hazard:
		∃ Establish site-specific procedures for working around identified hazards.
		∃ Other:
Cold Stress	1, 2, 3	∃ Provide warm break area and adequate breaks.
		∃ Provide warm, noncaffeinated beverages.
		∃ Promote cold stress awareness.
		∃ See *Cold Stress Prevention and Treatment* SOP (attached at the end of this plan if cold stress is a potential hazard).
Compressed Gas Cylinders		∃ Use caution when moving or storing cylinders.
		∃ A cylinder is a projectile hazard if it is damaged or its neck is broken.
		∃ Store cylinders upright and secure them with chains or by other means.
		∃ Other:
Confined Space		∃ Ensure compliance with 29 CFR 1910.146.
		∃ See *Confined Space Entry* SOP (H&S 5.1). Additional documentation is required.
		∃ Other:
Drilling	1, 2, 3	∃ See *Health and Safety on Drilling Rig Operations* SOP (H&S 5.3). Additional documentation may be required.
		∃ Landfill caps will not be penetrated without prior discussions with corporate health and safety staff.
		∃ Other:
Drums and Containers	1, 2, 3	∃ Ensure compliance with 29 CFR 1910.120(j) and WAC 296-843-180.
		∃ Consider unlabeled drums or containers to contain hazardous substances and handle accordingly until the contents are identified.
		∃ Inspect drums or containers and ensure integrity prior to handling.
		∃ Move drums or containers only as necessary; use caution and warn nearby personnel of potential hazards.
		∃ Open, sample, and/or move drums or containers in accordance with established procedures; use approved drum/container-handling equipment.
		∃ Other:
Electrical		∃ Ensure compliance with 29 CFR 1910 Subparts J and S and WAC 296-800-280.
		∃ Locate and mark energized lines.
		∃ De-energize lines as necessary.
		∃ Ground all electrical circuits.
		∃ Guard or isolate temporary wiring to prevent accidental contact.
		∃ Evaluate potential areas of high moisture or standing water and define special electrical needs.
		∃ Other:

Hazard	Task Number	Hazard Control Measures
Excavation and Trenching		∃ Ensure that excavations comply with and personnel are informed of the requirements of 29 CFR 1926 Subpart P and WAC 296-155 Subpart N.
		∃ Ensure that any required sloping or shoring systems are approved as per 29 CFR 1926 Subpart P and WAC 296-155 Subpart N.
		∃ Identify special personal protective equipment (PPE; see Section 7) and monitoring (see Section 8) needs if personnel are required to enter approved excavated areas or trenches.
		∃ Maintain line of sight between equipment operators and personnel in excavations/trenches. Such personnel are prohibited from working in close proximity to operating machinery.
		∃ Suspend or shut down operations at signs of cave in, excessive water, defective shoring, changing weather, or unacceptable monitoring results.
		∃ Other:
		∃ Other:
Fire and Explosion	1, 2, 3	∃ Inform personnel of the location(s) of potential fire/explosion hazards.
		∃ Establish site-specific procedures for working around flammables.
		∃ Ensure that appropriate fire suppression equipment and systems are available and in good working order.
		∃ Define requirements for intrinsically safe equipment.
		∃ Identify special monitoring needs (see Section 8).
		∃ Remove ignition sources from flammable atmospheres.
		∃ Coordinate with local firefighting groups regarding potential fire/explosion situations.
		∃ Establish contingency plans and review daily with team members.
		∃ Other:
Heat Stress	1, 2, 3	∃ Provide cool break area and adequate breaks.
		∃ Provide cool, noncaffeinated beverages.
		∃ Promote heat stress awareness.
		∃ Use active cooling devices (e.g., cooling vests) where specified.
		∃ See *Heat Stress Prevention and Treatment* SOP (attached at the end of this plan if heat stress is a potential hazard).
Heavy Equipment Operation	1, 2, 3	∃ Define equipment routes, traffic patterns, and site-specific safety measures.
		∃ Ensure that operators are properly trained and equipment has been inspected and maintained properly. Verify back-up alarms.
		∃ Ensure that ground spotters are assigned and informed of proper hand signals and communication protocols.
		∃ Identify special PPE (Section 7) and monitoring (Section 8) needs.
		∃ Ensure that field personnel do not work in close proximity to operating equipment.
		∃ Ensure that lifting capacities, load limits, etc. are not exceeded.
		∃ Other:
Heights (Scaffolding, Ladders, etc.)		∃ Ensure compliance with applicable subparts of 29 CFR 1910.
		∃ Identify special PPE needs (e.g., lanyards, safety nets, etc.)
		∃ Other:
Noise	1, 2, 3	∃ Establish noise level standards for on-site equipment/operations.
		∃ Inform personnel of hearing protection requirements (Section 7).
		∃ Define site-specific requirements for noise monitoring (Section 8).
		∃ Other: Ensure compliance with applicable subparts of WAC 296-817.
Overhead Obstructions	1, 2, 3	∃ Wear hard hat.
		∃ Other:

Hazard	Task Number	Hazard Control Measures
Power Tools	1, 2, 3	∃ Ensure compliance with 29 CFR 1910 Subpart P and WAC 296-807.
		∃ Other:
Sunburn	1, 2, 3	∃ Apply sunscreen.
		∃ Wear hats/caps and long-sleeve clothing.
		∃ Other:
Utility Lines		∃ Identify/locate existing utilities prior to work.
		∃ Ensure that overhead, underground, and nearby utility lines are at least 25 feet away from project activities.
		∃ Contact utilities to confirm locations, as necessary.
		∃ Other:
Weather Extremes	1, 2, 3	∃ Potential hazards: high winds, heavy rain
		∃ Establish site-specific contingencies for severe weather situations.
		∃ Provide for frequent weather broadcasts.
		∃ Weatherize safety gear, as necessary (e.g., ensure eye wash units cannot freeze, etc.).
		∃ Identify special PPE (Section 7) needs.
		∃ Discontinue work during severe weather.
		∃ Other:
Other: Working from boats	1, 2, 3	∃ Personal Flotation Devices (PFD) shall be worn at while working from the boats.

6.2 CHEMICAL HAZARD EVALUATION AND CONTROL

6.2.1 Chemical Hazard Evaluation

Potential chemical hazards are described by task number in Table 6-1. Hazard Evaluation Sheets for major known contaminants are provided as Attachment E.

Table 6-1
CHEMICAL HAZARD EVALUATION

Task Number	Compound	Exposure Limits (TWA) OSHA PEL	NIOSH REL[a]	ACGIH TLV	Dermal Hazard (Y/N)	Route(s) of Exposure[b]	Acute Symptoms	Odor Threshold/ Description	FID/PID Relative Response	Ionization Potential (eV)
1, 2, 3	PAHs * [Benzo(a)pyrene]	0.2 mg/m^3	0.1 mg/m^3	NA	Y	D, IH, IN, SC	Irritation to skin, warts	Solid		
1, 2, 3	PCBs	1 mg/m^3	0.001 mg/m^3	1 mg/m^3	Yes	D, E, IH, IN, SC	Eye irritation; chloracne	Hydrocarbon like		
1, 2, 3	Tin, organic (TBT)	0.1 mg/m^3	0.1 mg/m^3	0.1 mg/m^3	Y	D, IH, IN, SC	Irritation to eyes, skin, upper respiratory system;			
1, 2, 3	Dioxin/Furans* (2,3,7,8-TCDD)	None	Carceno gen	NA	Y	D, E, IH, IN, SC	Irritation to eyes, skin (chloroacne) , upper respiratory system;	Solid		
1, 2, 3	Arsenic	0.01 mg/m^3	0.002 mg/m^3	0.01 mg/m^3	Y	DA, E, IH, IN, SC	Ulceration of nasal septum, respiratory irritation, dermatitis, gastrointestinal disturbances, peripheral neuropathy, hyperpigmentation	Garlic odor		9.8152
1, 2, 3	Cadmium*	0.005 mg/m^3	Carceno gen	0.010 mg/m^3 (8 hr TWA)	N	IH, IN	Pulmonary edema, coughing, chest tightness/pain, headache, chills, muscle aches, nausea, vomiting, diarrhea, difficulty breathing, loss of sense of smell, emphysema, mild anemia	Odorless solid		8.994
1, 2, 3	Chromium	1 mg/m^3	0.5 mg/m^3	0.5 mg/m^3	Y	E, IH, IN, SC	Irritated eyes, sensitization dermatitis, histologic fibrosis of lungs	Odorless solid		6.767
1, 2, 3	Copper	1 mg/m^3	1 mg/m^3	1 mg/m^3	Y	E, IH, IN, SC	Irritation to eyes, skin, nose, and pharynx; metallic taste; dermatitis	Odorless Solid		7.726
1, 2, 3	Lead	0.050 mg/m^3	0.050 mg/m^3	0.05 mg/m^3	Y	E, IH, IN, SC	Weakness lassitude, facial pallor, pal eye, weight loss, malnutrition, abdominal pain, constipation, anemia, gingival lead line, tremors, paralysis of wrist and ankles, encephalopathy, kidney disease, irritated eyes, hypertension	Odorless Solid		7.417
1, 2, 3	Mercury	0.1 mg/m^3	0.1 mg/m^3	0.1 mg/m^3	Y	DA, E, IH, IN, SC	Eye and skin irritation; coughing, chest pain, dyspnea, bronchitis, irritability, indecision, headache, lassitude, stomatitis, and salivation,			

1, 2, 3	Zinc	5 mg/m^3	5 mg/m^3	5 mg/m^3	N	IH	Chills; aches; nausea; fever; cough; dry throat; headache; blurred vision; vomit; fatigue	Odorless Solid		9.394

Note: Use an asterisk (*) to indicate known or suspected carcinogens.

[a] No detectable exposure levels for proven carcinogenic substance.
[b] Dermal absorption = DA, eye contact = E, inhalation = IH, ingestion = IN, skin contact = SC.

Key:

ACGIH = American Conference of Governmental Industrial Hygienists.
eV = Electron volt.
FID = Flame ionization detector.
NIOSH = National Institute of Occupational Safety and Health.
OSHA = Occupational Safety and Health Administration.
PEL = Permissible exposure limit.
PID = Photoionization detector.
REL = Recommended exposure limit.
TLV = Threshold limit value.
TWA = Time-weighted average.

6.2.2 Chemical Hazard Control

An appropriate combination of engineering/administrative controls, work practices, and PPE shall be used to reduce and maintain employee exposures to a level at or below published exposure levels (see Section 6.2.1).

Applicable Engineering/Administrative Control Measures: ______________________________

____

PPE: See Section 7. ____

6.3 RADIOLOGICAL HAZARD EVALUATION AND CONTROL

6.3.1 Radiological Hazard Evaluation

Potential radiological hazards are described in the table below by task number. Hazard Evaluation Sheets for major known contaminants are provided as Attachment E.

Task Number	Radionuclide	DAC (µCi/mL)	Route(s) of Exposure	Major Radiation(s)	Energy(s) (MeV)	Half-Life

Key:

DAC = Derived air concentration.
MeV = Million electron volts.
µCi/mL = MicroCuries per milliliter.

6.3.2 Radiological Hazard Control

Engineering/administrative controls and work practices shall be instituted to reduce and maintain employee exposures to a level at or below the permissible exposure/dose limits (see Sections 4.2.3 and 6.3.1). Whenever engineering/administrative controls and work practices are not feasible or effective, any reasonable combination of engineering/administrative controls, work practices, and PPE shall be used to reduce and maintain employee exposures to a level at or below permissible exposure/dose limits.

Applicable Engineering/Administrative Control Measures: ______________________________

____

PPE: See Section 7. ____

7. LEVEL OF PROTECTION AND PERSONAL PROTECTIVE EQUIPMENT

7.1 LEVEL OF PROTECTION

The levels of protection (LOPs) selected for each work task based on an evaluation of the potential or known hazards, the routes of potential hazards, and the performance specifications of the PPE are listed in Table 7-1. On-site monitoring results and other information obtained from on-site activities will be used to modify these LOPs and the PPE, as necessary, to ensure sufficient personnel protection. The authorized LOP and PPE only shall be changed with the approval of the regional safety coordinator or designee. Level A is not included in the table because Level A activities, which are performed infrequently, require special planning and addenda to this SHASP.

Table 7-1				
Task Number	**Level of Protection**			**Modifications Allowed**
	B	**C**	**D**	
1			x	
2,3			x	

Note: Use "X" for initial levels of protection. Use "(X)" to indicate levels of protection that may be used as site conditions warrant.

7.2 PERSONAL PROTECTIVE EQUIPMENT

The PPE selected for each task is indicated in Table 7-2. E & E's PPE program complies with 29 CFR 1910.120 and 29 CFR 1910 Subpart I and is described in detail in the *CHSP*. Refer to 29 CFR 1910 for the minimum PPE required for each LOP.

Table 7-2						
Personal Protective Equipment	**Task Number/Level of Protection**					
	A	1	2,3			
Full-Face APR						
PAPR						
Cartridges:						
H						
GMC-H, GMC-P100						
GME-H, GME-P100						
Other:						
Positive-Pressure, Full-Face SCBA						
Spare Air Tanks (Grade D Air)						
Positive-Pressure, Full-Face, Supplied-Air System						
Cascade System (Grade D Air)						
Manifold System						
5-Minute Escape Mask						
Safety Glasses		X	X			
Monogoggles						
Coveralls/Clothing		X	X			
Protective Clothing:						
Tyvek		(x)	(x)			
Saranex						
Sijel						
Nomex						
Other:						
Splash Apron						
Inner Gloves:						
Cotton		X	X			
Nitrile		X	X			
Latex						
Silver Shield						
Other:						
Outer gloves:						
Viton						
Silver Shield						
Rubber						
Neoprene						
Nitrile		X	X			
Other:						
Work Gloves						
Safety Boots (as per ANSI Z41)		X	X			

Table 7-2						
Personal Protective Equipment	**Task Number/Level of Protection**					
	A	1	2,3			
Neoprene Safety Boots (as per ANSI Z41)						
Boot Covers (type:						
Hearing Protection (type:						
Hard Hat		X				
Face Shield						
Other: Rubber Boots		X				
Other:						

Key:

ANSI = American National Standards Institute.
APR = Air-purifying respirator.
PAPR = Powered air-purifying respirator.
SCBA = Self-contained breathing apparatus.

8. HEALTH AND SAFETY MONITORING

Health and safety monitoring will be conducted to ensure proper selection of engineering/administrative controls, work practices, and/or PPE so that employees are not exposed to hazardous substances at levels that exceed permissible exposure/dose limits or published exposure levels. Health and safety monitoring will be conducted using the instruments, frequency, and action levels described in Table 8-1. Health and safety monitoring instruments shall have been calibrated and/or performance-checked appropriately prior to use.

Table 8-1
HEALTH AND SAFETY MONITORING

Instrument	Task Number	Contaminant(s)	Monitoring Location	Monitoring Frequency	Action Levels[a]	
9 PID (e.g., MiniRAE/TVA 1000) 9 FID (e.g., TVA 1000)	1	PAHs, petroleum hydrocarbons	Breathing zone	Upon retrieval of all sediment grab samples	**Unknown Vapors** Background to 1 ppm: Level D 1 to 5 ppm above background: Level C 5 to 500 ppm above background: Level B >500 ppm above background: Level A	**Contaminant-Specific**
Oxygen Meter/Explosimeter					**Oxygen** <19.5% or >22.0%: Evacuate area; eliminate ignition sources; reassess conditions. 19.5 to 22.0%: Continue work in accordance with action levels for other instruments.	**Explosivity** $\leq$10% LEL: Continue work in accordance with action levels for other instruments; monitor continuously for combustible atmospheres. >10% LEL: Evacuate area; eliminate ignition sources; reassess conditions.
Radiation Alert Monitor (Rad-mini or RAM-4)					<0.1 mR/hr: Continue work in accordance with action levels for other instruments. $\geq$0.1 mR/hr: Evacuate area; reassess work plan and contact radiation safety specialist.	
Mini-Ram Particulate Monitor					**General/Unknown** Evaluate health and safety measures when dust levels exceed 2.5 milligrams per cubic meter.	**Contaminant-Specific**
HCN/H_2S (Monitox)					$\geq$4 ppm: Leave area and consult with site safety officer.	
Draeger Colorimetric Tubes					**Tube** **Action Level**	**Action**
Air Monitor/Sampler Type: Sampling Medium:					**Action Level**	**Action**

Table 8-1
HEALTH AND SAFETY MONITORING

Instrument	Task Number	Contaminant(s)	Monitoring Location	Monitoring Frequency	Action Levels[a]
Personal Sampling Pump Type: Sampling Medium:					**Action Level** **Action**
Micro R Meter					<2 mR/hr: Continue work in accordance with action levels for other instruments. 2 to 5 mR/hr: In conjunction with a radiation safety specialist, continue work and perform stay-time calculations to ensure compliance with dose limits and ALARA policy. >5 mR/hr: Evacuate area to reassess work plan and evaluate options to maintain personnel exposures ALARA and within dose limits.
Ion Chamber					See micro R meter action levels above.
Radiation Survey Ratemeter/Scaler with External Detector(s)					**Detector** **Action Level** **Action**
Noise Dosimeter (Sound Level Meter)					≤85 decibels as measured using the A-weighed network (dB[A]): Use hearing protection if exposure will be sustained throughout work shift. >85 dB(A): Use hearing protection. >120 dB(A): Leave area and consult with safety personnel.
Other:					
Other:					

[a] Unless stated otherwise, airborne contaminant concentrations are measured as a time-weighted average in the worker's breathing zone. Acceptable concentrations for known airborne contaminants will be determined based on OSHA/NIOSH/ACGIH and/or NRC exposure limits. As a guideline, half the PEL/TLV/REL, whichever is lower should be used.

Key:

ACGIH = American Conference of Governmental Industrial Hygienists.
ALARA = As low as reasonably achievable.
dB(A) = Decibels (A weighted).
FID = Flame ionization detector.
LEL = Lower explosive limit.
HCN = Hydrogen cyanide.
H_2S = Hydrogen sulfide.
mR/hr = Millirem per hour.
NIOSH = National Institute of Occupational Safety and Health.
NRC = Nuclear Regulatory Commission.
OSHA = Occupational Safety and Health Administration.
OVA = Organic vapor analyzer.
PEL = Permissible exposure limit.
PID = Photoionization detector.
ppm = Parts per million.
REL = Recommended exposure limit.
TLV = Threshold limit value.

9. DECONTAMINATION PROCEDURES

All equipment, materials, and personnel will be evaluated for contamination upon leaving the exclusion area. Equipment and materials will be decontaminated and/or disposed of, and personnel will be decontaminated, as necessary. Decontamination will be performed in the contamination reduction area or any designated area such that exposure to uncontaminated employees, equipment, and materials will be minimized. Specific procedures are described below.

Equipment/Material Decontamination Procedures (specified by work plan): Wash/rinse equipment with trisodium phosphate detergent. Solvent rinse stainless steel equipment when appropriate. Contain solvent waste for offsite disposal. Dispose of decontamination water to facility or sanitary sewer, or contain for offsite disposal.

Ventilation: All decontamination procedures will be conducted in a well-ventilated area.

Personnel Decontamination Procedures: Hand wash/rinse. Face wash/rinse. Shower ASAP. Dispose of PPE in municipal trash, or contain for disposal. Dispose of personnel rinse water to facility or sanitary sewer, or contain for offsite disposal.

PPE Requirements for Personnel Performing Decontamination: Boot wash/rinse. Glove wash/rinse, Outer glove removal.

Personnel Decontamination in General: Following appropriate decontamination procedures, all field personnel will wash their hands and faces with soap and potable water. Personnel should shower at the end of each work shift.

Disposition of Disposable PPE: Disposable PPE must be rendered unusable and disposed of as indicated in the work plan.

Disposition of Decontamination Wastes (e.g., dry wastes, decontamination fluids, etc.): To be determined on site

10. EMERGENCY RESPONSE

This section contains additional information pertaining to on-site emergency response and does not duplicate pertinent emergency response information contained in earlier sections of this plan (e.g., site layout, monitoring equipment, etc.). Emergency response procedures will be rehearsed regularly, as applicable, during project activities.

10.1 EMERGENCY RESPONSIBILITIES

All Personnel: All personnel shall be alert to the possibility of an on-site emergency; shall report potential or actual emergency situations to the team leader and SSO; and shall notify appropriate emergency resources, as necessary.

Team Leader: The field team leader will determine the emergency actions to be performed by E & E personnel and will direct these actions. The team leader also will ensure that applicable incidents are reported to appropriate E & E and client project personnel and government agencies.

SSO: The SSO will recommend health/safety and protective measures appropriate to the emergency.

Other:

10.2 LOCAL AND SITE RESOURCES (including phone numbers)

Ambulance: 911 (verify that there is 911 coverage in site vicinity)

Hospital: Olympic Memorial Hospital
908 Georgiana Street
Port Angeles, WA 98362

Directions to Hospital (map attached at the end of this plan as Attachment F):

Poison Control: **(800) 732-6985**

Police Department: 911. U.S. Coast Guard monitors Marine-band Channel 16 (Can be used to contact USCG in the event of an emergency)

Fire Department: 911

Client Contact: Cynthia Erickson, Department of Ecology, (360) 407-6361 or Joe Crossland, Department of Ecology, (360) 407-7219.

Site Contact: **Larry Dunn, LEKT Tribal Representative, (360) 460-7166**
Mark Madsen, City of Port Angeles, (360) 417-4804

On-Site Telephone Number: **Larry Dunn, LEKT Tribal Representative, (360) 460-7166**
Mark Madsen, City of Port Angeles, (360) 417-4804

Cellular Telephone Number: SSO, Mark Longtine: (206) 794-9750; Field Team Leader, Eric White: (503) 349-4441.

Radios Available: **Yes**

Other:

10.3 E & E EMERGENCY CONTACTS

Emergency contacts for E & E are listed in the following table.

E & E EMERGENCY CONTACTS	
E & E Emergency Response Center (open 24 hours)	**716/684-8940** Please follow contact instructions listed in Section 10.4 (below) when calling.
Dr. Paul Jonmaire, Corporate Health and Safety Director	716/684-8060 (office) 716/655-1260 (home)
Tom Siener, Corporate Safety Officer	716/684-8060 (office) 716/662-4740 (home)
Joe Grojean, Regional Office Contact	206/624-9537 (office) 206/232-0145 (home) 206/419-3420 (cell)
William Richards, Project Manager	206/624-9537 (office) 206/369-6152 (cell)

10.4 E & E EMERGENCY RESPONSE CENTER HOTLINE

The Emergency Response hotline is activated and accessed as follows:

1. Call 716/684-8940.
2. State, "This is an emergency."
3. Provide:

- Your name, region, and site.
- Your telephone number.
- Your location.
- Name of injured or exposed person.
- Nature of the emergency.
- Action(s) taken.

10.5 OTHER EMERGENCY RESPONSE PROCEDURES

On-Site Evacuation Signal/Alarm (must be audible and perceptible above ambient noise and light levels): Continuous sounding of horn = Emergency, leave site now. Grasping throat with hand = help me. Thumbs up = OK, understood.

On-Site Assembly Area: Boat house at command post on Ediz Hook.

Emergency Egress Route to Get Off Site: Evacuation route(s) and assembly area(s) will be designated by the SSO before work begins.

Off-Site Assembly Area: **To be determined on site**

Preferred Means of Reporting Emergencies: Notify appropriate emergency response authorities. The Field Team Leader of the specific crew will assume charge during a medical emergency until the ambulance arrives or until the injured person is admitted to the emergency room. Prevent further injury. Initiate first aid and CPR where feasible. Get medical attention immediately. Perform decontamination where feasible; lifesaving and first aid or medical treatment take priority. Make certain that the injured person is accompanied to the emergency room.

Site Security and Control: In an emergency situation, personnel will attempt to secure the affected area and control site access.

Emergency Decontamination Procedures: Perform decontamination where feasible; lifesaving and first aid or medical treatment take priority.

PPE: Personnel will don appropriate PPE when responding to an emergency situation. The SSO and Section 7 of this plan will provide guidance regarding appropriate PPE.

Emergency Equipment: Appropriate emergency equipment is listed in Attachment C. Adequate supplies of this equipment shall be maintained in the support area or other approved work location.

Incident Reporting Procedures: Notify appropriate emergency response authorities. The Field Team Leader of the specific crew will assume charge during a medical emergency until the ambulance arrives or until the injured person is admitted to the emergency room.

ATTACHMENT A

SITE-SPECIFIC HEALTH AND SAFETY PLAN ACCEPTANCE

ecology and environment, inc.
SITE-SPECIFIC HEALTH AND SAFETY PLAN ACCEPTANCE

Project: Port Angeles Harbor Sediment Investigation

Project No.: 002330.WD20.03

Project Location: Port Angeles, Washington

Project Manager: William Richards | Project Director: Ron Karpowicz

The undersigned acknowledge that they have read and understood and agree to abide by the health and safety plan.

Name (Printed)	Name (Signature)	Date

ATTACHMENT B

EXISTING SITE SAFETY PLAN ADDENDUM FORM

ecology and environment, inc.

EXISTING SITE SAFETY PLAN ADDENDUM FORM

Site Name:

Date of original SSP:

Date of amendment:

Date of proposed new work:

Added activities and hazard evaluations:

Added monitoring activities:

Level of protection: 9A 9B 9C 9D

Reason for up/downgrading:

PPE:

Decon:

Team Members	Responsibility

Equipment	Quantity	Equipment	Quantity

The terms of the original SSP shall be in effect except as noted on this form.

Prepared by:	**Date:**
Reviewed by:	**Date:**

INSTRUCTIONS: This form to be approved through normal channels and attached to original plan.

ATTACHMENT C

EQUIPMENT/SUPPLIES CHECKLIST

ecology and environment, inc.
EQUIPMENT/SUPPLIES CHECKLIST

Instrumentation	No.	**Emergency Equipment**	No.
TVA 1000 (Probe: eV)	1	First Aid Kit	1
MiniRAE (Probe: eV)		Stretcher	
OVA		Portable Eye Wash	
HNu (Probe: eV)		Blood Pressure Monitor	
Thermal Desorber		Fire Blanket	
O_2/Explosimeter with Calibration Kit		Fire Extinguisher	2
Photovac Tip		Thermometer (Medical)	
Magnetometer		Spill Kit	
Pipe Locator			
Weather Station		**Decontamination Equipment**	
Draeger Tube Kit (Tubes:)		Wash Tubs	2
Brunton Compass		Buckets	2
Real-Time Cyanide Monitor		Scrub Brushes	4
Real-Time H_2S Monitor		Pressurized Sprayer	1
Heat Stress Monitor		Spray Bottle	2
Noise Equipment		Detergent (Type: TRISODIUM PHOSPHATE)	1
Personal Sampling Pumps and Supplies		Solvent (Type: DENATURED ALCOHOL)	1
Mini Ram Dust Monitor		Plastic Sheeting	
Mercury Monitor		Tarps and Poles	
Spare batteries (Type:)		Trash Bags	X
		Trash Cans	
Radiation Equipment/Supplies		Masking Tape	
Documentation Forms		Duct Tape	X
Portable Ratemeter		Paper Towels	X
Scaler/Ratemeter		Face Mask	
1" NaI Gamma Probe		Face Mask Sanitizer	
2" NaI Gamma Probe		Step Ladders	
ZnS Alpha Probe		Distilled Water	X
GM Pancake Probe		Deionized Water	
Tungsten-Shielded GM Probe			
Micro R Meter		**Miscellaneous**	
Ion Chamber		Pump	
Alert Monitor		Surveyor's Tape	
Pocket Dosimeter		100' Fiberglass Tape	
Dosimeter Charger		300' Nylon Rope	
Radiation Warning Tape		Nylon String	
Radiation Decontamination Supplies		Surveying Flags	
Spare Batteries (Type:)		Camera	2
		Film	
Sampling Equipment		Bung Wrench	
8-oz Bottles	X	Soil Auger	
Half-Gallon Bottles		Pick	
VOA Bottles		Shovel	X
String		Catalytic Heater	
Hand Bailers		Propane Gas	
Thieving Rods with Bulbs		Banner Tape	
Spoons	X	Surveying Meter Stick	
Knives		Chaining Pins and Ring	
Filter Paper		Logbooks (Large, Small)	
Bottle Labels	X	Required MSDSs	
		Intrinsically Safe Flashlight	
Shipping Equipment		Potable Water	
Coolers	X	Gatorade or Equivalent	
Paint Cans with Lids, Seven Clips Each		Tables	2
Vermiculite		Chairs	2
Shipping Labels		Weather Radio	
DOT Labels:		Two-Way Radios	
"Up"		Binoculars	1
"Danger"		Megaphone	
"Inside Container Complies..."		Cooling Vest	
"Hazard Group"			

ecology and environment, inc. EQUIPMENT/SUPPLIES CHECKLIST			
Instrumentation	No.	**Emergency Equipment**	No.
Shipping Equipment (Cont.)			
Strapping Tape	X		
Baggies	X		
Custody Seals	X		
Chain-of-Custody Forms	X		
FedEx Forms	X		
Clear Packing Tape	X		
Permanent Markers	X		

NOTE: PERSONAL FLOATATION DEVICES NEEDED BY ALL FIELD TEAM MEMBERS PARTICIPATING IN VESSEL-BASED SAMPLING OPERATIONS

ATTACHMENT D

DAILY SAFETY MEETING RECORD

ecology and environment, inc.
DAILY SAFETY MEETING RECORD

General Information		
Project: Port Angeles Harbor Sediment Investigation		
Project No: 002330.WD20.03		
Project Location: Port Angeles, Washington		
Date:	Time:	Weather:
Specific Location:		
Planned Activities:		

Safety Topics Presented
Chemical Hazards Update:
Physical Hazards Update:
Radiation Hazards Update:
Review of Previous Monitoring Results:
Protective Clothing/Equipment Modifications:
Special Equipment/Procedures:
Drilling Safety Issues (including testing the operation of drill rig emergency stop switches):
Emergency Procedures:
Additional Topics/Observations:
Team Members' Comments/Suggestions:

ecology and environment, inc.

DAILY SAFETY MEETING RECORD

Initial Project Safety Checklist

1. Emergency information reviewed? ___ and made familiar to all team members?
2. Route to nearest hospital driven? ___ and its location known to all team members?
3. Health and safety plan readily available and its location known to all team members?
4. E & E drilling SOP on site? ___ and available for team member review?

ATTENDEES

Meeting shall be attended by all personnel who will be working within the exclusion area. Daily informal update meetings will be held prior to work and when site tasks and/or conditions change.

Name (Printed)	Name (Signature)	Date	Representing (Company/Agency)
Meeting Conducted By:			

ATTACHMENT E

HAZARD EVALUATION SHEETS FOR MAJOR KNOWN CONTAMINANTS

Arsenic (inorganic compounds, as As)

Arsenic (inorganic compounds, as As)	**CAS** 7440-38-2 (metal)
As (metal)	**RTECS** CG0525000 (metal)
Synonyms & Trade Names Arsenic metal: Arsenia Other synonyms vary depending upon the specific As compound. [Note: OSHA considers "Inorganic Arsenic" to mean copper acetoarsenite & all inorganic compounds containing arsenic except ARSINE.]	**DOT ID & Guide** 1558 152 (metal) 1562 152 (dust)

Exposure Limits	**NIOSH REL**: Ca C 0.002 mg/m^3 [15-minute] See Appendix A
	OSHA PEL: [1910.1018] TWA 0.010 mg/m^3

IDLH Ca [5 mg/m^3 (as As)] See: 7440382	**Conversion**

Physical Description

Metal: Silver-gray or tin-white, brittle, odorless solid.

MW: 74.9	BP: Sublimes	MLT: 1135°F (Sublimes)	Sol: Insoluble
VP: 0 mmHg (approx)	IP: NA		Sp.Gr: 5.73 (metal)
Fl.P: NA	UEL: NA	LEL: NA	

Metal: Noncombustible Solid in bulk form, but a slight explosion hazard in the form of dust when exposed to flame.

Incompatibilities & Reactivities

Strong oxidizers, bromine azide [Note: Hydrogen gas can react with inorganic arsenic to form the highly toxic gas arsine.]

Measurement Methods

NIOSH 7300, 7301, 7303, 7900, 9102; OSHA ID105
See: NMAM or OSHA Methods

Personal Protection & Sanitation (See protection) Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contaminated/Daily Remove: When wet or contaminated Change: Daily Provide: Eyewash, Quick drench	**First Aid** (See procedures) Eye: Irrigate immediately Skin: Soap wash immediately Breathing: Respiratory support Swallow: Medical attention immediately

Respirator Recommendations

(See Appendix E) NIOSH
At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Escape:
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted acid gas canister having an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters./Any appropriate escape-type, self-contained breathing apparatus
Important additional information about respirator selection

Exposure Routes

inhalation, skin absorption, skin and/or eye contact ingestion

Symptoms

Ulceration of nasal septum, dermatitis, gastrointestinal disturbances, peripheral neuropathy, respiratory irritation, hyperpigmentation of skin, [potential occupational carcinogen]

Target Organs

Liver, kidneys, skin, lungs, lymphatic system

Cancer Site

[lung & lymphatic cancer]

Cadmium dust (as Cd)

CAS

7440-43-9 (metal)

Cd (metal)

RTECS

EU9800000 (metal)

Synonyms & Trade Names

Cadmium metal: Cadmium
Other synonyms vary depending upon the specific cadmium compound.

DOT ID & Guide

2570 154 (cadmium compound)

Exposure Limits

NIOSH REL*: Ca See Appendix A [*Note: The REL applies to all Cadmium compounds (as Cd).]

OSHA PEL*: [1910.1027] TWA 0.005 mg/m^3 [*Note: The PEL applies to all Cadmium compounds (as Cd).]

IDLH

Ca [9 mg/m^3 (as Cd)] See: IDLH INDEX

Conversion

Physical Description

Metal: Silver-white, blue-tinged lustrous, odorless solid.

MW: 112.4	BP: 1409°F	MLT: 610°F	Sol: Insoluble
VP: 0 mmHg (approx)	IP: NA		Sp.Gr: 8.65 (metal)
Fl.P: NA	UEL: NA	LEL: NA	

Metal: Noncombustible Solid in bulk form, but will burn in powder form.

Incompatibilities & Reactivities

Strong oxidizers; elemental sulfur, selenium & tellurium

Measurement Methods

NIOSH 7048, 7300, 7301, 7303, 9102; OSHA ID121, ID125G, ID189, ID206
See: NMAM or OSHA Methods

Personal Protection & Sanitation

(See protection)
Skin: No recommendation
Eyes: No recommendation
Wash skin: Daily
Remove: No recommendation
Change: Daily

First Aid

(See procedures)
Eye: Irrigate immediately
Skin: Soap wash
Breathing: Respiratory support
Swallow: Medical attention immediately

Respirator Recommendations

(See Appendix E) NIOSH

At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Escape:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters./Any appropriate escape-type, self-contained breathing apparatus
Important additional information about respirator selection

Exposure Routes

inhalation, ingestion

Symptoms

Pulmonary edema, dyspnea (breathing difficulty), cough, chest tightness, substernal (occurring beneath the sternum) pain; headache; chills, muscle aches; nausea, vomiting, diarrhea; anosmia (loss of the sense of smell), emphysema, proteinuria, mild anemia; [potential occupational carcinogen]

Target Organs

respiratory system, kidneys, prostate, blood

Cancer Site

[prostatic & lung cancer]

See also: INTRODUCTION See ICSC CARD: 0020 See MEDICAL TESTS: 0035

Chromium metal

CAS

7440-47-3

Cr

RTECS

GB4200000

Synonyms & Trade Names

Chrome, Chromium

DOT ID & Guide

Exposure Limits

NIOSH REL: TWA 0.5 mg/m^3 See Appendix C

OSHA PEL*: TWA 1 mg/m^3 See Appendix C [*Note: The PEL also applies to insoluble chromium salts.]

IDLH

250 mg/m^3 (as Cr) See: 7440473

Conversion

Physical Description

Blue-white to steel-gray, lustrous, brittle, hard, odorless solid.

MW: 52.0	BP: 4788°F	MLT: 3452°F	Sol: Insoluble
VP: 0 mmHg (approx)	IP: NA		Sp.Gr: 7.14
Fl.P: NA	UEL: NA	LEL: NA	

Noncombustible Solid in bulk form, but finely divided dust burns rapidly if heated in a flame.

Incompatibilities & Reactivities

Strong oxidizers (such as hydrogen peroxide), alkalis

Measurement Methods

NIOSH 7024, 7300, 7301, 7303, 9102; OSHA ID121, ID125G
See: NMAM or OSHA Methods

Personal Protection & Sanitation

(See protection)
Skin: No recommendation
Eyes: No recommendation
Wash skin: No recommendation
Remove: No recommendation
Change: No recommendation

First Aid

(See procedures)
Eye: Irrigate immediately
Skin: Soap wash
Breathing: Respiratory support
Swallow: Medical attention immediately

Respirator Recommendations

NIOSH
Up to 2.5 mg/m^3:
(APF = 5) Any quarter-mask respirator. Click here for information on selection of N, R, or P filters.*

Up to 5 mg/m^3:
(APF = 10) Any particulate respirator equipped with an N95, R95, or P95 filter (including N95, R95, and P95 filtering facepieces) except quarter-mask respirators. The following filters may also be used: N99, R99, P99, N100, R100, P100. Click here for information on selection of N, R, or P filters.*
(APF = 10) Any supplied-air respirator*
Up to 12.5 mg/m^3:
(APF = 25) Any supplied-air respirator operated in a continuous-flow mode*
(APF = 25) Any powered air-purifying respirator with a high-efficiency particulate filter.*
Up to 25 mg/m^3:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters.
(APF = 50) Any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter*
(APF = 50) Any self-contained breathing apparatus with a full facepiece
(APF = 50) Any supplied-air respirator with a full facepiece
Up to 250 mg/m^3:
(APF = 2000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
Emergency or planned entry into unknown concentrations or IDLH conditions:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Escape:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters./Any appropriate escape-type, self-contained breathing apparatus
Important additional information about respirator selection

Exposure Routes

inhalation, ingestion, skin and/or eye contact

Symptoms

Irritation eyes, skin; lung fibrosis (histologic)

Target Organs

Eyes, skin, respiratory system

See also: INTRODUCTION See ICSC CARD: 0029 See MEDICAL TESTS: 0052

Copper (dusts and mists, as Cu)

CAS

7440-50-8

Cu

RTECS

GL5325000

Synonyms & Trade Names

Copper metal dusts, Copper metal fumes

DOT ID & Guide

Exposure Limits

NIOSH REL*: TWA 1 mg/m^3 [*Note: The REL also applies to other copper compounds (as Cu) except Copper fume.]

OSHA PEL*: TWA 1 mg/m^3 [*Note: The PEL also applies to other copper compounds (as Cu) except copper fume.]

IDLH

100 mg/m^3 (as Cu) See: 7440508

Conversion

Physical Description

Reddish, lustrous, malleable, odorless solid.

MW: 63.5	BP: 4703°F	MLT: 1981°F	Sol: Insoluble
VP: 0 mmHg (approx)	IP: NA		Sp.Gr: 8.94
Fl.P: NA	UEL: NA	LEL: NA	

Noncombustible Solid in bulk form, but powdered form may ignite.

Incompatibilities & Reactivities

Oxidizers, alkalis, sodium azide, acetylene

Measurement Methods

NIOSH 7029, 7300, 7301, 7303, 9102; OSHA ID121, ID125G
See: NMAM or OSHA Methods

Personal Protection & Sanitation

(See protection)
Skin: Prevent skin contact
Eyes: Prevent eye contact
Wash skin: When contaminated
Remove: When wet or contaminated
Change: Daily

First Aid

(See procedures)
Eye: Irrigate immediately
Skin: Soap wash promptly
Breathing: Respiratory support
Swallow: Medical attention immediately

Respirator Recommendations

NIOSH/OSHA
Up to 5 mg/m^3:

(APF = 5) Any quarter-mask respirator. Click here for information on selection of N, R, or P filters.*
Up to 10 mg/m^3:
(APF = 10) Any particulate respirator equipped with an N95, R95, or P95 filter (including N95, R95, and P95 filtering facepieces) except quarter-mask respirators. The following filters may also be used: N99, R99, P99, N100, R100, P100. Click here for information on selection of N, R, or P filters.*
(APF = 10) Any supplied-air respirator*
Up to 25 mg/m^3:
(APF = 25) Any supplied-air respirator operated in a continuous-flow mode*
(APF = 25) Any powered air-purifying respirator with a high-efficiency particulate filter.*
Up to 50 mg/m^3:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters.
(APF = 50) Any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter*
(APF = 50) Any self-contained breathing apparatus with a full facepiece
(APF = 50) Any supplied-air respirator with a full facepiece
Up to 100 mg/m^3:
(APF = 2000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
Emergency or planned entry into unknown concentrations or IDLH conditions:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Escape:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters./Any appropriate escape-type, self-contained breathing apparatus
Important additional information about respirator selection

Exposure Routes

inhalation, ingestion, skin and/or eye contact

Symptoms

Irritation eyes, respiratory system; cough, dyspnea (breathing difficulty), wheezing

Target Organs

Eyes, skin, respiratory system, liver, kidneys (increase(d) risk with Wilson's disease)

See also: INTRODUCTION See ICSC CARD: 0240 See MEDICAL TESTS: 0057

2,3,7,8-Tetrachloro-dibenzo-p-dioxin

CAS

1746-01-6

$C_{12}H_4Cl_4O_2$

RTECS

HP3500000

Synonyms & Trade Names

Dioxin; Dioxine; TCDBD; TCDD; 2,3,7,8-TCDD [Note: Formed during past production of 2,4,5-trichlorophenol, 2,4,5-T & 2(2,4,5-trichlorophenoxy)propionic acid.]

DOT ID & Guide

Exposure Limits

NIOSH REL: Ca See Appendix A

OSHA PEL: none

IDLH

Ca [N.D.] See: IDLH INDEX

Conversion

Physical Description

Colorless to white, crystalline solid. [Note: Exposure may occur through contact at previously contaminated worksites.]

MW: 322.0	BP: Decomposes	MLT: 581°F	Sol: 0.00000002%
VP(77°F): 0.000002 mmHg	IP: ?		Sp.Gr: ?
Fl.P: ?	UEL: ?	LEL: ?	

Incompatibilities & Reactivities

UV light (decomposes)

Measurement Methods

None available
See: NMAM or OSHA Methods

Personal Protection & Sanitation

(See protection)
Skin: Prevent skin contact
Eyes: Prevent eye contact
Wash skin: When contaminated/Daily
Remove: When wet or contaminated
Change: Daily
Provide: Eyewash, Quick drench

First Aid

(See procedures)
Eye: Irrigate immediately
Skin: Soap flush immediately
Breathing: Respiratory support
Swallow: Medical attention immediately

Respirator Recommendations

NIOSH
At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Escape:
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister having an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters./Any appropriate escape-type, self-contained breathing apparatus
Important additional information about respirator selection

Exposure Routes

inhalation, skin absorption, ingestion, skin and/or eye contact

Symptoms

Irritation eyes; allergic dermatitis, chloracne; porphyria; gastrointestinal disturbance; possible reproductive, teratogenic effects; in animals: liver, kidney damage; hemorrhage; [potential occupational carcinogen]

Target Organs

Eyes, skin, liver, kidneys, reproductive system

Cancer Site

[in animals: tumors at many sites]

See also: INTRODUCTION See ICSC CARD: 1467

Lead	**CAS** 7439-92-1
Pb	**RTECS** OF7525000
Synonyms & Trade Names Lead metal, Plumbum	**DOT ID & Guide**

Exposure Limits	NIOSH REL*: TWA (8-hour) 0.050 mg/m^3 See Appendix C [*Note: The REL also applies to other lead compounds (as Pb) -- see Appendix C.]
	OSHA PEL*: [1910.1025] TWA 0.050 mg/m^3 See Appendix C [*Note: The PEL also applies to other lead compounds (as Pb) -- see Appendix C.]

IDLH 100 mg/m^3 (as Pb) See: 7439921	**Conversion**

Physical Description

A heavy, ductile, soft, gray solid.

MW: 207.2	BP: 3164°F	MLT: 621°F	Sol: Insoluble
VP: 0 mmHg (approx)	IP: NA		Sp.Gr: 11.34
Fl.P: NA	UEL: NA	LEL: NA	

Noncombustible Solid in bulk form.

Incompatibilities & Reactivities

Strong oxidizers, hydrogen peroxide, acids

Measurement Methods

NIOSH 7082, 7105, 7300, 7301, 7303, 7700, 7701, 7702, 9100, 9102, 9105; OSHA ID121, ID125G, ID206
See: NMAM or OSHA Methods

Personal Protection & Sanitation

(See protection)
Skin: Prevent skin contact
Eyes: Prevent eye contact
Wash skin: Daily
Remove: When wet or contaminated
Change: Daily

First Aid

(See procedures)
Eye: Irrigate immediately
Skin: Soap flush promptly
Breathing: Respiratory support
Swallow: Medical attention immediately

Respirator Recommendations

(See Appendix E) NIOSH/OSHA
Up to 0.5 mg/m^3:

(APF = 10) Any air-purifying respirator with an N100, R100, or P100 filter (including N100, R100, and P100 filtering facepieces) except quarter-mask respirators. Click here for information on selection of N, R, or P filters.
(APF = 10) Any supplied-air respirator
Up to 1.25 mg/m^3:
(APF = 25) Any supplied-air respirator operated in a continuous-flow mode
(APF = 25) Any powered, air-purifying respirator with a high-efficiency particulate filter
Up to 2.5 mg/m^3:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters.
(APF = 50) Any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode
(APF = 50) Any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter
(APF = 50) Any self-contained breathing apparatus with a full facepiece
(APF = 50) Any supplied-air respirator with a full facepiece
Up to 50 mg/m^3:
(APF = 1000) Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode
Up to 100 mg/m^3:
(APF = 2000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
Emergency or planned entry into unknown concentrations or IDLH conditions:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Escape:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters./Any appropriate escape-type, self-contained breathing apparatus
Important additional information about respirator selection

Exposure Routes

inhalation, ingestion, skin and/or eye contact

Symptoms

Lassitude (weakness, exhaustion), insomnia; facial pallor; anorexia, weight loss, malnutrition; constipation, abdominal pain, colic; anemia; gingival lead line; tremor; paralysis wrist, ankles; encephalopathy; kidney disease; irritation eyes; hypertension

Target Organs

Eyes, gastrointestinal tract, central nervous system, kidneys, blood, gingival tissue

See also: INTRODUCTION See ICSC CARD: 0052 See MEDICAL TESTS: 0127

Mercury compounds [except (organo) alkyls] (as Hg)	CAS 7439-97-6 (metal)
Hg (metal)	**RTECS** OV4550000 (metal)
Synonyms & Trade Names Mercury metal: Colloidal mercury, Metallic mercury, Quicksilver Synonyms of "other" Hg compounds vary depending upon the specific compound.	**DOT ID & Guide** 2809 172 (metal)

Exposure Limits	
	NIOSH REL: Hg Vapor: TWA 0.05 mg/m^3 [skin] Other: C 0.1 mg/m^3 [skin]
	OSHA PEL†: C 0.1 mg/m^3

IDLH	Conversion
10 mg/m^3 (as Hg) See: 7439976	

Physical Description

Metal: Silver-white, heavy, odorless liquid. [Note: "Other" Hg compounds include all inorganic & aryl Hg compounds except (organo) alkyls.]

MW: 200.6	BP: 674°F	FRZ: -38°F	Sol: Insoluble
VP: 0.0012 mmHg	IP: ?		Sp.Gr: 13.6 (metal)
Fl.P: NA	UEL: NA	LEL: NA	
Metal: Noncombustible Liquid			

Incompatibilities & Reactivities

Acetylene, ammonia, chlorine dioxide, azides, calcium (amalgam formation), sodium carbide, lithium, rubidium, copper

Measurement Methods

NIOSH 6009; OSHA ID140
See: NMAM or OSHA Methods

Personal Protection & Sanitation	First Aid
(See protection) Skin: Prevent skin contact Eyes: No recommendation Wash skin: When contaminated Remove: When wet or contaminated Change: Daily	(See procedures) Eye: Irrigate immediately Skin: Soap wash promptly Breathing: Respiratory support Swallow: Medical attention immediately

Respirator Recommendations

Mercury vapor: NIOSH
Up to 0.5 mg/m^3:
(APF = 10) Any chemical cartridge respirator with cartridge(s) providing protection against the compound of concern†
(APF = 10) Any supplied-air respirator
Up to 1.25 mg/m^3:
(APF = 25) Any supplied-air respirator operated in a continuous-flow mode
(APF = 25) Any powered, air-purifying respirator with cartridge(s) providing protection against the compound of concern†(canister)
Up to 2.5 mg/m^3:
(APF = 50) Any chemical cartridge respirator with a full facepiece and cartridge(s) providing protection against the compound of concern†
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern†
(APF = 50) Any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode/PAPRTS(canister)
(APF = 50) Any self-contained breathing apparatus with a full facepiece
(APF = 50) Any supplied-air respirator with a full facepiece
Up to 10 mg/m^3:
(APF = 1000) Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode
Emergency or planned entry into unknown concentrations or IDLH conditions:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure- demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Escape:
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern/Any appropriate escape-type, self-contained breathing apparatus

Other mercury compounds: NIOSH/OSHA
Up to 1 mg/m^3:
(APF = 10) Any chemical cartridge respirator with cartridge(s) providing protection against the compound of concern†
(APF = 10) Any supplied-air respirator
Up to 2.5 mg/m^3:
(APF = 25) Any supplied-air respirator operated in a continuous-flow mode
(APF = 25) Any powered, air-purifying respirator with cartridge(s) providing protection against the compound of concern†(canister)
Up to 5 mg/m^3:
(APF = 50) Any chemical cartridge respirator with a full facepiece and cartridge(s) providing protection against the compound of concern†
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern†
(APF = 50) Any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode/PAPRTS(canister)
(APF = 50) Any self-contained breathing apparatus with a full facepiece
(APF = 50) Any supplied-air respirator with a full facepiece
Up to 10 mg/m^3:
(APF = 1000) Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode
Emergency or planned entry into unknown concentrations or IDLH conditions:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Escape:

(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern/Any appropriate escape-type, self-contained breathing apparatus
Important additional information about respirator selection

Exposure Routes

inhalation, skin absorption, ingestion, skin and/or eye contact

Symptoms

Irritation eyes, skin; cough, chest pain, dyspnea (breathing difficulty), bronchitis, pneumonitis; tremor, insomnia, irritability, indecision, headache, lassitude (weakness, exhaustion); stomatitis, salivation; gastrointestinal disturbance, anorexia, weight loss; proteinuria

Target Organs

Eyes, skin, respiratory system, central nervous system, kidneys

See also: INTRODUCTION See ICSC CARD: 0056 See MEDICAL TESTS: 0136

Coal tar pitch volatiles

CAS

65996-93-2

RTECS

GF8655000

Synonyms & Trade Names

Synonyms vary depending upon the specific compound (e.g., pyrene, phenanthrene, acridine, chrysene, anthracene & benzo(a)pyrene). [Note: NIOSH considers coal tar, coal tar pitch, and creosote to be coal tar products.]

DOT ID & Guide

2713 153 (acridine)

Exposure Limits

NIOSH REL: Ca TWA 0.1 mg/m^3 (cyclohexane-extractable fraction) See Appendix A See Appendix C

OSHA PEL: TWA 0.2 mg/m^3 (benzene-soluble fraction) [1910.1002] See Appendix C

IDLH

Ca [80 mg/m^3] See: 65996932

Conversion

Physical Description

Black or dark-brown amorphous residue.

Properties vary depending upon the specific compound.			

Combustible Solids

Incompatibilities & Reactivities

Strong oxidizers

Measurement Methods

OSHA 58
See: NMAM or OSHA Methods

Personal Protection & Sanitation

(See protection)
Skin: Prevent skin contact
Eyes: Prevent eye contact
Wash skin: Daily
Remove: No recommendation
Change: Daily

First Aid

(See procedures)
Eye: Irrigate immediately
Skin: Soap wash immediately
Breathing: Respiratory support
Swallow: Medical attention immediately

Respirator Recommendations

NIOSH
At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Escape:
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister having an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters./Any appropriate escape-type, self-contained breathing apparatus
Important additional information about respirator selection

Exposure Routes

inhalation, skin and/or eye contact

Symptoms

Dermatitis, bronchitis, [potential occupational carcinogen]

Target Organs

respiratory system, skin, bladder, kidneys

Cancer Site

[lung, kidney & skin cancer]

See also: INTRODUCTION See ICSC CARD: 1415 See MEDICAL TESTS: 0054

Chlorodiphenyl (54% chlorine)	**CAS** 11097-69-1
$C_6H_3Cl_2C_6H_2Cl_3$ (approx)	**RTECS** TQ1360000
Synonyms & Trade Names Aroclor® 1254, PCB, Polychlorinated biphenyl	**DOT ID & Guide** 2315 171

Exposure Limits	NIOSH REL*: Ca TWA 0.001 mg/m^3 See Appendix A [*Note: The REL also applies to other PCBs.]
	OSHA PEL: TWA 0.5 mg/m^3 [skin]

IDLH Ca [5 mg/m^3] See: IDLH INDEX	**Conversion**

Physical Description

Colorless to pale-yellow, viscous liquid or solid (below 50°F) with a mild, hydrocarbon odor.

MW: 326 (approx)	BP: 689-734°F	FRZ: 50°F	Sol: Insoluble
VP: 0.00006 mmHg	IP: ?		Sp.Gr(77°F): 1.38
Fl.P: NA	UEL: NA	LEL: NA	

Nonflammable Liquid, but exposure in a fire results in the formation of a black soot containing PCBs, polychlorinated dibenzofurans, and chlorinated dibenzo-p-dioxins.

Incompatibilities & Reactivities

Strong oxidizers

Measurement Methods

NIOSH 5503; OSHA PV2088
See: NMAM or OSHA Methods

Personal Protection & Sanitation (See protection) Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contaminated Remove: When wet or contaminated Change: Daily Provide: Eyewash, Quick drench	**First Aid** (See procedures) Eye: Irrigate immediately Skin: Soap wash immediately Breathing: Respiratory support Swallow: Medical attention immediately

Respirator Recommendations

NIOSH

At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Escape:
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister having an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters./Any appropriate escape-type, self-contained breathing apparatus
Important additional information about respirator selection

Exposure Routes

inhalation, skin absorption, ingestion, skin and/or eye contact

Symptoms

Irritation eyes, chloracne; liver damage; reproductive effects; [potential occupational carcinogen]

Target Organs

Skin, eyes, liver, reproductive system

Cancer Site

[in animals: tumors of the pituitary gland & liver, leukemia]

See also: INTRODUCTION See ICSC CARD: 0939 See MEDICAL TESTS: 0176

Tin (organic compounds, as Sn)	CAS
	RTECS
Synonyms & Trade Names Synonyms vary depending upon the specific organic tin compound. [Note: Also see specific listing for Cyhexatin.]	**DOT ID & Guide**

Exposure Limits	
	NIOSH REL*: TWA 0.1 mg/m^3 [skin] [*Note: The REL applies to all organic tin compounds except Cyhexatin.]
	OSHA PEL*: TWA 0.1 mg/m^3 [*Note: The PEL applies to all organic tin compounds.]

IDLH	**Conversion**
25 mg/m^3 (as Sn) See: tin-org	

Physical Description

Appearance and odor vary depending upon the specific organic tin compound.

Properties vary depending upon the specific organic tin compound.			

Incompatibilities & Reactivities

Varies

Measurement Methods

NIOSH 5504
See: NMAM or OSHA Methods

Personal Protection & Sanitation	**First Aid**
(See protection) Recommendations regarding personal protective clothing vary depending upon the specific compound. Recommendations regarding eye protection vary depending upon the specific compound. Recommendations regarding washing the skin vary depending upon the specific compound. Recommendations regarding the removal of personal protective clothing that becomes wet or contaminated vary depending upon the specific compound. Recommendations regarding the daily changing of personal protective clothing vary depending upon the	(See procedures) Eye: Irrigate immediately Skin: Water flush immediately Breathing: Respiratory support Swallow: Medical attention immediately

specific compound. Recommendations regarding the need for eyewash or quick drench facilities vary depending upon the specific compound.	

Respirator Recommendations

NIOSH/OSHA
Up to 1 mg/m^3:
(APF = 10) Any air-purifying half-mask respirator with organic vapor cartridge(s) in combination with an N95, R95, or P95 filter. The following filters may also be used: N99, R99, P99, N100, R100, P100. Click here for information on selection of N, R, or P filters.
(APF = 10) Any supplied-air respirator
Up to 2.5 mg/m^3:
(APF = 25) Any supplied-air respirator operated in a continuous-flow mode
(APF = 25) Any powered air-purifying respirator with an organic vapor cartridge in combination with a high-efficiency particulate filter.
Up to 5 mg/m^3:
(APF = 50) Any air-purifying full-facepiece respirator equipped with organic vapor cartridge(s) in combination with an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters.
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister having an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters.
(APF = 50) Any powered, air-purifying respirator with a tight-fitting facepiece and organic vapor cartridge(s) in combination with a high-efficiency particulate filter
(APF = 50) Any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode
(APF = 50) Any self-contained breathing apparatus with a full facepiece
(APF = 50) Any supplied-air respirator with a full facepiece
Up to 25 mg/m^3:
(APF = 2000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
Emergency or planned entry into unknown concentrations or IDLH conditions:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Escape:
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister having an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters./Any appropriate escape-type, self-contained breathing apparatus
Important additional information about respirator selection

Exposure Routes

inhalation, skin absorption, ingestion, skin and/or eye contact

Symptoms

Irritation eyes, skin, respiratory system; headache, dizziness; psycho-neurologic disturbance; sore throat, cough; abdominal pain, vomiting; urine retention; paresis, focal anesthesia; skin burns, pruritus; in animals: hemolysis; hepatic necrosis; kidney damage

Target Organs

Eyes, skin, respiratory system, central nervous system, liver, kidneys, urinary tract, blood

See also: INTRODUCTION See MEDICAL TESTS: 0230

# Zinc oxide	**CAS** 1314-13-2
ZnO	**RTECS** ZH4810000
Synonyms & Trade Names Zinc peroxide	**DOT ID & Guide** 1516 143

Exposure Limits	**NIOSH REL**: Dust: TWA 5 mg/m^3 C 15 mg/m^3 Fume: TWA 5 mg/m^3 ST 10 mg/m^3
	OSHA PEL†: TWA 5 mg/m^3 (fume) TWA 15 mg/m^3 (total dust) TWA 5 mg/m^3 (resp dust)

IDLH 500 mg/m^3 See: 1314132	**Conversion**

Physical Description

White, odorless solid.

MW: 81.4	BP: ?	MLT: 3587°F	Sol(64°F): 0.0004%
VP: 0 mmHg (approx)	IP: NA		Sp.Gr: 5.61
Fl.P: NA	UEL: NA	LEL: NA	
Noncombustible Solid			

Incompatibilities & Reactivities

Chlorinated rubber (at 419°F), water [Note: Slowly decomposed by water.]

Measurement Methods

NIOSH 7303, 7502; OSHA ID121, ID143
See: NMAM or OSHA Methods

Personal Protection & Sanitation	**First Aid**
(See protection) Skin: No recommendation Eyes: No recommendation Wash skin: No recommendation Remove: No recommendation Change: No recommendation	(See procedures) Breathing: Respiratory support

Respirator Recommendations

NIOSH/OSHA
Up to 50 mg/m^3:

(APF = 10) Any particulate respirator equipped with an N95, R95, or P95 filter (including N95, R95, and P95 filtering facepieces) except quarter-mask respirators. The following filters may also be used: N99, R99, P99, N100, R100, P100. Click here for information on selection of N, R, or P filters.
(APF = 10) Any supplied-air respirator
Up to 125 mg/m^3:
(APF = 25) Any supplied-air respirator operated in a continuous-flow mode
(APF = 25) Any powered air-purifying respirator with a high-efficiency particulate filter.
Up to 250 mg/m^3:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters.
(APF = 50) Any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode
(APF = 50) Any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter
(APF = 50) Any self-contained breathing apparatus with a full facepiece
(APF = 50) Any supplied-air respirator with a full facepiece
Up to 500 mg/m^3:
(APF = 1000) Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode
Emergency or planned entry into unknown concentrations or IDLH conditions:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus
Escape:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter. Click here for information on selection of N, R, or P filters./Any appropriate escape-type, self-contained breathing apparatus
Important additional information about respirator selection

Exposure Routes

inhalation

Symptoms

Metal fume fever: chills, muscle ache, nausea, fever, dry throat, cough; lassitude (weakness, exhaustion); metallic taste; headache; blurred vision; low back pain; vomiting; malaise (vague feeling of discomfort); chest tightness; dyspnea (breathing difficulty), rales, decreased pulmonary function

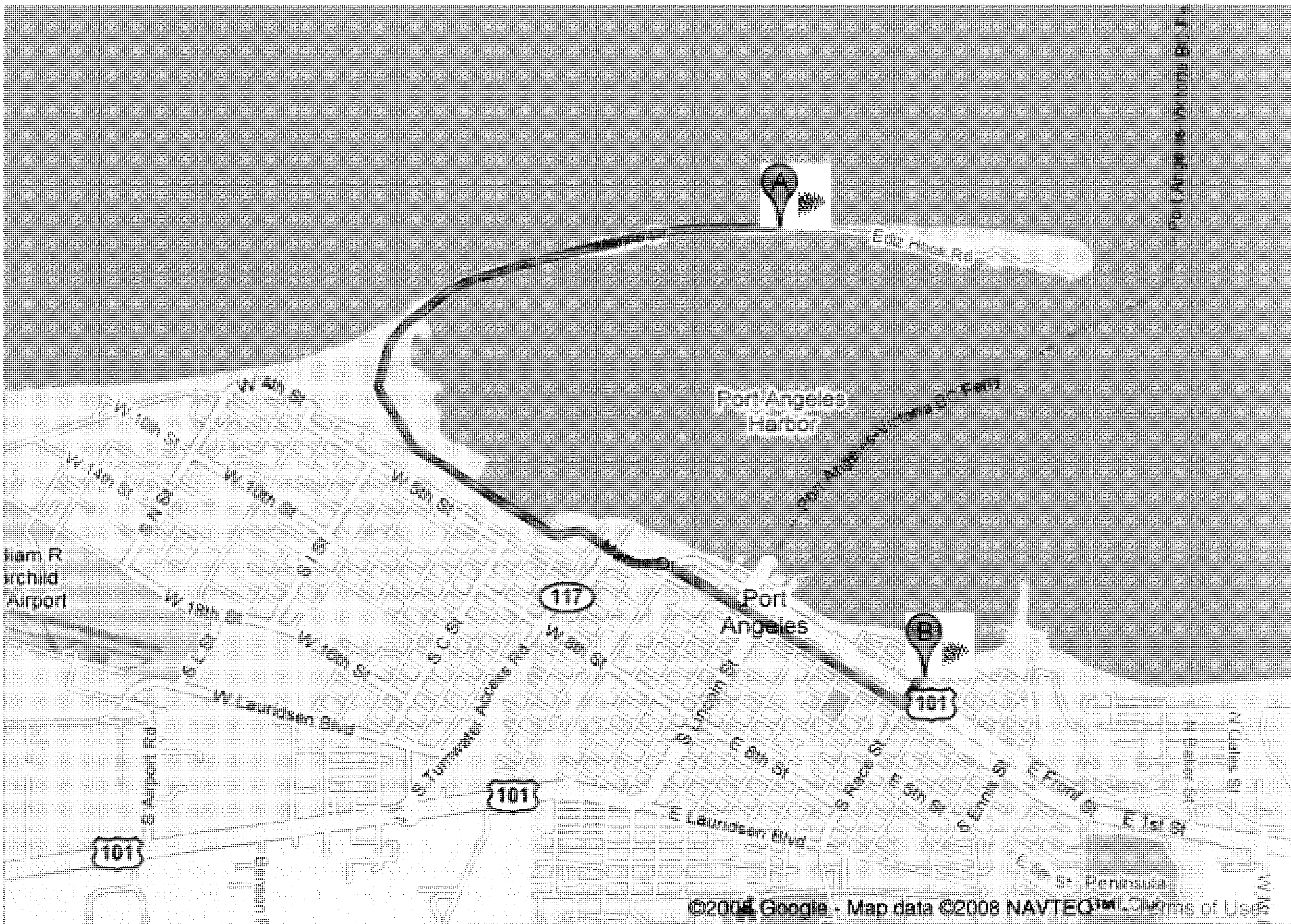
Target Organs

respiratory system

See also: INTRODUCTION See ICSC CARD: 0208 See MEDICAL TESTS: 0246

ATTACHMENT F

MAP TO HOSPITAL AND SITE MAP/SKETCH



☐ Avoid highways

Ediz Hook Rd
Port Angeles, WA 98363

Drive: 4.7 mi – about 13 mins

1.	Head **west** on **Ediz Hook Rd/Marine Dr** toward **Marine Dr** Continue to follow Marine Dr	2.9 mi
2.	Slight **left** to stay on **Marine Dr**	0.5 mi
3.	Continue on **W 1st St**	1.1 mi
4.	Turn **left** at **N Race St**	0.1 mi
5.	Turn **right** at **E Georgiana St**	49 ft

Olympic Memorial Hospital
908 Georgiana St, Port Angeles, WA 98362

These directions are for planning purposes only. You may find that construction projects, traffic, or other events may cause road conditions to differ from the map results.

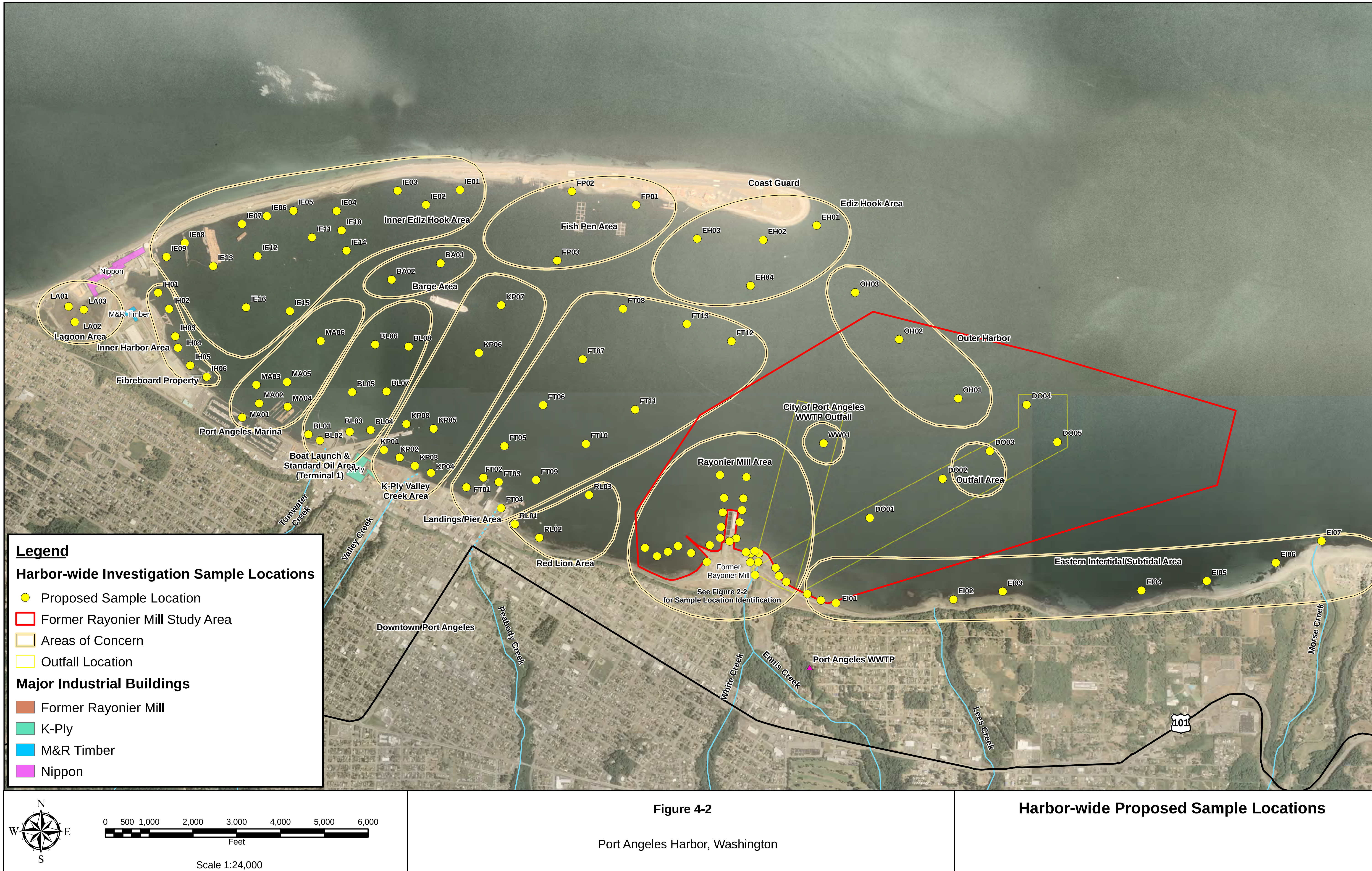


Figure 4-2

Port Angeles Harbor, Washington

Harbor-wide Proposed Sample Locations

source: ecology & environment, inc., 4/8/2008 ...\port_angeles_sta\fig4-2 proposed sample locs.mxd

ATTACHMENT G

BOATING SAFETY PLAN

Health and Safety Plan Attachment for Safe Boating

Introduction

For many of E & E's activities, it is necessary to use conventional boats or airboats to transport personnel and conduct work tasks. These tasks can be accomplished safely with the right combination of equipment, safety awareness and common sense.

Equipment Required for Boat Operations

1. Personal Flotation Devices (PFD)

All boats must carry one wearable PFD (Type I, II, III or Type V PFD) for each person aboard. A Type V PFD provides performance of a Type I, II, or III PFD (as marked on its label) and must be used according to the label requirements. Any vessel 16 ft and longer (except canoes and kayaks) must also carry one throwable PFD (Type IV PFD).

PFDs must be

- Coast Guard approved,
- in good and serviceable condition, and
- the appropriate size for the intended user.

Accessibility

- A PFD should be worn at all times when the vessel is underway. A wearable PFD can save your life, but only if you wear it.
- They should not be stowed in plastic bags, in locked or closed compartments or have other gear stowed on top of them.
- The best PFD is the one you will wear.
- Throwable devices must be immediately available for use.

2. Visual Distress Signals

All vessels used on coastal waters, the Great Lakes, territorial seas, and those waters connected directly to them, up to a point where a body of water is less than two miles wide, must be equipped with U.S.C.G. Approved visual distress signals. Vessels owned in the United States operating on the high seas must be equipped with U.S.C.G. Approved visual distress signals.

Pyrotechnic Devices

Pyrotechnic Visual Distress Signals must be Coast Guard Approved, in serviceable condition, and readily accessible.

- They are marked with an expiration date. Expired signals may be carried as extra equipment, but can not be counted toward meeting the visual distress signal requirement, since they may be unreliable.
- If pyrotechnic devices are selected a minimum of three are required. That is, three signals for day use and three signals for night. Some pyrotechnic signals meet both day and night use requirements.
- Pyrotechnic devices should be stored in a cool, dry location, if possible.
- A watertight container painted red or orange and prominently marked "DISTRESS SIGNALS" or "FLARES" is recommended.

3. Fire Extinguishers

Coast Guard Approved fire extinguishers are required on boats where a fire hazard could be expected from the motors or the fuel system. Extinguishers are classified by a letter and number symbol. The letter indicates the type fire the unit is designed to extinguish (Type B for example are designed to extinguish flammable liquids such as gasoline, oil and grease fires). The number indicates the relative size of the extinguisher. The higher the number, the larger the extinguisher.

Coast Guard approved extinguishers required for boats are hand portable, either B-I or B-II classification and have a specific marine type mounting bracket. It is recommended the extinguishers be mounted in a readily accessible position, away from the areas where a fire could likely start such as the galley or the engine compartment.

Extinguisher markings can be confusing because extinguishers can be approved for several different types of hazards. For instance, an extinguisher marked "Type A, Size II, Type B:C, Size I" is a B-I extinguisher.

Look for the part of the label that says **"Marine Type USCG"**

- Make sure Type B is indicated
- Portable extinguishers will be either size I or II. Size III and larger are too big for use on most recreational boats.

4. Ventilation

A powered ventilation system is required for each compartment in a boat that has a permanently installed gasoline engine with a cranking motor for remote starting.

5. Sound Producing Devices

Any vessel less than 39.4 feet/12 meters in length may carry a whistle or horn, or some other means to make an efficient sound signal to signal your intentions and to signal your position in periods of reduced visibility.

6. Navigation Lights

Recreational vessels are required to display navigation lights between sunset and sunrise and other periods of reduced visibility (fog, rain, haze, etc.).

7. Communication

Cell phones should be fully charged prior to leaving the dock

8. Additional Safety Equipment

- First Aid Kit
- Marine Radio, As applicable
- Dewatering Device & Backup bilge pump operable, alternative bailing device available
- Anchor and Line for Area
- Capacity/Certification of Compliance
- Charts of the area and compasses
- Mooring lines - bow, stern, and spring lines
- Bright flashlight or searchlight
- Alternate propulsion - paddle or oar
- Compass, As applicable
- Sunscreen and sunhat
- Drinking water

Weather conditions

On a warm sunny day there is nothing better than being in a boat on the water enjoying the elements while working. Slight changes in weather conditions, however, can adversely affect a body of water in a relatively short time period. If a boat and crew are in an exposed position this change could seriously jeopardize their safety. A boat operator should be knowledgeable relative to the weather patterns typical of the area in which work is to be done, and able to identify rapidly approaching frontal systems that could place the boat and crew in danger.

1. Wind

Heavy wind is one of the greatest hazards to a small boat on a large body of water. Wind can quickly whip the water surface into a severe chop with breaking white-capped waves. The greater the fetch (upwind distance over water) from the boat's position the worse the wind driven surface waves can be. If the boat is located in a shallow area downwind from deeper water the height of the wind driven waves can be expected to increase dramatically as they enter the shallows. Wind blowing in opposition to the direction of flow can create large swells and threaten the safety of boat and crew.

A boat operator must carefully assess wind conditions upon arrival to work in an area and determine if a significant hazard exists that could be avoided on a calmer day. A rule-of-thumb for estimating wind speed is to look for white caps which generally begin to appear at wind speeds approaching 20 miles per hour over calm water.

If possible, working with the bow into the wind is the safest position for the boat in windy conditions. However, working in a river requires that the bow be held against the direction of flow. If the wind opposes the current this could place the boat and crew in jeopardy as the steep wind driven swell will impact the boat's stern. This situation could potentially swamp the boat if the waves increase in size and begin to break over the transom.

2. Rain

Aside from personal discomfort, light rain does not present an extreme hazard to crews in small boats. Heavy rain over long durations can constitute a significant hazard if allowed to accumulate in the bottom of the boat. If the boat is transporting a load near maximum for its hull configuration the weight of the accumulated rain water could adversely effect stability or significantly reduce freeboard (distance from the waterline to the gunwale). Either of these could result in swamping or capsizing. Lightning storms are common in some locations and must be considered as a serious threat to the safety of boat and crew.

Again it is the operator's responsibility to assess the severity of the situation and react to protect the safety of the boat and crew. This action could be nothing more than pumping the excess rain water overboard on a periodic basis or may require that the work effort be temporarily aborted until the rain or lightning dissipates to a non-threatening level.

3. Extreme Conditions

Weather extremes range from hot temperatures and sun exposure to cold temperatures and freezing conditions. Most often small work boats do not provide protection from the elements. Working in the middle of a body of water almost always means complete exposure to the existing weather extremes.

The hazards here may be health risks as well as some potential for physical injury. In the case of extreme heat and sun exposure, the crew should always carry drinking water to help minimize the potential for dehydration. Some form of protection from the sun is essential and will aid in reducing the potential for dehydration in addition to minimizing the harmful effects of ultraviolet rays on human skin. Extreme heat combined with high wind can increase the rate of dehydration.

Extreme cold and freezing conditions may be more hazardous than heat. In addition to the more obvious concerns about hypothermia, dehydration is still a potential problem. Protective clothing is essential to minimize the effects of hypothermia. An accidental fall overboard could prove fatal if the victim is not properly clothed. Water robs the body of heat 25 times faster than air so the immediate problem is rescuing the overboard victim. Remember the 50/50 rule (i.e., an unprotected overboard victim in water less than or equal to 50 degrees Fahrenheit has a 50 percent chance of surviving for 50 minutes). In addition to these potential health risks a boat operator working in extreme cold and freezing conditions must watch for ice build-up on the boat's hull. Even though ice floats its mass above the waterline adds to the weight of the boat and its load. If ice is allowed to accumulate above the waterline as a result of splash from the wake or spray from wind blown waves the boat can become overloaded and settle in the water to a point where an otherwise insignificant volume of water could swamp and sink the boat.

3. Restricted Visibility

The most common cause of restricted visibility is fog. Heavy rain and snow, or in some areas, blowing dust can reduce visibility in the extreme as well. Operation during periods of extreme restricted visibility is not advised particularly in areas frequented by large commercial vessel traffic. When operation is essential during periods of restricted visibility standard navigation lights must be displayed. If the small work boat is not equipped with navigation lights it should not be used in these conditions. Also, proper horn or bell signals should be given as required by inland or international navigation rules for the size of vessel underway or anchored during periods of restricted visibility.

Navigation

1. Tidal Reaches

Streams in coastal areas present the boat operator with flow conditions generally unknown or inexperienced by most inland boat operators. The lower reaches of nearly all coastal streams are tidally affected. Changes in flow characteristics associated with daily tidal variations include some or all of the following: rise and fall of stage; increase and decrease in flow velocity; sudden appearance of breaking waves and turbulence; and possible reversals in flow direction. Boat operators working in tidal affected areas must understand these flow characteristics. Consulting tide and current tables, and navigation charts is essential to planning daily activities and minimizing potential hazards. Basic rules-of-thumb to operating in tidal reaches include: moving through shallows during rising (flood) tides to provide the greatest margin for error in the event of grounding the boat; timing of bar crossings from riverine into marine conditions during flood tides and never during the maximum ebb currents; and timing of sampling and measuring activities relative to tidal effects when flow reversals are common.

2. Flow Around Fixed Structures

Fixed structures including bridges, and dams are of particular concern to operators and crews working from boats. Boat operators should always familiarize themselves with any in-channel structure that could ultimately threaten the safety of their vessel and crew. Charts or maps of an area can provide valuable information related to the size and location of a structure across the channel. Regulatory agencies such as the State Department of Transportation, Corps of Engineers, Bureau of Reclamation, etc. can generally provide more detailed local information.

- **Bridges**

  Bridges may constitute major hazards to the boating public by restricting overhead clearance, generating extreme turbulence in the vicinity of piers located in the flow, or trapping debris and reducing the opening available between piers. During high stages, overhead clearance may be minimal for the passage of river traffic. In this case, if work must be done downstream of the bridge, one of two courses of action are necessary to protect the safety of vessel and crew: find an alternate location for launching the boat below the bridge; or call the bridge tender and request an opening of the lift or swing span if so equipped. The following list of actions will help to ensure the safety of vessel and crew when working in the vicinity of bridges.

- Never work from a boat in close proximity to and upstream of an excessively submerged bridge structure.
- If it is necessary to work from a boat upstream from a bridge during high flow or anytime the structure presents a threat to safety, two sources of power (main engine plus auxiliary or twin engines) should be onboard and running in the event the backup is immediately needed.
- Always carry an anchor of adequate size and design securely attached to a length of chain equal to one boat length, and a length of nylon line equal to three to five times the anticipated depth, to stop the vessel and hold it against the flow. This equipment must be ready to deploy in an instant with the end of the line attached to the boat.
- Cutting devices adequate to clear any line that becomes fouled on the boat and threatens its safety must be at the ready. These should include but are not limited to garden loppers, bolt cutters, cable shears, and a hatchet or machete.
- Avoid working in close proximity to bridge piers if possible.
- If it is necessary to work close to a bridge pier, approach the pier in the tail-wake from downstream keeping a sharp lookout for debris caught on the pier. Carefully work along side the pier and inside the wake or eddy line generated by its upstream face.
- Never put the boat across the upstream face of the pier where it could become trapped by the force of the current.

- **Dams**

  Dams impounding the flow are another source of hazards to boats operating in their vicinity. Dams are generally of two types which present different hazards to boat operators and crews. The first to consider is the large structure tens or possibly hundreds of feet high, and impounding a large reservoir for the purpose of power generation and/or flood control. These structures may have a lock channel to allow passage of vessels from one pool level to the next in the upstream or downstream direction. Boat operation in the vicinity of these large structures should be limited to the approaches to the navigation lock. Operation near any intake structure or in the tail race channel should be avoided as flow volumes, stream velocities, river stages, and associated turbulence can change unexpectedly. As an example, a small boat can be easily swamped or capsized by an unexpected wave surging from the outflow as the gates are reset to increase power generation or flows are increased to pass storm runoff.

  Low-head dams are the second type to consider. These structures may constitute the most dangerous man-made obstruction a boat operator might encounter. Most low-head dams span the entire width of the channel usually to pool the flow for diversion into an irrigation system or for some other purpose requiring a low hydraulic head as the driving force. Water passing over the face of these structures appears as a smooth even flow across the entire stream width usually falling ten feet or less. To the uninitiated there doesn't seem to be any hazard because the flow appears to be benign and almost tranquil in nature. The danger here is real and extreme. The plunging water creates a turbulent zone of reverse current (a hydraulic) at the downstream base of the dam. A boat can be drawn into the falling water and easily swamped. The tumbling action will then roll the boat over, submerge it, and push it away from the dam below the surface only to pull it and its occupants back into the falling water as they reach the surface. This continuous action can easily trap the boat and crew at the face of the dam with no hope of escape. The following list of actions will help to ensure the safety of vessel and crew when working in the vicinity of low-head dams. If possible avoid working above, below, or otherwise in close proximity to a low- head dam. This may not be appropriate either.

3. Canals

Canals are normally highly regulated man-made waterways. Any operator using a boat to transit these conduits of flow must understand the flow system and its hazards. Typically the water in any given canal system is allocated for some specific use. Regulation may be seasonal or associated with storm runoff. The system may consist of a series of diversions conveying flow to various points of use, and may include flow through tunnels or large diameter pipes, in addition to open channel conveyances. In short, use of boats in these types of flow systems should be avoided if at all possible and only undertaken after the operator and crew have contacted the agency responsible for management and regulation to become familiar with potential hazards built into the system.

Carbon Monoxide

CO - When docked, or rafted with another boat, be aware of exhaust emissions from the other boat.

Seasickness

Seasickness is caused when the minute inner ear organs that enable a human to balance are disturbed by the motion of the boat swaying and pitching. This movement sets off alarm signals to the brain causing nausea, headache, dizziness, and sometimes vomiting. This condition can be intensified by the lack of fresh air and inactivity. It can also be a person's worst nightmare at sea.

Fortunately, several remedies can be taken before setting sail. Pills can be obtained over the counter which help most people by sedating the balancing organs. The pills can cause drowsiness and should be taken with care. Some people find special wrist bands effective. There are also stick-on patches that can be worn on the skin behind the ear, but these are obtained by doctor's prescription only.

You can often avoid seasickness by staying busy and keeping your mind occupied by taking over the helm or any other activity that will keep you above decks. Look at the distant horizon rather than the water close at hand. Take deep breaths and drink plenty of water. The worst thing that a person can do is go below decks with no land or horizon to look at. Reading or staring at an object will assuredly bring on the affects of seasickness. If you are seasick and can't bear it anymore, lie down on your back with your eyes closed. This will greatly reduce the affects.

References:

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http://www.uscgboating.org/

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A Primer: Working From Boats, Thomas K. Edwards.
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U.S. Fish and Wildlife Service, Inside Region 3, June/July, 2002.
http://www.fws.gov/midwest/InsideRegion3/documents/ir311-02.pdf

Commander Bob's Boating Safety Notebook
http://www.commanderbob.com/

Nautical Know How
http://www.boatsafe.com/nauticalknowhow/seasick.htm

Appendix B

Sample Forms

Project: Port Angeles Harbor Sediment Characterization Study

Grab Sediment Sample Log

Date:______________________________ **Sample ID:**_______________

Time: _____________________________ **Area of Concern:**_________________

Location Data Harbor-Wide / Rayonier GPS Date/Time____________GPS PDOP______

Location (UTM Zone 10, NAD83, meters) X__________________ Y_________________

Boat/Sampling Team: ____

Bottom depth (ft):____________		Penetration depth (cm): ____________	
Sediment type:	***Sediment color:***	***Sediment Odor:***	***Comments:***
Cobble Gravel Sand VC C M F VF Silt Clay Organic matter Woody debris Shell debris Other:	Drab olive Brown Brown surface Gray Black Other:	None Slight Moderate Strong Overwhelming Sulfur Petroleum Other:	

Analyses	**Sample Containers**							
	16 oz glass jar	***16 oz poly***	***4 oz jar***	***Plastic bag***	***Lab***	***Immediate Analysis***	***Archive***	***MS/ MSD***
Dioxin/Furan	1				Axys			
Grain size/TOC		1			ARI			
SVOCs	1 (2 if arch)				ARI			
Resin / Guai					ARI			
Organotin					ARI			
Ammonia					ARI			
Sulfide			1		ARI			
Pesticide	1 (2 if arch)				TA			
PCB					TA			
TPH					TA			
Metal					TA			
Hg					TA			
Bioassay				1	NF			

_______________________________ _______________________________

Sampler Signatures

____

Sample Custodian Signature

Project: Port Angeles Harbor Sediment Characterization Study **Tissue Sample Log**

Date:____________________________ **Boat/Sampling Team:** ____________________________

Location Data Harbor-Wide / Rayonier **Area of Concern:**__________________ GPS Date/Time_______________ X______________ Y______________ GPS PDOP______			
Sample ID: _____________	Time: _____________	Depth from water surface (ft): _____	
Tissue type:	***Sample Type/No:***	***Weight / Length***	***Comments:***
Lingcod	Whole / Filet	Lbs/ in	
Geoduck	#: (5 min)	Lbs in	
Horse Clam	#: (5 min)	Lbs in	
Macroalgae	kelp / eelgrass	Lbs	
Location Data Harbor-Wide / Rayonier **Area of Concern:**__________________ GPS Date/Time_______________ Lat______________ Long______________ GPS PDOP______			
Sample ID: _____________	Time: _____________	Depth from water surface (ft): _____	
Tissue type:	***Sample Type/No:***	***Weight / Length***	***Comments:***
Lingcod	Whole / Filet	Lbs/ in	
Geoduck	#: (5 min)	Lbs in	
Horse Clam	#: (5 min)	Lbs in	
Macroalgae	kelp / eelgrass	Lbs	

___________________________________ ______________________________

Sampler Signatures

____

Sample Custodian Signature

PORT ANGELES SEDIMENT INVESTIGATION
WOOD MATERIAL CHARACTERIZATION FORM

Sample Station Identification:

WOOD MATERIAL DEPTH

Surface only ☐ **Partially Buried** ☐ **Entirely Buried:** ☐

PERCENT WOOD MATERIAL:

WOOD MATERIAL COLOR

Tan ☐ **Reddish** ☐ **Brown** ☐ **Olive Green** ☐ **Gray** ☐ **Black** ☐ **Other:**

EVIDENCE OF TEREDOS INFESTATION

None ☐ **Light** ☐ **Medium** ☐ **Heavy** ☐

TYPE OF WOOD MATERIAL

☐ **Bark** **Size:** **Species:**

☐ **Wood Chips** **Size:** **Decomposition State:**

☐ **Natural Detritus** **Description:**

☐ **Logs** **Description:**

☐ **Sawdust**

☐ **Pulp Fibers**

ADDITIONAL NOTES/COMMENTS:

Sediment Core Log, page 1

Station ID: ______________

Project:	Port Angeles Harbor Sediment Characterization Study	Date:	
Location Data:	Harbor-wide / Rayonier	Time:	
Area of Concern:		Boat:	
GPS Time:		Core Collection Method:	
Location (UTM Zone 10, NAD 83 meters):	X	Sample Team:	
	Y		

Coring Start Time: _______________
Water Depth:________________Ft.
Core Bottom Depth:_____________Ft.
Coring Finish Time: _______________
Overall Recovery (%):

Sample ID: _____________________________________ **Depth Interval:** _______in. to ______in.

Sediment Type (%): Cobble___/Gravel___/Sand (VC C M F VF)___/Silt___/Clay___/Organic mtrl___/Woody debris___/Shell debris___/Other:___

Sediment Color: Drab olive / Brown / Brown surface / Gray / Black / Other:

Sediment Odor: None / Slight / Moderate / Strong / Overwhelming / Sulfur / Petroleum / Other:

Biota:

Samples Collected:	Container	Analysis	Immediate Analysis	Archive for Later Analysis
	16 oz poly jar	TOC/Grain size	_______	_______
	16 oz glass jar	Dioxins/Furans	_______	_______
	16 oz glass jar	SVOCs / resin / TBT / Ammonia	_______	_______
	16 oz glass jar	Pest / PCBs / TPH / Metals / Hg	_______	_______

4 oz glass jar

Sulfide / Other: ________

core

Radioisotope Dating

NOTES:

Sediment Core Log, page 2 Station ID: ____________________

Depth (ft.)	Depth (in.)	Sample ID	Comments
	1		
	2		
	3		
	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
1	12		
	13		
	14		
	15		
	16		
	17		
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	22		

	23		
2	24		
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Appendix C

Standard Operating Procedures

Title:	**FIELD ACTIVITY LOGBOOKS**
Category:	DOC 2.1
Revised:	April 1998

STANDARD OPERATING PROCEDURE

FIELD ACTIVITY LOGBOOKS

ecology and environment, inc.
368 Pleasant View Drive / Lancaster, New York 14086 / (716) 684-8060

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Appendix

A Sample Logbook 11

1. Summary

This Standard Operating Procedure (SOP) establishes requirements for the entry of information into logbooks to ensure that E & E field activities are properly documented. The project manager (PM) and the field team leader (FTL) are responsible for ensuring that logbook entries provide sufficient information for the completion of an accurate and detailed description of field operations and meets the requirements of the contract or technical direction document (TDD).

This SOP describes logbook entry requirements for all types of projects, specifies the format that should be used, and provides examples. Some flexibility exists when implementing the SOP because different types of projects require different data collection efforts. This SOP does not address site safety logbook requirements or geotechnical logbook entries.

2. Purpose

Complete and accurate logbook entries are important for several reasons: to ensure that data collection associated with field activities is sufficient to support the successful completion of the project; to provide sufficient information so that someone not associated with the project can independently reconstruct the field activities at a later date; to maintain quality control (QC) throughout the project; to document changes to or deviations from the work plan; to fulfill administrative needs of the project; and to support potential legal proceedings associated with a specific project.

2.1 Adequate Field Information/Quality Control

QC procedures for data collection begin with the complete and systematic documentation of all persons, duties, observations, activities, and decisions that take place during field activities. It is especially important to fully document any deviations from the contract, project scope, work plans, sampling plans, site safety plans, quality assurance (QA) procedures, personnel, and responsibilities, as well as the reasons for the deviations.

Prior to entering the field, the project manager must indicate to the field team what pertinent information must be collected during field activity in order to meet the desired objectives of the data collection effort. The PM is responsible for reviewing the adequacy of the project logbooks both during and following completion of field activities, and is also responsible for meeting with the field team members to discuss any findings and to direct activities to correct any deficiencies, as appropriate. The PM also has the responsibility of ensuring that the logbooks become part of the project or TDD file.

2.2 Work Plan Changes/Deviation

The logbook is the document that describes implementation of the work plan and other appropriate contract documents and provides the basis for the project reports. It must include detailed descriptions of any and all deviation from the work plan and the circumstances that necessitate such changes. These changes will be reviewed for compliance with data quality objectives and include:

- Changes in procedures agreed to in the project planning stages;
- Any conditions that prevent the completion of the field effort, or that result in additional fieldwork must be noted (i.e., weather delays, government actions, physical obstructions, personnel/ equipment problems, etc.). Persons from whom permission was obtained to make such changes must be clearly documented.
- Any modifications requested by the client or client's representative that are contradictory to the contract or outside of the existing scope of work must be documented in detail because the cost of the project could be affected by such modifications.

2.3 Evidentiary Documentation

Field activity documentation can become evidence in civil and/or criminal judicial proceedings, as well as in administrative hearings. Field logbooks serve this purpose. Accordingly, such documentation is subject to judicial or administrative review. More importantly, it is subject to the review of an opposing counsel who will attempt to discredit its evidentiary value.

The National Enforcement Investigation Center (NEIC) and the United States Environmental Protection Agency (EPA) have prepared documents outlining their documentation needs for legal proceedings. These guidelines indicate the importance of accurate and clear documentation of information obtained during the inspections, investigations, and evaluations of uncontrolled hazardous waste sites. Consequently, attention to detail must be applied by E & E personnel to all field documentation efforts for all E & E projects. Project personnel must document where, when, how, and from whom any vital project information was obtained. This information is necessary to establish a proper foundation for admissible evidence.

3. Guidelines

Logbooks should contain a summary of any meeting or discussion held with a client or with any federal, state, or other regulatory agency that was on site during the field activities. The logbook should also describe any other personnel that appear on site, such as representatives of a potential responsible party (PRP).

The logbook can be used to support cost recovery activities. Data concerning site conditions must be recorded before the response activity or the passage of time eliminates or alters those conditions. Logbooks are also used to identify, locate, label, and track samples and their final disposition. In addition, data recorded in the logbook will assist in the interpretation of the analytical results.

Logbooks are subject to internal and external audits. Therefore, the recorded information should be consistent with and capable of substantiating other site documentation such as time cards, expense reports, chain-of-custody forms, shipping papers, and invoices from suppliers and subcontractors, etc. Logbooks also act as an important means of reconstructing events should other field documents such as data collection forms become lost or destroyed. Therefore, all mission-essential information should be duplicated in the logbook.

3.1 General Instructions

The following general guidelines must be used for all logbooks:

- At a minimum, one separate field activity logbook must be maintained for each project or TDD.
- All logbooks must be bound and contain consecutively numbered pages.
- No pages may be removed for any reason, even if they are partially mutilated or illegible.
- All field activities must be recorded in the site logbook (e.g., meetings, sampling, surveys, etc.).
- All information must be **printed legibly** in the logbook using water-proof ink, preferably black. If weather conditions do not permit this (i.e., if it is too cold or too wet to write with ink), another medium, such as pencil, may be used. The reason that waterproof ink was not used should be specifically noted in the logbook.
- The language used in the logbook should be objective, factual, and free of personal feelings or terminology that might prove inappropriate.
- Entries should be made in chronological order. Contemporaneous entries are always preferred because recollections fade or change over time. Observations that cannot be recorded during field activities should be recorded as soon after as possible. If logbook entries are not made during field activities, the time of the activity/ observation and the time that it is recorded should be noted.
- The first entry for each day will be made on a new, previously blank page.
- Each page should be dated and each entry should include the time that the activity occurred based on the 24-hour clock (e.g., 0900 for 9 a.m., 2100 for 9 p.m.).
- At the completion of the field activity, the logbook must be returned to the permanent project or TDD file.

3.2 Format

The information presented below is not meant to be all-inclusive. Each project manager is responsible for determining the specific information requirements associated with a field activity logbook. If someone other than the Project Manager is keeping the logbook, the Project Manager is responsible to convey to that individual, prior to the start of fieldwork, specific instructions on what type of information is required to be entered into the logbook. Information requirements will vary according to the nature and scope of the project. (Refer to Appendix A for an example of a completed logbook.)

Title Page

The logbook title page should contain the following items:

- Site name,
- Location,
- TDD No. or Job No.,
- PAN (an EPA site/task identification number), if applicable,
- SSID No. (Site ID number-assigned under CERCLA), if applicable,
- Start/Finish date, and
- Book ___ of ___.

First Page

The following items should appear on the first page of the logbook prior to daily field activity entries:

- TDD No. or Job No.,
- Date,
- Summary of proposed work (Reference work plan and contract documents, as appropriate),
- Weather conditions,
- Team members and duties, and
- Time work began and time of arrival (24-hour clock).

Successive Pages

In addition to specific activity entries and observations, the following items should appear on every logbook page:

- Date,
- TDD or Job No., and
- Signature (bottom of each page). If more than one person makes entries into the logbook, each person should sign next to his or her entry.

Last Page

In addition to specific activity entries and observations and the items that should appear on each successive page, the last page of the logbook should contain a brief paragraph that summarizes the work that was completed in the field. This summary can become especially important later on if more or less work was accomplished during the duration of the field activity.

3.3 Corrections

If corrections are necessary, they must be made by drawing a single line through the original entry in such a manner that it can still be read. *Do not erase or render an incorrect notation illegible*. The corrected entry should be written beside the incorrect entry, and the correction must be initialed and dated. Most corrected errors will require a footnote explaining the correction.

4. Documentation

Although the requirements and content of the field logbook will vary according to the site and the tasks to be performed, the following information should be included in every logbook:

4.1 Prior to Fieldwork

Summary of Proposed Work

The first paragraph of **each** daily entry should summarize the work to be performed on that day. For example:

> "Collect soil and groundwater samples from previously installed wells and ship samples to Analytical Services Center (ASC). Discuss removal with site owner."

The first paragraph becomes especially important later when discussing work plan deviations or explaining why more or less work was accomplished for that day.

Personnel

Each person to be involved in activities for the day, his/her respective role (sampler, health and safety, etc.), and the agency he/she represents should be noted in the logbook.

On-Site Weather Conditions

Weather conditions may have an impact on the work to be performed or the amount of time required to perform the proposed work; therefore, all weather on-site weather conditions should be noted, including temperatures, wind speed and direction, precipitation, etc., and updated as necessary. Similarly, any events that are impacted by weather conditions should be noted in the logbook.

Site Safety Meeting

Although minutes should be recorded for all site safety meetings under separate cover, the logbook should briefly summarize the site safety meeting and any specific site conditions and resultant site safety concerns.

4.2 Site Sketch

A site sketch should be prepared on the first day of field activities to indicate prominent site and environmental features. The sketch should be made either to scale or by noting the approximate distances between site feature. Area-specific sketches should be prepared as work is undertaken in such areas, and updated sketches should be drawn as work progresses.

Site Features

Examples of features to be noted on the site sketch include the following:

- Structures such as buildings or building debris;
- Drainage ditches or pathways, swales, and intermittent streams (include direction of overland runoff flow and direction of stream flow);
- Access roads, site boundaries, and utility locations;
- Decontamination and staging areas;
- Adjacent property data: the type of property that borders the site, information pertaining to ownership, and available addressees; and
- North arrow.

Changes in Site Conditions

Any deviation from previous site sketches or drawings presented in the work plan, and any changes that have occurred since the last site visit must be noted. Differences to be noted include the following:

- Demolished buildings;
- Changes to access routes;
- Damage to wells or equipment, or changes to the amount of such equipment believed to be on site,
- Changes resulting from vandalism;
- Destruction of reference points;
- Changes resulting from environmental events or natural disasters; and
- Locations of excavations, waste piles, investigation-derived waste (IDW), drum staging areas, etc.

In short, *any* site condition that varies from the conditions described in the work plan should be noted.

4.3 Monitoring Equipment and Activities

Any monitoring equipment used during field activities should be documented in the log-book. Information to be noted includes:

- The type of equipment with model and serial numbers. (HNu, OVA, etc.);
- The frequency at which monitoring is performed;
- Calibration results and the frequency at which the equipment is calibrated or tested;
- Background readings;
- Any elevated or unusual readings; and
- Any equipment malfunctions.

It is particularly important to note elevated or unusual equipment readings because they could have an impact on personal protection levels or the activities to be performed on site. If a change in the proposed work or protection levels occurs, it should be clearly noted in the log-book.

4.4 Sample Collection Activities

Because it represents the first step in an accurate chain-of-custody procedure, field sampling documentation must be complete. The following items should be documented in the log-book:

Sample Collection Procedures

The following items pertaining to sample collection procedures should be included in the logbook:

- Any pre-sampling activities (i.e., well purging and the number of volumes purged before sample collection);
- Results of the pre-sampling activities (i.e., pH/conductivity/ temperature readings for well water, results of hazard categorization testing, etc.);
- Any environmental conditions that make sample collection difficult or impossible (i.e., dry or flooded drainage paths, inclement weather conditions, etc.); and
- Any deviation from the work plan (i.e., additional samples and the reason for their collection, alternate sample locations, etc.).

Sample Information

The following information regarding sample data should be recorded in the logbook:

- Sample number and station location including relationship to permanent reference point(s);
- Name(s) of sampler(s);
- Sample description and any field screening results;
- Sample matrix and number of aliquots if a composite sample;
- Preservatives used, recipient laboratory, and requested analyses;
- QA/QC samples; and
- Shipping paper (airbill) numbers, chain-of-custody form numbers, and jar lot numbers.

Investigation-Derived Waste/Sample Shipment

Details pertaining to sampling equipment, decontamination, and IDW should be clearly delineated in the work plan. However, the following information should be included in the log-book:

- The type of IDW generated an the number of containers generated (each drum should be numbered and its contents noted);
- All information relevant to the characterization of the IDW;
- Any directions received from the client/workplan/contract relative to the management of the IDW;
- The disposition of IDW (left on site or removed from site);
- The number of sample containers shipped to the ASC or laboratory and the courier used (i.e., Federal Express, Airborne Express, etc.);
- Airbill or shipment tracking numbers; and
- The type of paperwork that accompanied the waste/sample shipment (e.g., manifests, etc.).

4.5 Photodocumentation

Photographs should be taken during all relevant field activities to confirm the presence or absence of contaminants encountered during fieldwork. Specific items to be documented in-clude:

- Sample locations and collection activities;
- Site areas that have been disturbed or impacted, and any evidence of such impacts (i.e., stressed vegetation, seepage, discolored water, or debris);
- Hazardous materials requiring disposal, including materials that may not appear in the work plan;
- Any evidence that attests to the presence or absence of contamination; and
- Any features that do not appear in the work plan or differ from those described in the work plan.

Documentation of any photographs taken during the course of the project must be provided in the logbook with a detailed description of what is shown in the photograph and the reason for taking it. This documentation should include:

- Make, model, and serial numbers of the camera and lens,
- Film type and number of exposures,
- Roll and frame number of the photograph;
- Direction or view angle of the photograph, and
- Name of the photographer.

4.6 Data Collection Forms

Certain phases of fieldwork may require the use of project-specific data collection forms, such as task data sheets or hazard categorization data sheets. Due to the specific nature of these forms, the information that should be included in the logbook cannot be fully discussed in this SOP. However, the following data should be included in the logbook:

- Results of any field tests or hazard categorization tests (i.e., ignitability, corrosivity, reactivity, etc.);
- The source from which any field sample was collected and its condition (i.e., drum, tank, lagoon, etc.).
- Other conclusions as a result of the data collected on data collection forms.

In many cases, rubber stamps that contain routine data collection forms can be manufactured ahead of time. These forms can be stamped into the logbook on an as-needed basis.

Appendix A

Sample Logbook

RI 6130

WEDNESDAY JANUARY 26, 1994

PROPOSED WORK FOR DAY: COLLECT GROUNDWATER SAMPLES FROM WELLS AND PIEZOMETERS AT SITE 1 AND SITE 3. SHIP SAMPLES TO THE ASC. CONTAINERIZE PURGE WATER. MEET WITH FRED CANSLER AND DISCUSS REMOVAL OF CANOPIES AT SITES 1 AND 3 AND FILLING OF EXCAVATIONS.

WEATHER ON SITE: CLOUDY AND WARM WITH A HIGH TEMPERATURE OF 50° F. RAIN SHOWERS WITH WINDS FROM THE SW AT 5-15 MPH.

E+E PERSONNEL ON SITE: G. JONES, J. MAYS, S. McCUNE

LOG

1330 ARRIVED ON SITE. THE GROUNDWATER SAMPLING CREW WAS PREPARING TO PURGE THE WELLS AND PIEZOMETERS IN THE FIELD ACROSS THE ROAD FROM SITE 1. PURGING OF WELLS BEING COMPLETED WITH HAND BAILERS SINCE PUMP IS INOPERATIVE.

1340 ARRIVED AT SITE 3. MW3-1 AND MW3-5 UNLOCKED AND OPEN; SECURED BOTH WELLS.

38 [signature] 1/26/94

RI 6130 1/26/94

1350 FRED CANSLER ARRIVED ON SITE. DISCUSSED REMOVAL OF CANOPIES AND CLOSURE OF EXCAVATIONS AT SITES 1 AND 3. FRED CANSLER STATED THAT HE HAS A SOURCE FOR THE ROCK AND FOR THE TOP SOIL FOR THE EXCAVATIONS.

1405 ARRIVED AT THE SITE WHERE FRED CANSLER PROPOSES TO REMOVE THE FILL FOR THE EXCAVATIONS. A HILL ON THE WEST SIDE OF THE WOODEN NICKLE IS IN THE PROCESS OF BEING REMOVED. THE ROCK CONSISTS OF WEATHERED SHALE SIMILAR TO THE ROCK REMOVED FROM THE EXCAVATIONS. FRED CANSLER PROPOSES TO USE THE ROCK TO FILL THE EXCAVATIONS TO WITHIN ONE FOOT OF GRADE.

1415 ARRIVED AT THE SITE WHERE FRED CANSLER PROPOSES TO REMOVE TOP SOIL FOR THE EXCAVATIONS. TOP SOIL REMOVED FROM THE YELLOW FREIGHT LOT IS IN PILES ON THE NORTH SIDE OF THE LOT.

1430 RETURNED TO SITE 3. FRED CANSLER WILL ARRANGE TO REMOVE THE CANOPY OVER THE EXCAVATION AT SITE 3 ON THURSDAY MORNING AND WILL ARRANGE TO BRING THE ROCK IN ON THURSDAY AFTERNOON. TWO TRUCKS WILL BE USED TO HAUL THE FILL. THE SUPPORTS HOLDING THE CANOPY

39 [signature] 1/26/94

TITLE: FIELD ACTIVITY LOGBOOKS

CATEGORY: DOC 2.1

REVISED: April 1998

1430 (CONT) WILL BE CUT AND THE CANOPY DRAGGED AWAY FROM THE EXCAVATION.

1445 CONTACTED JOY INMAN FROM ENVIRONICS. TANKERS WILL BE ON SITE ON THURSDAY TO PUMP OUT THE EXCAVATION AT SITE 3 AND ON FRIDAY TO REMOVE WATER AT SITE 1. A FRAC TANK WILL BE DELIVERED TO SITE 1 ON THURSDAY.

1515 SAMPLING CREW COMPLETED PACKING SAMPLES COLLECTED AT SITE 1. ALL WELLS AND PIEZOMETERS AT SITE 1 HAVE BEEN SAMPLED.

1530 SAMPLING CREW COMPLETED PACKING SAMPLES AND SECURING DRUMS OF PURGE WATER.

1535 SAMPLING CREW DEPARTED SITE TO DELIVER SAMPLES TO FEDERAL EXPRESS.

1600 CONTACTED TIM GRADY FROM E+E. DISCUSSED CONVERSATION WITH FRED CANSLER AND STATUS OF WELL/PIEZOMETER SAMPLING.

1615 SECURED FOR DAY.

WORK COMPLETED: COLLECTED GROUNDWATER SAMPLES FROM SITE 1 WELLS AND PIEZOMETERS. DISCUSSED REMOVAL OF CANOPIES AND FILLING OF EXCAVATIONS WITH FRED CANSLER. SHIPPED SAMPLES TO ASC

[signature] 1/26/94

THURSDAY JANUARY 27, 1994

PROPOSED WORK FOR DAY: COMPLETE COLLECTION OF GROUNDWATER SAMPLES AT SITE 3 AND SHIP THE SAMPLES TO THE ASC. REMOVE THE CANOPIES COVERING THE EXCAVATIONS AT SITES 1 AND 3. PUMP THE WATER OUT OF THE EXCAVATIONS AT SITES 1 AND 3 AND SHIP THE WATER OFF SITE TO OSCO. BACKFILL THE EXCAVATION AT SITE 3. REMOVE THE DRUMS FROM THE ROLL OFF BOX AND TRANSFER THE DRUMS TO THE WAREHOUSE.

WEATHER ON SITE: CLOUDY AND COOL WITH A HIGH TEMPERATURE OF 45°F. WINDS VARIABLE 10-20 MPH.

E+E PERSONNEL ON SITE: G. JONES, J. MAYS, S. MCCUNE

LOG

0700 SCOTT MCCUNE ARRIVED AT SITE 3.

0710 ENVIRONICS PERSONNEL ARRIVED AT SITE 3.

0715 HELD SITE SAFETY MEETING, DISCUSSED PHYSICAL AND CHEMICAL HAZARDS ASSOCIATED WITH SITE AND PROPOSED WORK FOR THE DAY.

0725 E+E SAMPLING TEAM ARRIVED ON SITE

 [signature] 1/27/94

TITLE: FIELD ACTIVITY LOGBOOKS

CATEGORY: DOC 2.1

REVISED: April 1998

1/27/94 RI6130

0730 E+E SAMPLING CREW COMMENCED COLLECTING SAMPLES AND PURGING MW3-1 AND MW3-2.

0800 FRED CANSLER ARRIVED ON SITE WITH PERSONNEL TO REMOVE THE CANOPY OVER THE EXCAVATION AT SITE 3. THE SUPPORTS WERE CUT AND THE CANOPY WAS DRAGGED AWAY FROM THE EXCAVATION WITH TWO TRACTORS.

0845 THE CANOPY REMOVAL AT SITE 3 COMPLETED AND THE CREW DEPARTED FOR SITE 1.

0850 COMMENCED PUMPING WATER FROM THE EXCAVATION INTO BRYSON TRAILER # 618CS.

0915 THE E+E SAMPLING TEAM COMPLETED COLLECTING THE GROUNDWATER SAMPLES FROM MW3-1, MW3-2, MW3-3, AND MW3-4. COMMENCED PACKING SAMPLES.

0935 COMPLETED FILLING BRYSON TRAILER # 618CS WITH 5,000 GALLONS OF WATER AND PREPARED MANIFEST # 00941 FOR LOAD. COMMENCED LOADING BRYSON TRAILER # 429.

1000 E+E SAMPLING TEAM DEPARTED THE SITE TO DELIVER SAMPLES TO FEDERAL EXPRESS.

1030 ARRIVED AT SITE 1. THE CANSLER CREW IS IN THE PROCESS OF REMOVING THE CANOPY OVER THE EXCAVATION. CANOPY IS NOT MOVING AS A UNIT.

42 [signature] 1/27/94

RI6130 1/27/94

1045 RETURNED TO SITE 3. ALL WATER IN THE EXCAVATION HAS BEEN REMOVED EXCEPT FOR THE ICE. BRYSON TRAILER # 429 LOADED WITH 5,200 GALLONS OF WATER. PREPARED MANIFEST # 00942 FOR LOAD. BOTH TANKERS DEPARTED THE SITE.

1100 ENVIRONICS PERSONNEL OPENED THE DRUMS OF DRILLING FLUIDS, DEVELOPMENT WATER AND PURGE WATER AND FOUND THE DRUMS FULL OF ICE. ENVIRONICS WILL CONTACT GARY SHOCKLEY AND RECOMMEND THAT THE DRUMS OF LIQUIDS BE TRANSPORTED TO OSCO FOR TREATMENT SINCE THEY CAN NOT BE BULKED.

1200 CANSLER CREW COMMENCED LOADING TRUCKS WITH STONE FROM THE SITE WEST OF THE WOODEN NICKEL.

1230 ARRIVED AT THE SITE WHERE THE STONE WAS BEING LOADED. THE FILL MATERIAL IS ALL UNDISTURBED WEATHERED BEDROCK.

1245 ARRIVED AT SITE 3. TWO LOADS OF ROCK FILL HAVE BEEN DUMPED IN THE EXCAVATION; AN ESTIMATED FOUR MORE LOADS OF STONE WILL BE NEEDED TO FILL THE EXCAVATION.

1300 ARRIVED AT SITE 1. BRYSON TRAILER # 617

43 [signature] 1/27/94

Title:	**GEOTECHNICAL LOGBOOK/ TRIP REPORT PREPARATION**
Category:	DOC 2.4
Revised:	April 1998

STANDARD OPERATING PROCEDURE

GEOTECHNICAL LOGBOOK/ TRIP REPORT PREPARATION

ecology and environment, inc.
368 Pleasant View Drive / Lancaster, New York 14086 / (716) 684-8060

TITLE:	**GEOTECHNICAL LOGBOOK/ TRIP REPORT PREPARATION**		
CATEGORY:	DOC 2.4	**REVISED:**	April 1998

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1. Introduction

This Standard Operating Procedure (SOP) outlines the procedures followed by Ecology and Environment, Inc. (E & E), for the entry of information into the geotechnical logbook, thereby ensuring that field activities are properly documented.

It is the responsibility of the site geologist to ensure that the proper information is collected in the field in order to fulfill the obligations of the contract.

2. Purpose

The purpose of this document is to establish the minimum content requirements of the geotechnical logbook entries for drilling projects. The document provides guidance to ensure that the documentation for drilling projects is correct, complete, and adequate for use in any potential legal proceeding. It is important to remember that field activity documentation can become evidence in civil and criminal law- enforcement proceedings, as well as in administrative hearings. Accordingly, such documentation is subject to judicial or administrative review; even more importantly, it is subject to the review of an opposing attorney attempting to discredit its value as evidence. Complete and accurate entries in the geotechnical logbook are important for two reasons: to maintain quality control, and to support any legal proceedings associated with the project.

3. Geotechnical Logbook Procedures

3.1 General Information

Information concerning the project can be found in the geotechnical logbook. The majority of the information should be obtained prior to arriving on site. Figure 1 is an example of a completed general information sheet.

CLIENT: Chemical Corporation of America

JOB NUMBER: ZZ-1020

SITE NAME: ABC Landfill

DRILLER: Paul Barth E+E Drilling and Testing Company

LOCATION: CITY/TOWN: Midway

STATE: Tennessee

PROJECT MANAGER: Buff Walter

FIELD TEAM LEADERS: Marilyn Frappa /

SITE SAFETY OFFICER(S): Greg Jones /

TEAM MEMBERS: Paul Barth (EEDT)
Kevin Williamson (EEDT)

JOB START/FINISH DATE: 1/4/94 / 1/18/94

BOOK 1 OF 3

E&E CORPORATE: (716) 684-8060	FAX (716) 684-0844
E&E EMERGENCY RESPONSE CENTER: (716) 684-8940	
E&E ANALYTIC SERVICE CENTER: (716) 631-0360	FAX (716) 631-0378
E&E EQUIPMENT SERVICE CENTER: (716) 681-9797	FAX (716) 681-4356
FEDERAL EXPRESS TOLL FREE: (800) 238-5355	

PROJECT/CLIENT CONTACT(S)	AFFILIATION	PHONE
Buff Walter	E + E	703/522-6065

For inquires regarding the distribution, scope, and/or organization of the Geotechnical Logbook please contact:

...

Figure 1 General Information

3.2 Daily Logs

3.2.1 General Guidelines

The following includes general guidelines for preparing the geotechnical logbook:

- A separate logbook must be maintained for each project.
- No pages can be removed for any reason, even if they are partially mutilated or illegible.
- All field activities (e.g., meetings, sampling, surveying) must be recorded in the geotechnical logbook.
- All information is **printed** legibly into the logbook in waterproof ink, preferably black. If weather conditions do not permit this (i.e., if it is too cold or too wet to write with ink), another medium such as a pencil may be used, but it should be specifically noted in the logbook why waterproof ink was not used.
- The language used in the geotechnical logbook should be objective, factual, and free of personal feelings or terminology that might prove inappropriate.
- Chronological entries are preferred. If entries cannot be made at the time observed, record them as soon as possible, noting both the time of the entry and the time of the observation.
- Each successive day's first entry is made on a new, blank page.
- Each page should be dated, and all entries should have a time notation based on the 24-hour clock (e.g., 0900 for 9:00 a.m., 2100 for 9:00 p.m.).
- At the completion of the drilling activity, the geotechnical logbook must be placed in the permanent project file.

3.2.2 Format

The information listed below is not meant to be all-inclusive. Each project manager is responsible for determining the information requirements for each geotechnical logbook; such information requirements will vary depending on the nature and scope of the project.

First Page: On the first page of every daily entry, the date and project number should be entered on the top line. The proposed work for the day, weather on site, and personnel on site follow below the date. Log entries include the time that personnel arrive on site, the time personnel depart the site, the time that site safety meetings are held (with signatures of the personnel attending the briefing), the levels of personal protection used by the team, specific activities undertaken (e.g., drilling operations, air monitoring, sample collection), and equipment calibration data. At the bottom of the page, the signature of the person keeping the log and the date should be entered.

Successive Pages: The date and project number should appear at the top of each successive page, and the person keeping the log should sign and date the page.

Last Page: On the last page of the daily log, the work completed that day and future plans and recommendations should be entered.

Samples: Each sample must be properly accounted for in the geotechnical logbook. Information entered in the log should include the location where the sample was collected; the time that the sample was collected; the type of sample (e.g., subsurface composite soil sample or groundwater sample); on-site measurement data (e.g., pH, temperature, conductivity); a preliminary description of the sample; preservatives used (if any); air monitoring instrument readings; and the Federal Express (or other carrier's) air bill number.

3.2.3 Photographs

If photographs are taken of soil samples, drill cuttings, or core samples, the following information should be entered in the geotechnical logbook:

- Time, location, direction, and weather conditions.
- Complete description or identification of the subject in the photograph and reason for taking the picture.
- Sequential number of photograph and film number.
- Camera type and serial number (e.g., Olympus 35-mm #1164916), and lens size and serial number (if appropriate).
- Name of photographer.

Upon return to the office, the above information will be used to prepare photograph logs.

3.2.4 Signature

Each page of the geotechnical logbook must be initialed by the person recording the information. When two individuals make entries on the same page, they must initial their own entries. The individual making the last entry on the page must sign and date the bottom of the page.

3.2.5 Corrections

If corrections are necessary, they may be made by drawing a single line through the entry and writing the corrected entry next to it. The correction must be initialed and dated. Do not render the incorrect notation illegible; make the correction in such a manner that the original entry can still be read.

3.3 Drilling Information

Information concerning the installation of the borehole is entered in the drilling log. The geotechnical logbook is divided in such a manner that the information for four boreholes can be entered in one logbook. In addition to information about the location, start and finish dates, drill rig, and driller, a sketch indicating the location where the borehole or well was installed should be drawn.

Sample information should also be included in this section. The number of blows it took to drive the split-barrel sampler 2 feet below the bottom of the hollow-stem augers in 6-inch intervals should be recorded. The amount of soil recovered in the split-barrel sampler, organic vapor readings noted in the sample, and soil components must also be recorded in this section. An example of a completed drilling log can be found in Figure 2.

3.4 Lithologic Description

A description of the materials used in the construction of the monitoring well and the type of well (e.g., screened or open-hole well) must also be recorded. Figure 3 is an example of a completed well installation diagram. In addition to the well installation diagram, a narrative description of the lithology of the soil and bedrock encountered is also recorded in this section.

3.5 Well Development Record

The proper development of monitoring wells will prevent the buildup of fines on the screened interval and will provide groundwater samples that are representative of the groundwater conditions. To determine the volume of water to be removed from the well, the inside diameter of the monitoring well or diameter of the borehole is determined and the appropriate line is found on the table in Figure 4.

DRILLING LOG FOR MW1-1

Project Name ABC Landfill RI

Site Location Midway, TN

Date Started/Finished 1/6/94 – 1/6/94

Drilling Company E&E Drilling & Testing

Driller's Name Paul Barth

Geologist's Name Marylyn Frappa

Geologist's Signature Marylyn Frappa

Rig Type (s) DIEDRICH D50

Drilling Method (s) 4.25" HSA

Bit Size (s) ______ Auger Size (s) 8" O.D.

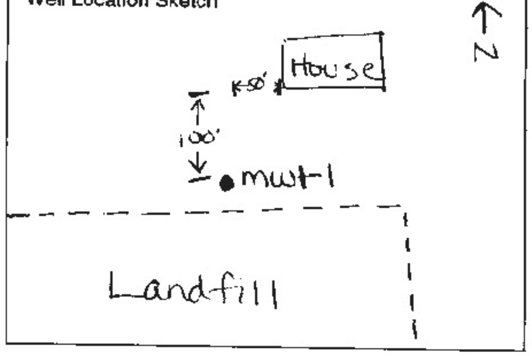
Auger/Split Spoon Refusal 24 ft

Total Depth of Borehole is 24 ft

Total Depth of Corehole is N/A

Water Level (TOIC)		
Date	Time	Level (Feet)
1/6/94	1640	16.25
1/8/94	0920	13.75
1/14/94	0830	13.86
1/14/94	1020	14.26

Well Location Sketch



Depth (Feet)	Sample Number	Blows on Sampler		Soil Components CL SL S GR	Rock Profile Recovery	(PPM) Head Space	Run Number	Core Recovery	RQD	Fracture Sketch	OVA (ppm)	Comments
0'-5' Asphalt												
1		10	9									
2	1	16	19	SL/S	16"	Ø PPM	1	N/A		NONE	Ø PPM	
3		7	8									
4	2	10	9	SL/S	6"	Ø PPM	2	N/A		NONE	Ø PPM	
5		6	8									
6	3	5	9	SL/S	10"	Ø PPM	3	N/A		NONE	Ø PPM	
7		4	11									
8	4	23	10	SL/S	6"	Ø PPM	4	N/A		NONE	Ø PPM	
9		7	8									
10	5	10	9	SL/S	4"	Ø PPM	5	N/A		NONE	Ø PPM	
11		6	9									
12	6	26	32	S/GR	5"	28 PPM	6	N/A		NONE	1 PPM	
13		12	24									
14	7	34	48	S/GR	6"	Ø PPM	7	N/A		NONE	Ø PPM	

Figure 2 Drilling Information

SCREENED WELL

Stick-up 2 ft

Inner Casing Material PVC

Inner Casing Inside Diameter 2 Inches

Top of Grout 0 ft

Borehole Diameter 8 Inches ft

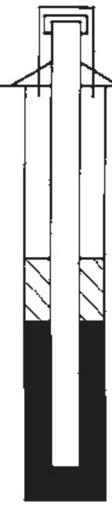
Top of Seal at 10 ft

Bottom of Seal at 12 ft

Top of Screen at 14 ft

Pack Type/Size:
- [x] Sand 00N
- [ ] Gravel
- [ ] Natural

Bottom of Screen at 24 ft



Lock Number IG031

Quanity of Material Used:
Betonite Pellets 2 Buckets
Cement 4 Bags
Cement/ Bentonite
Grout

Top of Sand Pack 12'

Screen Slot Size 0.010

Screen Type Continuous
- [x] PVC 2"
- [ ] Stainless Steel

Bottom of Hole at 24 ft

Bottom of Sandpack at 24'

OPEN-HOLE WELL

Stick-up ft

Inner Casing Material

Inner Casing Inside Diameter Inches

Top of Grout ft

Bottom of Outer Casing ft

Borehole Diameter ft

Bedrock ft

Bottom of Rock Socket/ Grout/Casing ft

Corehole Diameter

Bottom of Corehole ft

NOTE: See page 109 and 110 for well construction diagrams

Depth-ft.	NARRATIVE LITHOLOGIC DESCRIPTION	Moisture Content: Dry	Moist	Wet
	8" Asphalt then Fill - Black + Dry (Cuttings)	●	○	○
1	↓	●	○	○
2	Fill Materials, Mainly Black Cinders, Some white Ash Last 3"	●	○	○
3	↓	●	○	○
4	Brown Sandy-Silt Matrix about 50% Small Large Gravels, Subangular	●	●	○
5	↓	●	●	○
6	Same as above	○	●	○
7	↓	○	●	○
8	Same as about	○	●	○
9	↓	○	●	○
10	Same as about with large Gravel 1"-2", Moist, 1 PPm	○	●	○
11	↓	○	●	○
12	3" Rock + Ground Rock, Grey Sands Wet	○	●	○
13	↓	○	○	●
14		○	○	●

Figure 3 Well Construction/Lithologic Description

WELL DEVELOPMENT RECORD

SITE: ABC Landfill DATE: 1/14/94

LOCATION: Midway, TN WELL NO.: MW1-1

MEASUREMENT OF WATER LEVEL AND WELL VOLUME

- Prior to sampling, the static water level and total depth of the well will be measured with a calibrated weighted line. Care will be taken to decontaminate equipment between each use to avoid cross contamination of wells.
- The number of linear feet of static water (difference between static water level and total depth of well) will be calculated.
- The static volume will be calculated using the formula:

$$V = Tr^2 (0.163)$$

Where:
V = Static volume of well in gallons;
T = Depth of water in the well, measured in feet;
r = Inside radius of well casing in inches;
and 0.163 = A constant conversion factor which compensates for r^2h factor for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and (pi).
1 well volume (v) = _____ gallons.

Volume of Water in Casing or Hole

Diameter of Casing or Hole (n)	Gallons per Foot of Depth	Cubic Feet per Foot of Depth	Liter per Meter of Depth	Cubic Meters per Meter of Depth
1	0.041	0.0055	0.509	0.509×10^{-3}
11/2	0.092	0.0123	1.142	1.142×10^{-3}
2	0.153	0.0218	2.024	2.024×10^{-3}
21/2	0.255	0.0341	3.167	3.167×10^{-3}
3	0.367	0.0491	4.558	4.558×10^{-3}
31/2	0.500	0.0668	6.209	6.209×10^{-3}
4	0.653	0.0873	8.110	8.110×10^{-3}
41/2	0.826	0.1104	10.260	10.260×10^{-3}
5	1.020	0.1364	12.670	12.670×10^{-3}
51/2	1.234	0.1650	15.330	15.330×10^{-3}
6	1.469	0.1963	18.240	18.240×10^{-3}
7	2.000	0.2673	24.840	24.840×10^{-3}
8	2.611	0.3491	32.430	32.430×10^{-3}
9	3.305	0.4418	41.040	41.040×10^{-3}
10	4.080	0.5454	50.670	50.670×10^{-3}
11	4.937	0.6600	61.310	61.310×10^{-3}
12	5.875	0.7854	72.960	72.960×10^{-3}
14	8.000	1.0690	99.350	99.350×10^{-3}
16	10.440	1.3960	129.650	129.650×10^{-3}
18	13.220	1.7670	164.180	164.180×10^{-3}
20	16.320	2.1820	202.680	202.680×10^{-3}
22	19.750	2.6400	245.280	245.280×10^{-3}
24	23.500	3.1420	291.850	291.850×10^{-3}
26	27.580	3.6870	342.520	342.520×10^{-3}
28	32.000	4.2760	397.410	397.410×10^{-3}
30	36.720	4.9090	456.020	456.020×10^{-3}
32	41.780	5.5850	518.870	518.870×10^{-3}
34	47.160	6.3050	585.680	585.680×10^{-3}
36	52.880	7.0690	656.720	656.720×10^{-3}

1 Gallon = 3.785 liters
1 Meter = 3.281 feet
1 Gallon water weighs 8.33 lbs. = 37.785 kilograms
1 Liter water weighs 1 kilogram = 2.205 pounds
1 Gallon per foot of depth = 12.419 liters per foot of depth
1 Gallon per meter of depth = 12.419×10^{-3} cubic meters per meter of depth

INITIAL DEVELOPMENT WATER

WATER LEVEL (TOIC): 13.86'
WELL DEPTH (TD): 24
COLOR: Brown Silty
ODOR: Musty
CLARITY: Opaque

FINAL DEVELOPMENT WATER

WATER LEVEL (TOIC): 14.26'
WELL DEPTH (TD): 24'
COLOR: Clear
ODOR: None
CLARITY: Clear

DESCRIPTION OF DEVELOPMENT TECHNIQUE: Stainless Steel Hand Bailer. measured volume removed with bucket.

Figure 4 Well Development Record

3.6 Well Development—Parameter Measures

Physical measurements are made on samples of the groundwater during well development. At routine intervals, a sample of the development water is tested for temperature, conductivity, corrosivity (pH), and turbidity. The results of each test are recorded as shown in Figure 5. When two consecutive tests have the same readings, development of the well is considered complete.

3.7 Investigation-Derived Waste Inventory

In most instances, the drill cuttings, drilling fluids, development and purge water, and personal protective equipment must be containerized and handled as a hazardous waste as described by the Resource Conservation and Recovery Act (RCRA) until analytical results are available to reclassify the wastes. All hazardous wastes must be properly marked and labeled and must be disposed of in a specific period of time. The contents of each container, the source of the waste, the date that the waste was generated, the approximate volume of waste in the container, and the location where the container is being stored must be noted in the geotechnical logbook. Figure 6 is an example of a completed investigation-derived waste inventory sheet.

4. Trip Report

The geologist or team leader is responsible for filing a trip report upon returning to the office. The trip report must include information regarding the persons making the trip; the date of the trip; location of the trip; and, most importantly, the purpose of the trip. The trip report provides the means to convey information gathered and observed to the project manager. Trip reports should be written and submitted within two working days of return from a trip. Figure 7 shows the format for a trip report.

5. References

United States Environmental Protection Agency, 1986, RCRA Groundwater Monitoring Technical Enforcement Guidance Document, OSWER Directive 9950-1, September 1986.

__________, 1986, Region IV Engineering Support Branch, Standard Operating Procedures and Quality Assurance Manual, April 1986.

WELL DEVELOPMENT - PARAMETER MEASUREMENTS

TIME	TOTAL VOL. WITHDRAWN		pH	COND. (umhos/cm)	TEMP. (c)	TURB. (NTU)	COMMENTS
	GALS.	BORE VOL.					
0830	0	26	9.23	4.86	20°C	—	
0838	2	26	8.52	4.69	20.2°	—	
0845	4	26	8.49	4.67	20.3°	—	
0852	6	26	8.37	4.65	20.4°	—	
0900	8	26	8.14	4.63	20.5°	—	
0908	10	26	8.05	4.63	20.5°	—	
0913	12	26	7.96	4.58	20.4°	—	
0926	14	26	7.92	4.50	20.4°	—	
0933	16	26	7.91	4.49	20.6°	—	
0945	18	26	7.90	4.48	20.7°	—	
0953	20	26	7.89	4.42	20.8°	—	
1005	22	26	7.88	4.40	21.0°	—	
1014	24	26	7.88	4.39	21.1°	—	
1020	26	26	7.88	4.39	21.1°	—	

DEVELOPED BY: Kevin Williamson DATE 1/14/94

Figure 5 Well Development-Parameter Measurements

INVESTIGATION-DERIVED WASTE INVENTORY SHEET

Site: ABC Landfill, Midway, TN (ZZ-1020) No. of Drums 6

Inventory Date: January 15, 1994

Waste Source	Drum/Container ID Number	Date Generated	Contents (Solid, Liquids, etc.)	Approximate Volume	Drum Location/ Comments
MW1-1	ZZ001	1/6/94	Drill Cuttings	Full	Site 1 Staging Area
MW1-1	ZZ002	1/6/94	Drill Fluids	Full	Site 1 Staging Area
MW1-2	ZZ003	1/7/94	Drill Cuttings	Full	Site 1 Staging Area
MW1-2	ZZ004	1/7/94	Drill Fluids	Full	Site 1 Staging Area
MW1-1	ZZ005	1/14/94	Dev./Purge Water	½ Full	Site 1 Staging Area
MW1-2	ZZ006	1/14/94	Dev./Purge Water	½ Full	Site 1 Staging Area

Figure 6 Investigation-Derived Waste Inventory

TRIP REPORT

Project No. __________

FROM: Persons Making Trip

TO: Project Manager and/or Staff Members

DATE: Date of Trip

LOCATION: Region, Municipality, or Agency with Address Visited

PURPOSE: Reason for Trip

TRIP DISCUSSION: ____

____

____

____

____

____

____

List of Accompanying Contact Reports (if appropriate)
Person Contacted and Date

Figure 7 Trip Report Format

Title:	**SEDIMENT SAMPLING**
Category:	ENV 3.8
Revised:	March 1998

STANDARD OPERATING PROCEDURE

SEDIMENT SAMPLING

ecology and environment, inc.
368 Pleasant View Drive / Lancaster, New York 14086 / (716) 684-8060

TITLE:	**SEDIMENT SAMPLING**		
CATEGORY:	ENV 3.8	**REVISED:**	March 1998

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1. Introduction

This Standard Operating Procedure (SOP) describes the procedures for the collection of representative sediment samples. Analysis of sediment samples may determine whether concentrations of specific pollutants exceed established threshold action levels, and whether the concentrations of pollutants present a risk to public health, welfare, or the environment.

2. Scope

Included in this discussion are procedures for obtaining representative samples, quality assurance measures, proper documentation of sampling activities, and recommendations for personnel safety.

3. Method Summary

Sediment samples may be recovered using a variety of methods and equipment. These are dependent on 1) the depth of the water in which the samples will be collected; 2) the sediment's characteristics; 3) the volume of sediment required; and 4) the type of sample required (disturbed or undisturbed). Ultimately, the type of sampling device used should be consistent with the objective of the study.

Near-surface sediment samples may be collected using a scoop or spoon (if near shore or in shallow water), or sediment dredge or grab sampler (if in deeper water). To obtain other than surficial sediment samples, core samplers or split-spoon samplers are required.

All sampling devices should be cleaned using pesticide-grade acetone (assuming that acetone is not a target compound) or methanol, rinsed with distilled water, wrapped in aluminum foil, and custody sealed for identification. The sampling equipment should remain in this wrapping until needed. Each sampler should be used for one sample only. However, dedicated samplers may be impractical if there are a large number of sediment samples to be collected. In this case, samplers should be cleaned in the field using the decontamination procedures outlined in E & E's *Equipment Decontamination* SOP.

4. Sample Preservation, Containers, Handling, and Storage

The chemical preservation of sediments is not generally recommended. Refrigeration is usually the best approach, supplemented by a minimal holding time. Sediment samples should be handled according to standard techniques and project-specific requirements as detailed in project work/sampling plans and quality assurance project plans.

5. Potential Problems

Potential problems with sediment sampling include cross-contamination of samples and improper sample collection. Cross-contamination problems may be eliminated or minimized through the use of dedicated sampling equipment and bottles. If this is not possible or practical, then proper decontamination of sampling equipment is necessary. Improper sample collection can involve using inadequate or inappropriate sampling devices, contaminated equipment, disturbance of the matrix resulting in compaction of the sample, and inadequate homogenization of the sample where required, resulting in variable, nonrepresentative results.

6. Equipment

The following is a list of equipment and items typically used for sediment sampling:

- Sampling plan,
- Sample location map,
- Safety equipment, as specified in the health and safety plan,
- Compass,
- Survey equipment,
- Tape measure,
- Camera,
- Four-ounce and eight-ounce glass jars with teflon liners,

- 40-ml glass vials with teflon-backed septum,
- Plastic bags for sample jars,
- Logbook,
- Labels,
- Waterproof ink pen,
- Chain-of-custody forms,
- Shipping cooler,
- Decontamination supplies and equipment, as described in the work plan,
- Canvas or plastic sheeting,
- Stainless-steel scoops,
- Stainless-steel spoons,
- Stainless-steel mixing bowls, or pans,
- Hand-driven split-spoon sampler,
- Shovel,
- Stainless-steel hand auger,
- Sediment dredge/grab sampler,
- Manual, gravity, or mechanical coring devices, and
- Teflon beaker attached to a telescoping pole.

7. Reagents

Sediment sampling does not require the use of reagents except for decontamination of equipment. Refer to E & E's *Equipment Decontamination* SOP and the site-specific work plan for proper decontamination procedures and appropriate solvents.

8. Procedures

8.1 Office Preparation

- Prepare a sampling plan in accordance with contract requirements. Conduct a literature and information search and review available background information (e.g., topographic maps, soil survey maps, geological survey maps, other site reports, etc.) to determine the extent of the sampling effort, the sampling methods to be employed, and the type and amounts of equipment and supplies required.

- E & E corporate policy requires that a health and safety plan be prepared prior to commencing any sampling activity. The plan must be approved and signed by the corporate health and safety officer or his/her designee (e.g., the regional safety coordinator [RSC]).

- Obtain necessary sampling and monitoring equipment (see Section 6), and ensure that everything is in working order.

- Contact delivery service to confirm ability to ship all equipment and samples. Determine whether shipping restrictions exist.

- Prepare schedules and coordinate with staff, clients, property owners, and regulatory agencies, if appropriate.

8.2 Field Preparation

- Identify local suppliers of sampling expendables and overnight delivery services (e.g., Federal Express).

- Decontaminate or preclean all equipment before sediment sampling, as described in E & E's *Equipment Decontamination* SOP, or as deemed necessary.

- Calibrate all health & safety monitoring equipment daily.

- A general site survey should be performed prior to site entry, in accordance with the health and safety plan. A site safety meeting identifying physical and chemical hazards should be conducted prior to sampling activities.

- Identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All locations must be cleared of utilities by the property owner or utility companies prior to sediment sampling.

8.3 Sample Collection

Numerous techniques and sampling devices may be employed to collect representative sediment samples. A number of sampling-related factors can contribute to the loss of sample integrity, including washout of fine-grained sediments during retrieval; compaction due to sample wall friction; and sampling vessel- or person-induced disturbance of surficial layers. Choosing the most appropriate sediment sampler for a study will depend on the sediment's characteristics, the volume and efficiency required, and the objectives of the study.

Most samples will be grab samples, although occasionally, sediment taken from various locations may be combined into one composite sample to reduce the amount of analytical support required.

The following procedure is used to collect surface sediment samples from small, low-flowing streams or near the shore of a pond or lake:

1. The sampler should select the sampling location furthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments from migrating down to unsampled locations. This technique will also reduce the chances of cross-contaminating subsequent samples by sampling first in areas of suspected low contamination and working to the suspected higher concentration areas.

2. Using a precleaned, stainless-steel scoop, spoon, or other appropriate device, remove the required volume of sediment from the desired surface interval (e.g., 0-inch to 6-inch), place the sample in the appropriate precleaned glass jar, decant excess liquid as necessary, and secure the teflon-lined lid to the jar. If the sample is to be a composite sample, or if the sample is to be homogenized, the sediment is first placed in a stainless-steel mixing bowl and is homogenized prior to placement in the glass sample container. Samples for volatile organic analysis are not homogenized. Samples are handled in accordance with project-specific requirements.

3. Carefully and clearly identify the jar with the appropriate sample label, ensuring that all the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, secure the seal in place with clear tape, and refrigerate the sample. The clear tape should also cover the jar's label.

4. Use the chain-of-custody form to document the types and number of sediment samples collected for shipment to a laboratory for analyses.

5. In the field logbook record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements.

6. Decontaminate sampling equipment in accordance with E & E's *Equipment Decontamination* SOP.

The following procedure is used to collect subsurface sediment samples from small, low-flowing streams or near the shore of a pond or lake:

1. The sampler should select the sampling location farthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments from migrating downstream to unsampled locations, and will also reduce the chances of cross-contaminating subsequent samples.

2. Using a precleaned split-spoon sampler or other hollow coring device, drive the sampler to the required depth with a smooth continuous motion. Remove the coring device by rotating and lifting it in a single smooth motion until the sampler is free from the sediment.

3. Before the sediment sample can be removed from the sampling device, the overlying water must be removed from the sampler by slowly pouring or siphoning it off near one side of the sampler. Care should be taken to ensure that the sediments are not disturbed, and that the fine-grained surficial sediment and organic matter are not lost while removing the overlying water.

4. Disassemble the split-spoon sampler by placing pipe wrenches on either end of the sampler. Remove both ends and open the split spoon with a precleaned stainless-steel spoon. Recover the sediment core from a core tube by pushing the sample out with a precleaned stainless-steel spoon.

5. Collect the necessary sample by cutting the core with the handle of a precleaned stainless-steel spoon, placing the sample in the appropriate precleaned glass jar, and securing the teflon-lined lid to the jar. Samples are handled in accordance with project-specific requirements.

6. Carefully and clearly label the jar with the appropriate sample tag, ensuring that all of the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, and secure the seal in place with clear tape.

7. Use the chain-of-custody form to document the types and number of sediment samples collected and logged.

8. Record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements, in the field logbook.

9. Decontaminate sampling equipment as per E & E's *Equipment Decontamination* SOP.

The following procedure is used to collect surface samples from rivers or from deeper lakes and ponds:

1. The sampler should select the sampling location farthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments to migrate downstream to unsampled locations.

2. Using a precleaned sediment dredge or grab sampler, lower the sampler to the sediment layer with a polypropylene rope. Depending on the type of sampler used, the jaws of the sediment dredge will either automatically close, or will be triggered with a weighted messenger.

3. Recover the sampler and empty the sediment sample into a precleaned stainless-steel bowl. The water layer should be decanted slowly until only sediment remains in the bowl.

4. Using a precleaned stainless-steel spoon, remove the required volume of sediment. Place the sample in the appropriate precleaned glass jar, and secure the Teflon-lined lid to the jar.

5. Carefully and clearly identify the jar with the appropriate sample label, ensuring that all of the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, and secure the seal in place with clear tape. The clear tape should cover the sample label.

6. Use the chain-of-custody form to document the types and number of sediment samples collected for shipment to a laboratory for analyses.

7. Record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements, in the field logbook.

8. Decontaminate sampling equipment in accordance with E & E's *Equipment Decontamination* SOP.

The following procedure is used to collect subsurface samples from rivers or from deeper lakes and ponds:

1. The sampler should select the sampling location farthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments to migrate downstream to unsampled locations.

2. Attach a precleaned gravity or mechanical coring device to the required length of polypropylene sample line and allow the corer to freefall through the water to the bottom.

3. Determine the depth of sediment penetration, and if acceptable, retrieve the corer with a smooth, continuous lifting motion.

4. Remove the overlying water from the corer by slowly pouring or siphoning it off near one side of the sampler. Remove the nosepiece from the corer, and slide the sample out of the corer into a stainless-steel bowl or tray.

5. Collect the necessary sample by cutting the core with the handle of a stainless-steel spoon, placing the sample in the appropriate precleaned glass jar, and securing the teflon-lined lid to the jar. Samples are handled in accordance with project-specific requirements.

6. Carefully and clearly label the jar with the appropriate sample tag, ensuring that all of the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, and secure the seal in place with clear tape.

7. Use the chain-of-custody form to document the types and number of sediment samples collected for shipment to a laboratory for analyses.

8. Record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements, in the field logbook.

9. Decontaminate sampling equipment in accordance with E & E's *Equipment Decontamination* SOP.

8.4 Postoperations

1. Decontaminate all equipment according to E & E's *Equipment Decontamination* SOP prior to shipping the equipment back to the warehouse.

2. Organize field notes into the report format required by E & E's *Field Report Preparation* SOP. Logbooks should be maintained according to E & E's *Field Activities Log Book* SOP.

3. All samples should be shipped on the same day that they were collected to arrive at the laboratory not more than 24 hours after the samples were collected in accordance with E & E's *Sample Packaging* SOP.

9. Calculations

There are no specific calculations required for sediment sampling.

10. Quality Assurance

10.1 Sample Documentation

10.1.1 Sediment Sample Label

All sediment samples shall be documented in accordance with standard labeling techniques and project-specific requirements. The sediment sample label is completed to the fullest possible extent, prior to collecting the sample, and should contain the following minimum information:

- Site name or identification;
- Sample location and identifier;
- Date sample was collected in a day, month, year format (e.g., 03 JUN 91 for June 3, 1991);
- Time of sample collection, using 24-hour clock in the hours: minutes format; and
- Analysis required.

10.1.2 Logbook

A bound field logbook will be maintained by field personnel to record daily activities in accordance with E & E's *Field Activities Logbooks* SOP and include sample collection, tracking, and shipping information. A separate entry will be made for each sample collected. These entries should include information from the sample label and a complete description of the location from which the sediment sample was collected.

10.1.3 Chain-of-Custody

Use the chain-of-custody form to document the types and number of sediment samples collected and logged.

10.2 Sampling Plan Design

- Many of the activities critical to ensuring that the collected samples are of high quality take place in the pre-collection planning and preparation stage. Careful planning and attention to detail at this stage will result in a more successful sampling effort, and will ensure collection of the highest quality samples possible. Since site and sampling conditions vary widely, and no universal sampling procedure can be recommended, a detailed sampling plan, consistent with the objectives of the study, must be developed prior to any sampling activities.

- Any of the sampling methods described here should allow a representative sediment sample to be obtained if the sampling plan is properly designed.

- Consideration must also be given to the collection of a sample representative of all horizons present in the sediment. Selection of the proper sampling device will facilitate this procedure.

- A stringent quality assurance project plan (QAPP) should be outlined before any sampling operation is attempted. This should include, but not be limited to, the use of properly cleaned samplers and sample containers, chain-of-custody procedures, and collection of quality assurance samples such as field blanks, trip blanks, and duplicate samples.

11. Data Validation

The data generated will be reviewed according to quality assurance (QA) considerations identified in Section 10.

12. Health and Safety

Depending on site-specific contaminants, various protective programs must be implemented prior to sediment sampling. The site safety plan should be reviewed with specific emphasis placed on a protection program planned for direct contact tasks. Standard safe operating practices should be followed, including minimizing contact with potential contaminants in both vapor and solid matrix by using both respirators and disposable clothing.

Use appropriate safe work practices for the type of contaminant expected (or determined from previous sampling efforts):

Particulate or Metals Contaminants

- Avoid skin contact with and incidental ingestion of dust. Wash hands and other exposed skin areas routinely.
- Use protective gloves when collecting and handling the sediment samples.

Volatile Organic Contaminants

- Hexane acts as a carrier for a number of semivolatile organic compounds. The presence of hexane vapors in the air while decontaminating samplers indicates that the potential for exposure exists.
- If monitoring results indicate the presence of organic vapors, sampling activities must be conducted in Level C protection.
- Acetone can penetrate some types of surgical gloves; use the appropriate gloves, such as Scorpio neoprene gloves, when handling acetone.

13. References

American Society for Testing and Materials, 1993, ***ASTM Standards on Aquatic Toxicology and Hazard Evaluation***, Philadelphia, PA, ASTM Publication Code Number (PCN): 03-547093-16.

Burton, G. Allen, 1992, *Sediment* ***Toxicity Assessment***, Chelsea, MI.

Great Lakes National Program Office, 1985, ***Methods Manual for Bottom Sediment Sample Collection***, United States Environmental Protection Agency, Chicago, Illinois, EPA-905/5-85-004.

Municipal Environmental Research Laboratory, 1980, ***Samplers and Sampling Procedures for Hazardous Waste Streams***, United States Environmental Protection Agency, Cincinnati, Ohio EPA-600/280-018.

National Enforcement Investigations Center, 1980, ***Enforcement Considerations for Evaluations of Uncontrolled Hazardous Waste Sites by Contractors***, United States Environmental Protection Agency Office of Enforcement, Denver, Colorado.

Pacific Northwest Laboratories, 1987, ***Guidance for Sampling of and Analyzing for Organic Contaminants in Sediments***, United States Environmental Protection Agency, Criteria and Standards Division, Richland, Washington.

United States Department of Commerce, National Technical Information Service, 1985, ***Sediment Sampling Quality Assurance User's Guide***, Nevada University, Las Vegas, NV.

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STANDARD OPERATING PROCEDURE

SAMPLING EQUIPMENT DECONTAMINATION

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TITLE:	**SAMPLING EQUIPMENT DECONTAMINATION**		
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1. Scope and Application

The purpose of this procedure is to provide a description of methods for preventing or reducing cross-contamination and general guidelines for designing and selecting decontamination procedures for use at potential hazardous waste sites. The decontamination procedures chosen will prevent introduction and cross-contamination of suspected contaminants in environmental samples, and will protect the health and safety of site personnel.

2. Method Summary

Removing or neutralizing contaminants that have accumulated on personnel and equipment ensures protection of personnel from permeating substances, reduces/eliminates transfer of contaminants to clean areas, prevents the mixing of incompatible substances, and minimizes the likelihood of sample contamination.

Cross-contamination can be removed by physical decontamination procedures. The abrasive and non-abrasive methods include the use of brushes, high pressure water, air and wet blasting, and high pressure Freon cleaning. These methods should be followed by a wash/rinse process using appropriate cleaning solutions. A general protocol for cleaning with solutions is as follows:

1. Physical removal.
2. Non-phosphate detergent plus tap water.
3. Tap water.
4. 10% nitric acid.
5. Distilled/deionized water rinse.
6. Solvent rinse.
7. Total air dry.
8. Triple rinse with distilled/deionized water.

This procedure can be expanded to include additional or alternate solvent rinses that will remove specified target compounds if required by site-specific work plans (WP) or as directed by a particular client.

3. Interferences

The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte-free distilled/deionized water. Distilled water available from local grocery stores and pharmacies is generally not acceptable for final decontamination rinses. Contaminant-free deionized water is available from commercial vendors and may be shipped directly to the site or your hotel.

The use of an untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal water treatment system.

4. Equipment/Apparatus

The following are standard materials and equipment used as a part of the decontamination process:

- Appropriate protective clothing;
- Air purifying respirator (APR);
- Field log book;
- Non-phosphate detergent;
- Selected high purity, contaminant-free solvents;
- Long-handled brushes;
- Drop cloths (plastic sheeting);
- Trash containers;
- Paper towels;
- Galvanized tubs or equivalent (e.g., baby pools);
- Tap water;
- Contaminant-free distilled/deionized water;
- Metal/plastic container for storage and disposal of contaminated wash solutions;
- Pressurized sprayers, H_2O;
- Pressurized sprayers, solvents;
- Trash bags;
- Aluminum foil;
- Sample containers;

- Safety glasses or splash shield; and
- Emergency eyewash bottle.

5. Reagents

There are no reagents used in this procedure aside from decontamination solutions used for the equipment. The type of decontamination solution to be used shall depend upon the type and degree of contamination present and as specified in the project/site-specific Quality Assurance Project Plan (QAPP).

In general, the following solvents are utilized for decontamination purposes:

- 10% nitric acid wash (reagent grade nitric acid diluted with deionized/distilled water – 1 part acid to 10 parts water)[a];
- Acetone (pesticide grade)[b] ;
- Hexane (pesticide grade)[b];
- Methanol; and
- Methylene chloride[b].

[a] Only if sample is to be analyzed for trace metals.
[b] Only if sample is to be analyzed for organics requiring specific or specialized decontamination procedures. These solvents must be kept away from samples in order to avoid contamination by decon solvents.

6. Procedures

Decontamination is the process of removing or neutralizing contaminants that have accumulated on both personnel and equipment. Specific procedures in each case are designed accordingly and may be identified in either the Health and Safety Plan (HSP), WP, QAPP, or all three.

As part of the HSP, a personnel decontamination plan should be developed and set up before any personnel or equipment enters the areas of potential contamination. Decontamination procedures for equipment will be specified in the WP and the associated QAPP. These plans should include:

- Number and layout of decontamination stations;
- Decontamination equipment needed (see Section 4);

- Appropriate decontamination methods;

- Procedures to prevent contamination of clean areas;

- Methods and procedures to minimize worker contact with contaminants during removal of protective clothing;

- Methods and procedures to prevent cross-contamination of samples and maintain sample integrity and sample custody; and

- Methods for disposal of contaminated clothing, equipment, and solutions.

Revisions to these plans may be necessary for health and safety when the types of protective clothing, site conditions, or on-site hazards are reassessed based on new information.

Prevention of Contamination

Several procedures can be established to minimize contact with waste and the potential for contamination. For example:

- Employing work practices that minimize contact with hazardous substances (e.g., avoid areas of obvious contamination, avoid touching potentially hazardous substances);

- Use of remote sampling, handling, and container-opening techniques;

- Covering monitoring and sampling equipment with plastic or other protective material;

- Use of disposable outer garments and disposable sampling equipment with proper containment of these disposable items;

- Use of disposable towels to clean the outer surfaces of sample bottles before and after sample collection; and

- Encasing the source of contaminants with plastic sheeting or overpacks.

Proper procedures for dressing prior to entrance into contaminated areas will minimize the potential for contaminants to bypass the protective clothing. Generally, all fasteners (zippers, buttons, snaps, etc.) should be used, gloves and boots tucked under or over sleeves and pant legs, and all junctures taped (see the Health and Safety Plan for these procedures).

Decontamination Methods

All personnel, samples, and equipment leaving the contaminated area of a site must be decontaminated to remove any chemicals or infectious organisms that may have adhered to them. Various decontamination methods will either physically remove, inactivate by chemical detoxification/disinfection/sterilization, or remove contaminants by both physical and chemical means.

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques can be grouped into two categories: abrasive methods and non-abrasive methods.

6.1 Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The following reviews the available abrasive methods.

Mechanical

Mechanical methods include using brushes with metal, nylon, or natural bristles. The amount and type of contaminants removed will vary with the hardness of bristles, length of time brushing, and degree of brush contact. Material may also be removed by using appropriate tools to scrape, pry, or otherwise remove adhered materials.

Air Blasting

Air blasting equipment uses compressed air to force abrasive material through a nozzle at high velocities. The distance between nozzle and surface cleaned, air pressure, and time of air blasting dictate cleaning efficiency. The method’s disadvantages are its inability to control the exact amount of material removed and its large amount of waste generated.

Wet Blasting

Wet blast cleaning involves the use of a suspended fine abrasive. The abrasive/water mixture is delivered by compressed air to the contaminated area. By using very fine abrasives, the amount of materials removed can be carefully controlled.

6.2 Non-abrasive Cleaning Methods

Non-abrasive cleaning methods work by either dissolution or by forcing the contaminant off a surface with pressure. In general, less of the equipment surface is removed using non-abrasive methods.

High-Pressure Water

This method consists of a high-pressure pump, an operator controlled directional nozzle, and high-pressure hose. Operating pressure usually ranges from 340 to 680 psi, which relates to flow rates of 20 to 140 lpm.

Steam Cleaning

This method uses water delivered at high pressure and high temperature in order to remove accumulated solids and/or oils.

Ultra-High-Pressure Water

This system produces a water jet from 1,000 to 4,000 atm. This ultra-high-pressure spray can remove tightly-adhered surface films. The water velocity ranges from 500 m/sec. (1,000 atm) to 900 m/sec. (4,000 atm). Additives can be used to enhance the cleaning action, if approved by the QAPP for the project.

High-Pressure Freon Cleaning

Freon cleaning is a very effective method for cleaning cloth, rubber, plastic, and external/internal metal surfaces. Freon 113 (trichlorotriflorethane) is dense, chemically stable, relatively non-toxic, and leaves no residue. The vapor is easily removed from the air by activated charcoal. A high pressure (1,000 atm) jet of liquid Freon 113 is directed onto the surface to be cleaned. The Freon can be collected in a sump, filtered, and reused.

Physical removal of gross contamination should be followed by a wash/rinse process using cleaning solutions. One or more of the following methods utilize cleaning solutions.

Dissolving

Removal of surface contaminants can be accomplished by chemically dissolving them, although the solvent must be compatible with the equipment and protective clothing. Organic solvents include alcohols, ethers, ketones, aromatics, straight-chain alkanes, and common petroleum products. Halogenated solvents are generally incompatible with protective clothing and are toxic. Table 1 provides a general guide to the solubility of contaminant categories in four types of solvents.

Surfactants

Surfactants reduce adhesion forces between contaminants and the surface being cleaned and prevents reposition of the contaminants. Non-phosphate detergents dissolved in tap water is an acceptable surfactant solution.

Rinsing

Contaminants are removed and rinsing through dilution, physical attraction, and solubilization.

Disinfection/Sterilization

Disinfectants are a practical means of inactivating infectious agents. Unfortunately, standard sterilization methods are impractical for large equipment and personal protective clothing.

6.3 Field Sampling Equipment Cleaning Procedures

The following steps for equipment cleaning should be followed for general field sampling activities.

1. Physical removal (abrasive or non-abrasive methods).
2. Scrub with non-phosphate detergent plus tap water.
3. Tap water rinse.
4. 10% nitric acid (required during sampling for inorganics only).
5. Distilled/deionized water rinse.
6. Solvent rinse (required during sampling for organics only).
7. Total air dry (required during sampling for organics only).
8. Triple rinse with distilled/deionized water.

Table 1 lists solvent rinses which may be required for elimination of particular chemicals. After each solvent rinse, the equipment should be air-dried and triple-rinsed with distilled/deionized water.

Solvent rinses are not necessarily required when organics are not a contaminant of concern. Similarly, an acid rinse is not necessarily required if analysis does not include inorganics.

NOTE: Reference the appropriate analytical procedure for specific decontamination solutions required for adequate removal of the contaminants of concern.

Sampling equipment that requires the use of plastic or teflon tubing should be disassembled, cleaned, and the tubing replaced with clean tubing, if necessary, before commencement of sampling or between sampling locations.

Table 1 Decontamination Solvents

Solvent	Soluble Contaminants
Water	Low-chain compounds Salts Some organic acids and other polar compounds
Dilute Bases For example: ■ detergent ■ soap	Acidic compounds Phenol Thiols Some nitro and sulfonic compounds
Organic Solvents: For example: ■ alcohols (methanol) ■ ethers ■ ketones ■ aromatics ■ straight-chain alkanes (e.g., hexane) ■ common petroleum products (e.g., fuel oil, kerosene)	Nonpolar compounds (e.g., some organic compounds)

WARNING: Some organic solvents can permeate and/or degrade the protective clothing.

7. Quality Assurance/Quality Control

QA/QC samples are intended to provide information concerning possible cross-contamination during collection, handling, preparation, and packing of samples from field locations for subsequent review and interpretation. A field blank (rinsate blank) provides an additional check on possible sources of contamination from ambient air and from sampling instruments used to collect and transfer samples into sample containers.

A field blank (rinsate blank) consists of a sample of analyte-free water passed through/over a precleaned/decontaminated sampling device and placed in a clean area to attempt to simulate a worst-case condition regarding ambient air contributions to sample contamination.

Field blanks should be collected at a rate of one per day per sample matrix even if samples are not shipped that day. The field blanks should return to the lab with the trip blanks originally sent to the field and be packed with their associated matrix.

The field blank places a mechanism of control on equipment decontamination, sample handling, storage, and shipment procedures. It is also indicative of ambient conditions and/or equipment conditions that may affect the quality of the samples.

Holding times for field blanks analyzed by CLP methods begin when the blank is received in the laboratory (as documented on the chain of parameters and associated analytical methods).

Holding times for samples and blanks analyzed by SW-846 or the 600 and 500 series begins at the time of sample collection.

8. Health and Safety

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods (i.e., the method may react with contaminants to produce heat, explosion, or toxic products). Decontamination methods may be incompatible with clothing or equipment (e.g., some solvents can permeate and/or degrade protective clothing). Also, a direct health hazard to workers can be posed from chemical decontamination solutions that may be hazardous if inhaled or may be flammable.

The decontamination solutions must be determined to be compatible before use. Any method that permeates, degrades, or damages personal protective equipment should not be used. If decontamination methods do pose a direct health hazard, measures should be taken to protect personnel or modified to eliminate the hazard.

All site-specific safety procedures should be followed for the cleaning operation. At a minimum, the following precautions should be taken:

1. Safety glasses with splash shields or goggles, neoprene gloves, and laboratory apron should be worn.

2. All solvent rinsing operations should be conducted under a fume hood or in open air.

3. No eating, smoking, drinking, chewing, or any hand-to-mouth contact is permitted.

9. References

Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, 1988.

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STANDARD OPERATING PROCEDURE

SAMPLE PACKAGING

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1. Introduction

Liquid and solid environmental samples are routinely collected by E & E during field surveys, site investigations, and other site visits for laboratory analysis. Unless the samples have anesthetic, noxious, or other properties that could inhibit the ability of a flight crew member to perform his or her duty or are known to meet the established U.S. Department of Transportation criteria for hazardous material (i.e., explosive, corrosive, flammable, poisonous), they are not regulated as hazardous materials.

This Standard Operating Procedure (SOP) describes the packaging procedures to be used by E & E's staff to ensure the safe arrival of the samples at the laboratory for analyses. These procedures have been developed to reduce the risk of damage to the samples (i.e., breakage of the sample containers), promote the maintenance of sample temperature within the cooler, and prevent spillage of the sampled material should a container be broken.

In the event the sample material meets the established criteria of a DOT hazardous material, the reader is referred to E & E's Hazardous Materials/Dangerous Goods Shipping Guidance Manual (see H&S 5.5).

2. Scope

This SOP describes procedures for the packaging of environmental samples in:

- Coolers;
- Steel, aluminum and plastic drums; and
- 4GV fiberboard boxes.

The Hazardous Materials/Dangerous Goods Shipping Guidance Manual will complete the information needed for shipping samples by providing guidance on:

- Hazard determination for samples which meet the USDOT definition of a hazardous material;
- Shipping profiles for "standard" shipments;
- Shipping procedures for "non-standard" shipments;
- Marking of packages containing hazardous materials;
- Labeling of packages containing hazardous materials; and
- Preparation of shipping papers for hazardous materials shipment.

3. Sample Packaging Procedures

3.1 General

It is E & E's intent to package samples so securely that there is no chance of leakage during shipment. This is to prevent the loss of samples and the expenditure of funds for emergency responses to spills and the efforts necessary to re-obtain the sample.

Over the years, E & E has developed several "standard" package configurations for the shipping of environmental samples. These standard package configurations are described below.

Liquid samples are particularly vulnerable. Because transporters (carriers) do not know the difference between a package leaking distilled water and a package leaking a hazardous chemical, they will react to a spill in an emergency fashion, potentially causing enormous expense to E & E for the cleanup of the sample material. Therefore, liquids are to be packed in multiple layers of plastic bags and absorbent/cushioning material to preclude any possibility of leaks from a package. This section defines the standard packaging configurations for environmental samples.

3.2 Liquid Environmental Sample Packaging Procedures

Liquid environmental samples should be collected and preserved as outlined in the Standard Operating Procedures (SOP) for Surface Water Sampling (ENV 3.12), and Groundwater Well Sampling (ENV 3.7). ***Preserved water samples are not considered to meet the HM/DG definitions of Class 8 (Corrosive) and are therefore considered to be nonhazardous samples.*** Liquid environmental samples may be shipped using an 80-quart cooler or an outer package consisting of either a steel or aluminum drum. Because the steel and aluminum drums provide little insulating capability, they should not be used for samples that require icing.

Packaging Liquid Environmental Samples Using the 80-Quart Cooler

- Label and seal all water sample bottles according to appropriate sampling SOPs;
- Secure the bottle caps using fiberglass tape; and
- Place each amber, poly, and volatile organic analysis (VOA) bottle in a sealable plastic bag. Mark the temperature blank VOA bag for identification.

If a foam block insert is used:

- Line the cooler with two plastic bags;
- Place a foam insert (with holes cut to receive the sample bottles) inside the plastic bag;
- Place the bottles in the holes in the foam block;

- Fill void spaces with bagged ice to the top of the cooler;
- Fold over the plastic bags lining the cooler and secure shut with tape;
- Place Chain-of-Custody (C-O-C) form in a sealable bag and tape it to the inside of the cooler lid; and
- Secure the cooler with strapping tape and custody seal. Cover the custody seals with clear tape.

If vermiculite is used:

- Place 1 inch of inert absorbent material (vermiculite) in the bottom of the cooler;
- Line the cooler with two plastic bags;
- Place each sample bottle inside the inner bag;
- Fill the void spaces around the bottles with vermiculite to about half the height of the large bottles;
- Fill the remainder of the void spaces with bagged ice to within 4 inches of the top of the cooler, making sure the VOAs are in direct contact with a bag of ice;
- Fold over the plastic bags lining the cooler and secure shut with tape;
- Fill the remaining space in the cooler with vermiculite to the top of the cooler;
- Place C-O-C form in a sealable bag and tape it to the inside of the cooler lid; and
- Secure the cooler with strapping tape and custody seal. Cover the custody seals with clear tape.

Alternate Packaging Using 1A2/1B2 Drum

- Place 3 inches of inert absorbent material (vermiculite) in the bottom of the drum;
- Line the drum with two plastic bags;
- Place each sample bottle inside the inner bag;
- Fill the void spaces around the bottles with vermiculite to the height of the larger bottles;

- Fold over the plastic bags lining the drum and secure shut with tape;
- Fill the remaining space in the drum with vermiculite to the top of the drum;
- Place C-O-C form in a sealable bag and tape it to the inside of the drum lid; and
- Secure the drum with closing ring and apply custody seals. Cover the custody seals with clear tape.

3.3 Soil/Sediment Environmental Sample Packaging Procedures

Soil/sediment environmental samples should be collected as outlined in the SOP for Soil Sampling (ENV 3.13), and SOP for Sediment Sampling (ENV 3.8). Soil/sediment environmental samples may be shipped using an 80-quart cooler, a 4GV fiberboard combination package, or an outer package consisting of either a steel or aluminum drum. Because the steel and aluminum drums provide little insulating capability, they should not be used for samples that require icing.

Packaging Soil/Sediment Environmental Samples

- Label and seal each sample container according to SOPs;
- Secure the bottle caps using fiberglass tape;
- Place each sample bottle inside a sealable plastic bag and place it in its original shipping box or in individual fiberboard boxes. Mark the temperature blank bag for identification; and
- Secure the original shipping box with strapping tape, place shipping box in a plastic bag, and secure the plastic bag with tape.

If an 80-quart cooler is used:

- Place bubble pack or similar material on the bottom and sides of an 80-quart cooler;
- Place the bagged shipping boxes in the cooler with a layer of bubble pack between each box;
- Fill the void spaces with “blue ice” or ice in baggies to the top of the cooler;
- Place C-O-C form in a sealable baggie and tape it to the inside of the cooler lid; and
- Secure the cooler with strapping tape and custody seal. Cover the seals with clear tape.

If a 1A2/1B2 drum is used:

- Place 3 inches of inert absorbent material (vermiculite) in the bottom of the drum;
- Line the drum with two plastic garbage bags;
- Place the boxes inside the inner bag;
- Fill the space around the samples with vermiculite;
- Fold over the plastic bags lining the drum and secure shut with tape;
- Fill the remaining space around the bags with vermiculite to the top of the drum;
- Place C-O-C form in a sealable bag and tape it to the inside of the drum lid; and
- Secure the drum with the closing ring and apply custody seals. Cover the custody seals with clear tape.

Note: If a small number of samples are being shipped, it may be more practical to package them using the vermiculite or foam block configurations used for shipping liquid samples.

4. Shipping Procedures

Environmental samples are to be shipped as nonhazardous cargo. Unless the samples have anesthetic, noxious, or other properties that could inhibit the ability of a flight crew member to perform his or her duty or are known to meet the established U.S. Department of Transportation criteria for a hazardous material (i.e., explosive, corrosive, flammable, poisonous), they are not regulated as hazardous materials. When preparing the containers (i.e., cooler, drum, or box) for shipment, E & E staff must remove all labels from the outside container. Labels indicating that the contents may be hazardous are misleading and are not appropriate. Markings indicating ownership of the container, destination, and chain of custody labels are acceptable and can be attached as required.

When completing the paperwork for shipment, the standard nonhazardous forms must be used. Do not use the hazardous materials/dangerous goods airbills, either in total or in part; these forms are coded and their use will invite unnecessary questions. This will only serve to confuse Airborne or Federal Express' terminal personnel and will cause much frustration and the delay of sample shipment.

Environmental sample packages can be shipped overnight by both Airborne and Federal Express. When choosing between the two, cost should be considered. It is normally much cheaper to ship Airborne. For work conducted and paid for by E & E, it is E & E's policy that you must first attempt to ship by Airborne before considering Federal Express. In addition, Airborne tends to have remote locations open later in the evenings than Federal Express, which may be helpful when trying to complete a full day's sampling effort and still make the flights on time. Although both companies offer pickup of samples at the site, it is advisable to call ahead and ensure that this service is offered beforehand. In almost all cases, both companies will deliver to the laboratory of your choice on Saturdays. When planning for sampling activities, check with the companies in advance to verify pick-up and delivery schedules.

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BIOLOGICAL SPECIMEN SAMPLING

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1. Introduction

This Standard Operating Procedure (SOP) describes the procedures for the collection of representative biological specimen (biota) samples. Analysis of biota samples may determine whether concentrations of specific contaminants exceed established threshold action levels, or if the concentrations of contaminants present a risk to public health, welfare, or the environment.

1.1 Scope

Included in this SOP are procedures for obtaining representative samples; decontamination of sampling equipment; preservation methods for biota sample shipment; documentation of sampling activities; quality assurance measures; and recommendations for personal safety.

2. Permits and Licenses

During the planning stages of the project, the need for biota collection permits and licenses should be determined. Permitting regulations vary from state to state and in many cases, are specific to the numbers and types of organisms to be sampled/collected. Additionally, many permits are time- specific, with limiting time constraints in which all sampling/collecting operations need to be completed. Generally, information and acquisition of permits and licenses can be obtained by contacting the game and fisheries regulatory agency in the state where the sampling/collecting is to take place. Proper permitting, licensing and/or notification is required before any sampling/collecting can be initiated.

3. Method Summary

The type(s) of biota samples that will best indicate the bioaccumulation of specific contaminants must be determined during the planning stages of the project. Representatives from the vertebrate, invertebrate and/or floral communities will be chosen depending upon their particular roles within the ecosystem in question. Depending on the organisms selected and their habitats, different sampling and collecting methods will be utilized. Therefore, no universal sampling procedure can be recommended. A sampling plan must be completed before any sampling operation is attempted, and should include objectives of the study, number and type of samples required to meet these objectives, and procedures to collect these samples based on specimen habitat and site characteristics.

3.1 Potential Problems

Appropriate sampling points must be selected in order to provide representative samples prior to the actual sampling. During the course of biota sampling, there will be many occasions when mobile organisms will need to be collected. Because of this, there are potential problems that may occur, such as the accessibility of the habitats from which specimens need to be collected. Thorough planning and site background investigation should be performed before any attempt of biota sampling is made. All sample selection criteria should be detailed in the sampling plan. This will allow for both a safe and cost-effective sampling effort.

Another potential problem is in locating and collecting the necessary number of specimens needed, as well as the proper size classes, ages, sexes, etc., in compliance with the sampling plan. Again, thorough research is needed prior to the field effort to determine if the specimens to be collected are abundant during the time span in which field operations are to be performed. Creel surveys, game and fisheries agencies, and biological field guides are some sources that may be used to alleviate this problem.

Environmental factors that need to be considered during the development of a biota sampling plan include:

Terrestrial

- Time of year
- Recent rainfall/snowfall
- Vegetation cover
- Recent temperatures
- Substrate type
- Industrial influence
- Ground cover
- Light penetration
- Time of day
- Habitat disturbance

Marine/Aquatic

- Vegetation cover
- Recent rainfall/snowfall
- Recent temperatures
- Aquatic plant growth
- Presence of ice
- Water current
- Water body morphology
- Substrate type
- Industrial influence

- Time of year
- Time of day
- Light penetration
- Water temperature
- Salinity
- Habitat disturbance
- Turbidity
- pH

Aerial

- Recent temperatures
- Industrial disturbance
- Time of year
- Time of day
- Habitat disturbance
- Wind speed
- Vegetation types
- Ground cover

Benthic

- Aquatic plant growth
- Presence of ice
- Recent temperatures
- Water current
- Water body morphology
- Substrate type
- Industrial influence
- Time of year
- Time of day
- Salinity
- Habitat disturbance
- pH
- Water temperature

Planktonic

- Recent rainfall/snowfall
- Recent temperatures
- Aquatic plant growth
- Presence of ice
- Water current
- Water body morphology
- Industrial influence

- Time of year
- Time of day
- Light penetration
- Water temperature
- Salinity
- Habitat disturbance
- Turbidity
- pH

In the event that a sampling program must be undertaken during unfavorable environmental conditions for the primary species of concern, it is recommended that an alternate species be selected. This alternate species should occupy the same tropic level, share the same habitat, and have similar characteristics as the primary species of concern in order for the results of the sampling program to be conclusive.

4. Procedures

The following are examples of some of the procedures that may be used when performing biological specimen sampling. Due to the many types and lifestyles of organisms encompassed in biota sampling, a specific sampling procedure cannot be outlined. In the event of a biota sampling field effort, a more specific sampling plan should be made according to what species will be needed, types of habitats to be sampled, state and federal regulations, and the methods to be used to accomplish the task. Many states regulate specimen collection methods and should therefore be contacted when developing a sampling plan. The organisms are broken down into vertebrate, invertebrate, and floral representatives, which in turn are further broken down into the types of habitats/behaviors these organisms will assume.

4.1 Vertebrate Collection

All fish, amphibians, reptiles, birds, and mammals are representatives of the vertebrate division of animals. Since most vertebrates occupy a high level on the food chain, there are many occasions when they will be used for bioaccumulation studies. Also, population studies are common to determine if environmental changes are having any effects on vertebrate populations. Vertebrates can be found on land (terrestrial), in water (marine/aquatic), and in the air (aerial). Because of their diversity, different collection methods and equipment exist depending on the species being sampled. The following offers some examples of sampling methods and equipment according to the types of habitats being sampled.

4.1.1 Terrestrial

4.1.1.1 Collection Methods and Equipment

Terrestrial vertebrates can be captured or sampled by hand, with mechanical devices such as traps, snares, and nets, or by use of immobilizing drugs.

Most mammals can be captured with a variety of commercially available traps. Leg-hold steel traps with off-set and padded jaws and conebear steel traps have been successfully used in capturing many species of carnivores and large rodents, such as beaver and nutria. There is risk of injury or death to the animal with these traps, however, which may make their use unacceptable, especially when animals from field surveys will be used in subsequent in situ assays.

Small commercial snap-traps such as Victors and Museum Specials are used in sampling small mammal populations. Both can be successfully used to collect rats, mice, small squirrels, and shrews. Because both types are kill traps, they may cause damage to the cranium and internal organs, making specimens unacceptable for use in later laboratory studies.

Box-type live traps may represent the best tool for collecting mammals in ecological assessments of hazardous waste sites, and have been used successfully to capture mammals as large as deer and as small as shrews. Several types are commercially available, and many types can easily be constructed. The use of box-type live traps is advantageous because animals are less likely to be injured, they can be released for mark-recapture population studies, or they can be returned to the laboratory for use as bioaccumulators and bioindicators.

Mammals below the size of large canids can be captured with a variety of commercial live traps such as Havahart, Longworth, National, and Sherman. Sherman live traps may be the most appropriate trap for use in sampling indigenous rodent and insectivore populations at hazardous waste sites because they are inexpensive, easily transported and set, and can be thoroughly cleaned when removed from a contaminated site.

Snares have been used to capture game species, canids, and ground squirrels, and cannon and drop nets can be used to capture large herds of antelope and deer.

Conical and cylindrical pitfall traps can be used for small mammals, especially burrowing insectivores such as shrews. Pitfalls may be used in association with drift fences, or they may be set into the ground at the edge of fallen logs or at the base of trees.

Choice of bait will depend on the species to be captured and the type of trap being used. Small box traps such as Sherman traps can be baited with chicken scratch grain or a mixture of peanut butter and rolled oats, which may also be used to effectively bait snap traps. Larger box traps such as the Havahart may be baited with fruit, such as apples, to collect medium-sized rodents, or chicken entrails, sardines, or canned cat food to collect carnivores.

The use of injected drugs for the capture and control of mammals has changed substantially during the past decades. Complex projectile syringes and sodium bicarbonate-pressurized blow guns have made accurate delivery of drugs to the animal more certain. There are many different tranquilizing or anesthetizing drugs available for use in capturing mammals; however, the appropriate dose and type of drug are known for very few. Also, the use of drugs when capturing animals may confound data derived from later in situ studies.

There are several simple but effective traps that can be used when a sampling plan calls for the capture of reptiles, including box traps similar to those used for small mammals, pitfall traps set with drift fences, pole nooses, snares, and large rubber bands. The most reliable means of capturing reptiles and amphibians is accomplished by a walk through the sampling area, and turning over logs, rocks, and debris.

4.1.2 Marine/Aquatic

4.1.2.1 Collection Methods and Equipment

Quantifying fish population responses remains an important goal of water quality managers. Fish have been recommended for use in biomonitoring programs for at least five reasons: (1) regulators and the general public can easily understand the effects of pollution on fish; (2) fisheries have economic, recreational, and aesthetic values; (3) the identification of fishes is relatively easy (compared to that of invertebrates); (4) the environmental requirements of fish are well known; and (5) fish are perceived as integrators of effects at lower trophic levels. However, the size distribution and response of freshwater fishes is sometimes difficult to quantify due to wide variations in spatial distribution and year classes. Additional difficulties in the quantification of fish populations are caused by the selectivity and efficiency of the gears used. However, proper consideration of these factors allows unbiased comparisons of different habitats, leading to a successful biomonitoring program in which fishes are useful.

There are several techniques that can be used when collecting fish specimens for population studies or chemical analysis. Two techniques proven to function well in lotic environments are electrofishing and seining. In large rivers and in lakes, most data on fish abundance and distribution are provided by electrofishing or passive netting with gill, trammel, or fyke nets.

Electrofishing is based on the principle that when a direct current is applied between two electrodes in water, fish migrate toward the anode in a galvanotaxic response. The fish are momentarily stunned and can be easily captured with a dip net. The fish recover when removed from the electric field and can be readily identified, measured, weighed, and returned to the water. Electrofishing gear ranges from small backpack units suitable for small, wadeable streams to large, boat-mounted rigs for large rivers and lakes. Choice of electrode design, current settings, and pulse width depend on resistivity (related to hardness, ionic strength, and turbidity) of the water. Electrofishing in marine habitats is ineffective. Proper safety precautions must be considered and applied when electrofishing. Kill switches, safety rails, felt-soled rubber boots, rubber gloves, and life jackets should be used during electrofishing operations. Additionally, operators should be trained in electrofishing techniques, CPR, and electrical theory and safety (see Section 10, “Health and Safety”).

Seines consist of long lengths of netting rigged with styrofoam or plastic floats at the top and lead-weighted line at the bottom and is usually operated by pulling vertical poles tied to each end of the net. Seining is most effective in streams, ponds, and near shore areas of lakes and impoundments. In large lakes or marine waters where obstructions are few or lacking, large subsurface trawls can be pulled by boats to collect fish at different depths.

Passive netting techniques are commonly used to sample fish in large rivers and lakes. Gill nets are constructed of braided or monofilament lines typically of uniform mesh size, but sometimes with a number of different mesh sizes. Trammel nets are modified versions of gill nets, consisting of two outer panels of large mesh netting plus an inner panel of smaller mesh. Fish pass through the large mesh and are entangled in the fine mesh netting. Gill and trammel nets are usually fished on the bottom and are anchored perpendicularly to the anticipated direction of fish movement as a vertical fence; as fish swim into the nets, their gills become entangled. Fish caught in gill and trammel nets are often dead or injured on retrieval, which should be considered in the sampling plan, depending on sampling needs and objectives. These nets are usually operated overnight or for 24-hour periods.

Hoop nets and fyke nets are stationary nets that collect fish by entrapment. Hoop nets, consisting of mesh supported by a series of structural frames or hoops, are placed on the bottom of large streams and rivers parallel with the current. Fish are entrapped during normal, upstream movement. Most hoop nets have funnel openings to keep fish from escaping. Fyke nets are modifications of hoop nets in that they have wings or leaders that guide fish into the enclosure, and are generally used in shallower water.

The use of fish toxicants (piscicides) for sampling fish populations is a common practice, particularly in impounded waters and streams. Two of these toxicants, rotenone and antimycin, are commonly used to sample fish populations and have formulations currently registered for fishery use by the U.S.E.P.A., according to the Federal Environmental Pesticide Control Act. Rotenone kills fish by blocking oxygen uptake, and the fish suffocates. Antimycin kills fish by inhibiting respiration, but at a different site than rotenone. After the toxicant is applied to the body of water, dip nets can be used to scoop out specimens as they float to the surface. Common sense should be used when choosing to use a piscicide, and its application should be thoroughly considered. A decision should be based not only on the efficacy of a toxicant, but also on its persistence in the environment, toxicity to other animals, and its danger to man. Furthermore, use of piscicides is prohibited in many states.

The following techniques offer some alternatives for capturing amphibians and reptiles.

The dip net, consisting of a metal hoop with a net fixed to a wooden pole, provides a versatile collecting tool. A fine mesh net can retain small tadpoles and salamander larvae, while coarser mesh nets, larger hoops, and longer poles neatly entrap small turtles.

The seine, a more elaborate version of the dip net, may be placed across small creeks and streams. From a point upstream, collectors move toward the seine, turning over stones and loose objects. Specimens sweep downstream with the current and are trapped in the seine. Seining is most effective in waters free of dense vegetation.

An insect collecting net works as a miniature seine when held down against the bottom of a stream with the opening of the net upstream. Tadpoles and other amphibian larvae readily fall into a well-placed insect net.

In waters where thick vegetation persists, dredging can aid in collection. A dredge consisting of two troughs and covered with a fine mesh of chicken wire can be submerged and brought up under a mass of vegetation, capturing the animals living among the roots. Various meshes of wire give a degree of selectivity to the collecting operation. All small aquatic vertebrates may be trapped by this type of dredge.

Electric shock devices, funnel traps, hoop traps, pitfall traps, snares, gaffs, and conventional fishing techniques all provide effective means for amphibian and reptile collection. Selection of the particular gear to be used is dependent on the particular type of sampling program.

4.1.3 Aerial

4.1.3.1 Collection Methods and Equipment

Nets are most commonly used to capture birds, but as with any trapping program, the program must be planned to fit existing conditions in order to be successful. In general, the following points should be considered:

- The method must take into account the species to be trapped, its habits, food preferences, population size, wariness, etc. Each species varies greatly in its ease of capture with different traps and baits. Best results are usually obtained by building the trap for the birds rather than trying to mold the birds to fit the trap.

- The terrain at the trap site is often limiting. Topography will make some methods unfeasible, and vegetation will limit the use of others. Ease of access to the trap site and degree of portability must also be considered.

- The time of year will affect the number of birds in an area, their food preferences, flocking habits, and wariness. Seasonal weather conditions affect the mechanics of some traps, making them unusable.

- Traps differ in the number of birds they can capture at one time. If many birds are needed, a trap that takes 50 at a time will be better suited to the project than one working equally well but taking only one bird at a time.

- The time allotted for the trapping project will determine the speed with which the birds must be caught, as well as determine the general trap construction. If the trapping period is to be short, a trap capable of taking large numbers of birds will probably be desired; under these conditions one would not usually construct a highly complex or permanent trap.

- In some cases, the number of workers available may be limiting. For example, some drive-trapping techniques require a large crew.

- The funds available will limit the materials used, the number of trappers, the length of the operation, etc.

- Both Federal and State regulations apply to trapping and marking game species. Special permits are required, and certain techniques may be prohibited. Anyone anticipating a trapping program should have full knowledge of the regulations involved.

Some procedures for trapping birds include bait traps, accidental traps, drive traps, spotlighting, handnetting, and immobilizing with drugs.

If the sampling plan calls for the capture of bats, mist nets are the best devices to use. They are most effective when placed across the entry way to their roost sites or over standing water.

4.2 Invertebrate Collection

Approximately 95% of all species of animals are invertebrates. Invertebrates play crucial roles in community and ecosystem functions such as decomposition, grazing, predation, and pollination. Because invertebrates are numerous in species and individuals per species, they are relatively easy to obtain and study, and samples can usually be collected without depleting populations. Short life cycles and small size permit simple sampling techniques, but because of their diversity, many different collection methods exist depending on the species being sampled. The following offers some examples of sampling methods and equipment according to the types of habitats being sampled.

4.2.1 Benthic

4.2.1.1 Collection Methods and Equipment

Benthic invertebrates are the most common fauna used in ecological assessments of contaminants. Macroinvertebrates are operationally defined as the invertebrates retained by screens of mesh size greater than 0.2 mm. Microinvertebrates (e.g., rotifers, nematodes, gastrotrichs, etc.) may be of ecological interest, but their taxonomy is much less known; consequently, their sampling is not recommended for routine environmental assessments.

A variety of techniques may be used to collect macroinvertebrates from aquatic environments. In any given contaminant effects study, careful consideration must be given to the comparability of samples among stations. Not only must the type of sampling device be appropriate for the specific taxa and habitat type, but sampling effort (i.e., sample numbers and sample sizes) must be uniform at all stations. Macroinvertebrates can be collected and quantified by sampling either natural or standardized substrates.

Natural substrates can be sampled with net, grab, core, and vegetation samplers, or by hand-picking. Riffle areas with relatively fast currents and cobble and gravel substrates generally provide the most diverse community. Kick nets are an effective means of sampling a 1 square meter area of a riffle. Hess and Surber samplers are commonly used to collect benthic invertebrate fauna in shallow riffle habitats in streams. These two samplers are similar in that each encloses a defined area (0.1 square meter) of substrate. Substrate within the confines of the sampler is disturbed and mixed by hand or stake to a depth of 10 cm. Large rocks within the sampling area are manually lifted from the substrate and brushed or scrubbed from the mouth of the sampler to dislodge attached or clinging invertebrates, which are carried downstream into the net by the current; a current velocity of at least 0.05 meters per second (m/s) is required for effective use of the Surber or Hess sampler.

Surber and Hess samplers generally do not operate effectively in large rivers, estuaries, lakes, or other habitats with soft substrates because the current necessary to dislodge and wash invertebrates into the sampler net is lacking. Furthermore, water that is too deep flows over the top of the sampler. Consequently, core and grab samplers are used in these habitats.

Corers, such as the Kajak-Brinkhurst and Phleger types, are recommended for soft substrates such as silts or clays. Corers consist of long, open tubes and rely on gravity to penetrate the substrate. Various closure methods are used to seal the tube before it is retrieved from a fixed area of sediment.

Various types of grab samplers are available for sampling macroinvertebrates in different habitats. Grab samplers operate by isolating and removing an area of substrate defined by the area of the open jaws of the apparatus. Choice of a sampler depends on the type and size of substrate and depth of water in the aquatic habitat. Two of the most popular are the Ekman and Ponar types. Ekman grab samplers are useful for sampling relatively shallow habitats containing soft mud and silt in water with little current. One person, using a pole mount or remote messenger, can easily sample the benthos with an Ekman grab sampler from a boat or while wading in shallow water. The grabs are difficult to use on pebbly or rocky bottoms because gravel often impedes jaw closure. Ponar grab samplers are used to sample substrates such as sand, gravel, or small rocks in medium-to-deep rivers, estuaries, and lakes. The Ponar dredge is heavy and usually requires a boat and winch for operation.

Specialized sampling devices have been developed for sampling invertebrates on aquatic vegetation. The simplest technique is the sweep net. To collect invertebrate fauna for qualitative samples, a researcher merely sweeps a net at random through strands of vegetation for a given amount of time or a given number of sweeps. Other more quantitative devices enable a worker to isolate a standard area of vegetation, clip or cut the plants, and remove the sample and associated fauna. The Wilding stovepipe sampler is a metal cylinder useful for isolating vegetation in soft sediments. The Macan, Minto, and McCauley samplers are more elaborate devices containing sharpened, horizontal cutting surfaces in conjunction with a sampling chamber or box.

Macroinvertebrates can also be semiquantitatively collected with several different varieties of standardized sampling substrates. Such substrates, which are placed into aquatic environments, can be made of artificial components such as tempered hardboard plates (i.e., the Hester-Dendy sampler), or of natural materials such as wire baskets containing gravel or rocks. Using standardized substrates to collect organisms relies on the colonization behavior of macroinvertebrates. Caution must therefore be used to ensure data validity. Optimum time for colonization of substrate samplers before collection is six weeks. Care should be taken to ensure uniformity in colonization time, depth, light penetration, temperature, and current velocity when making comparisons between samples obtained with standardized substrates. The benefit of these types of samplers is their comparability among sites and relative ease of use. The principle drawback is their relative selectivity in types and numbers of invertebrates collected; not all taxa are collected in the same proportions in which they occur in natural substrates. Thus, standardized samplers are considered semiquantitative techniques. If suitable reference sites are available, however, one can assume that differences among sites measured are indicative of hazardous waste site effects.

4.2.2 Planktonic

4.2.2.1 Collection Methods and Equipment

Many devices are available for sampling plankton, and sampling techniques for phytoplankton and zooplankton are similar. The choice of an individual sampling technique, sample size, and sample numbers, will depend upon the characteristics of the aquatic habitat (in terms of depth, density of organisms, and spatial variation). Samplers are broadly categorized into four types: closing samplers, traps, pumps, and nets.

Closing samplers (e.g., bottles or tubes) are lowered into the water to a particular depth and closed with a drop-weight messenger; examples are the Van Dorn and Kemmerer models. These samplers take a quantitative sample of water at a chosen depth, collecting all forms of nannoplankton and ultraplankton. Closing samplers can be obtained or constructed for many different volumetric requirements. A series of closing-bottle samplers can be vertically arranged to sample simultaneously at multiple depths to determine plankton stratification. In shallow water, plankton stratification can be mechanically integrated by using a depth-integrating column sampler. These types of closing samplers capture a known volume of water by extending a tube through the water column from the surface to the bottom. The water cores sampled typically vary in length (from one to several meters long) and diameter (from one to several centimeters), depending upon the experimental conditions. Because these samplers integrate plankton distributions throughout the water column, they yield no useful information on plankton stratification.

Traps such as the Juday, Patalas, and Schindler types, which have been used for zooplankton sampling, are basically large closing-type samplers that can be lowered into the water to sample water volumes of 10 to 30 liters. The large size of the traps is thought to reduce avoidance by the more agile zooplankters, such as adult copepods, and to increase sampling efficiency for potentially rare species. The maneuverability of relatively large traps can make them somewhat more difficult to maneuver than other samplers.

Various pumps have also been applied in plankton sampling. Pumps can either be motorized or hand-operated, but motorized pumps are preferred because they provide uniform delivery rates. Both submersible and boat-mounted pumps have been used. Sample size is determined by using a flowmeter or by collecting the sample in a calibrated container. Pumps can be used to either take discrete samples at a particular depth, or integrated samples over a range of depths. They allow a researcher to easily increase or decrease sample size by changing the pumping time or pumping rate, and are easily controlled for use in a variety of aquatic habitats. However, pumps have been criticized as being expensive and somewhat bulky. In addition, care must be taken to insure that organisms are not damaged by the pumping device, and that pumps are adequately flushed to prevent cross-contamination of samples.

Conical nets are also commonly used for quantitative zooplankton sampling. Pore sizes of the nets typically range from 60 to 80 micrometers (μm). Because a mesh of this size does not retain ultraplankton and nannoplankton, net samples for phytoplankton are qualitative. Net samplers are towed with a rope for a desired distance or time. Sample size is determined by a flowmeter, the distance towed, or other estimate of sample volume (such as distance multiplied by aperture area). Net samples can be taken in either vertical or horizontal tows, depending on the desired sampling strata. Some net samplers, such as the Birge closing net, have a closure feature that enables the operator to sample discrete depths or distance.

Collected samples can be isolated or concentrated by using various techniques. Both phytoplankton and zooplankton can be isolated using settling chambers. Zooplankton can be isolated by using a net or other sieving device of a mesh size compatible with the original collection method. After isolation, plankton samples must be preserved and stored for taxonomic identification.

4.2.3 Terrestrial

4.2.3.1 Collection Methods and Equipment

Because it is normally impossible to count all of the invertebrates in a habitat, it is necessary to estimate the population by sampling. A sample program that includes the distribution, size, and number of samples will need to be established. For example, the sampling of a particular insect population must address the distribution and life-cycle of the insect involved. Assuming that the life-cycle is known, preliminary work will be necessary to gain some knowledge of the distribution of the insect and the work involved when sampling. The worker will also need to be clear as to the exact nature of the sampling effort he or she is proposing.

It must be decided whether a single habitat (i.e., field, woodland, etc.) is to be sampled, or representatives of a habitat type from a wide geographical area. Also, the magnitude of population change to be recorded must be decided, due to many species of invertebrates exhibiting ten-fold or even hundred-fold population changes in a single season. Once the number and size of the samples and the sampling plan is determined, sampling can begin.

Soil samples are usually taken with a corer; golf-hole borers or metal tubing sharpened at one end make simple corers, but it has been suggested that some animals may be killed by compression when the core is forced from such instruments, and furthermore, the core should be disturbed as little as possible; therefore, more elaborate corers have been developed. In general, the larger the animal and the sparser its population, the bigger the sample. The depth to which it is necessary to sample varies with the animal and the condition of the soil. It will be particularly deep in areas with marked dry seasons, and many soil animals have seasonal and diel vertical migrations.

With the O'Conner split corer, the risk of compressing the sample by forcing it out of the corer is avoided. Furthermore, after the soil core is exposed, it can be easily divided into the different soil layers.

Depending on the condition of the substrate being cored (e.g., frozen soil, manure heaps, etc.) other types of equipment may be used. Suitable samples of young plants and the soil around them can be collected with a scissor type of sampler. Fallen leaves and other debris are usually sampled with a metal box with the top and bottom missing and the lower edge sharpened.

After the substrate sample or core has been collected, the organisms must then be extracted by either mechanical or behavioral methods. Mechanical methods have the advantage that they theoretically extract all stages, mobile and sedentary, and are in no way dependent on the behavior of the animal or the condition of the substrate. Also, samples for mechanical extraction may be frozen for long periods before use. Their disadvantages are that, compared with behavioral methods, the operator must expend a great deal of time and energy on each sample, damage may be done to the animals, and as mobile and immobile animals are extracted, it may be difficult to distinguish animals that were dead at the time of sampling from those that were alive. Some mechanical processes that can be used to separate the animals from the soil and vegetable matter include sieving, flotation, sedimentation, elutriation and differential wetting.

When using behavioral methods, the animals are made to leave the substrate under some stimuli (i.e., heat, moisture [lack or excess], or chemical). The advantage of this method is that, unlike the mechanical methods, once the extraction has been set up it may be left virtually unattended, and thus large quantities of materials may be extracted simultaneously. Another important advantage is the ability to extract animals from substrates containing large amounts of vegetable material. The disadvantage is that, because it is based on the animal's behavior, the extraction efficiency will vary with the condition of the animals and be influenced by changes in climate, water content, etc. If samples must be retained for several days, polythene bags are suitable containers. Obviously, eggs and other immobile stages cannot be extracted behaviorally.

4.2.4 Aerial

4.2.4.1 Collection Methods and Equipment

Many insects occupy air as their habitat, and an appropriate sampling apparatus must be selected. Sticky and water traps, and suspended and insect nets are some options, but their efficiency is greatly influenced by wind speeds. Other types of traps include exposed cone suction traps, enclosed cone suction traps, and rotary traps.

Three factors influence the choice of the type of suction trap: (1) the density of the insects being studied; (2) the wind speeds in the sample area; and (3) the necessity for information on periodicity. If information is required on periodicity, then a trap with a catch-segregating mechanism must be used. The latter two factors generally give the same indications; the sparser the insects, the larger the desired air intake (in order to sample an adequate number), and the stronger the winds, the stronger (larger) the trap should be. At ground level and up to 3-4 feet among vegetation, insect populations are usually dense and wind speeds rarely exceed 6 mph. In these conditions, an exposed cone suction trap is generally used. In more exposed situations (higher above ground level), enclosed cone suction traps should be used.

4.3 Floral Collection

Vegetation is the dominant biological component of terrestrial ecosystems, with nominally ten biomass units of plants, to four biomass units of microbial organisms, to one biomass unit of animals. Depending upon the species, soil characteristics, and environmental stresses, 40% to 85% of the plant mass resides below ground and is in contact with chemicals in the soil. The impact of hazardous waste on vegetation may be realized in a variety of ways and with different consequences. On the macroscale, plants are the biological source of energy as well as the nutritional components for animals. Furthermore, the structure of the vegetation, in concert with the abiotic landscape features, establishes habitat that animals rely on for protection from adverse weather and predators.

4.3.1 Terrestrial

4.3.1.1 Collection Methods and Equipment

If leaf, stem, and/or root sections need to be collected, a collection method needs to be chosen. Generally, the typical tools needed for collection of terrestrial flora include a knife or ax, a tree borer, scissors or clippers, a machete, and a tape measure. The cutting tool chosen should be rugged enough to handle the stems and roots to be collected. Tree borers can be used to collect stem and root cores for age and growth rate analysis. A tape measure is needed to measure the diameter at breast height (DBH) of the trees and shrubs.

If the plant specimen needs to be packaged and transported, it should be carefully placed, with a sample label, into a plastic bag to ensure sample integrity. If the specimen is to be used for identification purposes, it should be pressed in a plant press or flimsy as soon as possible. As with any biota specimen sampling program, proper documentation procedures must be followed (see Section 8, "Documentation").

4.3.2 Marine/Aquatic

4.3.2.1 Collection Methods and Equipment

When aquatic or marine floral specimens are collected, it is usually accomplished by dipping with a pond net or strainer. If the plant species needed cannot be satisfactorily obtained using these methods, specialized samplers can be used. Some of these include the Hess sampling cylinder for floating vegetation, the Gerking sampler, the Wisconsin Trap, McCauley's samplers, and sampling cages. Selection of a sampling method depends on the species being sought, its depth in the water column, the substrate, the part of the plant needed, size of specimen(s) needed and type of root and stem systems the plant has. All of these factors need to be addressed and outlined in the job-specific sampling plan.

Methods for phytoplankton collection are the same as the methods for zooplankton collection (see Section 4.2.2.1, "Planktonic Collection Methods and Equipment").

5. Decontamination

Decontamination is the process of removing or neutralizing contaminants that have accumulated on both personnel and equipment. Specific procedures for each are designed accordingly and must be indicated in either the Health and Safety Plan, Work Plan, Quality Assurance Project Plan (QAPP), or all three.

During biota sampling operations, it may or may not be necessary to decon equipment between uses. The determination of decon procedures is task-specific and depends on the site being sampled and the levels of contamination within the matrices from which the specimens will be collected. If equipment or personnel decontamination is necessary, a task-specific decon procedure must be designed and included in either the Site Safety Plan, Work Plan or QAPP. Refer to E & E's SOP for Sample Equipment Decontamination and Personnel Decontamination for decon equipment, solvents, and procedures necessary for the task to be performed. Appropriate decontamination procedures must be selected prior to field sampling.

6. Specimen Preservation

To assure specimen integrity during and after collection, proper preservation techniques need to be maintained throughout the sampling effort. This will ensure that the specimens' chemical, physical, and biological characteristics are intact for subsequent identification and analytical purposes. Depending on the organisms being collected, different preservation techniques apply. Correspondence with the laboratory contracted to perform the analytical work should be initiated in order to determine how to preserve the specimen samples in accordance with their analytical requirements. Specific preservation methods need to be determined prior to the field effort, and as such, must be outlined in the job specific Work Plan and QAPP.

The chemical preservation of biota samples is not generally recommended. Refrigeration or dry ice is usually a better approach, supplemented by a minimal holding time.

7. Specimen Packaging and Shipping

The U.S. Department of Transportation (DOT) and the International Air Transport Association (IATA) have promulgated regulations for the packaging and shipping of hazardous materials. It must be realized that even if the biota samples are not considered to be hazardous materials, the preservation techniques used for shipping purposes may be (e.g., when shipping dry ice as a preserving agent inside a biota sample package otherwise considered non-hazardous). To assure proper packaging and shipping procedures are met, refer to E & E's SOP for Sample Packaging and Shipping.

8. Documentation

Thorough and accurate documentation is integral to maintaining the integrity of biota sampling operations. All work activities shall be properly documented to enable participants to reconstruct the events that occurred sufficiently for legal testimony uses. Documentation methods include logbooks, field data sheets, photographs, sample labels, and chain-of-custody forms.

Logbooks

A bound field notebook with consecutively numbered pages will be maintained by field personnel to record daily activities, including sample collection and tracking information. A separate entry will be made for each sample collected. Entries should include information from the sample label and a complete physical description of the specimen. Entries will be made in waterproof ink, dated, and signed. Refer to E & E's SOP- for Field Activities Logbooks.

Field Data Sheets

Field data sheets should be generated and filled out in the field throughout the biota sampling effort. Included on these sheets should be, at the minimum:

- Date
- Location (state, county, etc.)
- Specimen description (Species, sex, weight, length, age, etc.)
- Collector(s)
- Remarks (Physical features, anomalies, etc.)
- Sample number

See Appendix A for example Field Data Sheets.

Photographs

Photographs should be taken to document field conditions and activities throughout the field effort. Each photo should be numbered according to frame, and an entry should be made in a logbook including the following information:

- Date and time
- Sequence number of the photograph on the film roll
- Subject of photograph
- Direction in which photograph is showing
- Reason photograph was taken
- Signature of photographer
- Weather conditions
- Camera/lens system used

After the photograph is developed, this information should be transferred onto the back of the photograph.

Sample Labels

All specimen samples shall be documented in accordance with E & E's SOP for Sample Packaging and Shipping. All specimen sample labels should be filled out at the time of collection and should contain the following:

- Site name or identification
- Sample location and identifier
- Date sample is collected
- Species
- Analysis required
- Sampling personnel
- Comments and other relevant observations (e.g., physical features, anomalies, etc.)
- Specimen length and weight

If plastic bags are being used during specimen collection, the above information should be included on each. Remember that when labeling, a permanent waterproof marker should be used.

Chain-of-Custody Forms

Use the chain-of-custody form to document the types and numbers of specimen samples collected and logged. Refer to E & E's SOP for Sample Packaging and Shipping for directions on filling out this form.

9. Quality Assurance

A quality assurance (QA) plan must be designed and included in the QAPP for the specific activities that are to be performed. At the minimum, the following QA procedures should apply:

- All data must be documented on field data sheets and/or within field logbooks;

- All instrumentation must be operated in accordance with the operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling or operation and must be documented; and
- All deliverables must receive peer review prior to release.

10. Health and Safety

Personal safety is always the most important factor in any sampling operation. A thorough site background investigation must be completed before any sampling operations begin. A task-specific Site Safety Plan (SSP) must be drawn up, reviewed and approved before any fieldwork is to take place. This SSP is to be taken into the field and adhered to, ensuring that all operations are undertaken within the appropriate health and safety protocols. Under no circumstances will these health and safety protocols be compromised.

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APPENDIX A

FIELD DATA SHEET

FIELD DATA SHEET

PERMANENT PLANT LABEL

Project Name: ____________________ Time of Collection: ________________________

Project No: ____________________ Date of Collection: ________________________

Collector's Name: ____________________ Collection No. ________________________

Location: __________________________ County/Parish: ___________________________ State: _____________

USGS Quad: _____________________________________ Aerial Photo No.: ________________________________

Location: ____

____

____

General Habitat: _

____

Micro habitat: _

____

Description (Information not discerned by looking at a dried specimen): _____________________________________

____

____

Taxonomic Identification: ____

(To be filled in by botanist)

Relinquished by: ______________________________________ Time: ______________ Date:________________

Received by: ____ Time: ______________ Date:________________

Relinquished by: ______________________________________ Time: ______________ Date:________________

Received by: ____ Time: ______________ Date:________________

FIELD DATA SHEET

PERMANENT ANIMAL LABEL

Project Name: ____________________ Time of Collection: ________________________

Project No: ____________________ Date of Collection: ________________________

Collector's Name: ____________________ Collection No. ________________________

Location: __________________________ County/Parish: ___________________________ State: _____________

USGS Quad: _____________________________________ Aerial Photo No.: ________________________________

Location: ____

____

____

General Habitat: _

____

Micro habitat: _

____

Specimen Description: Length: _____________________ Weight: ______________________________

Sex:: _______________________ Age: _________________________________

Remarks: ____

____

Taxonomic Identification: ____

(To be filled in by botanist)

Relinquished by: ______________________________________ Time: ______________ Date:________________

Received by: ____ Time: ______________ Date:________________

Relinquished by: ______________________________________ Time: ______________ Date:________________

Received by: ____ Time: ______________ Date:________________

Appendix D

Human Health and Ecological Risk Assessment Work Plan

Port Angeles Harbor
Sediment Characterization Study
Port Angeles, WA

Appendix D
Human Health and Ecological Risk Assessment Work Plan

FINAL

Prepared for

Washington State Department of Ecology
Toxics Cleanup Program
300 Desmond Drive
Lacey, Washington 98504

Contract No. C0700036
Work Assignment No. EANE020

June 26, 2008

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Acronyms/Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
BaP	benzo(a)pyrene
BSAF	biota-to-sediment accumulation factor
BW	body weight
CalEPA	California Environmental Protection Agency
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPCs	chemicals of potential concern
cPAHs	carcinogenic polynuclear aromatic hydrocarbons
CPF	cancer potency factor
CSF	cancer slope factor
CSL	cleanup screening level
CSM	conceptual site model
CT	central tendency
E & E	Ecology and Environment, Inc.
Ecology	Washington State Department of Ecology
ED	exposure duration
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
HI	hazard index
HPAHs	high molecular weight PAHs
HQ	hazard quotient
IHSs	indicator hazardous substances
IR	ingestion rate
IRIS	Integrated Risk Information System
LOAEL	lowest observed adverse effect level
M m_3	million cubic meters
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/kg-day	milligram per kilogram per day
µg/kg	micrograms per kilogram
MDL	method detection limit
mL	milliliters
MTCA	(State of Washington) Model Toxics Control Act
NCEA	National Center for Environmental Assessment
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effect level
NSSP	National Shellfish Sanitation Program
NWFSC	Northwest Fisheries Science Center
ORNL	Oak Ridge National Laboratory
PAHs	polynuclear aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCDDs	polychlorinated dibenzo-p-dioxins

PCDFs	polychlorinated dibenzofurans
PCP	pentachlorophenol
PPRTVs	EPA's Provisional Peer-Reviewed Toxicity Values
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RfD	reference dose
RME	reasonable maximum exposure
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SF	slope factor
SMCJ	*Shelton-Mason County Journal*
SQS	Sediment Quality Standards
STSC	The Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center
SUF	site use factor
TBT	tributyltin
TEF	toxic equivalency factor
TRVs	toxicity reference values
TEQ	total toxic equivalent concentration
UCL	upper confidence limit
USFWS	United States Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WOE	weight-of-evidence
WRCC	Western Region Climate Center

1.0 Introduction

Port Angeles Harbor (Harbor), Washington has been identified as a priority environmental restoration project by the Washington State Department of Ecology (Ecology) as part of the Puget Sound Initiative. Ecology's Toxics Cleanup Program has identified the Harbor for focused source control actions, sediment cleanup, and restoration efforts. Environmental investigations throughout the Harbor have indicated that chemicals of concern generated by intensive industrialization and urbanization activities exist within the Harbor. These investigations have indicated that chemicals in marine sediments and biota may pose a risk to human and environmental receptors. Values in these studies exceed the Washington State Sediment Management Standards (SMS) (Chapter 173-204 Washington Administrative Code (WAC), Ecology 1995) and other established thresholds of environmental concern (U.S. EPA 1998, Long & Morgan 1991, Long et al. 1995).

As part of the effort to clean up and restore the Harbor, there is a need to characterize marine sediment issues throughout the Harbor as related to current and historic potential contaminant sources. Ecology has tasked Ecology and Environment, Inc., (E & E) with conducting sediment investigations and a risk assessment focusing on the marine environment and associated terrestrial and aquatic source areas.

1.1 Risk Assessment Overview

This work plan provides methods for conducting a human health and ecological risk assessment for Port Angeles Harbor. In addition, technical memoranda providing additional details regarding the human health and ecological exposure evaluation process will be developed in consultation with Ecology risk assessors. These memoranda will be finalized prior to initiating the risk assessment.

Data collected during previous investigations as well as data collected during the upcoming field event described by E & E (2008a) will be utilized in the risk assessment, provided these data meet the quality assurance (QA)/quality control (QC) criteria outlined by E & E (2008a) and the data usability criteria described in Section 3 of this work plan.

The risk assessment report will provide a summary of the risk assessment methods, including deviations (if any) from the work plan, quantitative estimates of risk to human health and ecological receptors, and uncertainties associated with the risk assessment process.

1.2 Document Structure

This risk assessment work plan consists of the following sections:

Section 2, Background and Scope – Describes the site setting, history, and other background information and presents a preliminary conceptual site model.

Section 3, Data Evaluation – Provides the methods for evaluation of site data for usability in risk assessment and selection of indicator hazardous substances.

Section 4, Human Health Risk Assessment Methodology – Presents the proposed methodology for the human health exposure assessment, toxicity assessment, and risk characterization.

Section 5, Ecological Risk Assessment Methodology – Presents the proposed methodology for the ecological exposure assessment, ecological effects assessment, and risk characterization.

2.0 Background and Scope

2.1 Existing Studies and Data Gaps

Numerous studies have characterized chemical constituents in sediment as well as wood waste distribution in Port Angeles Harbor (E & E 2008b).

Despite sampling efforts to date, additional sampling is necessary to characterize the horizontal and vertical extent of constituents of potential concern in sediment, the extent of biological impacts, and the distribution of wood waste in the Harbor. The *Summary of Existing Information and Identification of Data Gaps Report* (SEIDGR, E & E 2008b) identified sources of chemical contaminants associated with historical and on-going commercial and industrial activities in the Harbor and general urban point and non-point input sources to the Harbor (combined sewer outfalls (CSOs), creek discharges, run-off). This information was used to identify data needs for further characterization of the Harbor and to support the human health and ecological risk assessment.

Table 4-3 of the SAP (E & E 2008a) includes a list of specific areas within the Harbor that were identified in the SEIDGR as potential or known areas of contamination and that will be the focus for future sampling. Specific analytes will be tested for in each planned sampling area, based on known or suspected releases from potential sources identified in the SEIDGR. Table 4-3 also notes locations where sediment samples will be collected for bioassays (E & E 2008a).

2.2 Location and Setting

The City of Port Angeles is on the northern coast of the Olympic Peninsula in Clallam County, Washington. The city features 26 miles (42 km) of marine shoreline, including Ediz Hook, a 2.5-mile-long sand spit. The Harbor is bounded to the west and south by the City of Port Angeles and to the north by Ediz Hook. The Harbor is considered a deep water harbor, with depths greater than 90 feet near the eastern end of Ediz Hook. Intertidal shorelines exist in the southeastern portion of the Harbor, as well as along the eastern shoreline of Ediz Hook (E & E 2008b).

Port Angeles Harbor is affected by current and historical chemical inputs from industrial and municipal sources (see Section 2.2.1). The marine waters of Port Angeles Harbor are listed as impaired by the State of Washington under Section 303(d) of the Clean Water Act (CWA), due to low dissolved oxygen levels (U.S. EPA 2004a).

2.2.1 History

Over the past century, Port Angeles Harbor has hosted a number of industries, including saw mills and plywood manufacturing, pulp and paper production facilities, marine shipping and transport, boat building and refurbishing, marinas, and commercial fishing enterprises. Since the early 1900s, pulp and paper mills have dominated Port Angeles' industrial sector. Four major mills and one plywood manufacturing company began operations between 1914 and 1941 along the Port Angeles waterfront. One of those mills, Nippon, remains in operation. K-Ply, a plywood manufacturing facility, closed in March 2008. Sizable over-water log booming areas along the nearshore of the Harbor were, and in some cases still are, associated with these businesses.

Prior to the passage of the Clean Water Act of 1972 (CWA), untreated process effluent from the mill facilities was discharged into the Harbor (Shea et al. 1981). Following passage of the CWA, industrial wastewater from mills was treated before discharge to the Harbor. The Rayonier mill site is one significant source of constituents of concern in marine sediments from various chemicals derived from the paper and pulp mill process, and remediation/redevelopment of this site is an important component of the Port Angeles Harbor investigation.

Port Angeles Harbor has supported many industries associated with commercial and recreational shipping, including goods transport, ferry services, and other marine logistical operations. Petroleum-based facilities have been a significant part of the Harbor's industrial community as part of those shipping services. A number of petroleum bulk stations and terminals have been located near the Harbor waterfront since the 1920s in conjunction with the shipping and lumber industries. Many of these facilities have experienced episodes with leaking aboveground and underground storage tanks. There have been crude oil and fuel spills since the 1980s from tankers refueling or running aground. Other general businesses along the Port Angeles waterfront include automotive services, telecommunications, a newspaper, and other urban businesses.

The City of Port Angeles has an estimated population of 18,640 people (Oldham 2007), with associated municipal wastewater and stormwater infrastructure to support the local community. Historically and currently, the Harbor has received discharges from the CSOs, the City of Port Angeles wastewater outfall on the side of the Harbor, septic systems in various stages of disrepair outside the city limits, and non-point source runoff from stormwater (CPAPWD 2006, CCMRC 2001). The Harbor also receives direct surface water discharge from the six freshwater creeks in the area, all of which have varying degrees of residential and commercial land-use influences. Five of the creeks are listed as impaired in terms of water quality and biological quality by the Clallam County Stream Keepers (CCDCD 2004).

Shellfish harvesting and fishing historically have been important commercial and subsistence activities in the Harbor, particularly for the Lower Elwha Klallam Tribe (LEKT), who are subsistence-level consumers of shellfish (ATSDR 2000a, Ecology 2008a). Harbor fisheries have been impacted due to environmental quality issues (Beaverson 1998, Clallam County Marine resources Interactive Workshop 2001). Anthropogenic impacts from various sources including wastewater pollution, industrial-based contaminants, and stormwater runoff may have contributed to apparent declines in shellfish and fish populations, as well as to the closure of historic shellfish tracts for commercial harvesting (Beaverson 1998; Clallam County Marine Resources Interactive Workshop 2001).

2.2.2 Demographics and Land Use

The greater Port Angeles area has a long history of inhabitation and mixed land uses. Native Americans from the LEKT were the first humans to settle in and around Port Angeles, primarily near the mouth of Ennis Creek. Two former Klallam villages, I'e'nis and Tse-whit-zen, once stood where Port Angeles is today. The approximately 650 members of the LEKT currently reside in the lower Elwha River Valley and on bluffs just west of Port Angeles (Ecology 2008a). Tribal lands include about 1,000 acres on and near the Elwha River (Ecology 2008a). The Lower Elwha Klallam Tribe's reservation lands (427 acres) are located on the east side of the Elwha River at its mouth, on the northern edge of the Olympic Peninsula directly across from Victoria, British Columbia. Fishing and gathering are important tribal activities (NWIFC 2008).

Spanish explorers en route to exploring Vancouver Island named the town's natural harbor Puerto de Nuestra Señora de Los Angeles (History Link 2008). From 1887 to 1904, the property now occupied by Rayonier was used by the Puget Sound Cooperative Colony (Integral 2006). In 1890, the city of Port Angeles became incorporated. During the early part of the twentieth century, establishment of lumber, pulp, paper, and plywood mills along the Harbor boosted the local economy (History Link 2008). The immediate Harbor surroundings are diversified in their use, ranging from commercial to residential.

Within the city limits of Port Angeles, zoning today includes mixed industrial, commercial, recreational, and residential. In addition to mixed residential and commercial structures, the city of Port Angeles contains publicly owned treatment works (POTW), the Olympic Memorial Hospital, and elementary through senior high schools.

Clallam County has had higher growth rates than the state average over the past eight years. The census data demonstrate a 9.7 percent population growth rate, which is higher than the state's average annual growth rate of 8.5 percent. The 2006 population estimate for Clallam County was 70,400 persons, and the county contained 33,517 housing units at the end of 2006. The 2000 census indicated 3,692 units currently occupied in the city of Port Angeles. The census also reported a total of 30,683 housing units for all of Clallam County, 11 percent of which were located in Port Angeles. The total area of Clallam County is 1,739.45 square miles, with an average of 37.1 occupants per square mile, according to the 2000 census. The census also reported an average of 2.31 persons per household and a median household income of $40,391 per person. The per capita income in 1999 was $19,517. Persons who fell below the poverty level as defined by the federal government totaled 12.3 percent of the county's population (Census 2008).

2.2.3 Climate

The average annual precipitation for Clallam County is consistently less than 30 inches per year (NOAA 2008a). This is one of the lowest rates in the state, where precipitation ranges from greater than 240 inches per year to less than 25 inches per year. Average maximum temperatures in this coastal zone range from 65° to 70° F during the summer months and 45° to 50° F during the winter months (NOAA 2008a). Peak temperatures are rarely greater than 90° F in the summer or lower than 30° F in the winter. The coldest temperatures are typically associated with cold air blowing from the interior of Canada and down through the Puget Sound area. Freezing temperatures generally arrive in November (NOAA 2008a).

Wind data collected in 2006 from an Ecology monitoring station (No. 53009) at the base of Ediz Hook showed prevailing winds from the west and west-southwest, with an average wind speed of 6.5 knots. Wind speeds at Ediz Hook typically are lowest between March and November and highest between November and late February. Wind speeds recorded on the bluff south of the Rayonier property between 1997 and 1999 averaged 2 to 3 knots (Malcolm Pirnie 2007a).

2.2.4 Geology

The geology of Port Angeles Harbor is discussed in detail by Malcolm Pirnie (2007a). Elevations in the industrial area (near the former Rayonier Mill location) range from sea level to approximately 75 feet above sea level. Terrain elevations decrease to the north (toward the water) and increase to the south (toward the Olympic Mountains). Hills within a mile southeast and southwest of the former Rayonier Mill site gradually rise toward the foothills of the Olympic Mountains, which are approximately five miles from the site.

The local geology is characterized by Tertiary bedrock overlain by Pleistocene deposits and recent alluvium deposit. The industrial area (including the former Rayonier Mill site) lies in an area of alluvium deposited by Ennis Creek, beach deposits from the Strait of Juan de Fuca, and fill material. Along the bluffs south of the former Rayonier Mill Site lie deposits of Vashon Till, which is a mix of gravel and cobbles in a matrix of sand, clay, and silt. Depth to bedrock in the area is unknown but likely variable, based on local isolated outcrops of the Tertiary Twin River Formation (Malcolm Pirnie 2007a).

Area groundwater has been characterized by HLA (1993), Landau (1997), and EPA (E & E 1998). There is unconfined groundwater beneath the former Rayonier Mill Site in a shallow water-bearing zone consisting of near-surface fill and alluvial deposits. The depth to groundwater in this zone ranges from less than 1 foot below ground surface (bgs) to 12 feet bgs. The water-bearing zone varies from 12 feet bgs to more than 30 feet bgs. Groundwater elevations are influenced by tides (E & E 1998) and to a lesser degree by surface water fluctuations in Ennis Creek (Malcolm Pirnie 2007a).

Groundwater elevation measurements made in previous investigations indicate a predominantly northerly groundwater flow direction towards Port Angeles Harbor, with a locally variable lateral component of Ennis Creek. The Uplands RI (Integral 2006) presents an analysis of groundwater conditions at the site. The gradient after the first high tide was measured at 0.0072 feet per foot and 0.0082 feet per foot after the first low tide (HLA 1993).

2.2.5 Geology and Sediment

Sediment characterization in Port Angeles Harbor has focused on characterization of wood waste and contaminants associated with industrial, municipal, and commercial sources (SAIC 1999, Foster Wheeler 2001). As reported in Malcolm Pirnie (2007a), these studies have shown that wood waste covers approximately 25 percent (500 acres) of the bottom of Port Angeles Harbor. Most of the wood waste occurs in the north and west portions of the Harbor. Size and abundance of wood debris decrease offshore.

2.2.6 Hydrology

Water movement in Port Angeles Harbor is affected by tides, stream flow, wind, coriolis force, and shoreline and bottom configuration. Collectively, these influences result in directional currents, tidal eddies, vertical mixing, and other water movements, as described by Malcolm Pirnie (2007a).

Stream Flow

The Harbor receives direct surface water discharge from six freshwater creeks in the area, Tumwater, Valley, Peabody, White, Ennis, and Lees creeks. White and Ennis creeks converge and run through the former Rayonier Mill site as Ennis Creek. These flows have the potential to transport contaminants to the Harbor.

Tides

Tidal studies have indicated a mean tidal range of 1.3 m and a diurnal range of 2.2 m at Ediz Hook. The interaction of the tidal flow in the nearshore area creates several eddies termed “tidal eddies,” which are transient but can significantly affect nearshore water movement. Five eddies are found on the east side of points and spits in the study area on the flood tide and seven eddies are evident on the west side of points and spits on the ebb tide. At the end of the tidal phase, the eddies move away from the shore (Malcolm Pirnie 2007a).

Currents

Between Port Angeles and Dungeness Spit, there is a net countercurrent eastward along the shoreline. Eddies may induce currents in the surface water (0-5 m) that travel seaward (westward) in the mid-channel area and inland (eastward) in the nearshore area. Mid-channel currents are stratified vertically, with less saline water (from less-dense freshwater inputs) at the surface (0-50 m) moving seaward, and deep ocean water (>50 m) moving landward (Malcolm Pirnie 2007a).

Wind

Prevailing winds throughout most of the year (March – October) are from the west and west-southwest, and for the remainder of the year have no consistent direction (Malcolm Pirnie 2007a).

2.2.7 Ecology

Port Angeles Harbor is an urban embayment with commercial, industrial, and recreational uses. The Harbor is partially protected from the Strait of Juan de Fuca by Ediz Hook. Ennis Creek, a freshwater creek, flows through the former Rayonier Mill area and discharges to the marine waters approximately 500 feet east of Rayonier’s dock (Malcolm Pirnie 2007a). Morse, Lee’s, Ennis, and White Creeks flow into the eastern Harbor area, whereas Peabody, Valley, and Tumwater Creeks flow into the central Harbor area. Other creeks flow through the City of Port

Angeles and convey contaminants from residential, commercial, and industrial activities to the Harbor.

The aquatic environment in Port Angeles Harbor is an ecological transition zone between marine habitat west of Port Angeles and estuarine habitat east of the Harbor (Shea et al., 1981). Marine species present in the area include salmonids, bottomfish, shellfish (crabs and clams), algae, and other species. Shea et al. (1981) place the organisms found in the Port Angeles area into the following categories:

- Phytoplankton and other marine plants
- Zooplankton
- Shellfish
- Other invertebrates
- Fish
- Birds
- Mammals

Phytoplankton and other marine plants

This category includes phytoplankton, benthic and macroalgae, and seagrasses. Phytoplankton includes green algae, blue-green algae, euglenoids, diatoms, dinoflagellates, and microflagellates. These species are the primary producers that support the higher organisms in the food web.

Benthic diatoms and macroalgae are found on bottom substrates in Port Angeles Harbor. Seagrass (particularly eelgrass, *Zostera marina*) occurs in the Port Angeles Area, primarily inside Ediz Hook and inside Dungeness Spit, east of Port Angeles (Malcolm Pirnie 2007a).

Zooplankton

Zooplankton are small primary consumers that feed mainly on phytoplankton. These animals float and drift in the water, providing a major food source for higher trophic-level animals such as baitfish, sportfish, and commercially-fished species. Three types of zooplankton, icthyoplankton (eggs and larval forms of fish and shellfish), microzooplankton (microscopic organisms), and macrozooplankton (very small, but visible, marine animals) occur in Port Angeles Harbor. Icthyoplankton are found seasonally in the Harbor. Microplankton and macroplankton are found in abundance in the Harbor area (Malcolm Pirnie 2007a).

Shellfish

Shellfish include clams, crabs, and shrimp. Clams are bottom-feeders, while shrimp and crabs consume living or dead organic material. Several species of shellfish are found in the Harbor area. Shellfish harvest is restricted in sections of Port Angeles Harbor (Malcolm Pirnie 2007a).

Fish

As described in the Marine Remedial Investigation (Malcolm Pirnie 2007a), more than 60 species of marine fish have been documented in the Port Angeles area. Five salmonid species (Chinook, coho, chum, pink, and sockeye salmon) may occur in the Harbor. Steelhead and cutthroat trout may occur in Tumwater and Ennis creek when they are migrating or following schools of forage fish. Salmonids generally migrate through the Port Angeles area as adults returning to freshwater areas to spawn or as juveniles migrating to open water. Some species (for example Chinook and coho salmon) may occur in the Harbor area year-round, particularly if forage fish are present.

Common bottomfish species in Port Angeles Harbor include lingcod, copper rockfish, quillback rockfish, black rockfish, English sole, Dover sole, rock sole, starry flounder, sand dabs, and perch (Malcolm Pirnie 2007a). The migratory range for bottomfish is limited, and these species may be found year-round in the Harbor and surrounding area.

Forage fish found in Port Angeles include herring, smelt, anchovies, and sand lance. Herring and sand lance may be found in Port Angeles year-round, although they likely migrate and are seasonally abundant (Malcolm Pirnie 2007a).

Species such as clams, flatfish, and crabs are found on the subtidal areas of the bench along the southern portion of the Harbor. Rockfish are occasionally found around some of the structures, such as the Rayonier deep water outfall (Malcolm Pirnie 2007a).

In 2006 and 2007, NOAA surveyed fish species by seining at three intertidal locations within Port Angeles Harbor (two Ediz Hook sites and one Ennis Creek site). Results of the seining are presented in Table 2-1, below (NOAA 2008b). Over forty species were collected, which shows that the intertidal fish community in Port Angeles Harbor is diverse. Based on abundance, surf smelt and shiner perch appear to be the dominant fish species in the intertidal zone.

Table 2-1 Beach Seining Results for Ediz Hook and Ennis Creek Sites (NOAA 2008b)

Year	2006		2007	
Sites	E. Hook Sites	Ennis Cr.	E. Hook Sites	Ennis Cr.
Effort (# of hauls)	13	10	28	14
Chinook 0+ hatchery	0	2	3	13
Chinook 0+ wild	5	9	511	79
Chinook 1+ hatchery	0	0	2	3
Chinook 1+ wild	0	1	0	1
Coho 0+ hatchery	0	3	0	8
Coho 0+ wild	1	54	0	0
Coho 1+ hatchery	0	0	0	7
Coho 1+ wild	0	0	0	6
Chum salmon 0+	14	1	415	17
Pink salmon 0+	212	0	0	0
Steelhead juv wild	0	2	0	0
Cutthroat juv wild	0	16	0	3

Table 2-1 Beach Seining Results for Ediz Hook and Ennis Creek Sites (NOAA 2008b)

Year	2006		2007	
Sites	E. Hook Sites	Ennis Cr.	E. Hook Sites	Ennis Cr.
American shad	0	13	0	1
Pacific herring	0	20	185	5
Surf smelt	171	262	13	1202
Northern anchovy	0	0	8	13
Sand lance	0	64	1065	2
Striped perch	20	0	89	0
Pile perch	1	0	12	0
Shiner perch	168	136	100	5
English sole	13	272	5	17
Sand dab	0	1	47	25
Starry flounder	2	12	8	2
Sand sole	0	153	4	10
Unid sculpin	0	0	2	4
Buffalo sculpin	7	22	25	10
Great sculpin	1	0	9	0
Silver spotted sculpin	5	5	32	0
Staghorn sculpin	60	33	78	10
Bay pipefish	42	1	5	3
Tube snout	10	1	8	0
Snake prickleback	0	2	0	0
Crescent gunnel	21	8	36	1
Saddleback gunnel	5	19	48	7
Pinpoint gunnel	24	20	83	9
Red gunnel	0	0	2	0
Unid gunnel	0	5	0	0
Northern clingfish	0	0	3	0
Tomcod	0	0	1	0
Sandfish	0	0	2	2
Lingcod	4	3	49	1
Unid greenling	17	31	8	0
Unid rockfish	14	0	0	1
Threespine stickleback	0	0	1	0
Totals:	**817**	**1171**	**2859**	**1467**

Birds

Marine birds found in the Port Angeles area principally use the U.S. Fish and Wildlife Service (USFWS) Dungeness National Wildlife Refuge (DNWR), which includes Dungeness Spit, Dungeness Bay, and the surrounding open water (Shea et al. 1981). Shorebirds and waterfowl (ducks and geese) are migratory species, and abundance generally is highest in fall and winter. Species noted in the Harbor include loons, grebes, cormorants, herons, geese, dabbling ducks, sea ducks, rails, gulls, and kingfishers. Grebes, cormorants, and waterfowl are found along the long stretch of shoreline west of Port Angeles (Malcolm Pirnie 2007a).

Intertidal and shallow tidal submerged grasses such as eelgrass and associated benthic invertebrates are food resources used by many birds. Diving ducks (bay ducks), cormorants, grebes, herons, hawks, eagles, gulls, terns, kingfishers, and alcids all may consume fish. Areas of particularly abundant food and shelter for birds as noted by Shea et al. (1981) include the mouth of Morse Creek and the Dungeness River. Eelgrass (found in nearshore beds) also is a principal dietary component for brant and other herbivorous species (Malcolm Pirnie 2007a).

Mammals

Twenty marine mammals are found in or near Port Angeles Harbor, eight of which are common, six occasional, and six infrequently seen. Seals and marine birds are found in the area surrounding the DNWR. Some marine mammal species, including harbor seals, also may use the area near the former Rayonier Mill (Malcolm Pirnie 2007a).

Threatened and Endangered Species

According to Malcolm Pirnie (2007a), species of concern that inhabit the northern portion of the Olympic Peninsula include the Steller's sea lion (*Eumetopias jubatus*), Pacific harbor porpoise (*Phocoena phocoena*), Orca whale (*Orcinus orca*), brown pelican (*Pelecanus occidentalis*), bald eagle (*Haliaeetus leucocephalus*), merlin (*Falco columbarius*), peregrine falcon (*Falco peregrinus*), common murre (*Uria aalge*), marbled murrelet (*Brachyramphus marmoratus*), pileated woodpecker (*Dryocopus pileatus*), western toad (*Bufo boreas*), Puget Sound chinook salmon (*Oncorhynchus tshawytscha*), Hood Canal summer chum (*Oncorhynchus keta*), bull trout (*Salvelinus confluentus*), and coho salmon (*Oncorhynchus kisutch*). Given their habitat requirements, many of these species have the potential to occur in Port Angeles Harbor.

2.3 Potential Constituents of Concern

Constituents of potential concern to Harbor sediments and biota were identified based on known chemical associations with historic and current land uses, as well as a significant amount of data collected during prior sediment investigations within the Harbor (E & E 1998 and 1999, Malcolm Pirnie 2007a and 2007b). These investigations identified chemicals that exceed the SMS, those that are commonly associated with wood debris degradation that could contribute to exceeding SMS biological criteria, and chemicals known to bioaccumulate. The following chemicals were identified in the SEIDGR (E & E 2008b) as constituents of potential concern:

- Dioxins and furans
- PCBs
- Chlorinated pesticides
- Semi-volatile organic compounds (SVOCs), including polynuclear aromatic hydrocarbons (PAHs), phenols, and phthalates
- Resin acids/guaiacols
- Tributyltin (TBT)

- Ammonia, sulfides, and TOC
- Heavy metals, including inorganic and organic forms

Many of these chemicals are known to be persistent in the environment and potentially bioaccumulative. Of particular concern are dioxins/furans, PCBs, and PAHs. Dioxins/furans are byproducts formed during combustion of organic compounds in the presence of chloride and during pulp bleaching practices. Dioxin/furan-producing processes include incineration of municipal and medical wastes, boilers/industrial furnaces, diesel heavy-duty trucks, sintering plants, automobiles using either leaded or unleaded gasoline, oil-fired utilities, lightweight aggregate kilns that combust hazardous waste, petroleum refining, crematoria, and drum reclamation (U.S. EPA 2006). Penta (pentacholorophenol) is sometimes used as a wood preservative in lumber and plywood mills; its production produces dioxins/furans. Usually carried out to sediments in an oil/penta phase, dioxins/furans are left behind once the oil and penta degrade. This dioxin/furan contamination of technical-grade penta has an identifiable chemical signature that is different than either stack emissions or combustion byproducts (Pers. Comm. Dr. Teresa Michelsen 2008). Dioxins/furans can also be produced as byproducts from production of PCB mixtures. Dioxin/furan source assessments conducted in Washington show incinerators, hog fuel (wood waste) boilers, mills that produce bleached pulp and paper, cement kilns, and municipal wastewater treatment plants as medium to high priority for source reduction/control (Ecology 1998).

PCBs are synthetic mixtures of chlorinated compounds that are no longer manufactured in the U.S. but are still found in many products. PCBs have been used as coolants and lubricants in electrical equipment (transformers, capacitors), and are found in older fluorescent lighting fixtures and electrical appliances, paints, pesticide additives, sealants, and hydraulic oils (ATSDR 2000b). PCBs were extensively used in ship manufacturing as a fire retardant, and may be introduced into waters through ship-building and decommissioning activities, as well as during ship maintenance and release of oily bilgewater.

Dichlorodiphenyltrichloroethane (DDT) is a chlorinated pesticide once widely used in the U.S. before it was banned in 1972. Dichlorodiphenyldichloroethylene (DDE) and dichlorodiphenyldichloroethane (DDD) are derivatives of DDT that contaminate commercial DDT preparations; their use has also been banned. These fairly insoluble chemicals are highly persistent in the environment, particularly in sediment and biota (ATSDR 2002).

SVOCs are a class of compounds that include PAHs, phenols, methylphenols, and phthalates. Pyrogenic PAHs are a group of over 100 chemicals formed during incomplete burning of coal, oil and gas, garbage, or other organic substances. PAHs are usually found as a mixture of two or more chemicals in coal tar, crude oil, creosote, marine diesel fuel and exhaust, automobile exhaust and street runoff through CSOs and storm drains, roofing tar, and products used to make dyes, plastics, and pesticides (ATSDR 1996). Phenols are a class of widely distributed chemicals that are both manufactured and naturally occurring. Phenols are used primarily in production of phenolic resins and manufacture of synthetic fibers, slimicides, and disinfectants, as well as in various consumer products (ATSDR 2006). Cresols are methylphenols; with PAHs, they make up creosote, which is produced from high temperature treatment of wood or coal, or from the resin of the creosote bush. Creosote is used as a preservative in marine lumber applications (dolphins, pilings). Creosoted pilings and remnants are a continuous source of marine pollution because they leach methylphenols and PAHs to marine waters and sediments. Abandoned pilings usually wash up on beaches and leach PAHs into the coastal habitat for years (MRC 2008). Phthalates are widely distributed synthetic compounds, used primarily in vinyl products, plastics, and personal care products such as fragrances and nail polish. Phthalates are widely present in CSO and stormwater discharges.

Resin acids and guaiacols are plant-derived chemicals found in association with wood debris, hardwood tar, and pulp and paper mill processes (Malcolm Pirnie 2007a). Resin acids are a component of most softwoods and are usually released from wood chips during the pulping process. Their acute toxicity towards fish and other aquatic life has been shown in previous studies. Resin acids may account for as much as 70% of the toxicity of effluents (Li et al. 1996). Guaiacols are toxic to humans as well as aquatic organisms (PAN 2008).

Tributyltin (TBT) is a highly toxic compound used as an anti-fouling agent in marine paints applied to the bottom of boats. It is ubiquitous in use and can be released to marine sediments through leaching from paint into the water and when vessel hulls are scraped. Any harbor or bay with large international vessel traffic will have on-going TBT sources. NOAA's Mussel Watch Program, a long-term status and trends program that monitors contaminants in sediments and mussels, includes TBT as an important monitored analyte (NOAA 2007).

Metals such as inorganic arsenic, lead, zinc, copper, mercury, and cadmium occur naturally from geologic processes and are also used extensively in manmade products (including paints, cigarettes, fertilizers, industrial solvents, batteries, thermometers, dental fillings, light bulbs, and more; ATSDR 2008). Common sources of metals from anthropogenic sources include car brake dust, incineration, medical and municipal waste, boat paints, other vessel-related sources (for example anodes and mercury-containing instruments), and automotive manufacturing and wrecking disposal (ATSDR 2008).

2.4 Chemical Migration Pathways

Chemicals enter Port Angeles Harbor through numerous pathways. These include discharge of contaminated groundwater, storm water runoff, dry or wet (precipitation) deposition of airborne compounds, and discharge of industrial and municipal wastewater into streams and waterways/Harbor. Discussed below are sources of chemical contaminants, chemicals known to enter Port Angeles Harbor, media and pathways through which these chemicals enter the Harbor, and the fate of these compounds once in the Harbor.

2.4.1 Chemical Release and Transport

Wood Product Facilities

Chemicals associated with wood product facilities include resins and fatty acids/guaiacols, PAHs, PCBs, dioxins/furans, and volatile organic compounds (VOCs). Resins and fatty acids/guaiacols are associated with wood waste byproducts and log booming areas, and enter the Harbor through stormwater runoff. PAHs are released during fuel leaks/spills and heavy machinery use and migrate to the Harbor in groundwater. PCBs and dioxins/furans from hydraulic fluid spills/leaks enter the Harbor in groundwater. PCB- and dioxin/furan-contaminated storm water also enters the Harbor. VOCs enter the Harbor through contaminated site runoff (E & E 2008b).

This risk assessment also will evaluate potential effects of wood debris in Port Angeles Harbor.

Marine/Shipping Services

Chemicals released during boat building/repair and operations in Port Angeles Harbor include heavy metals, PCBs, SVOCs, TBT, and PAHs. Heavy metals, PCBs, SVOCs, and TBT are released during ship building and repair, particularly as paint is applied to or scraped from boat hulls (TBT is a component of boat hull paint). Gasoline and diesel spills, leaking underground storage tanks, creosote pilings, and boat exhaust release PAHs to the environment. These compounds enter the Harbor directly and in groundwater and storm water (E & E 2008b).

Creosote-treated Lumber

PAHs from creosote-treated lumber leach directly into marine waters at rates that depend on several factors, including water chemistry, temperature, and salinity, as well as wood type and age (E & E 2008b).

Petroleum Storage Facilities

SVOCs (including total petroleum hydrocarbons) and heavy metals from crude and refined petroleum products are the primary chemicals of concern associated with petroleum-based facilities and major fuel spills. Petroleum products have entered soil and groundwater at many locations along the Harbor waterfront. Groundwater may have been a route for chemical migration to Harbor sediments. Storm water runoff from these areas also may contribute petroleum compounds to the Harbor environment. Acute point-source spills, particularly of heavier oil materials, are potential pathways for these compounds into marine sediments and biota (E & E 2008b).

Municipal Works

The City of Port Angeles operates several facilities along the Harbor. A sewage treatment plant (STP) located near the Rayonier site has one deepwater outfall discharge point that began discharging in 1969. Since then, the STP has had occasional untreated effluent discharges to the Harbor. The city also has an extensive stormwater system operating under an NPDES permit that drains approximately 10,000 ac (4,047 ha) of the Port Angeles watershed. Several storm water outfalls discharged untreated storm water to the Harbor in the past. The STP receives leachates from the Mt. Pleasant Landfill, which holds solid waste from the decommissioned Rayonier Pulp Mill.

Chemicals of potential concern in storm water, effluent, and untreated sewage include heavy metals, phenols, dioxins, PCBs, pesticides, and SVOCs. Total organic carbon/total suspended solids, organic chemicals, and metals are a concern in biosolids released to the Harbor (E & E 2008b).

Commercial Fish and Shellfish Harvesting

Chemicals associated with commercial fish pens include PCBs, pesticides, and dioxins/furans. Farmed salmon are fed a concentrated feed derived from smaller fish that may contain pollutants. Salmon, a relatively oily, fatty fish, can bioaccumulate the PCBs, dioxins, and pesticides from the feed. Excess feed and feces from the pens is released to the ocean floor, and may introduce chemicals into the sediment and biota, as well as cause habitat damage by smothering the benthic community beneath and around the net cages (E & E 2008b).

Residential Inputs

SVOCs, PCBs, and heavy metals are found in some commercial and residential products, as well as on road surfaces (SVOCs and metals only). These chemicals become associated with storm water runoff from yards, roads, and other paved surfaces, which then enters the Harbor. These compounds also enter septic systems, which may leak and contaminate surface and groundwater (E & E 2008b).

2.4.2 Fate of Chemicals in the Harbor

Waterborne chemicals discharged into Port Angeles Harbor can be affected by water movement, including tidal action, currents, and eddies. Chemicals may be broken down in the water column (for example, through photolysis), volatilize, or be diluted. Other chemicals may adsorb to organic material in the water column or partition to sediment.

VOCs and aromatic acids are highly unstable and are removed rapidly from the water column through various mechanisms, including volatilization and/or dilution and dispersal in seawater (E & E 1998). PAHs in the aquatic environment are present in dissolved form and adsorbed to particulate materials in the water column. PAHs also partition to sediment (E & E 2008b). Low molecular weight PAHs dissolve more readily in the water column than do heavier PAH compounds. The higher molecular weight PAH compounds in creosote tend to accumulate in sediment and can be introduced to filter feeding benthic organisms (E & E 2008b).

PCBs in the aquatic environment are highly persistent, with low solubility in water. PCBs have a high affinity for suspended solids and sediment, particularly those high in organic carbon. PCBs are highly soluble in animal fat tissue due to their low water solubility and high octanol/water partition coefficients.

As a result of their relatively low water solubilities, dioxins/furans strongly adsorb to sediments and bioaccumulate in aquatic organisms. Because they degrade very slowly by chemical and biological processes, dioxins/furans are persistent environmental contaminants (Smith et al. 1988).

Chemicals in sediment and water can be taken in by marine biota through various feeding and filtering uptake mechanisms, particularly for benthic organisms, whose life stages are closely associated with the sediment layers. Certain compounds including PCBs, PAHs, heavy metals, and dioxins/furans present in lower-level benthic animals such as clams, shrimp, mussels, and worms may bioaccumulate up the food web to higher-level predators such as salmon, rockfish, and lingcod. Chemical uptake by seagrasses and macroalgae also is possible, but less well studied compared with uptake by fish and benthos (Chiou 2002).

In situ bioturbation by burrowing organisms such as geoduck, clams, and worms can re-suspend or re-release contaminants into the upper surface sediment layers and water column. Releases of pesticides, PCBs, and dioxins/furans from the feces of pen-reared salmon into sediment also may occur (E & E 2008b).

2.5 Exposure Pathways and Scenarios

In general terms, a conceptual site model depicts media that may contain site-related constituents, potential human and ecological receptors, and potential routes of exposure of receptors to site-related constituents. A complete pathway requires the presence of site-related chemical constituents in an environmental medium that receptors are likely to contact.

2.5.1 Conceptual Site Model for Ecological Receptors

The ecology of Port Angeles Harbor indicates that five principal groups of ecological receptors have a high potential to be exposed to contaminants that accumulate in sediment and/or the food chain: seagrasses and macroalgae, benthic invertebrates, fish, birds, and mammals. Figure 2-1 provides a preliminary ecological conceptual site model for Port Angeles Harbor featuring these receptor groups. Seagrasses and macroalgae may be exposed to site-related chemicals through direct contact with and uptake from sediment. Benthic invertebrates and fish may be exposed to site-related chemicals through direct contact with sediment and ingestion of food (plant and animal) that has accumulated contaminants. Aquatic vegetation, benthos, and fish also may be exposed to chemicals in water, but this means of exposure likely is minimal for the highly hydrophobic chemicals (PCBs, dioxins/furans, PAHs) that are the focus of this investigation. Birds and mammals may be exposed to site-related chemicals through incidental ingestion of sediment and consumption of food (plant and animal) that has accumulated contaminants. Dermal exposure of birds and mammals to chemicals in sediment is considered a negligible route of exposure due to protection provided by external coverings (fur, feathers, and scales). Exposure through incidental consumption of surface water also is considered negligible for wildlife because chemicals typically occur at much lower concentrations in water than in sediment or biota.

2.5.2 Conceptual Site Model for Human Receptors

The Port Angeles HHRA will evaluate the risk from site-related constituents to four groups of receptors:

- Current/future subsistence fisher, adult and child;
- Current/future recreational fisher, adult and child;
- Current/future residential user, adult and child, and
- Current/future recreational user, adult and child.

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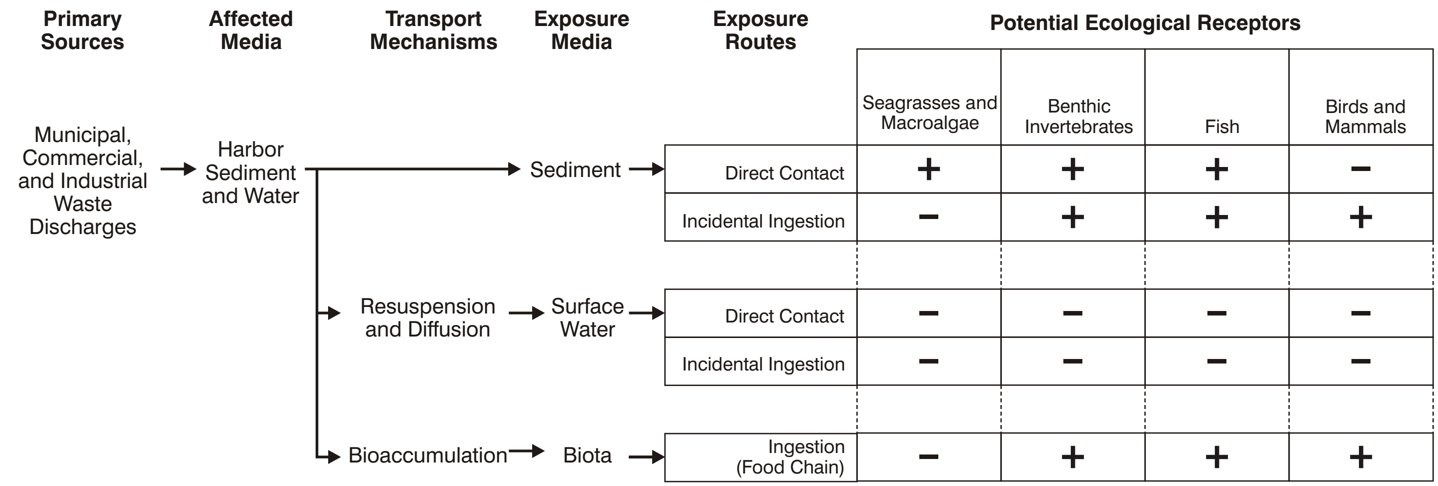


Key

+ = Complete Pathway
– = Incomplete or Insignificant Pathway

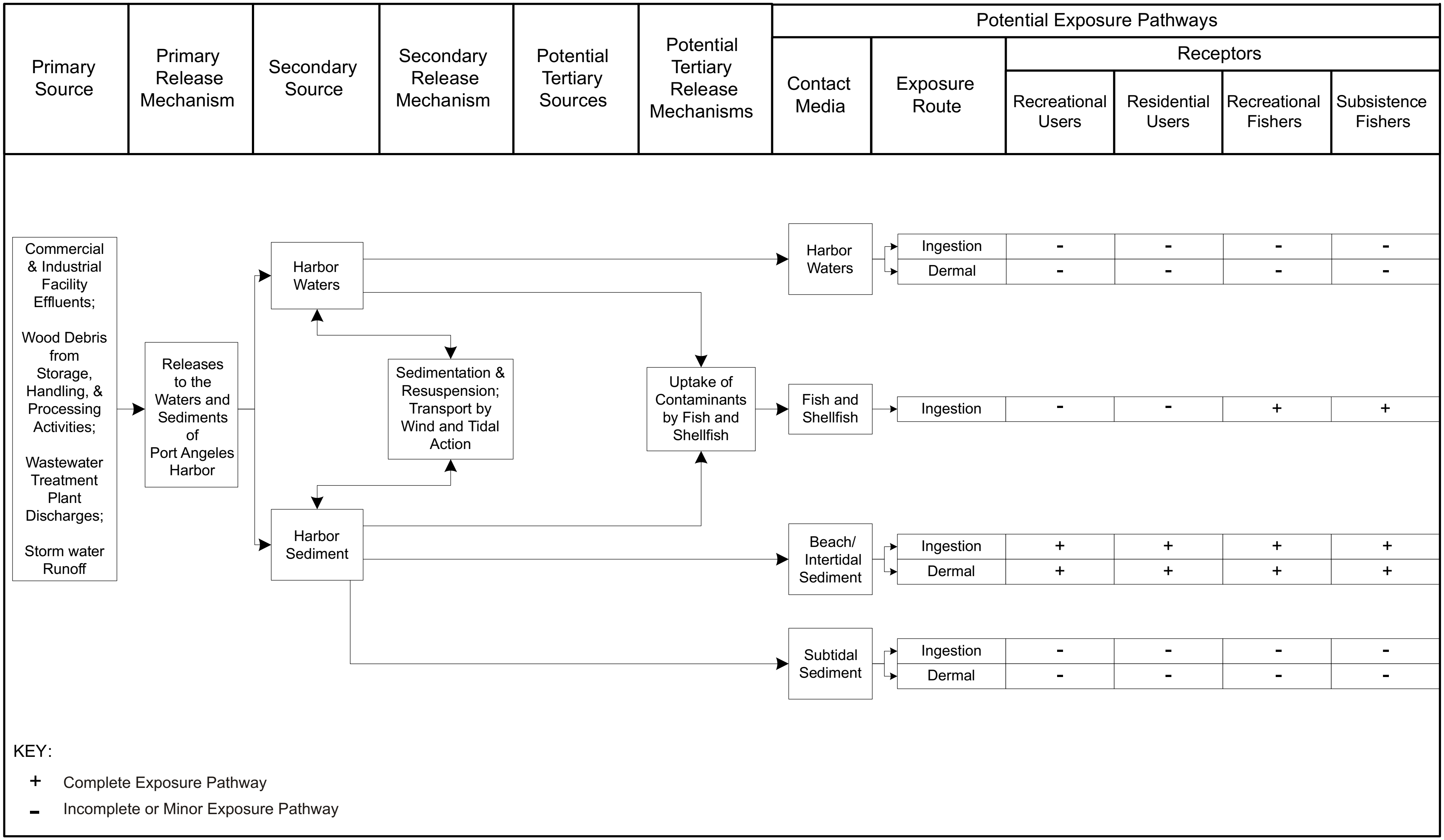
SOURCE: Ecology and Environment, Inc. 2008

Figure 2-1 Preliminary Ecological Conceptual Site Model, Port Angeles Harbor Sediment Characterization Study

Figure 2-2 provides a preliminary conceptual site model for human receptors in the Port Angeles Harbor environment. Risk-based screening values protective of exposures to these receptors will be used to determine which chemical analytes will be retained for further evaluation for each receptor group, as discussed in Section 3.3.1. Subsistence fishers may be exposed to site-related chemicals through dermal exposure to water and sediment, incidental ingestion of surface water and sediment, and ingestion of shellfish and fish. Exposure pathways are the same for the recreational fisher population, although the frequency and magnitude of exposure are expected to be lower.

Residential users may experience dermal exposure to surface water and sediment, and incidental ingestion of surface water and sediment. Residential users also may consume fish and shellfish. However, because this exposure pathway is assessed for the recreational and subsistence fisher scenarios, it will not be quantitatively evaluated for the residential user. Exposure pathways are the same for the recreational user, although frequency and magnitude of exposure may differ. As with the residential user, recreational users may consume fish and shellfish; however, consumption rates are expected to be much higher in the recreational and subsistence fisher populations. Therefore, exposure through consumption of fish and shellfish will not be quantitatively evaluated for the recreational user. Additionally, while all populations may contact directly or ingest surface water, this is expected to provide relatively minor exposure and will not be quantified.

Subsistence fishing by the LEKT is of particular importance in this risk assessment. As with other Native American tribes, the 20 tribes of the Northwest Indian Fisheries Commission (NWIFC) operate as sovereign governments. Each tribe manages its own salmon, finfish, and shellfish fisheries within guidelines jointly developed in cooperation with the Washington Department of Fish and Wildlife (WDFW) (NWIFC 2008). Harvest of fish and shellfish is grouped into three types: commercial (sold to wholesale or retail markets), subsistence (for personal consumption), and ceremonial (for use at cultural events) (NWIFC 2008). The LEKT, including other tribes of the NWIFC, harvest Chinook, Coho, pink, chum, steelhead, and sockeye salmon. Tribal members also harvest several species of shellfish, including geoducks, pink and spiny scallops, rock scallops, and hardshell clams (littleneck, butter, and horse clams) (MPE 2008). Further discussion of LEKT use of Port Angeles fisheries will be provided in the risk assessment report, in addition to discussion of other target populations.



SOURCE: Ecology and Environment, Inc. 2008

Figure 2-2 HHRA Preliminary Conceptual Site Model, Port Angeles Harbor Sediment Characterization Study

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3.0 Data Evaluation

All available chemical data for Port Angeles Harbor collected within the previous 10 years will be evaluated to determine usability according to the data quality criteria discussed below. In addition, data collected during the 2008 field event (E & E 2008a) will be evaluated for usability according to these criteria. Results of benthic toxicity tests will be evaluated for data quality according to criteria provided in the SAP (E & E 2008a). The rules for data treatment described below will be implemented once a complete project dataset is compiled.

3.1 Data Usability Criteria

As discussed in Section 2.2, analytes were selected for this investigation based on the Summary of Existing Information and Identification of Data Gaps Report (E & E 2008b). This report highlights chemicals associated with historical operations that are thought or known to have been released to the harbor. A comprehensive list of analytes is provided in the SAP (E & E 2008a).

Relevant data that meet the established quality criteria outlined in the project SAP (E & E 2008a) will be considered for use in the risk assessment. Data also will be evaluated according to Guidance for Data Usability for Risk Assessment (U.S. EPA 1992), which provides minimum data requirements to ensure that data will be appropriate for risk assessment use. The guidance addresses the following issues relevant to assessing data quality for risk assessment:

- Data sources—Consider the type of data collected (for example, field screening data and fixed laboratory data) and determine if data meet QA/QC objectives outlined in the project SAP.

- Consistency of data collection methods—Review sample collection methods for appropriateness relative to the target analytes, media, and laboratory analytical methods; review field logs to identify sample collection quality issues; and identify differences in sample collection methods, if any, for different field investigations.

- Analytical methods and detection limits—Evaluate methods for appropriateness for the target analytes and media and determine if detection limits are low enough for risk-based evaluation.

- Data quality indicators—Review data validation reports for data quality issues.

3.2 Data Treatment

Data determined to be acceptable for use in the risk assessment may be treated or modified according to the rules listed below. Treatment may relate to detected or non-detected analytes, data qualifiers, and duplicate sample results. Other treatment rules may relate to specific classes of chemicals, such as dioxins and furans, PCBs, and carcinogenic PAHs (cPAHs).

3.2.1 Qualified Data

At times, problems are identified in laboratory analytical results. In such cases, detected analytes may be assigned a data qualifier. As described in the SAP (E & E 2008a), data qualifiers will be assigned according to QA1 or QA2 guidelines and will be consistent with Ecology's Environmental Information Management data reporting system (Ecology 2008b). It is not uncommon to identify problems with analytical data associated with the chemical concentration, the chemical identity, interference from other analytes, and/or matrix interferences (U.S. EPA 1989).

The four dominant data qualifiers used in environmental investigations include REJ, U, J, and B. Additional qualifiers are defined by Ecology (2008b). Validated data will be reviewed and any results flagged with REJ qualifiers, indicating the result was rejected by the data validator, will not be included in the risk assessment data set. U qualifiers indicate that the analyte was not detected. Treatment of U-qualified data is discussed in the following section. J qualifiers indicate that the chemical is detected and its identity is certain, but the concentration is estimated. These results will be included in the risk assessment dataset. J qualifiers may result when there was interference with the sample analysis or when contamination was detected in the blank samples. In the latter case, the result may be flagged with a B qualifier. Positive hits for common laboratory contaminants (including acetone, 2-butanone, methylene chloride, phthalate esters, and toluene) that are flagged with a B qualifier are assumed to be present in the sample due to laboratory contamination if the concentration is less than ten times the maximum amount detected in any laboratory blank. If the analyte is detected at a concentration greater than ten times the maximum amount detected in any laboratory blank sample, then the analyte will be reported as a positively detected analyte without qualifiers. B-qualified data will be assumed to be present at the detection limit and B1-qualified data will indicate that the result has been blank-corrected.

3.2.2 Non-Detect Data

U qualifiers indicate that the analyte was not detected at the method detection limit (MDL). The MDL is the lowest concentration that can be reliably measured and reported with 99 percent confidence that the value is greater than zero (Ecology 2007a). If an analyte is not detected in any investigative samples for a particular medium and detection limits are below SQS chemical criteria, then it will be assumed that the chemical is not present and it will not be considered further in the risk assessment.

In most cases, U-qualified data will be assumed to be present at a concentration equal to one-half of the MDL. In some cases, substitution of the MDL with a concentration of one-half of the MDL may not be an acceptable approach to evaluating U-qualified data (Ecology 2007a). Exceptions to this substitution method will be based on the frequency of detection of the analyte and distribution and skewness of the data, as provided by MTCA (Chapter 173-340-740 WAC). When data are censored, or are skewed due to a high frequency of nondetect results, statistical methods may be used to substitute surrogate concentrations for nondetect results (e.g., bootstrapping). Ecology (2007a) and EPA guidance (Singh and Singh 2007) will be consulted to determine an appropriate approach to treatment of censored datasets and an explanation of treatment of all nondetect concentrations will be provided in the risk assessment report.

An additional consideration for treatment of nondetected results pertains to dioxins/furans; co-planar, dioxin-like PCBs; and PAHs. For these chemical classes, two approaches will be followed to describe concentrations. One approach will be that congeners or cPAH constituents that are not detected in any sample in the dataset will be assigned a value equal to zero. The second approach is for any non-detected congeners or cPAH constituents that are detected in one or more samples in the dataset; in this instance, the detection limit will be replaced with a value equal to one-half the MDL. Results using both approaches will be presented in the risk assessment.

3.2.3 Treatment of Duplicate Samples

Field duplicates will not be collected, although matrix spike/matrix spike duplicate samples will be collected and analyzed for QA/QC purposes (E & E 2008a). Only investigative samples will be included in the risk assessment dataset.

3.2.4 Application of Toxic Equivalency Factors and Calculation of Total Toxic Equivalent Concentrations

Chemical concentrations for carcinogenic dioxins/furans; co-planar, dioxin-like PCBs; and PAHs are usually modified by a toxic equivalency factor (TEF) and then each class of chemical is summed to obtain a TEQ. The TEF is an estimate of the relative toxicity of a chemical compared to a reference chemical. The TEQ represents the total contribution of the individual congeners for total dioxin/furan, PCB, and/or cPAH toxicity. A list of TEFs and a more complete discussion of this methodology is provided in *Evaluating the Toxicity and Assessing the Carcinogenic Risk of Environmental Mixtures Using Toxicity Equivalency Factors* (Ecology 2007b).

The TEQ for dioxins/furans and co-planar, dioxin-like PCBs is expressed in terms of the toxicity of the reference chemical, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Separate TEQs for dioxins/furans and for co-planar, dioxin-like PCBs also will be calculated to determine the relative contribution of each group of congeners to the TEQ for 2,3,7,8-TCDD. The TEQ for cPAHs is expressed in terms of the toxicity of the reference chemical, benzo(a)pyrene (BaP).

The TEFs developed by the World Health Organization (Van den Berg et al. 1998, 2006) will be used to calculate the TEQ for 2,3,7,8-TCDD for mammals, birds, and fish. Ecology has adopted the TEFs recommended by the California Environmental Protection Agency (2005) for evaluation of cPAHs (Ecology 2007b). A list of TEFs and a discussion of the toxicological basis for their use will be provided in the toxicity assessment section of the risk assessment report.

3.3 Selection of Indicator Hazardous Substances

MTCA acknowledges that at some sites where a large number of chemicals are present, it can be useful to eliminate from further consideration those chemicals that represent a small contribution to overall threat to human health and the environment. Chemicals that are not eliminated are referred to as indicator hazardous substances (IHSs) under MTCA (WAC 173-340-703, Ecology 2007a). The IHS selection process will be completed following further consultation with Ecology and receipt of the validated data. The selected IHSs and the process for their selection will be described in *Technical Memorandum #1, IHS Selection and Revised CSM*, which will be developed prior to completion of the risk assessment. *Technical Memorandum #1* also will include a revised CSM.

3.3.1 Human Health Screening Process

Ecology considers several parameters in the selection of IHSs, including frequency of detection, evaluation of essential nutrients, toxicological and physical characteristics of each chemical, and natural background concentrations. These parameters are consistent with EPA human health risk assessment guidance (U.S. EPA 1989).

3.3.1.1 Frequency of Detection

The first step in selecting IHSs will be to assess the frequency of detection for all analytes. Analytes that were not detected in any sample and that do not have MDLs exceeding risk-based screening levels will not be evaluated in the risk assessment. Analytes with a low frequency of detection (for example, 5%) in a medium also may be eliminated from further consideration because they could be attributable to laboratory contamination, may be an artifact of the sampling methodology, or may not be site-related. However, chemicals known to be site-related or that cluster in specific areas of the harbor (indicating a potential hotspot) will be evaluated.

3.3.1.2 Evaluation of Essential Nutrients

EPA (U.S. EPA 1989) recommends removing chemicals from further consideration if they are generally considered “essential nutrients” because some naturally-occurring chemicals are beneficial to human life. These are chemicals that are toxic only at very high doses, are essential human nutrients, and are present at concentrations that would not be due to sources identified in the summary of chemical sources for Port Angeles Harbor (E & E 2008b). The essential nutrients which will not be included in the list of IHSs include magnesium, calcium, sodium, and potassium.

3.3.1.3 Use of Screening Values

Screening values are typically selected from a variety of sources for media that could be primary sources of exposure. Screening values are usually based on either residential or worker exposure scenarios. As noted in the discussion of the preliminary CSM, people who may have contact with media in Port Angeles Harbor include subsistence and recreational fishers, recreational users, and area residents. The primary pathway for human contact with contaminated sediments is through contact with marine biota such as fish and shellfish that contact marine surface sediments. However, there are no marine sediment quality standard (SQS) numerical concentration criteria for the protection of human health (WAC 173-204-320). As mentioned above, a separate technical memorandum will be developed that will outline the selected screening levels and the basis for their selection. These values then will be used to screen analytical data and identify IHSs.

3.3.1.4 Evaluation of Background

Substances related to human activities that are consistently present in the vicinity of a site but are not the result of a release from the site under investigation are referred to as "area background" substances (Ecology 2007a). Substances present in the environment that have not been influenced by local human activities but are the result of geologic processes or the result of global cycling of anthropogenic-generated substances are referred to as "natural background" substances (Ecology 2007a). Naturally occurring substances may include metals and radionuclides, while anthropogenic or human-enhanced substances may include PCBs, mercury, and radionuclides. Dungeness Bay will serve as background in the study. Site investigation data will be compared to reference and background, as appropriate.

The SMS (WAC 173-204-200) provides a slightly different term, reference sediment sample. A reference sediment sample represents the non-anthropogenically affected surface sediment quality of the sediment sample. The reference area sample must be similar to the investigational area sample in terms of grain size, organic content, and other physical and chemical parameters and must not exceed SQS of WAC 173-204-320. The reference area for this investigation is Dungeness Bay and sample results collected at this reference area will be compared with Port Angeles Harbor samples. Additional discussion of the use of any reference and background data will be provided in the risk assessment report.

3.3.2 Ecological Screening Process

Chemicals to be included in the ecological risk assessment will be selected by comparing maximum chemical concentrations in sediment with sediment benchmarks. *Washington State Sediment Management Standards* (Chapter 173-204 WAC) will be used preferentially as screening benchmarks, as described in Section 5.5. In addition, all detected chemicals in sediment, fish, or shellfish samples with a log K_{ow} greater than 3.5 will be including in the ecological risk assessment. Such chemicals may pose a hazard to wildlife that feed on biota from Port Angeles Harbor. Chemicals that appear to be associated with toxicity in bioassays also will be included, such as ammonia, sulfides, and TOC. Finally, selection of chemicals to be included in the ecological risk assessment will follow the general guidelines described above regarding frequency of detection, essentiality, and background concentrations.

3.4 Exposure Areas

Data will be grouped into appropriate exposure areas, which will allow for calculation of risks associated with each area to facilitate further site investigation planning as well as to facilitate risk management and land-use decision-making. Generally, data will be grouped into areas where people or ecological receptors are expected to contact exposure media over the duration of exposure.

3.5 Calculation of Exposure Point Concentrations

An exposure point concentration (EPC) is used to estimate the magnitude of exposure for each receptor (human or ecological) that may contact IHSs present in Harbor media. EPCs are estimates of the average concentration in a medium that someone may contact over time (U.S.

EPA 1989). To account for uncertainty in estimating a true average concentration, EPA recommends calculating the 95% upper confidence limit (UCL) of the arithmetic mean concentration for each exposure area (U.S. EPA 1992, 2002b). Typically, the lesser of the UCL or the maximum detected concentration for each IHS is used as the EPC.

UCLs will be calculated according to EPA guidance (1992, 2002b) using EPA's EPC calculation software, ProUCL Version 4.0 (Singh and Singh 2007 and Singh et al. 2007)[1]. For exposure areas containing fewer than 10 data points, the maximum value will be used as the EPC. For exposure areas containing 10 or more data points, ProUCL will be used to test the data for a lognormal or normal distribution and to calculate a UCL. The method for calculating the UCL will depend on the distribution of the dataset. When the data are normally distributed, the Student's *t*-statistic will be used to calculate the UCL and the *H*-statistic will be used to calculate the UCL for lognormal datasets. When a dataset does not fit a normal or lognormal distribution, nonparametric methods described by Singh and Singh (2007) and Singh et al. (2007) and presented in the ProUCL software may be used to calculate a reasonable UCL. Estimated EPCs, including distribution of data and statistic used for calculation, will be provided in *Technical Memorandum #1*. Uncertainties associated with EPC calculations will be included in the final risk assessment report, including use of modeled EPCs, whole body clam tissue EPCs for human health risk assessment, and other sources of uncertainty.

[1] ProUCL Version 4.0 and the User's Guide (Singh et al. 2007) can be downloaded for free at: http://www.epa.gov/esd/tsc/software.htm.

4.0 Human Health Risk Assessment Methodology

4.1 Overview

The following section outlines the methodology for the human health risk assessment. This section consists of methods for the exposure assessment (Section 4.2), toxicity assessment (Section 4.3), risk characterization (Section 4.4), and uncertainty evaluation (Section 4.5).

The exposure assessment describes how exposures to receptors will be quantified for each anticipated exposure pathway, while the toxicity assessment explains how the toxicity of carcinogenic and noncarcinogenic IHSs is estimated. The information from the exposure and toxicity assessments is then combined to generate quantitative estimates of risk. The risk assessment report will provide a detailed discussion of uncertainty associated with each step of the risk assessment and will indicate how each issue may impact the overall risk estimates.

The risk assessment will draw upon federal and state guidance, in addition to information presented in peer-reviewed publications, including but not limited to the following documents:

- *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A* (U.S. EPA 1989);
- *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part B, Development of Risk-Based Preliminary Remediation Goals* (U.S. EPA 1991);
- *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment* (U.S. EPA 2004b);
- *Exposure Factors Handbook* (U.S. EPA 1997); and
- Evaluating the Toxicity and Assessing the Carcinogenic Risk of Environmental Mixtures Using Toxicity Equivalency Factors (Ecology 2007b).

4.2 Exposure Assessment

An exposure assessment estimates the type and magnitude of human exposure to IHSs. A complete exposure pathway must exist for exposure and subsequent risks to occur. A complete pathway must include the following elements (U.S. EPA 1989):

- A source and mechanism for release of constituents;
- A transport or retention medium;
- A point of potential human contact (exposure point) with the affected medium; and
- An exposure route.

The exposure pathway is not considered complete if any one of these elements is missing. The preliminary CSM (Figure 2-2) illustrates each of the possible exposure pathways relevant to receptors present at Port Angeles Harbor.

Exposures are quantified using an algorithm that represents exposure. Inputs to this algorithm are assumptions based on site-specific and other applicable information. EPA (1989) provides a generalized exposure algorithm used in risk assessment, which is modified for each exposure pathway:

$$I = \frac{EPC \times CR \times EF \times ED \times F \times ABS}{BW \times AT}$$

where

I = Intake, the amount of chemical taken in by the receptor (mg chemical/kg body weight/day)

EPC = Exposure point concentration, the chemical concentration contacted over the exposure period at the exposure point (mg chemical/kg sediment)

CR = Contact rate, the amount of exposure medium contacted per unit time or event (*e.g.*, sediment ingestion rate (mg/day))

EF = Exposure frequency, how often exposure occurs (days/year)

ED = Exposure duration, how long exposure occurs (yr)

F = Intake fraction, fraction of media contacted that is assumed to be from the contaminated source (unitless)

ABS = Absorption factor, an adjustment factor to account for relative absorption of a chemical from the medium of interest compared to absorption from the exposure medium in the toxicity study(ies) used to derive the toxicity value (unitless)

BW = Body weight, the average body weight over the exposure period (kg)

AT = Averaging time, period over which exposure is averaged (days)

The variables shown in the exposure algorithm above are called exposure factors and vary depending on the population being evaluated. Each population (subsistence fisher, recreational fisher, recreational user, or residential user) will be characterized by exposure factor assumptions regarding the contact rate, frequency of contact with exposure media, duration of exposure, and other parameters unique to each population. Exposure factors will be obtained from several regulatory agency and literature sources, including the EPA (1989, 1991, 1997, 2004b) and Lower Elwha Klallam Tribe (Ecology 2008; U.S. EPA 2007a).

Exposure factors specific to each exposure scenario will be selected following consultation with Ecology and will be presented in a separate *Technical Memorandum #2, Exposure Assessment*. The memorandum will include factors for a reasonable maximum exposure (RME) scenario and a central tendency (CT) scenario for each receptor population, as defined by EPA (U.S. EPA 1989). The RME scenario is a combination of high-end and average exposure values and is used to represent the highest reasonable exposure that could occur. The CT scenario is based on average estimates of exposure. The RME scenario provides a health-protective estimate of exposure that is reasonable but is still well above the average exposure level, while the CT scenario provides an estimate of exposure for most individuals within a population.

4.2.1 Identification of Exposure Scenarios

Section 2 describes the preliminary CSM, including potential exposure pathways and receptors of concern for Port Angeles Harbor. As shown in Figure 2-2, relevant exposure media include surface water, beach and intertidal sediment (accessible at the harbor's edge waters), subtidal sediment, and fish and shellfish. Populations that might encounter these exposure media are identified as current and future adult and child receptors of subsistence fishers, recreational fishers, residential users, and recreational users.

The preliminary CSM identifies potentially complete exposure routes but does not attempt to classify routes as "major" or "minor" routes. The risk assessment will discuss the significance of each route and will include a revised CSM which will note routes evaluated quantitatively versus those evaluated qualitatively. The scenarios proposed for evaluation in this risk assessment include adult and child receptors under current and future conditions for the following populations:

- Subsistence fisher;
- Recreational fisher;
- Residential user; and
- Recreational user.

The exposure pathways for the subsistence and recreational fisher populations and the residential and recreational user populations are expected to be similar, but will differ from each other in the frequency and magnitude of exposure. Generally, the recreational and subsistence fisher scenarios will include consumption of fish and shellfish and contact with beach and intertidal sediment. While the recreational and residential users also may consume fish and shellfish from the Harbor, these scenarios will focus on more intensive contact with beach and intertidal sediment. All populations may contact Harbor surface water but intake via contact with surface water is expected to be minor relative to direct contact with sediment and consumption of marine biota.

Complete descriptions of each exposure scenario, including exposure factors for each receptor population and exposure areas relevant to each scenario, will be provided to Ecology in a separate document, *Technical Memorandum #2, Exposure Assessment*, which will be developed following consultation with Ecology and completion of *Technical Memorandum #1, IHS Selection and Revised CSM*.

4.3 Toxicity Assessment

The toxicity assessment compiles information on adverse health effects that the IHSs could cause and provides an estimate of the dose-response relationship for each IHS (the relationship between the extent of exposure and increased likelihood and/or severity of adverse effects). The dose-response relationship provides the basis for development of toxicity values used in the risk assessment. Toxicity values and a brief narrative describing the toxicity of each IHS will be provided in the risk assessment report.

Toxicity values for the IHSs will be presented in the risk assessment report according to the following hierarchy recommended in EPA's *Human Health Toxicity Values in Superfund Risk Evaluations* (2003):

- Integrated Risk Information System (IRIS) Computer Database. IRIS is the preferred source of information because this database contains the most recent toxicity values that have been reviewed extensively by EPA.

- EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs). The Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (STSC) develops PPRTVs on a chemical-specific basis. These values will be consulted if a toxicity value is not available on IRIS.

- Other Values. In the absence of established values from IRIS or PPRTVs, toxicity values from several sources (California EPA (CalEPA) toxicity values, EPA regional toxicologists, Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles, or National Center for Environmental Assessment (NCEA)) may be used.

When no other values are available, surrogate values may be used in consultation with Ecology risk assessors. Surrogates are selected based on similar structure, mechanism of action, and toxicity.

4.3.1 Assessment of Carcinogens

EPA (2005a) uses a weight-of-evidence (WOE) approach to evaluate the likelihood that a substance is a carcinogen. After data from human and animal studies are reviewed, a chemical is characterized as (1) known human carcinogen (WOE Class A), (2) probable human carcinogen (WOE Class B1 or B2), (3) possible human carcinogen (WOE Class C), or (4) not classifiable regarding human carcinogenicity (WOE Class D). If an evaluation reveals that a substance is not a carcinogen, it is classified as WOE Class E (U.S. EPA 2005a). The weight-of-evidence classifications for each IHS will be presented in the risk assessment report.

The approach for assessing the toxicity of carcinogenic and noncarcinogenic IHSs is presented in the following sections. Special subpopulations may be more susceptible to the toxic effects of exposure to IHSs. These subpopulations include the elderly, infants and children, people with pre-existing illnesses, and fetuses. As described in the following sections, uncertainty factors are used to provide additional protection for sensitive subpopulations.

The toxicity of a chemical at low doses is estimated from high-dose cancer bioassays. Consistent with one of the current theories of carcinogenesis, EPA (1989) has selected the linearized multistage model to estimate toxicity values. In this model, EPA uses the 95 percent UCL of the slope of the dose-response curve, or slope factor, to estimate carcinogenicity. Using these procedures, the regulatory agencies are unlikely to underestimate the actual carcinogenic potency of an IHS. The carcinogenic potency is represented by an IHS's cancer slope factor (CSF) and is expressed as risk per milligram per kilogram per day [$(mg/kg\text{-}day)^{-1}$].

EPA (2004b) has not developed CSFs for dermal exposure to all chemicals, but has provided a method for extrapolated dermal CSFs from oral CSFs. This route-to-route extrapolation has a scientific basis because an absorbed chemical's distribution, metabolism, and elimination patterns are usually similar regardless of exposure route. However, dermal toxicity values are typically based on absorbed dose, whereas oral exposures are usually expressed in terms of administered dose. Consequently, if adequate data regarding the gastrointestinal absorption of an IHS are available, then dermal CSFs may be derived by applying a gastrointestinal absorbance factor to the oral toxicity value (U.S. EPA 2004b). For chemicals lacking a gastrointestinal absorbance value, absorbance is assumed to be 100 percent and the oral CSF will be used to estimate toxicity via dermal absorption.

4.3.2 Assessment of Noncarcinogens

To evaluate noncarcinogenic effects, EPA (1989) defines acceptable exposure levels as those to which the human population, including sensitive subgroups, may be exposed without adverse effects during a lifetime or part of a lifetime, incorporating an adequate margin of safety. The potential for adverse health effects associated with noncarcinogens (for example, organ damage, immunological effects, birth defects, and skin irritation) usually is assessed by comparing the estimated average daily intake (that is, exposure dose) to a reference dose (RfD).

EPA develops the RfD by identifying the no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL) in the scientific literature. NOAELs and LOAELs may be derived from either human epidemiological studies or animal studies; however, because human data are often lacking, these levels are usually derived from laboratory animal studies in which relatively high doses are administered. Uncertainty factors are then applied to the NOAELs and LOAELs to compensate for the data limitations inherent in the experiments, in addition to uncertainties associated with extrapolating high-dose animal data to the relatively low-dose environmental exposure situations in humans.

RfDs are expressed in units of mg/kg-day. The RfD is an estimate (with uncertainty possibly spanning an order of magnitude) of the daily intake to humans (including sensitive subgroups) that should not result in an appreciable risk of deleterious effects. EPA assigns a qualitative level of confidence (low, medium, or high) to the study used to derive the toxicity value, database, and RfD. The relative degree of uncertainty associated with the RfDs and the level of confidence EPA assigns to the data and the toxicity value are considered when evaluating the quantitative results of the risk assessment.

RfDs are developed for specific exposure routes (oral, dermal, and inhalation). The extrapolation of inhalation and dermal RfDs from oral RfDs will be discussed in the risk assessment report if such RfDs are used. RfDs for all IHSs will be presented in the risk assessment report.

4.4 Risk Characterization

The risk characterization is the calculation of upper-bound excess lifetime cancer risks and noncarcinogenic hazards for each scenario described in the refined CSM that will be provided in the risk assessment report. The exposure parameters described in Section 4.2 will be integrated with the toxicity information provided in Section 4.3 to obtain risk and hazard estimates for each scenario. Risks and hazards will be summed for each target population across all pathways to obtain an estimate of total potential risk and hazard.

4.4.1 Risks for Carcinogens

The potential for someone to develop cancer as a result of exposure to Port Angeles Harbor media will be estimated using the exposure and toxicity assumptions. The estimated intake will be multiplied by the chemical-specific CSF to determine the cancer risk, as shown below:

$$Risk = Intake \times CSF$$

where:

Intake = Lifetime average daily intake (mg/kg-day)

CSF = Cancer slope factor $(mg/kg\text{-}day)^{-1}$

This linear relationship is valid only at cancer risk levels less than 1×10^{-2}. The calculated risk is an upper-bound probability of an individual developing cancer over a lifetime. The actual risk is likely to be no more than, and probably less than, the calculated risk.

Cancer risks will be determined separately for exposure to each chemical through each exposure pathway. People may be exposed to IHSs through multiple pathways; for that reason, cancer risks then will be summed across the exposure pathways representative of each exposure scenario to obtain the total potential excess lifetime cancer risk for each scenario.

Federal and state environmental laws and regulations recognize that estimates of very small levels of risk are insignificant. The concept of *de minimis* risk refers to a specific level below which risks are so small that they are not of potential regulatory concern. In risk assessment, government agencies define as *de minimus* excess lifetime cancer risks less than 1×10^{-6}. Ecology has set acceptable target levels at 1×10^{-5} for multiple exposure pathways and/or multiple IHSs, and requires that the risk for an individual IHS via individual exposure pathways shall not exceed 1×10^{-6}.

4.4.2 Risks for Noncarcinogens

The potential for adverse effects resulting from exposure to noncarcinogens will be assessed by comparing the chemical-specific intake to its RfD, yielding an HQ, as follows:

$$HQ = \frac{Intake}{RfD}$$

where:

HQ = Hazard quotient (unitless)

Intake = Average daily intake (mg/kg-day)

RfD = Reference dose (mg/kg-day)

The reference dose (RfD) is calculated using exposure parameters similar to those of the intake in risk assessment and is an exposure level at which no adverse effects are expected to occur, although the absence of all risks cannot be ensured (U.S. EPA 1989). An adequate margin of safety is incorporated into the reference dose to ensure protection of sensitive populations (U.S. EPA 1989). As mentioned earlier, the reference dose is considered a "soft" estimate, with bounds of uncertainty that can span an order of magnitude.

HQs will be provided for exposure to individual chemicals through each exposure pathway, for each target population. HQs for individual chemicals will be summed to yield a hazard index (HI). A person could be exposed to multiple IHSs through various pathways. Therefore, the HIs will be summed across all exposure pathways for each scenario. The IHS-specific HQs will be summed separately according to the major health effects and target organs affected, because the effects of exposure may not be additive for all IHSs, and summing all effects together may lead to overestimating the potential for adverse health effects.

4.5 Uncertainty Assessment

Uncertainty is inherent in every step of the risk assessment process and will be discussed in relation to its impact on the risk assessment results. For example, the intake of each IHS for each receptor will be uncertain because assumptions must be made for exposure factors such as contact rate, frequency, and duration. Similarly, the uncertainty underlying a toxicity estimate for a particular IHS may be great or small, depending on the confidence EPA provides in the toxicity database or critical study on which the toxicity estimate is based. The risk assessment report will include an evaluation of the uncertainty associated with each step of the risk assessment process.

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5.0 Ecological Risk Assessment Methodology

5.1 Overview

E & E will prepare an ecological risk assessment (ERA) for the Harbor to determine whether sediment contamination from historic and ongoing municipal, commercial, and industrial activities poses a risk to ecological receptors at the site, including threatened and endangered species. The results of the ERA will be used to help determine whether remedial measures are necessary to protect and/or restore the natural environment and, if they are, will aid in the selection of appropriate remedial goals.

The methodology used in the ERA will be consistent with Washington State and United States Environmental Protection Agency (U.S. EPA) guidance, including but not limited to:

- *Sediment Management Standards, Chapter 173-204 WAC*;
- *Model Toxics Control Act Chapter 70.105D RCW [Amended 2007] and Cleanup Regulation Chapter 173-340 WAC [Amended November 2007]* (Ecology 2007a);
- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (U.S. EPA 1997);
- *Guidelines for Ecological Risk Assessment* (U.S. EPA 1998); and
- *Wildlife Exposure Factors Handbook* (U.S. EPA 1993).

In addition to the above-mentioned state and federal guidance documents, E & E will use publications from Oak Ridge National Laboratory (ORNL) and articles from the peer-reviewed literature, as appropriate.

The ERA will include an ecological characterization, final list of assessment and measurement endpoints, wildlife exposure analysis, ecological effects assessment, risk characterization, and uncertainty evaluation. These components of the ERA are discussed in turn below.

5.2 Ecological Characterization

E & E will prepare an ecological characterization of Port Angeles Harbor based on site-specific information contained in previous site reports, general information on the ecology of Puget Sound, and observations made by E & E personnel during site-investigation activities. The marine environment of Port Angeles Harbor and the plant, invertebrate, fish, and wildlife species found there will be described. The U.S. FWS and WDFW will be contacted for current information on threatened and endangered species in the site vicinity. A brief description of the site ecology is provided in Section 2 as background.

5.3 Assessment and Measurement Endpoints

In an ERA, assessment endpoints are expressions of the ecological resources that are to be protected (U.S. EPA 1997). An assessment endpoint consists of an ecological entity and a characteristic of the entity that it is important to protect. According to EPA (1998), assessment endpoints do not represent a desired achievement or goal, and should not contain words such as protect or restore or indicate a direction for change such as loss or increase. Assessment endpoints are distinguished from management goals by their neutrality (U.S. EPA 1998).

Measurements used to evaluate risks to the assessment endpoints are termed "measures" and may include measures of effect (for example, results of sediment toxicity tests), measures of exposure (for example, chemical concentrations in sediment) and/or measures of ecosystem and receptor characteristics (for example, habitat characteristics) (U.S. EPA 1998). Based on the site ecology, site-related contaminants, and the preliminary ecological conceptual site model, the ecological resources most at risk from sediment contamination at Port Angeles Harbor include aquatic vegetation, benthic invertebrates, benthic fishes, mammals, and birds. The assessment endpoints and measures for these receptors are listed in Table 5-1. Receptors with low potential for contact with contaminated sediment, such as phytoplankton and zooplankton, will not be quantitatively evaluated.

5.4 Wildlife Exposure Analysis

Exposure analysis is the first step in the wildlife risk assessment process. In this step, wildlife exposure to site-related chemicals is estimated using measured concentrations of chemicals in environmental media and exposure parameters for the chosen receptor species. Because potential impacts to aquatic plants, benthos, and fish will be examined using direct measurements of effects, comparison of media concentrations to published guidelines, and/or evaluation of habitat quality, the exposure assessment will apply only to the wildlife species being evaluated.

Potential wildlife receptors and exposure pathways were discussed generally in Section 2.3 and identified in the preliminary conceptual site model. This section identifies specific wildlife exposure scenarios that will be evaluated in the assessment and discusses how wildlife exposure to chemicals in the environment will be quantified.

5.4.1 Wildlife Exposure Scenarios and Pathways

Six wildlife species representing different functional groups will be evaluated:

- Brant (*Branta bernicla*);
- Double-crested cormorant (*Phalacrocorax auritus*);
- Greater scaup (*Aythya marila*);
- Harbor seal (*Phoca vitulina*);
- Raccoon (*Procyon lotor*), and
- Bald Eagle (*Haliaeetus leucocephalus*).

Table 5-1 Summary of Assessment Endpoints, Measures, and Data Needs for the Ecological Risk Assessment for the Port Angeles Harbor Marine Environment

Assessment Endpoint[a]	Representative Species	Measure	Data Needs	Are recent data available?
Marine Vegetation and Macroalgae	Eelgrass, Kelp	Sediment habitat quality.	Wood-waste distribution in sediment.	Yes, in SAIC (1999). Additional data collection planned as part of harbor-wide investigation.
Benthos	Clams, Polychaetes, Crabs	Sediment chemical concentrations compared with marine sediment standards and benchmarks.	Results for site-related chemicals in sediment.	See SAP for identification of existing sample locations. Planned as part of harbor-wide investigation.
		Sediment bioassay results.	Sediment bioassays results.	Only in limited area around Rayonier site. Planned as part of harbor-wide investigation.
		Sediment habitat quality.	Wood-waste distribution in sediment.	Same as above for marine vegetation and macroalgae.
Fish	Rock Sole, Starry Flounder, Lingcod	Fish tissue chemical concentrations compared with tissue standards and benchmarks.	Results for site-related chemicals in fish (whole body).	Yes, a limited number of sole and flounder whole-body samples are available from Rayonier RI. Collection of additional samples is planned as part of harbor-wide investigations.
Carnivorous Birds	Bald Eagle Cormorant	HQ method based on measured concentration of site-related chemicals in sediment and fish.	Results for site-related chemicals in sediment and fish (whole body).	Yes for sediment. Yes for flatfish (see above). Additional fish sampling planned for harbor-wide investigation.

Table 5-1 Summary of Assessment Endpoints, Measures, and Data Needs for the Ecological Risk Assessment for the Port Angeles Harbor Marine Environment

Assessment Endpoint[a]	Representative Species	Measure	Data Needs	Are recent data available?
Omnivorous Birds	Greater Scaup	HQ method based on measured concentration of site-related chemicals in sediment, marine vegetation, and marine invertebrates (shrimp).	Results for site-related chemicals in sediment, marine vegetation, and shrimp.	Yes for sediment. Yes for shrimp; three samples are available for Port Angeles Harbor from Malcolm Pirnie (2007a). No for marine vegetation. Analysis of eelgrass or macroalgae and additional invertebrates planned as part of harbor-wide investigation.
Herbivorous Birds	Black Brant	HQ method based on measured concentration of site-related chemicals in sediment and marine vegetation.	Results for site-related chemicals in sediment and marine vegetation.	Yes for sediment. No for marine vegetation. Analysis of eelgrass or macroalgae is planned as part of harbor-wide investigation.
Carnivorous Mammals	Harbor Seal	HQ method based on measured concentration of site-related chemicals in sediment, marine fish (flounder, rock sole), and marine invertebrates (horse clam, geoduck, Dungeness crab).	Results for site-related chemicals in sediment, fish, and marine invertebrates.	Yes for sediment, flatfish, and clams near Rayonier site. Additional fish and shellfish sampling planned for harbor-wide investigation.
Omnivorous Mammals	Raccoon	HQ method based on measured concentration of site-related chemicals in sediment, marine fish (flounder, rock sole), and marine invertebrates (shrimp, oysters).	Results for site-related chemicals in sediment, fish, and marine invertebrates.	Yes for sediment. Yes for coonstripe shrimp based on Malcolm Pirnie (2005). Additional fish and shellfish sampling planned as part of harbor-wide investigation.

Note:
[a] Sustainability (growth, survival, and reproduction) of the listed communities and wildlife populations in Port Angeles Harbor.

Key:
HQ = hazard quotient.

The cormorant, harbor seal, and bald eagle are piscivorous and therefore may be highly exposed to bioaccumulative contaminants. The omnivorous raccoon is known to forage in the intertidal zone and thus may be exposed to contaminants in water, sediment, and prey. The brant and scaup are waterfowl that often forage in shallow water habitats and thus may be exposed to contaminants in water, sediment, and prey in the littoral zone of Port Angeles Harbor.

For these five wildlife receptors, E & E will evaluate exposure from incidental ingestion of contaminated sediment and consumption of contaminated prey. Exposure through drinking will not be quantitatively evaluated because Port Angeles Harbor is a saltwater system. Although wildlife may consume small amounts of surface water while feeding, such consumption is likely to account for only a small faction of total chemical exposure because chemicals typically occur at much greater concentrations in sediment and biota than in surface water. Direct contact with contaminated water and sediment is assumed to be a minor route of exposure for wildlife due to the protection provided by fur and feathers and will not be quantitatively evaluated. A summary of important life-history characteristics of the chosen receptor species is provided below.

5.4.1.1 Brant

The brant is a small goose that breeds in the Arctic, winters from Alaska south to Baja California, and remains near saltwater throughout the year (Kaufman 1996). Brant feed almost exclusively on plants. During the winter, they feed predominantly on eelgrass, salt marsh plants, and green algae. During the breeding season, brant feed on Arctic grasses and sedges, forbs, and moss. Brant forage on exposed vegetation and rooted plants in shallow water but do not dive; at high tide, they feed on dislodged leaves floating at the surface.

5.4.1.2 Double-Crested Cormorant

The double-crested cormorant is the most widely distributed cormorant in North America (Kauffman 1996). It is very adaptable and will use almost any aquatic habitat, including rocky northern coasts, mangrove swamps, large reservoirs, and small ponds. The double-crested cormorant nests in trees near water, on sea cliffs, or on ground on islands. The diet of this species varies with season and place and includes a wide variety of fish, crabs, shrimp, crayfish, frogs, salamanders, eels, and sometimes snakes, mollusks, and plant material. It forages mostly by diving from the surface and swimming underwater, propelled by its feet. This species may forage in clear or muddy water and usually forages at mid to upper levels more often than near the bottom.

5.4.1.3 Greater Scaup

Greater scaup breed in Alaska and northern Canada and spend the winter on the Pacific or Atlantic coast (Kaufman 1996). During summer, this species occurs on lakes and bogs in semi-open country near the northern limits of the boreal forest, and out onto the tundra. In winter, greater scaup occur mainly on coastal bays, lagoons, and estuaries. In winter, the diet includes mainly mussels, clams, oysters, snails, and other mollusks. In summer, the diet includes plants such as pondweeds, wild celery, sedges, and grasses, as well as insects and crustaceans. The greater scaup usually forages by diving and swimming underwater; bringing larger food items to the surface to be eaten. Occasionally, the greater scaup will forage by dabbling or upending in shallow water.

5.4.1.4 Harbor Seal

Harbor seals range from Alaska to Baja California along the Pacific coast (U.S. EPA 1993). They inhabit a wide variety of environments and are able to tolerate a wide range of temperatures and water salinities. In western North America, the harbor seal inhabits tidal mudflats, sand bars, shoals, river deltas, estuaries, bays, coastal rocks, and offshore islets, even ranging up rivers into freshwater areas in search of food. Habitats used for haulouts include cobble and sand beaches, tidal mud flats, offshore rocks and reefs, and man-made objects such as piers and log booms. The diet of the harbor seal varies seasonally and includes bottom-dwelling fish such as sole and flounder; invertebrates such as octopus, crabs, and clams; and pelagic species that can be caught in periodic aggregations, such as herring and squid. Harbor seals are opportunistic, consuming different prey in relation to their availability and ease of capture. They hunt alone or in small groups.

5.4.1.5 Raccoon

The raccoon is the most abundant and widespread medium-sized omnivore in North America. Raccoons are found near virtually every aquatic habitat (U.S. EPA 1993). They also are common in suburban residential areas and cultivated and abandoned farmlands. Raccoons use surface water for both drinking and foraging. Raccoons are omnivores and opportunistic feeder. They feed primarily on fleshy fruits, nuts, acorns, and corn, but also eat grain, insects, frogs, crayfish, eggs, and virtually any animal and vegetable matter. The proportion of the diet depends on location and season, although plant material is usually a more important component of the diet than animal material. Typically, it is only in the spring and early summer that raccoons eat more animal than plant material. Raccoons typically are active from sunset to sunrise, but will change their activity pattern to accommodate food availability. For example, salt marsh raccoons may become active during the day to take advantage of low tide.

5.4.1.6 Bald Eagle

The bald eagle is a top predator in many aquatic ecosystems in North America and the second largest raptor (bird of prey) in North America (Peterson1980). Bald eagles are found throughout North America, and extensive breeding populations are found in Alaska and northern Canada and along the Atlantic Coast from Florida to Maine and up through the Maritime Provinces of Canada (Buehler 2000). Bald eagles are opportunistic foragers that frequently scavenge for dead or dying fish, waterfowl, and mammals or steal prey from other birds. They are typically found in coastal areas or along the margins of rivers and lakes. Bald eagles are known to occur in the northern portion of the Olympic Peninsula (see Section 2.2.6) and may use Port Angeles Harbor and nearby coastal areas for foraging. Because the bald eagle consumes larger and presumably older fishes than the cormorant, its exposure to bioaccumulative chemicals may be greater.

5.4.2 Quantification of Exposure

Chemical exposure for wildlife will be calculated as the sum of exposures from diet and incidental sediment ingestion. Dietary exposure will be calculated by multiplying the chemical concentration in each food item by its fraction of the total diet and summing the contribution from each item. This sum is then multiplied by the receptor's site use factor (SUF), exposure duration (ED), and ingestion rate (IR), and divided by the receptor's body weight (BW), as shown in the following equation:

$$EE_{diet} = \frac{[(C_1 \times F_1) + (C_2 \times F_2) + ...(C_n \times F_n)] \times SUF \times ED \times IR}{BW}$$

where:

EE_{diet} = Estimated exposure from diet (mg/kg-day);

C_n = Chemical concentration in food item *n* (mg/kg dry weight);

F_n = Fraction of diet represented by food item *n*;

SUF = Site use factor (unitless);

ED = Exposure duration (unitless);

IR = Ingestion rate of receptor (kg/day dry weight); and

BW = Body weight of receptor (kg fresh weight).

The SUF indicates the portion of an animal's home range represented by the site. If the home range is larger than the site, the SUF equals the site area divided by the home range area. If the site area is greater than or equal to the home range, the SUF is equal to 1. ED is the percentage of the year spent in the site area by the receptor species. Home-range size, IR, diet composition, and BW for the brant, double-crested cormorant, greater scaup, harbor seal, bald eagle, and raccoon will be taken from EPA (1993), Sample and Suter (1994), Sample et al. (1996), Kaufman (1996), and/or other applicable references.

Wildlife exposure to chemicals through incidental sediment ingestion is estimated in a manner similar to that used for dietary exposure. Specifically, the sediment chemical concentration is multiplied by the sediment IR and then multiplied by the SUF and ED and divided by BW. Sediment ingestion estimates for the receptor species will be taken from Sample and Suter (1994), Sample et al. (1996), Beyer et al. (1994), and/or other applicable references.

The total exposure for a receptor will be calculated as the sum of the exposure from diet and incidental sediment ingestion, as represented by the following equation:

$$EE_{total} = EE_{diet} + EE_{sediment}$$

where:

EE_{total} = total exposure (mg/kg-day);

EE_{diet} = estimated exposure from diet (mg/kg-day);

$EE_{sediment}$ = estimated exposure from sediment ingestion (mg/kg-day).

5.4.3 Exposure Point Concentrations

EPCs for site-related chemicals in sediment and biota will be developed as described below.

5.4.3.1 Sediment

As described in Section 3.4, E & E will use ProUCL version 4.0 to calculate the 95% UCL on the arithmetic average concentration for chemicals in sediment. The sediment EPCs will be area-weighted as appropriate based on the wildlife receptor being evaluated. For example, for the raccoon, only intertidal and splash-zone sediment samples will be used to estimate exposure. The sediment EPCs will be used to estimate exposure from incidental sediment ingestion, as described in Section 5.4.2. In addition, the sediment EPCs may be used to model uptake of sediment contaminants into wildlife prey if site-specific data on contaminant levels in wildlife prey are lacking.

5.4.3.2 Seagrass and Macroalgae

As described in the SAP (E & E 2008a), eelgrass (*Zostera spp*.) and/or kelp (order Laminariales.) will be collected and analyzed for site-related chemicals. These data will be used as input for the exposure assessment for the Brant and Greater Scaup.

5.4.3.3 Benthic Invertebrates

Benthic invertebrates are readily consumed by the scaup, raccoon, and harbor seal. The scaup and raccoon are likely to prey on the smaller invertebrate species that occur in the intertidal zone and/or littoral zone of Port Angeles Harbor, such as the coonstripe shrimp (*Pandalus danae*) and oysters (*Ostreola* spp.). A limited number of coonstripe shrimp and shellfish samples were analyzed for site-related chemicals by Malcolm Pirnie (2007a). These data will be used as input for the exposure assessment for the raccoon and scaup. The harbor seal is likely to consume larger benthic invertebrate species that occur in the deeper waters of the harbor, such as the Dungeness crab and horse clam. A limited number of Dungeness crab and horse clam samples were analyzed for site-related chemicals by Malcolm Pirnie (2007a). Additional clam samples will be collected during the harbor-wide investigation. These data will be used as input for the exposure assessment for the harbor seal.

5.4.3.4 Fish

Fish are the preferred prey of the harbor seal, double-crested cormorant, and bald eagle. The harbor seal is known to prey on flatfish, such as the sole and flounder. The eagle may be expected to scavenge dead or dying flatfish and/or other fish species floating on the water surface or that wash ashore. A limited number of rock sole (*Pleuronectes bilineata*) and starry flounder (*Platichthys stellatus*) samples were analyzed for site-related chemicals by Malcolm Pirnie (2007a). These data will be used in the exposure assessment for the harbor seal and bald eagle. The cormorant preys on smaller fish species, such as the surf smelt (*Hypomesus pretiosus*) and shiner perch (*Cymatogaster aggregata*). Unfortunately, no data on contaminant levels in these species or similar species are available for Port Angeles Harbor. In lieu of these data, E & E will use data on contaminant levels in sole and flounder from Port Angeles Harbor, or model levels of site-related chemicals in forage fish, to estimate dietary exposure for the cormorant.

5.5 Ecological Effects Assessment

The ecological effects assessment establishes concentrations and doses of chemicals that are associated with toxicity. For benthic life, appropriate sediment quality benchmarks are selected. For fish, critical tissue concentrations associated with effects on fish can be selected. For wildlife, reference doses are selected. Lastly, for some receptor groups, ecological effects can be measured directly using bioassay methods. This section describes the selection of media benchmarks, references doses, and bioassays for the Port Angeles Harbor ERA.

5.5.1 Sediment Quality Benchmarks

Sediment benchmarks will be taken from the following sources in order of preference:

- *Washington State Sediment Management Standards* (Chapter 173-204 WAC);
- *A Compendium of Environmental Quality Benchmarks* (MacDonald et al. 2000);
- *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision* (Jones et al. 1997); and
- *NOAA Screening Quick Reference Tables* (Buchman 1999).

Other sources also may be used if those listed above do not provide benchmarks for all chemicals of interest in sediment at the site. Bioassay results or elevation above reference concentrations may be used if sediment quality benchmarks cannot be identified.

5.5.2 Fish Tissue Benchmarks

Critical fish-tissue concentrations associated with adverse effects on fish will be taken from the following sources:

- *Lower Duwamish Waterway. Quality Assurance Project Plan: Fish and Crab Tissue Collection and Chemical Analysis. Appendices A to E* (Windward 2004);

- *A Compendium of Environmental Quality Benchmarks* (MacDonald et al. 2000);

- *Linkage of Effects to Tissue Residues: Development of a Comprehensive Database for Aquatic Organisms Exposed to Inorganic and Organic Chemicals* (Jarvinen and Ankley 1999);

- *Phase 1 Fish Tissue Sampling Data Evaluation, Upper Columbia River Site CERCLA RI/FS* (CH2MHILL 2006); and

- *Assessments of Chemical Mixtures via Toxicity Reference Values Overpredict Hazard to Ohio River Fish Communities* (Dyer et al. 2000).

Other sources also may be used if those listed above do not provide benchmarks for all chemicals of interest in fish at the site.

5.5.3 Wildlife Toxicity Analysis

No observed adverse effect levels (NOAELs) and lowest observed adverse effect levels (LOAELs) based on chronic effects on reproduction and/or growth will be the preferred toxicity reference values (TRVs) for the wildlife risk assessment. Chronic NOAELs and LOAELs will be taken from the following sources:

- EPA (2005b-j, 2006a, b, 2007b-e) for metals;

- Review of Navy–EPA Region 9 BTAG Toxicity Reference Values for Wildlife (CH2MHILL 2000); and

- Toxicological Benchmarks for Wildlife: 1996 Revision (Sample et al. 1996).

Other sources also may be used if those listed above do not provide TRVs for all chemicals of interest at the site, including information provided in peer-reviewed literature. If necessary, E & E will develop chronic NOAELs and LOAELs from subchronic or acute toxicity data using uncertainty factors recommended by Sample et al. (1996).

5.5.4 Bioassay Methods

Three different sediment bioassays will be conducted at selected sediment sampling stations to directly measure sediment toxicity, or the lack thereof, in Port Angeles Harbor:

- 10-day amphipod (*Rhepoxynius abronius, Eohaustorius estuarius, or Ampelisca abdita*) test (survival endpoint);

- 48-hour larval test (normal development endpoint) (*Mytilus galloprovincialis or Dendraster excentricus*)

- 20-day juvenile polychaete (*Neanthes arenaceodentata*) test (survival and growth endpoints)

These tests directly measure the combined effect of all sediment contaminants on benthos (PSEP 1995). Section 6.2 of the *Sampling and Analysis Plan* provides further detail on the bioassay methods.

5.6 Risk Characterization

The risk characterization section of the ERA will provide a summary of potential risks to the assessment endpoints listed in Table 5-1. The significance of the risks will be discussed.

Potential risks to wildlife receptors posed by site-related chemicals will be evaluated by calculating a hazard quotient (HQ) for each contaminant for each endpoint species. The HQ will be determined by dividing the total exposure (EE_{otal}) by the appropriate TRV, as shown in the following equation:

$$HQ = \frac{EE_{total}}{TRV}$$

HQs for each receptor will be calculated based on both the NOAEL and LOAEL (abbreviated as HQ-NOAEL and HQ-LOAEL, respectively). For a given receptor and chemical, a HQ-NOAEL greater than 1 indicates that the estimated exposure exceeds the highest dose at which no adverse effect was observed. Such a result does not necessarily imply that the receptor is at risk, especially if the HQ-NOAEL is only marginally above 1. A HQ-LOAEL greater than 1 suggests that a chronic adverse effect is possible to an individual receptor, assuming that the estimated exposure for that receptor is accurate.

Similarly, HQs for risks to benthic life and fish will be calculated by dividing chemical concentrations in sediment and tissue, respectively, by the appropriate benchmarks. If a resultant HQ is greater than 1, a potential risk exists for adverse effects from exposure to that chemical.

In addition, the growth and survival results for the sediment bioassays listed in Section 5.5.4 will be examined to identify locations of potential toxic effects. Bioassay results will be weighted more heavily than predictions of chemical toxicity to benthos based on calculated HQs.

Finally, potential risks to benthic life and aquatic vegetation will be inferred based on impacts to sediment habitat quality in areas of wood-waste deposition.

The ecological significance of HQs greater than 1 and of sediment habitat impacts will be discussed from the perspective of the weight-of-evidence of the chemical and biological data. Factors entering into this discussion could include bioavailability of contaminants, extent of contaminated areas, and uncertainties in the toxicology of the chemicals.

5.7 Uncertainty Assessment

The final analysis in the risk assessment will be a discussion of uncertainties in the analysis and possible effects these uncertainties could have on the interpretation of the results. Because modeling techniques will be used in the assessment of wildlife risks, uncertainties are associated with most portions of the risk calculations. However, the use of conservative assumptions throughout the analysis will ensure that risks are unlikely to be underestimated.

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Appendix E

Sediment Trend Analysis Implementation Plan

Port Angeles Harbor
Sediment Characterization Study
Port Angeles, WA

Appendix E
Sediment Trend Analysis
Implementation Plan

FINAL

Prepared for

Washington State Department of Ecology
Toxics Cleanup Program
300 Desmond Drive
Lacey, Washington 98504

Contract No. C0700036
Work Assignment No. EANE020

June 5, 2008

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Acronyms/Abbreviations

E & E	Ecology and Environment, Inc.
Ecology	Washington State Department of Ecology
GeoSea	GeoSea Consulting Ltd.
STA	Sediment Trend Analysis

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1.0 Introduction

Due to over a century of industrial activities surrounding and within Port Angeles Harbor, Washington, the surrounding sediments are known to have various levels of contaminants and a significant amount of wood debris that covers the bottom or has been transported and subsequently buried. The Washington Department of Ecology (Ecology) has tasked Ecology and Environment, Inc. (E & E) to investigate the extent of the environmental degradation in Port Angeles Harbor. Successful restoration and/or cleanup of the harbor is largely dependent on a thorough understanding of the natural physical processes operating in the environment, the nature of the sediments, their dynamic behavior and their sources and sinks. Sediment Trend Analysis (STA) will be implemented to assist in the characterization of sediment transport in Port Angeles Harbor.

1.1 Summary of Sediment Trend Analysis

STA was invented and has been developed by GeoSea Consulting Ltd (GeoSea). The published theory relates sediments in a given transport direction by a sediment transfer function, X(s), so that d2(s) = d1(s)X(s) where d1(s) and d2(s) are grain-size distributions of any two samples and 's' is grain-size in phi units. Depending on the shape of X(s), the function that describes the relative probability of any particular size being moved (i.e., eroded, transported and deposited), d2(s) may become finer, better sorted and more negatively skewed, or coarser, better sorted and more positively skewed than d1(s). Either relationship between d1(s) and d2(s) suggests that transport is occurring in the direction defined by the location of the two samples.

The shape of X(s) also determines the nature of the processes resulting in transport and provides the interpretation with respect to erosion, deposition, or dynamic equilibrium. This information is particularly useful in determining the fate and behavior of contaminants.

Patterns of net sediment transport are determined over two dimensions by finding, with the assistance of software developed by GeoSea, sample sequences that produce statistically acceptable trends. A final interpretation is accepted only when all, or nearly all, of the samples are contained in mutually supporting sequences that produce a coherent pattern over the entire study area. When required by the sediment characteristics, separate trend analyses are undertaken on the different facies that may be present (i.e., mud, sand, sandy mud, etc.).

Although STA has been widely applied to the assessment of particle-associated contaminants, it has not been used previously as a technique to establish the transport of wood debris. However, it appears reasonable to make as an initial assumption that its movement will not be greatly different from that established by the sediments. In undertaking the STA, considerable effort will be made to observe and assess the bark content in each sample and its relationship with the sedimentary particles. In this way, correlation will be made between visual observations with the results of the STA.

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2.0 Technical Approach

2.1 Data Requirements

The fundamental data required for STA are the grain-size distributions of bottom sediments taken on a regular sampling grid covering the area of interest. It is essential that sampling cover all environments that are likely to be affecting the movement and deposition of sediment inside the harbor. For this reason, the sampling design is intended to be sufficient to understand the seaward dynamics of Ediz Hook, the influence of the Strait of Juan de Fuca, and the importance of nearby rivers as potential sediment sources. The sampling design is presented in Figure 1, and includes a sample spacing interval of 125 m. The number of samples included in this design is 788.

2.2 Objectives

The specific objectives of the Sediment Trend Analysis are to:

- Collect 788 sediment grab samples from Port Angeles and adjacent waters.
- Visually assess and record each sample with respect to the relationship between wood material and sediments. Selected samples will be photographed to obtain a record of the various relationships between wood material and sediments.
- Analyze all samples for their grain-size distributions and establish, using the technique of sediment trends, the present patterns of transport and the dynamic behavior of the sediments associated with Port Angeles Harbor. Similar to item 2 (above), samples will also be photographed to provide further documentation of sediment-wood material mixtures.
- Determine areas of erosion, stability (dynamic equilibrium) and deposition as well as identifying sediment sources and sinks.
- Correlate and discuss the derived patterns of transport with known and/or probable processes as determined by the sediment trends themselves, existing literature and/or ongoing studies.
- Correlate the results of the STA with existing contaminant data and the qualitative assessments of wood material content.
- Use the above findings to assess the probable fate and behavior of both wood material and contaminants, optimum monitoring strategies, and remediation options to minimize adverse environmental consequences.

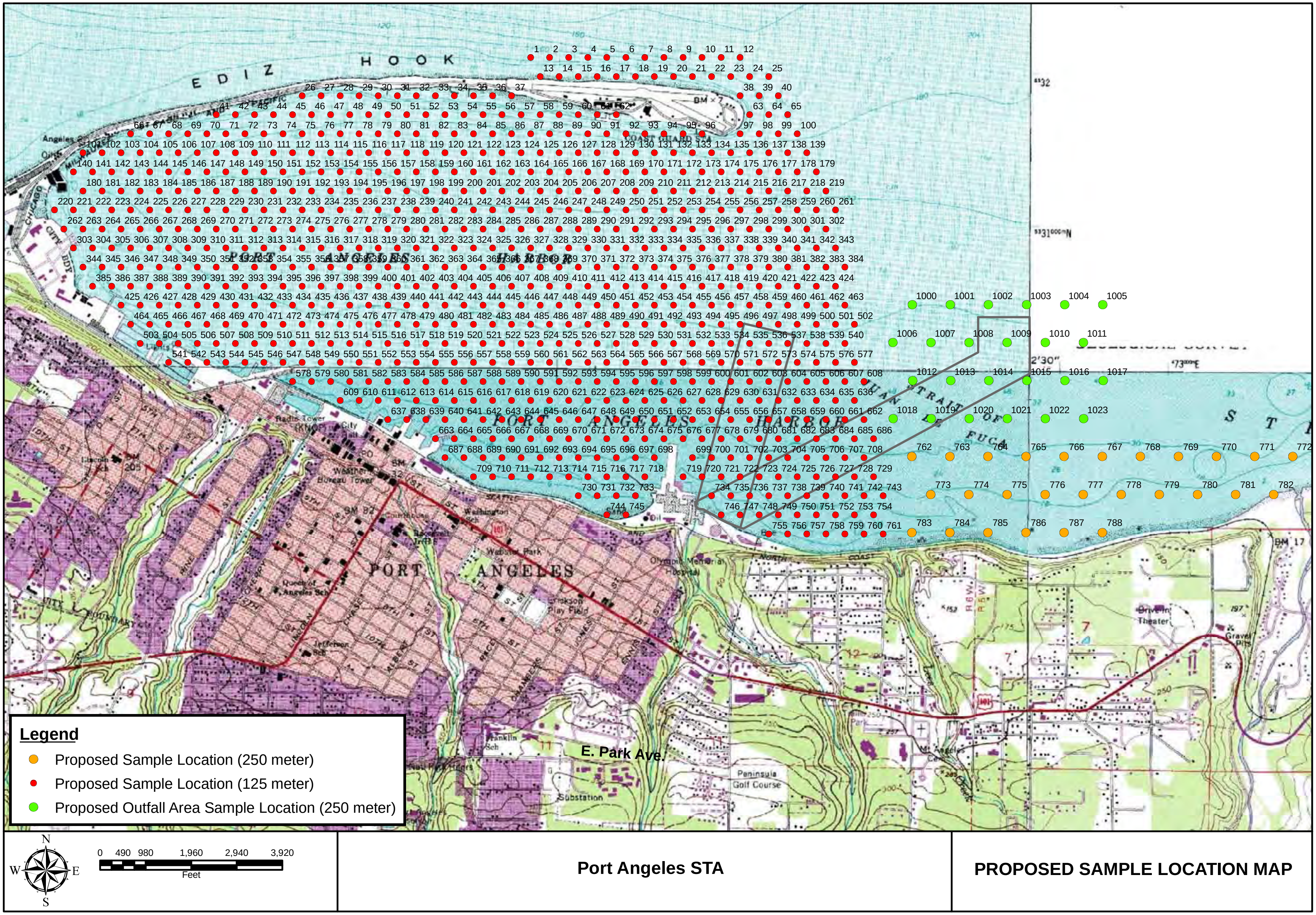
2.3 Sediment Collection Methods

Samples will be collected using a Caribe, hard-bottom inflatable vessel containing an electric winch and grab sampler. Positioning will be accomplished with a wireless Garmin GPS system with a nominal accuracy of 1.0 m. Using a Bluetooth connection, position data are linked directly to an HP iPAQ containing specialized GeoSea navigation programming. All sample observations will be recorded directly into the iPAQ. It is anticipated that the field program will take 20 days to complete, including travel, field mobilization time, and possible downtime due to weather conditions.

All samples will be analyzed for grain-size distribution using a Malvern MasterSizer 2000 laser particle size analyzer. This instrument is capable of determining the size spectrum of particles with sizes between 0.02µm and 2000µm. The distributions, combined with sieve data for sizes >1500µm, are "merged" using an algorithm developed by GeoSea. It is essential that all distributions are measured at ½ phi class intervals and that closure of the tails is less than 1 per cent.

2.4 Wood Material Characterization

The STA field crew will carefully document the presence and nature of wood material in all samples collected. STA samples will be examined for wood material immediately following retrieval of the grab sample and prior to any processing of sediment sample material for STA analysis. A Wood Material Characterization form will be completed for all samples (see Appendix B). Results and interpretation of the characterizations will be provided in the project Sediment Investigation Report.



Port Angeles STA

PROPOSED SAMPLE LOCATION MAP

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3.0 Personnel

Patrick McLaren

B.Sc. (1969): University of Calgary, Geology
M.Sc. (1972): University of Calgary, Geology
Ph.D. (1977): University of South Carolina, Geology

Dr. McLaren founded GeoSea in 1986 and will be the project manager and responsible for the overall project. He will take part in the field program and undertake the Sediment Trend Analysis, the presentation of the interpretation, and the preparation of the final report. Dr. McLaren has studied geomorphology, hydrology and sedimentology since 1972 and has published widely on all these subjects.

Steven Hill

B.Sc. (1970): University of British Columbia, Hons. Physics
M.Sc. (1979): University of Victoria, Marine Biology
Ph.D. (1991): University of British Columbia, Oceanography

Dr. Steven Hill worked with GeoSea from 1995 to 2004 and is now independent but in direct association with GeoSea. He undertakes company research and will carry out all the GIS requirements of the project including quality control, maps, and development of the final product.

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4.0 Schedule

Implementation of the STA fieldwork, data evaluation, and reporting will be conducted in accordance with the schedule milestones in the table below.

STA Activity	Dates/Milestone
Fieldwork/Sample Collection	March 14, 2008 – April 3, 2008
Data Reduction/Evaluation	April 4, 2008 – May 23, 2008
Draft STA Report	July 25, 2008
Final STA Report	August 25, 2008

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Appendix F

Current Meter Study Plan

Port Angeles Harbor
Sediment Characterization Study
Port Angeles, WA

Appendix F
Current Meter Study
Implementation Plan

FINAL

Prepared for

Washington State Department of Ecology
Toxics Cleanup Program
300 Desmond Drive
Lacey, Washington 98504

Contract No. C0700036
Work Assignment No. EANE020

June 5, 2008

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Attachment

Attachment 1 Health and Safety Plan for Current Meter Study

Acronyms/Abbreviations

ADCP	Acoustic Doppler Current Profiler
ADP	Acoustic Doppler Profiler
ADVO	Acoustic Doppler Velocimeter Ocean
E & E	Ecology and Environment, Inc.
Ecology	Washington State Department of Ecology
GeoSea	GeoSea Consulting Ltd.
Harbor	Port Angeles Harbor
HEC	Herrera Environmental Consultants
STA	Sediment Trend Analysis

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1.0 Introduction

Due to over a century of industrial activities surrounding and within Port Angeles Harbor (Harbor), Washington, sediments are known to have various levels of contaminants and there is a significant amount of wood debris that covers the bottom or has been transported and subsequently buried. The transport of sediments and wood debris is heavily influenced by the dynamic water circulation processes in the Harbor. There is presently conflicting and/or a lack of concrete information on these hydrographic processes in the Harbor, particularly with regard to the directional circulation patterns of surface and subsurface currents (Pers. comm. Larry Dunn, March 2008, Malcom Pirnie 2007, and Shea et al. 1981). No conclusive studies have been conducted to determine bottom current flow, and initial observations indicate that subsurface flow may be markedly different from surface flows (Pers. comm. Larry Dunn, March 2008, and Shea et al. 1981). As part of the Sediment Characterization Study being conducted by the Washington Department of Ecology (Ecology), further information is needed concerning the general circulation and wave patterns in the Harbor in order to ascertain how those processes potentially affect sediment contaminant transport. This current meter study, in conjunction with the Sediment Trend Analysis (STA) study, will aid in the interpretation of the natural physical processes operating in the environment, the nature of the sediments, their dynamic behavior and their sources and sinks in Port Angeles Harbor.

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2.0 Technical Approach

2.1 Data Requirements

The specific objectives of the Current Study are to determine the general circulation of water in the Harbor throughout the spring-neap (two-week) tidal cycle, the presence or absence of near-bed transport, and the environmental conditions that drive transport when it occurs.

The study will consist of two parts. The first portion of the study will identify the general currents within the Harbor through the use of bottom-mounted tripods. These tripods will measure currents in the water column and within the bottom boundary layer in deeper portions of the harbor. To support these observations, a geomorphic assessment of the shoreline and marine waters between the mouth of Morse Creek and the tip of Ediz Hook will be performed as the second part of the study. This analysis will include the geomorphic ramifications of all human activities in and surrounding the Harbor, and the probable fate of past sediment-bound pollutant discharges. The result of the geomorphic survey will be a listing of the physical processes potentially responsible for transport of sediment material in shoreline areas. Because of the local variability in the presence of swell (waves originating in the open ocean), these nearshore geomorphic measurements will also provide an estimate of the spatial distribution of wave energy.

2.2 Field Methods

The tripod deployment will include three tripods. Upward-looking current profiles and near-bottom single point currents will be collected at each location as well as wave, temperature, pressure, and turbidity measurements. For the geomorphic survey, nearshore and shallow subtidal areas will be visually observed during spring (low) tides. Geomorphic indicators will be visually identified and compared to existing maps of sediment transport along the Port Angeles shoreline. Measurements of the volume of recent deposition will be made at sediment source sites (i.e. creek deltas) where recent sedimentation can be easily identified to provide an estimate of the influx of new sediment into the Harbor.

2.2.1 Personnel

Evans Hamilton will deploy the tripods and process the data collected from them. Professional geomorphologists from Herrera Environmental Consultants (HEC) will perform the nearshore survey and coordinate with Evans Hamilton on results interpretation and presentation.

2.2.2 Measurement Locations

Measurements will be collected at three stations (Figure 1) for one-month deployments covering March 26 to April 25, 2008. The dates and locations of each site are listed in Table 1. Anchorages shown on Figure 1 are the locations of permanent anchors for boat moorage in the open Harbor, and were avoided when locating tripod stations.

The nearshore geomorphic survey will examine all known active sources of sediment input to Port Angeles Harbor, as well as appraise shoreline conditions between the tip of Ediz Hook and the mouth of Morse Creek.

2.2.3 Instrumentation at Station 1 and Station 2

The specific instruments to be used at each location and their respective measured parameters are listed in Table 2. Sontek Acoustic Doppler Profilers (ADP) will be used to measure currents in the water column above the instrument package as well as temperature and pressure. A Sontek Hydra will be used to collect the single point current and temperature data from the Sontek Acoustic Doppler Velocimeter Ocean probe (ADVO), and pressure data from the PAROS pressure sensor (Figure 2). The Hydra is an integrated instrument data logging system that allows greater data file sizes, and therefore, higher sampling rates and longer deployment times. Wave and temperature data will be collected using a Coastal Leasing MacroWave. The MacroWave measures pressure (ICS Strain Gauge or Paroscientific Digiquartz) and temperature (internal YSI thermistor) to record wave height and water level. The D&A OBS®-3 sensor measures suspended solids and turbidity using optical backscatter.

2.2.4 Instrumentation at Station 3

A Teledyne-RDInstruments Acoustic Doppler Current Profiler (ADCP) will be used to measure currents in the water column above the instrument package as well as temperature and pressure, and waves. A Coastal Leasing MacroDopp will be used to collect the single point current, temperature, and pressure data from the Nortek Vector Acoustic Doppler Velocimeter (Vector ADV) (Figure 3). A Coastal Leasing MacroLite will measure turbidity with a D&A OBS-3 turbidity monitor and temperature with an internal YSI thermistor.

2.3 Data Analysis

Evans Hamilton, with support from Herrera, will prepare a report that contains the range of current, wave and turbidity observed, interpretations of general circulation and wave patterns, correlation of currents to observed water levels at the NOAA tide gage in Port Angeles, correlation of wave activity to reported winds at local airports, and the correlation of the bed shear stress to sediment resuspension events (i.e., times that indicate turbidity). This analysis will also evaluate existing numerical models of the area and identify the potential effort needed for predictive estimates of transport within the Harbor.

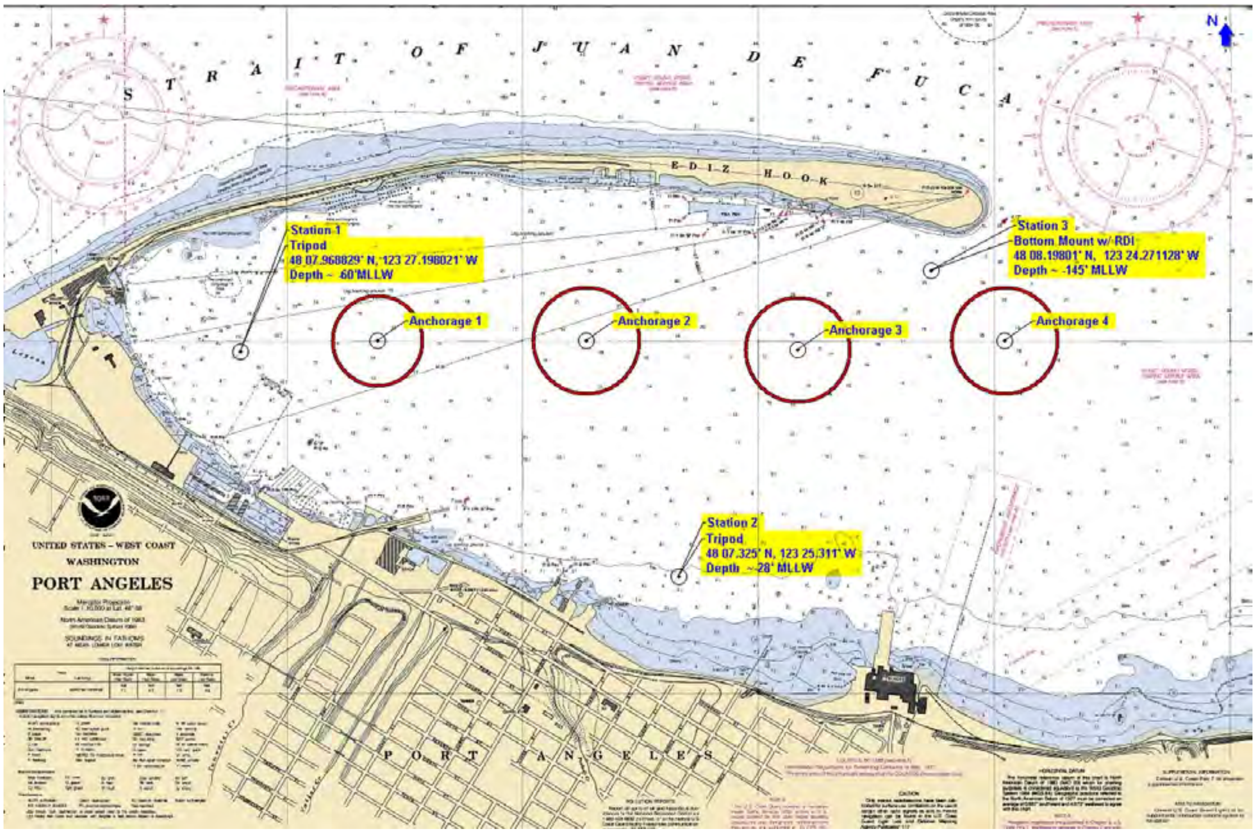

Figure 1 Instrument Deployment Locations, Stations 1, 2, and 3

Figure 2 Instrument Package for Stations 1 & 2

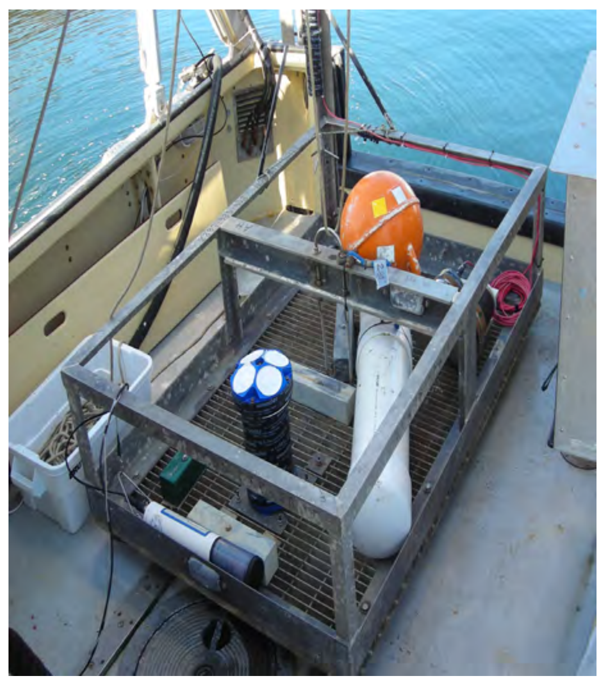

Figure 3 Instrument Package for Station 3

Table 1 Station Dates and Locations

Station Number	Latitude	Longitude	Depth at Deployment	Deployment Date	Recovery Date
Station 1	48 07.969' N	123 27.198' W	-70' MLLW	26-Mar-08	25-Apr-08
Station 2	48 07.325' N	123 25.311' W	-30' MLLW	26-Mar-08	25-Apr-08
Station 3	48 08.198' N	123 24.271' W	-150' MLLW	26-Mar-08	25-Apr-08

Table 2 Deployed Instrumentation and Measured Parameters

Equipment	Manufacturer	Serial Number	Frequency	Parameters Measured*
Station 1				
ADP	SONTEK	C-4	500 kHz	CP, T, P
ADVo	SONTEK	B116	5 MHz	C, T, P, Dist
HYDRA	SONTEK	7	Logger (ADVo, Paros)	
Pressure Sensor	PAROS	69455	N/A	P
MacroWave	Coastal Leasing	10713	50 psi	T,P,W
OBS-3	D&A	2598	2 Hz	Tb
866-Release	Benthos	29	Tx12/Rx 11 kHz	
Tripod	Pacific International Eng.	NAV	N/A	
Station 2				
ADP	SONTEK	C-122	1500 kHz	CP, T, P
ADVo	SONTEK	B70	5 MHz	C, T, P, Dist
HYDRA	SONTEK	NAV	Logger (ADVo, Paros)	
Pressure Sensor	PAROS	69455	N/A	P
MacroWave	Coastal Leasing	10715	50 psi	T,P,W
OBS-3	D&A	2537	2 Hz	Tb
866-Release	Benthos	328	Tx12/Rx 14 kHz	
Tripod	Pacific International Eng.	NAV	N/A	
Station 3				
ADCP (waves)	RD- Instruments	10347	600 kHz	CP, T, P
MacroLite	Coastal Leasing	10485	N/A	T + logger for OBS-3
OBS-3	D&A	2539	2 Hz	Tb
Vector ADV	Nortek	0839/4218	8Hz	C, T, P
MacroDopp	Coastal Leasing	10750	Logger (ADV)	
866-Release	Benthos	148	Tx12/Rx 13.5 kHz	
Open Side Bottom mount	EHI	NAV	NAV	

*CP = Current Profile, C = Currents at one depth, T = Temperature, P = Pressure, Tb = Turbidity, Dist = Distance above Bottom, W = Waves

3.0 Schedule

Implementation of the current study fieldwork, data evaluation, and reporting will be conducted in accordance with the schedule milestones in the table below.

STA Activity	Dates/Milestone
Fieldwork/Sample Collection	March 2008 – April 2008
Data Reduction/Evaluation	May 2008
Draft Current Study Report	July 25, 2008
Final Current Study Report	August 25, 2008

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Attachment 1. Health and Safety Plan for Current Meter Study

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HEALTH AND SAFETY PLAN

PORT ANGELES HARBOR
SEDIMENT INVESTIGATION
BOTTOM CURRENT STUDY

Prepared for

Ecology and Environment, Inc.

368 Pleasant View Drive

Lancaster, NY 14086

Prepared by

Evans-Hamilton, Inc.

4608 Union Bay Place N.E.

Seattle, Washington 98105-4026

March 2008

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HEALTH AND SAFETY PLAN APPROVAL

This Health and Safety Plan (HASP) has been reviewed and approved for deployment of bottom mounted current moorings within Port Angeles Harbor, Washington. This site HASP has been written for the use of Evans-Hamilton, Inc. (EHI) personnel and its subcontractors. EHI claims no responsibility for its use by others. The plan is written for the specific site conditions, purposes, dates, and personnel specified and must be amended if these conditions change.

PREPARED BY:

Carol Coomes, Project Manager — Date
Evans-Hamilton, Inc. — March 14, 2008

REVIEWED BY:

Kevin Redman, Safety Officer — Date
Evans-Hamilton, Inc. — March 14, 2008

ACCEPTED BY:

Name, Title — Date
Organization

1 INTRODUCTION

Evans-Hamilton, Inc. (EHI) is under contract with Ecology and Environment, Inc. (E&E), who is contracted by the Washington State Department of Ecology (Ecology), to collect current data from the bottom water column within Port Angeles Harbor (Harbor). EHI operations for March and April 2008 include deployment/retrieval of three bottom mounts. Figure 1 shows the general location of the work site. Five sites are referenced on figure 1 with preference given to sites 1-3 for deployment.

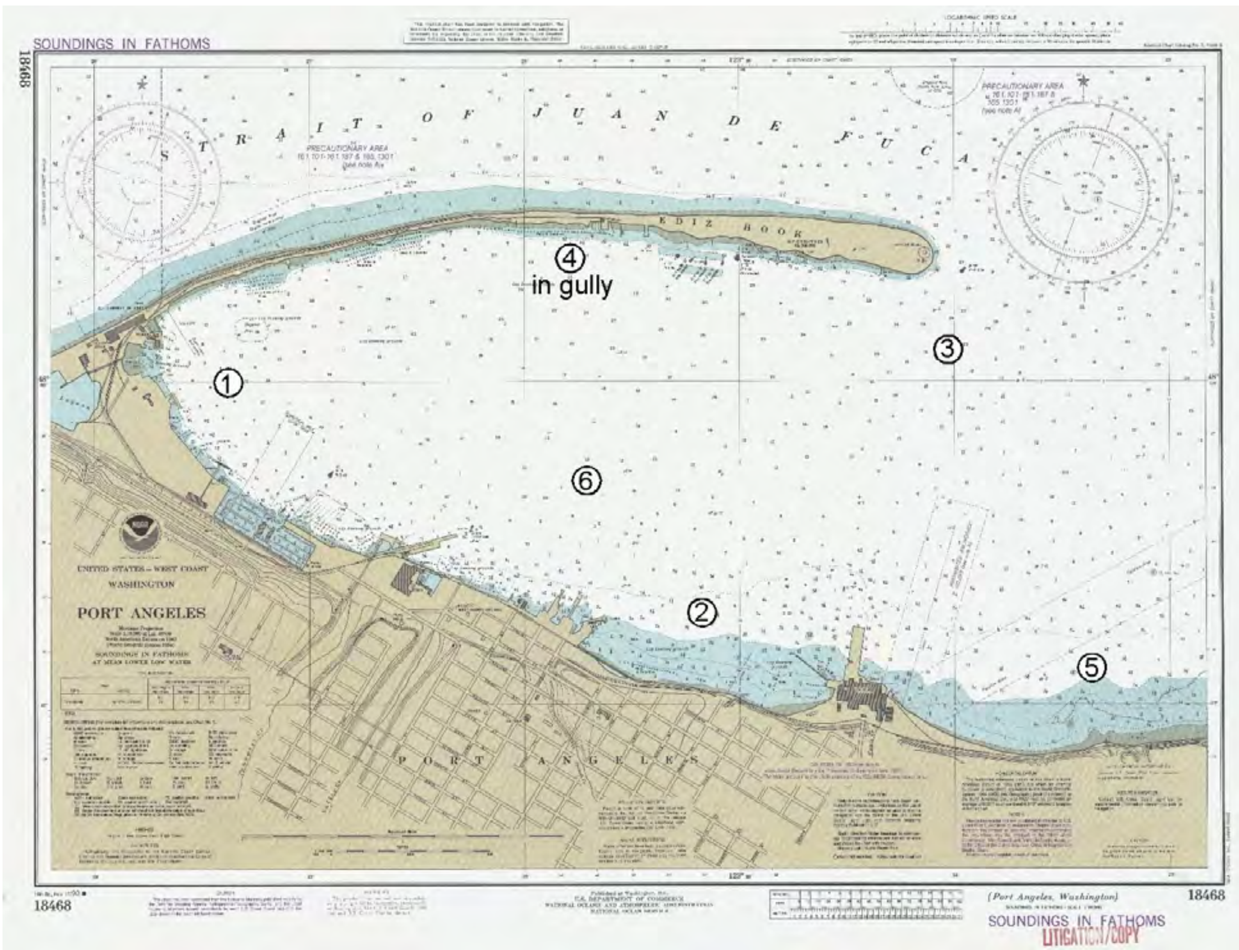


Figure 1. Prioritized bottom current locations within Port Angeles Harbor.

Sections and forms of this HASP which directly reference the Scope of Work are attached in Appendix B. These are certifications, including the vessel captain's license.

2 COMPANY SAFETY POLICY FOR EVANS-HAMILTON, INC.

Evan-Hamilton, Inc.'s primary focus is the safety and well being of all individuals working on the project, be they EHI employees, subcontractors, or client representatives,. In an effort to keep everyone safe we have established certain requirements and guidelines that pertain to our specific industry.

The purpose of this policy is to develop a high standard of safety throughout all operations of Evans-Hamilton, Inc. and to ensure that no employee is required to work under any conditions, which are hazardous or unsanitary.

We believe that each employee has the right to derive personal satisfaction from his/her job and the prevention of occupational injury or illness is of such consequence to this belief that it will be given top priority at all times.

It is our intention here at Evans-Hamilton, Inc. is to initiate and maintain complete accident prevention and safety training programs. Each individual from top management to the working person is responsible for the safety and health of those persons in their charge and co-workers around them. By accepting mutual responsibility to operate safely, we will all contribute to the well being of our fellow employees, and ourselves.

All Evans-Hamilton, Inc. field personnel involved in fieldwork on this project are required to comply with this HASP. The contents of this HASP reflect the types of activities to be performed. The HASP may be revised based on new information and/or changed conditions during site activities. Revisions will be documented in the change form in Appendix A.

3 SITE DESCRIPTION AND PROJECT SCOPE

3.1 Site Description

The area of interest for data collection lies within and at the entrance to Port Angeles Harbor, WA (Figure 1).

3.2 Scope and Duration of Work

The scope of work involves:

- Collecting bottom currents at three locations to provide information regarding the transport of sediment and wood debris.

Deployment and retrieval operations will be conducted from a vessel of adequate size and lifting capability for the respective type of bottom mounts (tripods). Each tripod will be outfitted with an upward looking acoustic Doppler current profiler (ADCP), a microwave gauge, a single point current meter, and an optical backscatter sensor (OBS). The estimated duration in the field work is one day in March 2008 for deployment and one day in April 2008 for recovery of the tripods.

4 HEALTH AND SAFETY PERSONNEL

Evans-Hamilton, Inc. will be assisted by one other contractor to perform the required scope of work. This contractor is:

- M/V Brendan D. II, Sound Vessels, Inc.

EHI will have an individual on the sampling vessel to ensure that health and safety procedures are followed at all times.

Key health and safety personnel and their responsibilities are described below. These individuals are responsible for the implementation of this HASP.

Project Manager—Carol Coomes (EHI): The Project Manager (PM) has overall responsibility for the successful outcome of the project. The PM will ensure that adequate resources and budget are provided for the health and safety staff to carry out their responsibilities during fieldwork. The PM, in consultation with the HSM, makes final decisions concerning implementation of the HASP.

Field Coordinator—Kevin Smith (EHI): A qualified Field Coordinator (FC) will be assigned for each type of monitoring task that will be conducted in the field. The FC will support field-sampling activities and coordinate between the technical and health and safety components of the field program. The FC has the responsibility to ensure that work is performed according to the Field Safety Plan (FSP). The FC also has the authority to stop work if conditions arise that pose an unacceptable health and safety risk to field crew. The FC will also be responsible for ensuring the implementation of this HASP aboard the sampling vessel. The FC is responsible for initiating changes to the HASP, which must be approved by the HSM. The FC or designee shall be present during field sampling and handling operations.

Health and Safety Coordinator—Jeff Cox (EHI): The Health and Safety Coordinator (HSC) will not be present during fieldwork, but will be readily available, if required, for consultation regarding health and safety issues during fieldwork.

Vessel Captain—Mr. Ian Fraser (M/V Brendan D. II): The respective vessel captain and the FC will coordinate health and safety oversight of operations aboard the vessel. The captain will also have stop work authority for safety reasons. Work will be resumed after the captain and the FC agree that the situation that precipitated a stop work decision has been corrected.

Field Crew: All field crew have stop work authority for safety reasons. All field crew have the responsibility to report any potentially unsafe or hazardous conditions to the captain or FC immediately.

5 HAZARD EVALUATION AND CONTROL MEASURES

This section covers potential physical hazards that may be associated with the proposed project activities, and presents control measures for addressing these hazards. The activity hazard analysis, Section 5.2, lists the potential hazards associated with each site activity and the recommended site control to be used to minimize each potential hazard. Confined space entry will not be necessary for this project, so hazards associated with this activity are not discussed in this HASP.

5.1 Physical Hazards

5.1.1 Slips, Trips, and Falls

As with all fieldwork sites, caution should be exercised to prevent slips on slick surfaces. In particular, sampling from a floating platform requires careful attention to minimize the risk of falling down or falling overboard. The same care should be used in rainy conditions. Wearing boots with good tread, made of material that does not become overly slippery when wet, can minimize slips.

Trips are always a hazard on the uneven deck of a boat or in a cluttered work area. The deck of the vessel will have moving cables, and there are numerous stationary fittings and tie-downs that present potential tripping hazards. Personnel will keep work areas as free as possible from items that interfere with walking and will be aware of stationary obstacles on deck.

Falls may be avoided by working as far away from exposed edges as possible. For this project, the potential for falling is associated primarily with deployment and recovery of the field equipment over the stern of the vessel, and with boarding and disembarking the vessel at the dock.

5.1.2 Field Equipment

Before field activities begin, there will be a training session for all field personnel pertaining to the equipment that will be onboard the vessel. The captain will review vessel-specific hazards and safety procedures and will point out the location and proper use of all safety equipment. For example, field personnel will be shown the locations of all fire extinguishers, flotation rings, and first aid kits and their appropriate uses.

A major hazard during field operations will be the deployment and retrieval of the bottom tripods. The tripods will have multiple instruments attached and will require coordination between the vessel captain and field crew to safely deploy and retrieve. Close attention will need to be made when the tripods are lifted and retrieved over the side of the ship. Loads will need to be properly controlled with tag lines when moving the tripods, and proper attention will need to be made to keep hands, and feet clear of the operation. All ropes and deployment equipment will need to be checked prior to commencing any operation.

Other hazards when working on a vessel involve the overhead cables, davits, and A-frames while lifting heavy equipment. All field personnel working on the back deck will wear hard hats and steel-toed boots.

5.1.3 Falling Overboard

The majority of the field operations will be done from a vessel. As with any work from a floating platform, there is a chance of falling overboard. A personal floatation device (PFD) for each crew person will be available in the boat at all times. PFDs will be worn while working from the vessel.

5.1.4 Manual Lifting

Heavy equipment must be lifted and moved on and off the vessels. Back strain can result if lifting is done improperly. During any manual handling tasks, personnel should lift with the load supported by their legs and not their backs. For heavy loads, an adequate number of people will be used, or if possible, a mechanical lifting/handling device. All tripods will be lifted to/from the vessel using a mechanical device.

5.1.5 Heat Stress

Scheduled field operations will not be occurring in summer, so high temperatures should not be encountered. If temperatures do rise to summer conditions, the potential for heat stress may occur if impermeable personal protective equipment (PPE) is worn or if strenuous work is performed under hot conditions with inadequate water. When the core body temperature rises above 100.4°F, the body cannot sweat to cool down, and heat stress can occur. Heat stress may be identified by the following symptoms: dizziness, profuse sweating, skin color change, vision problems, confusion, nausea, fatigue, fainting, and clammy skin. Personnel exhibiting such symptoms will be removed to a cool shady area, given water, and allowed to rest. Fresh drinking water will be provided aboard the vessel. All field team members will monitor their own condition and that of their co-workers to detect signs of heat stress.

5.1.6 Hypothermia

Hypothermia is abnormal lowering of the core body temperature caused by exposure to a cold environment. Wind chill as well as wetness or water immersion can play a significant role. Typical signs of hypothermia include fatigue, weakness, and lack of coordination, apathy, and drowsiness. Confusion 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 the temperature to normal. Current medical practice recommends slow warming of the individual followed by professional medical care. Moving the person to a sheltered area and wrapping them in a blanket can accomplish this portion of the task. If possible, the person should be placed in a warm room. In emergency situations where body temperature falls below 90°F and shelter is not available, a sleeping bag, blankets, and body heat from another individual can be used to help raise body temperature.

5.1.7 Weather

In general, field team members will be equipped for the normal range of weather conditions. The FC will be aware of current weather conditions, and of the potential for those conditions to pose a hazard to the field crew. Some conditions that might force work stoppage are electrical storms, high winds, or high waves resulting from winds.

5.2 Activity Hazard Analysis

The activity hazard analysis summarizes the field activities to be performed, outlines the hazards associated with each activity, and presents controls that can reduce or eliminate the risk of the hazard occurring.

Table 1 presents the activity hazard analysis for the following activities:

- Deployment and retrieval of instrument platforms

Table 1
Activity Hazard Analysis

Activity	Hazard	Control
Deployment and retrieval of tripods	Falling overboard	Avoid working near the edge of the vessel, if possible. Stay inside of perimeter barriers on the deck.
	Cuts, head injuries, crushed toes	Wear gloves, steel-toed boots, and hard hats.
	Back or muscle strain	Use appropriate lifting technique when handling grab sampler or any other pieces of potentially heavy equipment. Enlist help if necessary.
	Skin or eye contact with potentially contaminated sediments	Wear modified Level D PPE, including eye protection.
	Slipping/tripping on slick or uneven deck	Wear steel-toed boots with gripping tread. Be aware of obstacles and wet patches on deck and select a path to avoid them. Keep deck clean and organized as best as possible.
	Injury from winch line snapping	Ensure that winch line is not frayed.
	Injury from equipment falling or swinging	Wear a hard hat and steel-toed boots at all times; be in the appropriate position on deck when equipment is in operation.
	Hearing damage	Use hearing protection as appropriate for conditions.

6 PERSONAL PROTECTIVE EQUIPMENT AND SAFETY EQUIPMENT

Appropriate PPE will be worn as protection against potential hazards. In addition, a PFD will be required when working on the vessel. Prior to donning PPE, the workers will inspect their equipment for any defects that might render the equipment ineffective.

Fieldwork will be conducted in Level D, as discussed below in Sections 6.1. Situations requiring PPE beyond Level D are not anticipated for this project. Should the FC determine that PPE beyond Level D is necessary at a given location, the FSC will notify the HSM to select an alternative.

6.1 Level D Personal Protective Equipment

Workers performing general activities in which skin contact with contaminated materials is unlikely and in which inhalation risks are not expected will wear Level D PPE. Level D PPE includes the following:

- Cotton overalls or other task-specialized outer garb (e.g., raingear)
- Steel-toed boots
- Leather, cotton, or chemical-resistant gloves, as the type of work requires
- Hard hat, if overhead hazard exists
- Safety glasses, if necessary
- Hearing protection, if necessary

6.2 Safety Equipment

In addition to PPE that will be worn by shipboard personnel, basic emergency and first aid equipment will also be provided. Equipment will include:

- A copy of this HASP
- PFD
- First aid kit adequate for the number of personnel

Evans-Hamilton, Inc. will provide this equipment, which must be at the location(s) where field activities are being performed. Equipment will be checked daily to ensure its readiness for use.

7 TRAINING REQUIREMENTS

Individuals performing work at locations where potentially hazardous materials and conditions may be encountered must meet specific training requirements. It is not anticipated that personnel will encounter hazardous concentrations of contaminants in sediments clinging to the retrieved tripods. Therefore training will consist of site-specific instruction for all personnel and oversight of inexperienced personnel for one working day. The following sections describe the training requirements for work at this site.

7.1 Training Requirements

The project team has the requisite experience and technical skills to successfully conduct the tasks associated with this project. All consultant team personnel involved have extensive experience in the deployment and retrieval of marine equipment.

At least two people on each field crew will have a current certification in first aid and cardio-pulmonary resuscitation (CPR) by the American Red Cross.

7.2 Project Specific Training

All personnel must read this HASP and be familiar with its contents before beginning work. They shall acknowledge reading the HASP by signing the field team HASP review form contained in Appendix A. The form will be kept in the project files.

The FC or a designee will provide and document project-specific training during the project kickoff meeting and whenever new workers arrive onboard. Field personnel will not be allowed to begin work until project-specific training is completed and documented by the FC. Training will address the HASP and all health and safety issues and procedures pertinent to field operations. Training will include, but not be limited to, the following topics:

- Activities with the potential for chemical exposure
- Activities that pose physical hazards, and actions to control the hazards
- Ship access control and procedures
- Use and limitations of PPE
- Decontamination procedures
- Emergency procedures

- Use and hazards of field equipment
- Location of emergency equipment on the vessel
- Vessel safety practices

7.3 Daily Safety Briefings

The FC or a designee and the captain will present safety briefings before the start of each day's activities. These safety briefings will outline the activities expected for the day, update work practices and hazards, and address any specific concerns associated with the work location, and review emergency procedures and routes. The safety briefings will be documented in the logbook.

8 RECORDING AND RECORD KEEPING

The FC or a designee will record health-and safety-related details of the project in the field logbook. The logbook must be bound and the pages must be numbered consecutively. Entries will be made with indelible ink. At a minimum, each day's entries must include the following information:

- Project name or location
- Names of all personnel
- Level of PPE worn and any other specifics regarding PPE
- Weather conditions
- Type of fieldwork being performed

The person maintaining the entries will initial and date the bottom of each completed page. Blank space at the bottom of an incompletely filled page will be lined out. Each day's entries will begin on the first blank page after the previous workday's entries.

As necessary, other documentation will be obtained or initiated by the FC. Other documentation may include field change requests, medical and training records, exposure records, accident/incident report forms, Occupational Safety and Health Administration (OSHA) Form 200s, and material safety data sheets. Appendix A contains copies of key health and safety forms.

9 MONITORING PROCEDURES FOR SITE ACTIVITIES

A monitoring program that addresses the potential site hazards will be maintained. For this project, air and dust monitoring will not be necessary. No volatile organic compounds (VOCs) have been identified at elevated concentrations among the expected contaminants, and the sampled media will be wet and will not pose a dust hazard. Monitoring procedures will consist of crew self-monitoring.

All personnel will be instructed to look for and inform each other of any deleterious changes in their physical or mental condition during the performance of all field activities. Examples of such changes are as follows:

- Headaches
- Dizziness
- Nausea
- Blurred vision
- Cramps
- Irritation of eyes, skin, or respiratory system
- Changes in complexion or skin color
- Changes in apparent motor coordination
- Increased frequency of minor mistakes
- Excessive salivation or changes in papillary response
- Changes in speech ability or speech pattern
- Symptoms of heat stress or heat exhaustion (Section 5.1.6)
- Symptoms of hypothermia (Section 5.1.7)

If any of these conditions develop, the affected person(s) will be moved from the immediate work location and evaluated. If further assistance is needed, personnel at the local hospital will be notified, and an ambulance will be summoned if the condition is thought to be serious. If the condition is the result of sample collection or processing activities, procedures and/or PPE will be modified to address the problem.

10 SAFE WORK PRACTICES

Following common sense rules will minimize the risk of exposure or accidents at a work site.

These general safety rules will be followed on site:

- Always use the buddy system
- Be aware of overhead and underfoot hazards at all times
- Get immediate first aid for all cuts, scratches, abrasions, or other minor injuries
- Report all accidents, no matter how minor, to the FC
- Be alert to your own and other workers' physical condition
- Do not climb over or under obstacles of questionable stability
- Make eye contact with equipment operators before moving into the range of their equipment

11 EMERGENCY RESPONSE PLAN

As a result of the health and safety hazards associated with the field activities, the potential exists for an emergency situation to occur. Emergencies may include personal injury, exposure to hazardous substances, fire, explosion, or release of toxic or non-toxic substances (spills). OSHA regulations require that an emergency response plan be available for use onboard to guide actions in emergency situations.

Onshore organizations will be relied upon to provide response in emergency situations. The local fire department and ambulance service can provide timely response. The nearby US Coast Guard facility can respond to water emergencies. EHI personnel and subcontractors will be responsible for identifying an emergency situation, providing first aid if applicable, notifying the appropriate personnel or agency, and evacuating any hazardous area. Shipboard personnel will attempt to control only very minor hazards that could present an emergency situation, such as a small fire, and will otherwise rely on outside emergency response resources.

The following sections address pre-emergency preparation, identify individual(s) who should be notified in case of emergency, provide a list of emergency telephone numbers, offer guidance for particular types of emergencies, and provide directions and a map for getting from any sampling location to a hospital.

11.1 Pre-Emergency Preparation

Before the start of field activities, the FC will ensure that preparation has been made in anticipation of emergencies. Preparatory actions include the following:

- Meeting with the captain and equipment handlers concerning the emergency procedures in the event that a person is injured. Appropriate actions for specific scenarios will be reviewed. These scenarios will be discussed and responses determined before the sampling event commences.
- A training session given by the captain informing all field personnel of emergency procedures, locations of emergency equipment and their use, and proper evacuation procedures.
- A training session given by senior staff operating field equipment, to apprise field personnel of operating procedures and specific risks associated with that equipment.

- Ensuring that field personnel are aware of the existence of the emergency response plan, its location as Section 12 of the HASP, and ensuring that a copy of the HASP accompanies the field team(s).

11.2 Site Emergency Coordinator

The FC will serve as the Project Emergency Coordinator in the event of an emergency. The FC will designate a replacement for times when he is not onboard or is not serving as the Project Emergency Coordinator. The designation will be noted in the logbook. The Project Emergency Coordinator will be notified immediately when an emergency is recognized. The Project Emergency Coordinator will be responsible for evaluating the emergency situation, notifying the appropriate emergency response units, coordinating access with those units, and directing interim actions onboard before the arrival of emergency response units. The Project Emergency Coordinator will notify the HSM and the PM as soon as possible after initiating an emergency response action. The PM will have responsibility for notifying the client.

11.3 Emergency Response Contacts

All personnel must know whom to notify in the event of an emergency situation, even though the FC has primary responsibility for notification. Table 2 lists the names and phone numbers for emergency response services and individuals.

11.4 Recognition of Emergency Situations

Emergency situations will generally be recognizable by observation. An injury or illness will be considered an emergency if it requires treatment by a medical professional and cannot be treated with simple first-aid techniques.

Table 2
Emergency Response Contacts

Contact	Telephone Number
Emergency Numbers	
Ambulance	911
Police	911
Fire	911
Emergency Responders	
U.S. Coast Guard – Port Angeles	
Emergency	911
General information	(360) 457-4404
Emergency Contacts	
Evans-Hamilton, Inc. Project Manager	
Carol Coomes	(206) 526-5622 (office) (206) 369-1911 (cell)
Evans-Hamilton, Inc. Field Coordinator	
Kevin Smith	(206) 526-5622 (office) (425) 773-0722 (cell)
Evans-Hamilton, Inc. Health and Safety Coordinator	
Jeff Cox	(206) 526-5622
Evans-Hamilton, Inc. Field Personnel	
Legare Smith	(206) 526-5622 (office) (843) 345-6779 (cell)
Marine Vessel Brendan D. II	
Ian Fraser	(360) 385-4486 (cell)

11.5 Fire

Shipboard personnel will attempt to control only small fires, should they occur. If an explosion appears likely, personnel will follow evacuation procedures specified by the captain in the training session. If a fire cannot be controlled with a fire extinguisher on board that is part of the required safety equipment, personnel will either withdraw from the vicinity of the fire or use additional fire fighting equipment, or evacuate the boat as specified by the captain in the training session.

11.6 Personal Injury

In the event of serious personal injury, including unconsciousness, possibility of broken bones, severe bleeding or blood loss, burns, shock, or trauma, the first responder will immediately do the following:

- Administer first aid, if qualified
- If not qualified, seek out an individual who is qualified to administer first aid, if time and conditions permit

- Notify the Project Emergency Coordinator of the incident, the name of the individual, the location, and the nature of the injury

The Project Emergency Coordinator will immediately do the following:

- Notify the captain and the appropriate emergency response organization
- Assist the injured individual
- Follow the emergency procedures for retrieving or disposing equipment reviewed in the training session and leave the site en route to the predetermined land-based emergency pick-up
- Designate someone to accompany the injured individual to the hospital
- If an emergency situation (i.e., broken bones or injury where death is imminent without immediate treatment) occurs, the FC or captain will call 911 and arrange to meet the response unit at the nearest accessible dock
- Notify the HSM and the PM

If the Project Emergency Coordinator determines that emergency response is not necessary, he or she may direct someone to decontaminate and transport the individual by vehicle to the nearest hospital. Directions and a map showing the route to the hospital are in Section 13.10.

If a worker leaves the ship to seek medical attention, another worker should accompany him or her to the hospital. When in doubt about the severity of an injury or exposure, always seek medical attention as a conservative approach and notify the Project Emergency Coordinator.

The Project Emergency Coordinator will have responsibility for completing all accident/incident field reports, OSHA form 200s, and other required follow-up forms.

11.7 Overt Personal Exposure or Injury

If an overt exposure to toxic materials occurs, the first responder to the victim will initiate actions to address the situation. The following actions should be taken, depending on the type of exposure:

Skin Contact:

- Wash/rinse the affected area thoroughly with copious amounts of soap and water
- If eye contact has occurred, eyes should be rinsed for at least 15 minutes using the eyewash that is part of the emergency equipment onboard and in the lab
- After initial response actions have been taken, seek appropriate medical attention

Inhalation:

- Move victim to fresh air
- Seek appropriate medial attention

Ingestion:

- Seek appropriate medical attention

Puncture Wound or Laceration:

- Seek appropriate medical attention

11.8 Spills and Spill Containment

Sources of bulk chemicals or other materials subject to spillage are not expected to be used during this project. Accordingly, a spill containment procedure is not required for this project.

11.9 Emergency Route to the Hospital

The name, address, and telephone number of the hospital that will be used to provide medical care is as follows:

Olympic Memorial Hospital
939 Caroline St
Port Angeles, WA 98362
(360) 417-7000
Olympicmedical.org

Figure 2 is a map of the route from City Pier to Olympic Memorial Hospital. Directions from the vicinity of the City Pier to Olympic Memorial Hospital are as follows:

- Depart City Pier toward Port Angeles on N Lincoln Street (south) for 120 yards
- Turn RIGHT (west) onto US-101 (E. Front Street) for 10 yards
- Turn LEFT (south) onto US-101 (N Lincoln Street) for 131 yards
- Turn LEFT (east) onto US-101 (E 1st St) for 0.7 mile
- Turn LEFT (north) onto N Race Street for 0.2 mile
- RIGHT (east) onto Caroline Street for 76 yards
- Arrive 939 Caroline St. Port Angeles WA, Olympic Memorial Hospital

Figure 2 Map showing route from City Pier to Olympic Memorial Hospital.

APPENDIX A

SAFETY RECORD FORMS

HEALTH AND SAFETY PLAN ACKNOWLEDGEMENT

I have reviewed the site-specific HASP prepared by Evans-Hamilton, Inc., dated March 2008, for the Port Angeles Bottom Current Study fieldwork. I understand the purpose of the plan, and I consent to adhere to its policies, procedures, and guidelines while an employee of Evans-Hamilton, Inc. or its subcontractors.

Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date
Employee signature	Company	Date

FORM 1

MODIFICATION TO HEALTH AND SAFETY PLAN
EVANS-HAMILTON, INC.

DATE ___/___/___

Project: Port Angeles Bottom Current Study, March 2008

Modification:

____
____
____
____

Reasons for Modification:

____
____
____
____
____

Site Personnel Briefed

Name: ______________________________ Date: _________________________

Name: ______________________________ Date: _________________________

Name: ______________________________ Date: _________________________

Name: ______________________________ Date: _________________________

Name: ______________________________ Date: _________________________

Name: ______________________________ Date: _________________________

Name: ______________________________ Date: _________________________

Approvals

Evans-Hamilton, Inc. Health and Safety Manager:________________________________

Site Safety and Health Officer: ____

Evans-Hamilton, Inc. Program Manager: ______________________________________

FORM 2

EVANS-HAMILTON, INC.
EMPLOYEE EXPOSURE / INJURY INCIDENT / SPILL / NEAR MISS REPORT
(Use additional page if necessary)

Date: ____ Time: ______________________

Name: ______________________________ Employer: _______________________________

Type of Occurrence: employee exposure, injury incident, spill, near miss

SITE NAME AND LOCATION: ____
Site Weather (clear, rain, snow, etc.): ____

Nature of Illness/Injury: ____

SYMPTOMS: ____
Action Taken: Rest _________ First Aid ___________ Medical _________________

Transported By: ____

Witnessed By: ____

Hospital's Name: _______________________ Treatment: ______________________

Describe in detail how this Accident/Incident/Spill/Near Miss occurred. (If a spill, list the name of the compounds, quantities and method of clean-up/containment.)

____

____

____

____

What was the person doing at the time of the accident/incident? ___________________

____

PERSONAL PROTECTIVE EQUIPMENT WORN:

____

____

What immediate action was taken to prevent recurrence? _________________________

____

____

Employee's Signature: ________________________________ Date: _____________

Supervisor's Signature: _______________________________ Date: _____________

Site Safety Representative's Signature: ___________________ Date: _____________

FORM 3

SAFETY MEETING RECORD
EVANS-HAMILTON, INC.

DATE _____/_____/_____ TIME _____________

Project: Port Angeles Bottom Current Study

Person Conducting Meeting:

Topics Addressed:

Signatures of Persons Attending Meeting:

___________________________________	___________________________________
___________________________________	___________________________________
___________________________________	___________________________________
___________________________________	___________________________________
___________________________________	___________________________________
___________________________________	___________________________________
___________________________________	___________________________________
___________________________________	___________________________________
___________________________________	___________________________________
___________________________________	___________________________________

APPENDIX B

VESSEL DOCUMENTATION

FORM 4

FLOAT PLAN
EVANS-HAMILTON, INC.

DATE _____/_____/_____

VESSEL INFORMATION (make/model or local identifier)

____

PERSONNEL ON BOARD

____

____

____

ACTIVITY TO BE PERFORMED

Deployment of three (3) bottom current mounts.

____

____

____

EXPECTED TIME OF DEPARTURE ____

ROUTE ____

EXPECTED TIME OF RETURN ____

MEANS OF COMMUNICATION ____

DEPT. OF HOMELAND SECURITY, U.S. COAST GUARD, CG-2849 (REV. 6-04)

SERIAL NUMBER
1198128

ISSUE NUMBER 1

UNITED STATES COAST GUARD

LICENSE

U.S. MERCHANT MARINE OFFICER

This is to certify that

***** IAN EDWARD FRASER *****

having been duly examined and found competent by the undersigned is licensed to serve for the term of five years from the below issue date as:

MASTER OF STEAM OR MOTOR VESSELS OF NOT MORE THAN 50 GROSS REGISTERED TONS (DOMESTIC TONNAGE) UPON INLAND WATERS.

Given under my hand this 23rd *day of* August 2007 .

C. M. Urtz

C. M. URTZ, USCG, BY DIRECTION
OFFICER IN CHARGE, MARINE INSPECTION

ISSUE PORT: SEATTLE, WA
EXPIRATION DATE: AUGUST 23, 2012

MAR-18-08 09:21 AM

P.02

Appendix G

Cultural Resources Monitoring Protocols

PORT ANGELES HARBOR SEDIMENT INVESTIGATION
CULTURAL RESOURCES MONITORING AND REPORTING PROTOCOLS

This protocol addresses cultural resources monitoring procedures to be conducted during the Port Angeles Harbor sediment investigation project. The project involves the collection of sediment samples from subtidal areas of the harbor. Both surface sediment samples (0-12 inches in depth) and subsurface sediment samples (up to 12 feet in depth) will be collected during the investigation. Due to the potential presence of cultural artifacts in harbor sediments, cultural resources monitoring is required.

Document Existing Information

Under this task, E & E has searched the archives at the Washington Department of Archaeology and Historic Preservation (DAHP) and has obtained and reviewed existing information pertaining to previous marine cultural resources investigations within or near Port Angeles Harbor. A similar search has also been conducted for onsite resources to help in determining the potential for the existence of cultural resources near the project site. Following data review, E & E will prepare an interpretive report on the findings of the monitoring and the cultural setting of the area (see reporting task below).

Sediment Sampling and Analysis Cultural Resources Monitoring

The methodologies described here are consistent with standard cultural resources monitoring practices, and with the Lower Elwha Klallam Tribe (LEKT or Tribe) Monitoring and Discovery Plan, which has been provided to E & E by the Tribe.

The intent of the cultural resources monitoring is to have a qualified archaeologist present during the collection of sediment core samples in water depths of less than 50 feet in Port Angeles Harbor. Core samples will be collected using a 12 foot (3.7 meters) vibracorer. As needed, an impact or gravity corer will be employed to facilitate successful sampling. In most cases, the cores will be advanced to a depth of 4 feet (1.2 meters) or refusal. In some locations, the cores will be advanced to a maximum depth of 12 feet (3.7 meters) to delineate the depth of wood debris in the Harbor. The core sample will be documented and sediment from the first 12 inches (30 centimeters) below the wood debris will be collected for chemical analysis as part of the Port Angeles Harbor sediment investigation.

E & E will provide notification to the LEKT and the City of Port Angeles archaeologist 24 hours prior to the start of sampling activities requiring archaeological monitoring. An E & E archaeologist will examine all sediment core samples collected from Port Angeles Harbor in water depths of less than 50 feet (see attached map of sample locations). In addition, E & E's archaeologist will be notified immediately if a cultural artifact is encountered in a surface sediment sample. Cultural materials that may be encountered can include, but may not be limited to, fire modified rock, animal bone, lithic debitage, flaked or ground stone tools, cordage and fibers, charcoal, ash, exotic rocks and minerals, historic bottles, ceramic shards, nails, wire, and wood. All finds will be extensively documented using photographs, sketches, scaled drawings and written descriptions.

In the event of the discovery of an artifact, the LEKT, City of Port Angeles, and Ecology will be notified as soon as feasible. The points of contact for the Tribe will include:

- Primary Contact: Bill White, Tribal Archaeologist (360) 460-1617
- Secondary Contact: Larry Dunn, Tribal Cleanup Project Manager (360) 452-8471 xt. 126

The points of contact for the City of Port Angeles include:

- Primary Contact: Derek Beery, City of Port Angeles Archaeologist (360) 417-4704
- Secondary Contact: Nathan West, Deputy Director of Community and Economic Development (360) 417-4751

In addition, Dr. Rob Whitlam of DAHP (360-586-3080) will be kept informed of all communications with the LEKT and the City of Port Angeles archaeologist.

Any discovered artifacts will be carefully cleaned, analyzed, treated per the LEKT's request, and the property owner will be notified of the recovery. Aquatic land ownership in the Harbor includes the following:

- Washington Department of Natural Resources, Brady Scott, (360) 732-0013 (all sample stations except as noted below).
- Port of Port Angeles, Dave Hagiwara, (360) 457-1138 (sample station RL01)
- Private Owner (sample station RL02)
- Rayonier Properties, LLC (sample stations LP01, LP02, LP03, CO01, EC01, EC02, EC05, EE01, EE02, EE03, EE04, EE05, and EI01).

Since all artifacts encountered are the property of the landowner from which the artifact is recovered, the landowner will be offered the artifacts. The land owner, Tribe, City of Port Angeles, and Ecology will be provided with copies of all of the documentation associated with the find, including the isolate record form required by the DAHP.

In the event that cultural strata are present in any of the core or surface sediment samples, the find will be documented to the greatest extent possible, the strata will be carefully removed from the core, packaged with seawater to maintain the integrity of the strata. The landowner and the Tribe will be contacted as soon as is feasible and DAHP site record forms will be completed for the find. The cultural strata will be relinquished to the appropriate landowner. Since the core sample locations are not in close proximity to each other, work stoppages due to continued or ongoing impacts to cultural resources is not anticipated if an artifact is encountered. However, in the event of discovery of an artifact during sampling, E & E will confer with the Tribe and Ecology about the potential need for relocation of planned coring sites or other remedies to avoid impacts to cultural resources.

The City of Port Angeles is not a landowner in this project; however the City archaeologist, has an interest in the results of the monitoring and will be present when E & E conducts tests in the Rayonier Area in Ennis Creek. This area is of particular interest due to the existence of an historic, ethnographic Klallam village. The boundaries of this site have not been defined. At this time, there are no known archaeological sites at the selected sample locations.

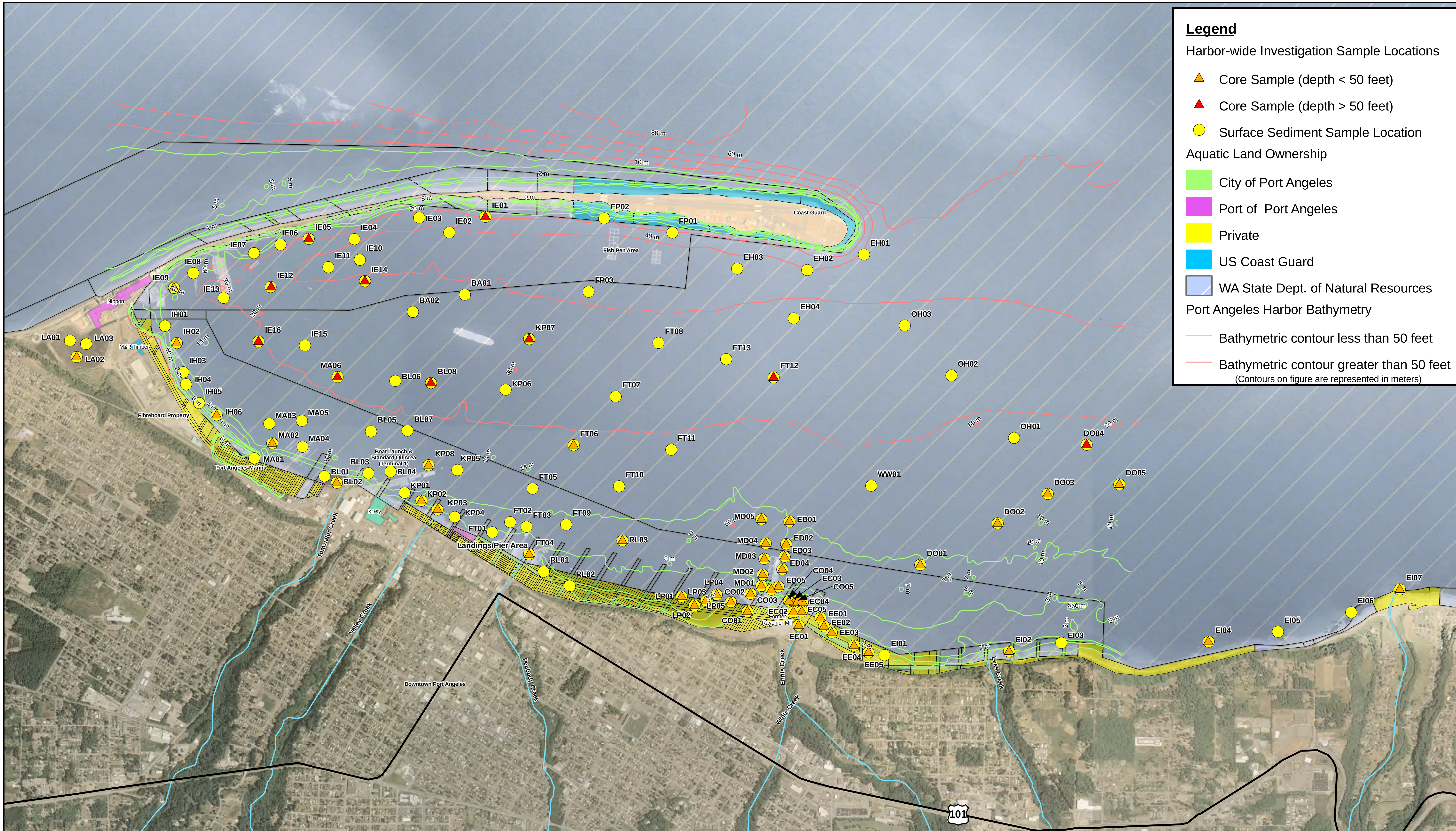
In the event that human remains are encountered in any of the core samples, the E & E archaeologist will immediately notify the Port Angeles City Police, the Port Angeles archaeologist, and the Clallam County Coroner. The Tribe and the DAHP will also be notified should it be determined that the remains are of Native American origin. Documentation (photographs) of human remains will not be collected until approval is issued by the City of Port Angeles archaeologist and or the Tribe. Contact information for the police and the Coroner is as follows:

- Port Angeles Police Department (non-emergency): (360) 452-4545
- Clallam County Coroner : Deborah Kelly: (360) 417-2297

Prepare Cultural Resources Monitoring Report

E & E will prepare a Cultural Resources Monitoring Report detailing the procedures used in the field and a summary of any cultural resources encountered during the sediment sampling. This report will be included in the Sediment Investigation Report as an appendix. Since the DAHP does not currently have a standard report format for cultural resources monitoring activities, the Archaeological Resource Management Reports (ARMR) Guidelines will be used. These Guidelines were developed by the California Office of Historic Preservation to standardize cultural resources reports and are commonly used as a report standard by local governments. They are consistent with the Washington State Standards for Cultural Resources Reporting for excavation activities. Under these Guidelines the report will consist of the following sections:

1. **Management Summary/Abstract**
2. **Introduction**
3. **Setting**
4. **Investigation Design**
5. **Monitoring Methods**
6. **Report of Findings**
7. **Discussion/Interpretation**
8. **Management Considerations**
9. **References**
10. **Appendices**



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W E
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0 500 1,000 2,000 3,000 4,000 5,000 6,000 7,000
Feet
Scale 1:24,000

Port Angeles Harbor, Washington

Sample Locations

source: ecology & environment, inc., 3/10/2008 ...\port_angeles_sta\harbor_core_samples.mxd