4.1.4

WORK PLAN

# *Terminal 4 Early Action Engineering Evaluation/Cost Analysis*

PORT OF PORTLAND

**Port of Portland**
**Portland, Oregon**

**February 23, 2004**

USEPA SF
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# *Terminal 4 Early Action Engineering Evaluation/Cost Analysis*

Respectfully submitted,

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## Acronyms and Abbreviations

| | |
|---|---|
| ADCM | Acoustic Doppler Current Meter |
| ADCP | Acoustic Doppler Current Profiler |
| ADDAMS | Automated Dredging and Disposal Alternatives Management System |
| AOC | Administrative Order on Consent |
| ARAR | applicable or relevant and appropriate requirement |
| AST | aboveground storage tank |
| ASTM | American Society for Testing and Materials |
| BA | biological assessment |
| BEP | bis(2-ethylhexyl)phthalate |
| BMP | best management practice |
| BSAF | biota-sediment accumulation factor |
| CDF | confined disposal facility |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| cfs | cubic feet per second |
| City CPD | City of Portland Commission of Public Docks |
| CLP | Contract Laboratory Program |
| COPC | constituent of potential concern |
| CRD | Columbia River Datum |
| CST | column settling test |
| DDT | dichlorodiphenyltrichloroethane |
| DEQ | Oregon Department of Environmental Quality |
| DGPS | differential global positioning system |
| DQO | data quality objective |
| DRET | dredging elutriate test |
| ECSI | Environmental Cleanup Site Information |
| EE/CA | engineering evaluation/cost analysis |
| ERL | Effects Range Low |
| ERM | Effects Range Medium |
| FSP | field sampling plan |
| ft | foot, feet |
| HASP | health and safety plan |
| HHRA | human health risk assessment |
| IRM | International Raw Materials |
| KMBT | Kinder Morgan Bulk Terminals |
| LNAPL | light nonaqueous-phase liquid |
| MET | modified elutriate test |
| MOU | memorandum of understanding |
| MSL | mean sea level |
| NAVD | North American Vertical Datum |
| NELAP | National Environmental Laboratory Accreditation Program |
| NGVD | National Geodetic Vertical Datum |
| NOAA | National Oceanic and Atmospheric Administration |
| NPDES | National Pollutant Discharge Elimination System |
| NPL | National Priorities List |
| NTCRA | Non-Time-Critical Removal Action |
| ODFW | Oregon Department of Fish and Wildlife |
| OHW | Ordinary High Water |

| | |
|---|---|
| OTC | Oregon Terminal Company |
| OWR&N Co. | Oregon-Washington Railroad and Navigation Company |
| PAH | polycyclic aromatic hydrocarbon |
| PBT | persistent bioaccumulative toxin |
| PCB | polychlorinated biphenyl |
| PEC | Probable Effects Concentration |
| PEL | Probable Effects Level |
| Port | Port of Portland |
| PRPs | potentially responsible parties |
| PSDDF | Primary-Secondary Consolidation, and Desiccation of Dredged Fill |
| QAPP | quality assurance project plan |
| RAO | Removal Action Objective |
| RD&D | research, development, and demonstration |
| RI/FS | remedial investigation/feasibility study |
| SAP | sampling and analysis plan |
| SCPT | seismic cone penetrometer test |
| SOW | Statement of Work |
| SQG | sediment quality guideline |
| SPT | Standard Penetration Testing |
| SVOC | semivolatile organic compound |
| SWMP | stormwater management program |
| SWPCP | stormwater pollution control plan |
| TBC | To Be Considered |
| TBT | tributyltin |
| TCLP | toxicity characteristics leaching procedure |
| TCLT | thin-column leaching test |
| tDDT | total DDT |
| TEC | Threshold Effects Concentration |
| TEL | Threshold Effects Level |
| tPCB | total PCBs |
| TPH | total petroleum hydrocarbons |
| TOC | total organic carbon |
| TRV | Toxicity Reference Value |
| TSCA | Toxic Substances Control Act |
| UPRR | Union Pacific Railroad |
| USACE | U.S. Army Corps of Engineers |
| USATS | U.S. Army Transport Service |
| USC&GS | U.S. Coast and Geodetic Survey |
| USEPA | U.S. Environmental Protection Agency |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | U.S. Geological Survey |
| UST | underground storage tank |
| VCP | Voluntary Cleanup Program |
| VOC | volatile organic compound |

Section 1

# 1. Introduction and Purpose

In 2000, the U.S. Environmental Protection Agency (USEPA) added the Portland Harbor Superfund Site (Superfund Site or Site) to the National Priorities List (NPL) pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, 42 U.S.C. § 9601, *et seq.* (CERCLA or Superfund) (USEPA, 2001a). As is shown in Figure 1-1 and described in Section 2.1, the Superfund Site Assessment Area encompasses about 6 miles of the Willamette River in Portland, Oregon and includes the Terminal 4 facility. The Port of Portland (Port) owns Terminal 4 and leases land there to several marine shipping operations. Figure 1-2 shows the current aerial view of Terminal 4.

In fall 2001, the USEPA and ten of the Superfund Site's potentially responsible parties (PRPs) entered into an Administrative Order on Consent for Remedial Investigation/Feasibility Study (RI/FS), CERCLA-10-2001-0240 (USEPA, 2001a). The RI/FS will characterize the nature and extent of contamination and assess the biological and human health risks at the Superfund Site. The Administrative Order on Consent allows Early Actions to be conducted to address known risks at specific locations within the Superfund Site. Contaminants found in Terminal 4 sediment samples led to a determination that a removal action at Terminal 4 is necessary to protect the public health, welfare, or the environment. Accordingly, the Port is conducting this removal action under an Administrative Order on Consent for Removal Action (hereinafter AOC), CERCLA 10-2004-0009, executed by the Port and USEPA in October 2003. The Terminal 4 Removal Action Area, which is defined in the AOC and in Section 2.1, is shown on Figure 1-3.

The Terminal 4 Removal Action will address only contaminated sediment. However, before the Port cleans up the sediment, the Port intends to address contaminated surface water and groundwater that is migrating to the river from the Terminal 4 uplands. This work will involve identifying sources in the Slip 1 and Slip 3 uplands and, where appropriate, performing necessary source control activities. The uplands work, already under way, is being conducted pursuant to a Voluntary Agreement between the Port and the Oregon Department of Environmental Quality (DEQ) (Oregon DEQ, 2003a) and pursuant to a DEQ Record of Decision (Oregon DEQ, 2003b). USEPA, DEQ and other government agencies agreed in a Memorandum of Understanding (MOU) that DEQ would be the lead agency for work relating to the upland portion of the Superfund Site.

The AOC requires the Port to conduct an engineering evaluation and cost analysis (EE/CA) on various alternatives for the Terminal 4 Removal Action. Data collection under the EE/CA will focus on acquiring only the information necessary and sufficient to compare Removal Action alternatives, select a preferred alternative, prepare a design, and implement the selected alternative. Broad-based characterization studies and general assessments are not necessary.

Under the AOC, the USEPA may, pursuant to CERCLA or other applicable law, require the Port to perform activities in addition to the Terminal 4 Removal Action work. (AOC § XX ¶¶ 63, 64). Thus, although the USEPA and the Port will strive, and have as a goal, to make the Removal Action work the final remedy and response action for the Removal Action Area, information learned from the Superfund Site risk assessments and RI/FS may require that additional response action be taken.

Terminal 4 is an active marine terminal. For this reason, the EE/CA and the selected Removal Action alternative will be designed and implemented to prevent interference with ongoing Terminal 4 operations and to allow flexibility in current and future Terminal 4 land use.

This work plan is written to present the EE/CA work to be performed at Terminal 4 and to fulfill the requirements set forth in the AOC and in the Statement of Work (SOW) attached to the AOC as Appendix B. In particular, Section II-1 of the SOW sets forth the following work plan requirements:

*Respondent shall submit an EE/CA Work Plan that will include a summary of existing information, a project work plan, a Sampling and Analysis Plan (SAP) and a Health and Safety Plan (HASP).*

*The EE/CA Work Plan shall include, at a minimum, the following information:*

- *Introduction/Purpose;*
- *Brief description of Port of Portland Terminal 4 Removal Action Area characteristics, including ecological and physical characteristics;*
- *Identification of historic and potential ongoing sources of contamination to the Port of Portland Terminal 4 Removal Action Area, including past and present operations, drainage, discharges, or other releases;*
- *Summary of existing information on upstream and upland contamination sources that have the potential to contaminate the Removal Action Area, including a description of environmental investigations, environmental cleanups and planned upland source control measures that will be conducted under agreements with DEQ as the lead agency;*
- *Terminal 4 historical information including dredging history and identification of past and present property owners, operators, and major tenants in the Port of Portland Terminal 4 Removal Action Area as well as owners and operators of all immediately adjacent upland properties;*
- *Summary of current Port and tenant marine and associated facility operations and potential access or operational constraints on Work Plan implementation;*
- *Description of the nature and extent of contamination in the Port of Portland Terminal 4 Removal Action Area, to the extent known, including a summary of existing sediment quality data with a comparison to existing sediment quality guidelines that represent a range of levels including low or no effects (e.g., Threshold Effects Concentrations [TECs], Threshold Effects Levels [TELs], Effects Range Low [ERLs]), as well as levels at which some effects are expected (e.g., Probable Effects Concentrations [PECs], Effects Range Medium [ERMs]). Existing chemistry data will be reviewed to establish Category 1 and Category 2 data categories in accordance with the Portland Harbor RI/FS protocols;*
- *Summary of results from sediment toxicity testing conducted to date;*
- *If accepted by the Tribes, a reference to the cultural resource survey performed in consultation with the Tribes, or a process for reaching agreement with the Tribes on a survey, and a process for developing procedures to protect and address such cultural resources;*
- *A description of the analysis to be conducted to determine the likelihood of post Removal Action recontamination of the Port of Portland Terminal 4 Removal Action Area by upland or upstream sources of contamination;*
- *Identification of Removal Action Objectives (RAOs), potential Applicable or Relevant and Appropriate Requirements (ARARs), and To Be Considered (TBCs) for the Port of Portland Terminal 4 Removal Action Area, in consultation with State of Oregon and other partners on the Removal Action;*
- *A description of the analysis to be conducted to determine disposal facility options for contaminated sediment, including a description of the public participation process for selecting a disposal facility; and*
- *Other information (including maps and figures) necessary to gain a general understanding of the Port of Portland Terminal 4 Removal Action Area.*

*Respondent shall also identify data gaps that will be filled by the collection and analysis of field data. Investigation activities will focus on problem definition and will result in data of adequate quality and technical content to evaluate the following:*

- *Nature, extent, and volume of sediment contamination;*
- *Potential human health and ecological risks resulting from sediment contamination;*
- *Engineering characteristics of the Removal Action Area including sediment consistency, dredgeability, potential slope stability issues related to dredging, and potential sediment consolidation issues associated with capping;*
- *Potential water quality effects associated with dredging, piling removal, sheet pile installation, capping, or disposal technologies;*
- *Alternative technologies for sediment remediation including capping, dredging, treatment (not including treatability testing, which is reserved and may be performed later, if needed) and disposal (on-Site and off-Site); and*
- *Potential impacts to threatened or endangered species, other biological receptors, and the potential habitat benefits and impacts of the removal action and related disposal.*

*The procedures Respondent plans to implement when conducting all field activities will be detailed in the SAP that will be included in the EE/CA Work Plan. The SAP will ensure that sample collection and analytical activities are conducted in accordance with technically acceptable protocols and that data meet data quality objectives. The SAP provides a mechanism for planning field activities and consists of a Field Sampling Plan (FSP) and a Quality Assurance Project Plan (QAPP). Details are provided in Section III of this SOW.*

*Respondent shall also prepare HASP that is designed to protect personnel from physical, chemical and other hazards posed by field sampling efforts. Details are set forth in Section III of this SOW.*

Table 1-1 provides a detailed cross reference of the SOW requirements outlined above and the work plan sections that address them. Sections 2 through 4 deal primarily with historical and existing conditions at Terminal 4 and the Removal Action Area. Section 5 presents a conceptual model for the Removal Action Area based on potential sources of contamination, pathways of exposure, and receptors. Sections 6, 7, and 8 describe the work to be performed under the EE/CA. As part of the continuing collaborative process to implement the Port's Early Action, a Response to Comment document, attached as Appendix F, was developed to identify and respond to each comment provided on the Terminal 4 EE/CA draft work plan. The responses to comments were reviewed during a February 13, 2004, meeting and additional responses incorporated into the document. The following list summarizes the information contained in each section and appendix of this work plan:

- Section 2, Removal Action Area Characteristics, provides information on the location, history, land use, and physical, ecological, engineering, hydrogeologic, and hydraulic characteristics of the Removal Action Area.

- Section 3, Potential Sources of Contamination, provides information on potential sources of contamination to the Removal Action Area.

- Section 4, Summary of Existing Data on Sediment Quality and Toxicity, evaluates existing information on sediment quality, existing toxicity testing data, and the proposed constituents of potential concern in the Removal Action Area.

- Section 5, Preliminary Conceptual Model of the Removal Action Area, presents both ecological and geochemical models for the Removal Action Area based on potential sources of contamination and pathways of exposure to, and receptors within, the Removal Action Area.

- Section 6, Data Gaps and Data Quality Objectives, identifies data gaps and discusses proposed data-gathering activities to fill the data gaps, as appropriate.

- Section 7, Removal Action Area Characterization Activities, discusses how data-gathering activities will be executed.

- Section 8, Removal Action Evaluation Approach, explains the proposed approach to the EE/CA.

- Section 9, References, lists documents and other references cited in the text.

- Appendices provide additional detail on field work, sampling, analysis, and quality assurance (Appendix A), health and safety (Appendix B), deep geotechnical exploration logs (Appendix C), NOAA figures (Appendix D), historical aerial photographs (Appendix E), and tabulated responses to USEPA comments on the 12/30/03 Draft EE/CA Work Plan (Appendix F).

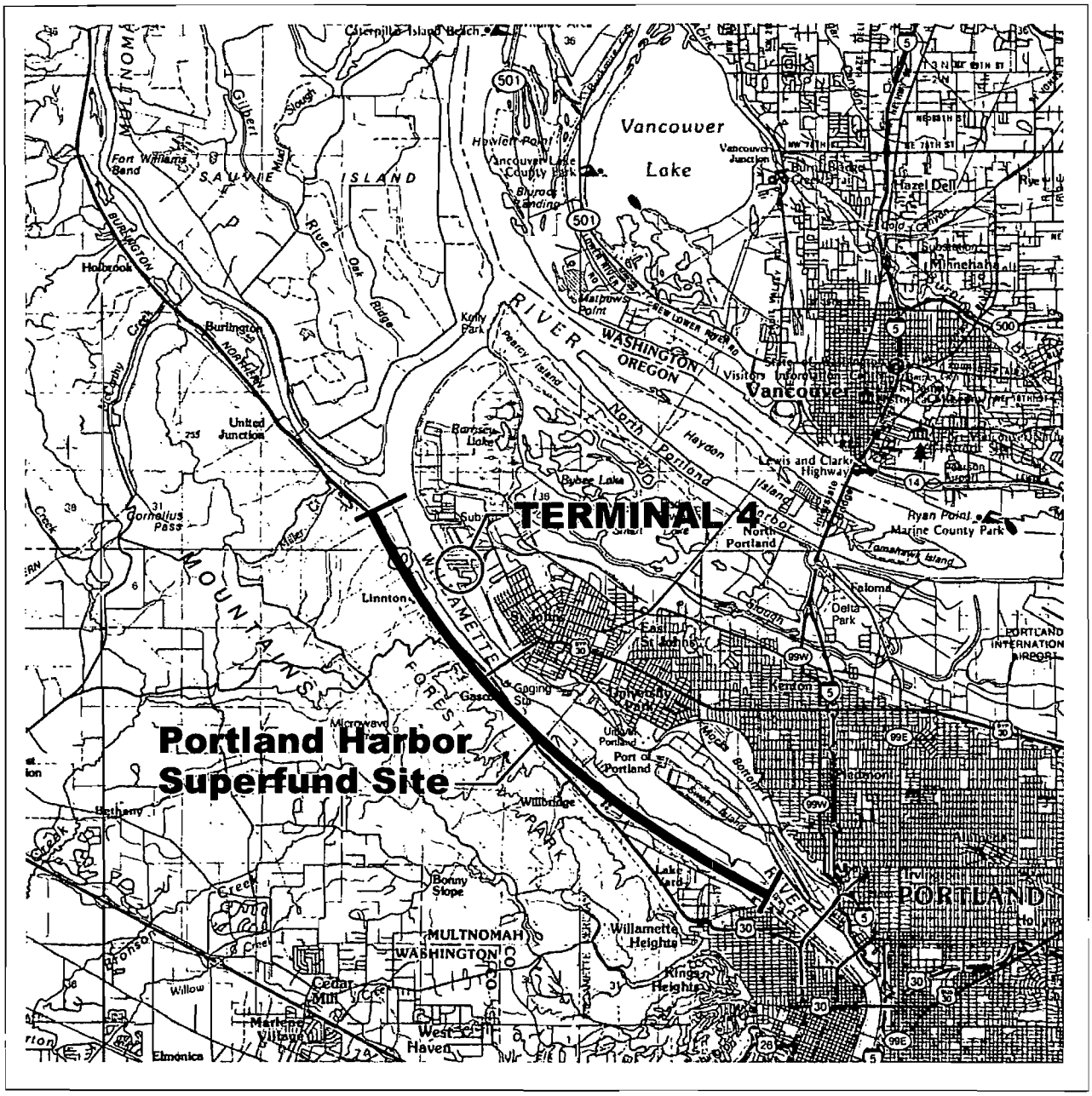
**Table 1-1**
**SOW EE/CA Work Plan Requirements and Work Plan Section References**

| SOW Requirement | Work Plan Section Reference |
|---|---|
| Respondent shall submit an EE/CA Work Plan that will include a summary of existing information, a project work plan, a Sampling and Analysis Plan (SAP) and a Health and Safety Plan (HASP) | Existing information is presented in Sections 2.0 through 4.0. The project plans are presented in Sections 6.0 through 8.0. The SAP is in Appendix A and the HASP is in Appendix B. |
| Introduction/Purpose | Section 1 |
| Brief description of Port of Portland Terminal 4 Removal Action Area characteristics, including ecological and physical characteristics | Section 2.4 presents physical characteristics. Section 2.5 presents ecological characteristics. |
| Identification of historic and potential ongoing sources of contamination to the Port of Portland Terminal 4 Removal Action Area, including past and present operations, drainage, discharges, or other releases | Section 2.2 presents a history of Terminal 4. Section 3.0 presents an assessment of the potential sources. |
| Summary of existing information on upstream and upland contamination sources that have the potential to contaminate the Removal Action Area, including a description of environmental investigations, environmental cleanups and planned upland source control measures that will be conducted under agreements with DEQ as the lead agency | Presented in Section 3.0. |
| Terminal 4 historical information including dredging history and identification of past and present property owners, operators, and major tenants in the Port of Portland Terminal 4 Removal Action | Presented in Section 2.2. |

| SOW Requirement | Work Plan Section Reference |
|---|---|
| Area as well as owners and operators of all immediately adjacent upland properties | |
| Summary of current Port and tenant marine and associated facility operations and potential access or operational constraints on Work Plan implementation | Port and tenant marine operations are presented in Section 2.2.3.3. Operational constraints on work plan implementation are presented in Section 8.5.2. |
| Description of the nature and extent of contamination in the Port of Portland Terminal 4 Removal Action Area, to the extent known, including a summary of existing sediment quality data with a comparison to existing sediment quality guidelines that represent a range of levels including low or no effects (e.g., Threshold Effects Concentrations [TECs], Threshold Effects Levels [TELs], Effects Range Low [ERLs]), as well as levels at which some effects are expected (e.g., Probable Effects Concentrations [PECs], Effects Range Medium [ERMs]). Existing chemistry data will be reviewed to establish Category 1 and Category 2 data categories in accordance with the Portland Harbor RI/FS protocols | Presented in Section 4.0. |
| Summary of results from sediment toxicity testing conducted to date | Presented in Section 4.5 |
| If accepted by the Tribes, a reference to the cultural resource survey performed in consultation with the Tribes, or a process for reaching agreement with the Tribes on a survey, and a process for developing procedures to protect and address such cultural resources | A cultural resource survey, prepared in 2003, is presented in summary form in Section 2.2.1; the complete report has not yet been approved for public release. Section 2.2.1 describes the Port's past and planned efforts to reach agreement with the Tribes on the survey and the procedures set forth in the FSP for protecting and addressing such cultural resources. |
| A description of the analysis to be conducted to determine the likelihood of post Removal Action recontamination of the Port of Portland Terminal 4 Removal Action Area by upland or upstream sources of contamination | Presented in general terms in Section 7.7. Based on an agreement with USEPA reached on November 21, 2003, a technical memorandum will be issued after additional stakeholder input on this issue is gathered. |
| Identification of Removal Action Objectives (RAOs), potential Applicable or Relevant and Appropriate Requirements (ARARs), and To Be Considered (TBCs) for the Port of Portland Terminal 4 Removal Action Area, in consultation with State of Oregon and other partners on the Removal Action | Presented in Section 8.0. |
| A description of the analysis to be conducted to determine disposal facility options for contaminated sediment, including a description of the public participation process for selecting a disposal facility | Presented in Section 8.3.3. |
| Other information (including maps and figures) necessary to gain a general understanding of the Port of Portland Terminal 4 Removal Action Area | Presented throughout the work plan. |

| SOW Requirement | Work Plan Section Reference |
|---|---|
| Respondent shall also identify data gaps that will be filled by the collection and analysis of field data. | Presented in Section 6.0. |
| Investigation activities will focus on problem definition and will result in data of adequate quality and technical content to evaluate nature, extent, and volume of sediment contamination | Presented in Sections 6.9 and 7.8. |
| Investigation activities will focus on problem definition and will result in data of adequate quality and technical content to evaluate potential human health and ecological risks resulting from sediment contamination | Presented in Sections 5.0, 6.5, and 7.4. |
| Investigation activities will focus on problem definition and will result in data of adequate quality and technical content to evaluate engineering characteristics of the Removal Action Area including sediment consistency, dredgeability, potential slope stability issues related to dredging, and potential sediment consolidation issues associated with capping | Presented in Sections 6.6 and 7.5. |
| Investigation activities will focus on problem definition and will result in data of adequate quality and technical content to evaluate potential water quality effects associated with dredging, piling removal, sheet pile installation, capping, or disposal technologies | Presented in Sections 6.10 and 7.9. |
| Investigation activities will focus on problem definition and will result in data of adequate quality and technical content to evaluate alternative technologies for sediment remediation including capping, dredging, treatment (not including treatability testing, which is reserved and may be performed later, if needed) and disposal (on-Site and off-Site) | Presented in Section 8.3. |
| Investigation activities will focus on problem definition and will result in data of adequate quality and technical content to evaluate potential impacts to threatened or endangered species, other biological receptors, and the potential habitat benefits and impacts of the removal action and related disposal | Presented in Sections 6.5, 7.4, and 8.6. |
| The procedures Respondent plans to implement when conducting all field activities will be detailed in the SAP that will be included in the EE/CA Work Plan. The SAP will ensure that sample collection and analytical activities are conducted in accordance with technically acceptable protocols | The SAP is in Appendix A. |

| SOW Requirement | Work Plan Section Reference |
|---|---|
| and that data meet data quality objectives. The SAP provides a mechanism for planning field activities and consists of a Field Sampling Plan (FSP) and a Quality Assurance Project Plan (QAPP). Details are provided in Section III of this SOW. | |
| Respondent shall also prepare HASP that is designed to protect personnel from physical, chemical and other hazards posed by field sampling efforts. Details are set forth in Section III of this SOW. | The HASP is in Appendix B. |
| | |




0 2 4

Scale in Miles

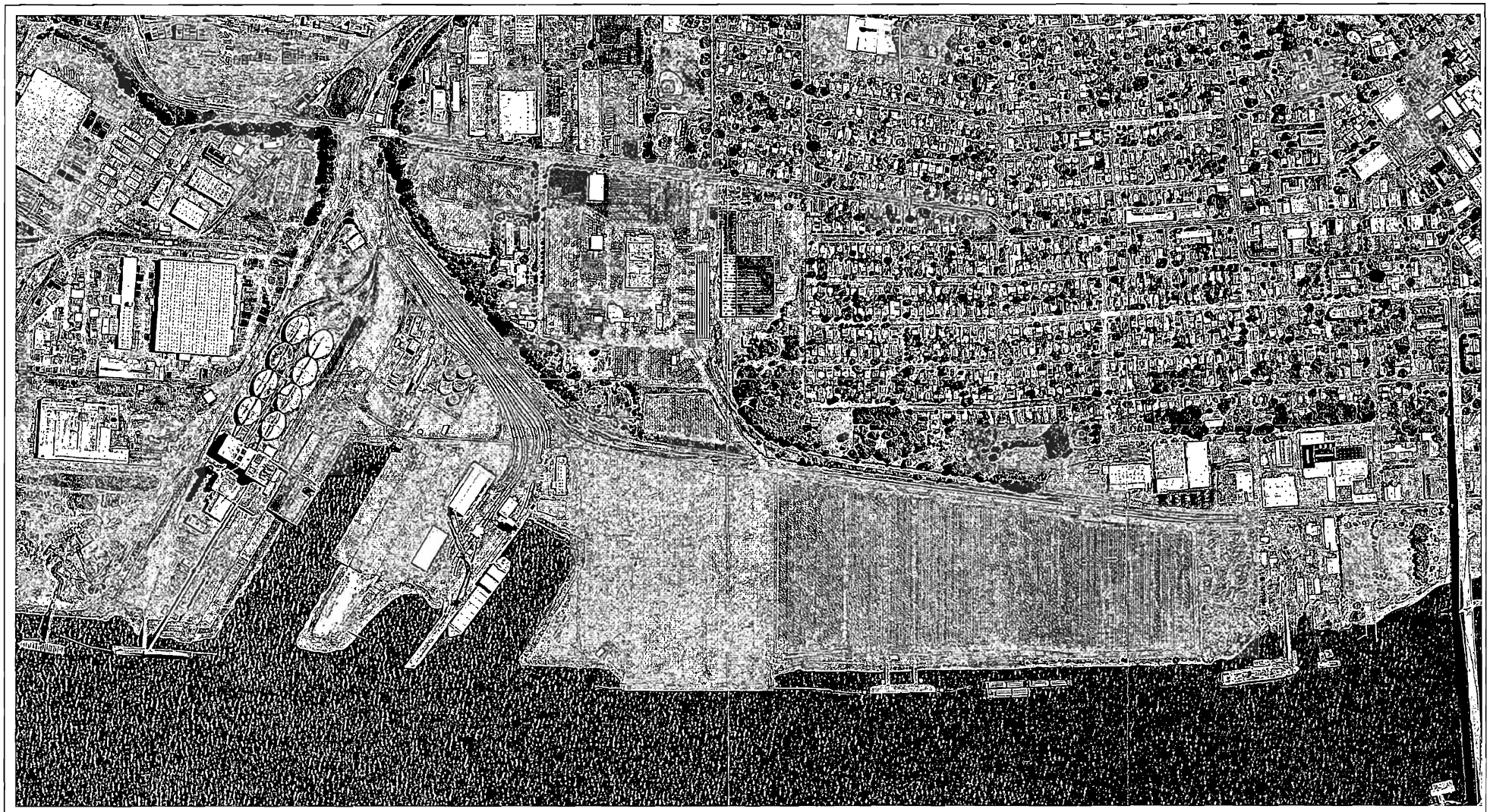
N

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

VICINITY MAP

BBL
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
1-1



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0 600 1200

Approximate Scale in Feet

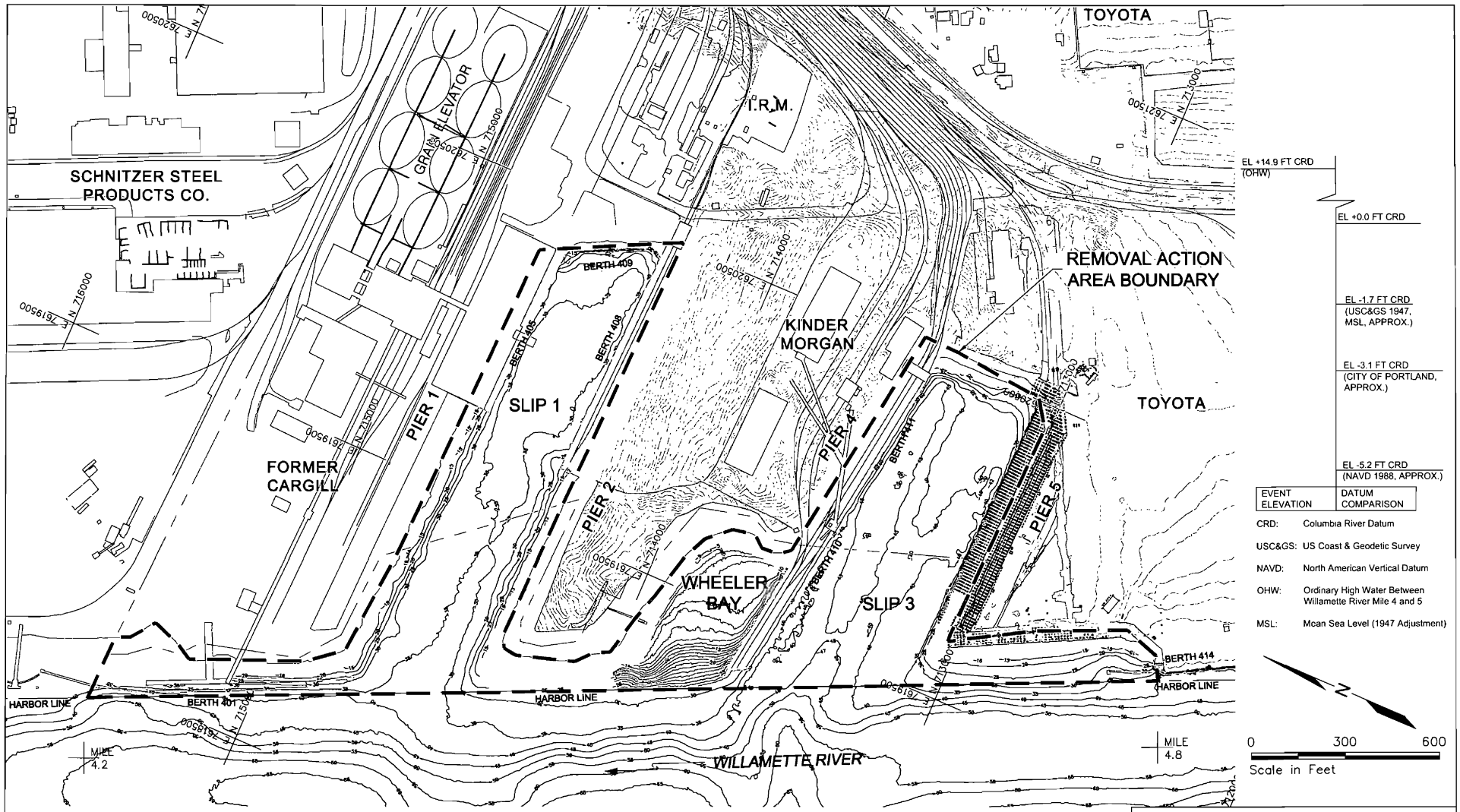
Note: Date of Photo: July 9, 2002

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

TERMINAL 4 AERIAL PHOTOGRAPH

BBL
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
1-2




Existing Piers

Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.

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TERMINAL 4 EARLY ACTION WORK PLAN

REMOVAL ACTION AREA PLAN

BBL
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
1-3

DWG NAME: G:\project\Clients\BBL\Terminal 4\t4_001.dwg
DATE: 02/17/04 2:20pm

Section 2

# 2. Removal Action Area Characteristics

This section summarizes the history, current use and characteristics of Terminal 4 and the Removal Action Area. This information is provided to establish the general context for the Terminal 4 Removal Action Area and to support evaluation of potential sources (Section 3), development of a preliminary conceptual model (Section 5), and planning for the work to be performed under the EE/CA (Sections 6, 7, and 8).

Throughout this work plan, reference is made to "the head of the slip" and "the mouth of the slip." The head of the slip is the east, or land-bounded, end of the slip. The mouth of the slip is the west, or river-bounded, end.

The Port has granted access to the Terminal 4 facility for the purpose of conducting work specified in this work plan. All individuals needing access to the facility for this purpose must still inform the Port to coordinate the timing of any particular visit.

## 2.1 Area Setting and Boundaries

The **Removal Action Area** is within the Port of Portland's **Terminal 4 Facility** located at 11040 North Lombard Street in Portland, Oregon. The Terminal 4 facility itself is within or adjacent to the **Portland Harbor Superfund Site**. The Removal Action Area and the Portland Harbor Superfund Site are defined in the AOC as follows:

> **Portland Harbor Superfund Site** or "Superfund Site" or "Site" shall mean the Portland Harbor Superfund Site, in Portland, Multnomah County, Oregon, listed on the National Priorities List (NPL) on December 1, 2000, 65 Fed. Reg. 75179-01. The Site consists of the areal extent of contamination, including all suitable areas in proximity to the contamination necessary for implementation of response action, at, from and to the Portland Harbor Superfund Site Assessment Area from approximately River Mile 3.5 to River Mile 9.2 (Assessment Area), including uplands portions of the Site that contain sources of contamination to the sediments at, on or within the Willamette River. The boundaries of the Site will be initially determined upon issuance of a Record of Decision for the Portland Harbor Superfund Site.
>
> **Removal Action Area** or "Terminal 4 Removal Action Area"...shall mean that portion of the Site adjacent to and within the Port of Portland's Terminal 4 at 11040 North Lombard, Portland, Multnomah County, Oregon: extending west from the ordinary high water line on the northeast bank of the lower Willamette River to the edge of the navigation channel, and extending south from the downstream end of Berth 414 to the downstream end of Berth 401, including Slip 1, Slip 3, and Wheeler Bay.

The Terminal 4 facility is divided into three areas for the purpose of environmental characterization and possible remedial action. These areas are described below and depicted on Figure 2-1.

> **Terminal 4 Slip 1 Upland Area** is located at the north end of Terminal 4 and consists of uplands bounded to the north by the property boundary with the Schnitzer Steel facility, to the east by the Terminal 4 property boundary, to the south by Wheeler Bay

and the Terminal 4 Slip 3 Upland Facility (see Figure 2-1), and to the west by the ordinary line of the low water of the Willamette River (Oregon DEQ, 2003a).

**Terminal 4 Slip 3 Upland Area** is located east and south of Slip 3 and consists of uplands bounded to the north by the Terminal 4 Slip 1 Upland Facility (see Figure 2-1), to the east by the Terminal 4 property boundary, to the south by the Terminal 4 Auto Storage Area (see Figure 2-1), and to the west by the ordinary line of low water of the Willamette River (Oregon DEQ, 2003b).

**Terminal 4 Auto Storage Area** is located at the south end of Terminal 4 and consists of uplands bounded to the north by the Terminal 4 Slip 3 Upland Facility (see Figure 2-1), to the east and south by the Terminal 4 property boundary, and to the west by the ordinary line of low water of the Willamette River.

These three upland areas are in various stages of environmental investigation or remedial action pursuant to a Voluntary Agreement and a Record of Decision (Oregon DEQ, 2003a; Oregon DEQ, 2003b). As discussed in Section 1, these areas will not be actively investigated under this work plan.

## 2.2 Area History and Current Use

This section summarizes the history and current use of Terminal 4 and the Removal Action Area. General historical and cultural resource information provides an underlying context for the modern development of the marine facilities. Detailed information on facility development and operations is provided as a foundation for understanding the nature of potential contamination sources (Section 3) on or near Terminal 4.

This section presents the best information available at the time this work plan was prepared. However, research is ongoing and new findings may augment or supersede the information presented here. In particular, as described in Section 1, the Port is working with DEQ to identify contaminant sources in the Terminal 4 Slip 1 and Slip 3 uplands and to perform appropriate source control activities. As part of that work, the Port is compiling information regarding the use of, hazardous substance releases on, and remedial investigations of those areas. The Port will incorporate into the EE/CA any new information discovered during that process and will provide access to the documents containing contain such information.

### 2.2.1 Cultural Resources

Information presented in this section is summarized from A Cultural Resources Reconnaissance Survey of the Port of Portland's Terminal 4, Portland, Oregon (Final Draft) (AINW, 2003), which was prepared by Archaeological Investigations Northwest. The complete report has not yet been approved for public release.

Copies of the draft cultural resources report for Terminal 4 were provided to all six Tribes on August 11, 2003, and a meeting was held with Tribal representatives to discuss the Terminal 4 cultural resources report on October 7, 2003. No comments or concerns regarding the report or cultural resources at Terminal 4 were expressed at the October 7 meeting nor have any comments been received subsequently. Letters requesting Tribal concurrence with the report and its findings were sent to the Tribes on February 10, 2004, and follow-up telephone contacts will be made with each of the Tribes. In addition, no comments have been received from the Tribes regarding the proposed Archaeological Monitoring Protocol outlined in the Terminal 4 field sampling plan. The Port will be further coordinating with the Tribes regarding the proposed protocol to

ensure that it addresses Tribal concerns. As needed and appropriate, the Port will revise the cultural resources report or modify the Archaeological Monitoring Protocol after additional Tribal consultation as defined above.

#### 2.2.1.1 Native American Cultural Resources

Terminal 4 lies within the traditional homeland of the Chinookan peoples who occupied most of the lower Columbia River valley at the time of Euroamerican contact. The present Portland area was historically occupied by groups speaking two Upper Chinookan dialects, Multnomah and Clackamas. The confluence of the Willamette and Columbia rivers and the Lower Willamette River were major resource locations and regularly drew native peoples from throughout the Columbia River drainage for seasonal fishing and trading expeditions (French and French, 1998; Silverstein, 1990).

William Clark of the Lewis and Clark Expedition made a brief exploration up the Lower Willamette River in April 1806. He and his men camped near a small Chinookan village on the east bank of the Willamette. Clark's description and maps of the location indicate this village was in the vicinity of Terminal 4. The village, designated "Ne-mal-quin-ner's," had an estimated population of 200. The residents of the village were absent at the time of Clark's visit and he was told by his Indian guide that the Ne-mal-quin-ner's people usually lived at Willamette Falls, moving to the lower river settlement "when they Come down to the Valley to gather Wappato" (Moulton, 1990, 1991).

There are no written references to the Ne-mal-quin-ner village or any settlement at that location after the time of the Lewis and Clark Expedition. A well-known archaeological site at the mouth of Gatton's Slough (the lower course of the slough was buried by construction of Terminal 4) is likely to have been the remains of Ne-mal-quin-ner's village. Prior to construction of Slip 1, Gatton's Slough was formerly a natural surface drainage feature discharging to the Willamette River. This feature is shown on Figure 2-20, and is discussed further in Section 2.2.2. John Wacheno, a Clackamas Indian, told an anthropologist in 1934 of a village in the St. Johns area known as wÜxsûn, the residents of which fished for sturgeon at the mouth of the Willamette River (Drucker, 1934). Treaties in 1855 led to the relocation of many Chinookans, and other native peoples who had traditionally used the Lower Willamette River, onto reservations. Accounts of early settlers in the St. Johns area indicate, however, that some Indians remained along the river through the 1850s and into the 1860s (Dickson, 1976; Singleterry, 1976). Other Indians are known to have left the reservations seasonally to visit traditional resource locations.

Other than the archaeological site at the mouth of Gatton's Slough, the only reported archaeological resources at Terminal 4 are a few artifacts apparently collected in the 1960s and 1970s by a former worker at the terminal. One of these artifacts was a net weight collected from under Pier 5 in Slip 3 (Schenkenberger, 1981). An archaeological reconnaissance survey of Terminal 4 conducted in January 2003 included an examination of the accessible banks and beaches. The bank exposures indicated that they are composed of dredged sands and silts. No evidence of any archaeological resources associated with American Indian use or occupation was observed (AINW, 2003).

On the basis of a review of historical-period records and other materials, the alignment of the historical-period Willamette River bank and the banks of the former Gatton's Slough have been identified as high-probability areas for archaeological resources associated with American Indian use and occupation of the Terminal 4 area (AINW, 2003).

#### 2.2.1.2 Euroamerican Cultural Resources

The Terminal 4 area was initially of little interest to Euroamerican settlers because it was low, marshy, and subject to frequent flooding. A Donation Land Claim encompassing the future Terminal 4 location was settled in 1846 by James Loomis and his family, who built a cabin along the bank of the Willamette River. This occupation was probably short-lived. By the 1890s, the only use of the Terminal 4 location appears to have been for grazing cattle and possibly for growing hay. The Ogden family purchased the future Terminal 4 location in 1897 but built their house on the higher ground to the northeast. More intensive development occurred in the years before World War I, with construction of the railroad along the eastern edge of the floodplain in 1907 to 1908. A dock for ships to transfer oil to the Union Pacific Railroad and an associated pipeline were built in 1906 to 1907 along the south side and to the east of the future location of Slip 3. These are the only known uses of the Terminal 4 location prior to construction of Terminal 4, which began in 1917.

### 2.2.2 Physical History

The landscape and physical features of Terminal 4 have changed significantly in the past century with the preparation of the land for use as a marine terminal. What was once Willamette River floodplain occupied by grasslands, wet prairies, and small ponds (AINW, 2003) was modified by grading, dredging, and filling beginning as early as 1906 to 1907.

Prior to development, the banks of the terminal location were lined with trees, and Gatton's Slough (which discharged to the Willamette River) traversed the northern portion of the property (U.S. Coast and Geodetic Survey, 1895). A small stand of trees was located on the floodplain immediately south of the slough, beyond which were several small swales and ponds. The remainder of the area was occupied by grasslands, which were probably wet prairies. A U.S. Coast and Geodetic Survey (USC&GS) map from 1895 depicts a building (possibly a farmhouse) located at the eastern edge of the floodplain (southeast of the location of the now-removed Warehouse 6) along with a series of trees suggestive of a small orchard.

In 1897, the Ogden family purchased the land around lower Gatton's Slough. They built a house on the higher ground overlooking the floodplain, probably close to the modern entrance to Terminal 4 on North Lombard Street. In addition to farming, the Ogden family reportedly drilled for oil near the mouth of the slough, without success (Minkler, 1976).

The rural landscape portrayed in the 1895 map began changing in the first decade of the 1900s. The first development at Terminal 4 occurred in 1907 to 1908 when the Oregon-Washington Railroad and Navigation Company (OWR&N Co., a Union Pacific Railroad affiliate and part of the Union Pacific Railroad system, hereafter referred to as Union Pacific) constructed a railroad along the eastern edge of the floodplain (the railroad alignment now serves as the eastern boundary of Terminal 4). By 1912, Union Pacific had constructed its oil-supply dock for locomotives and, on the east slope above the rail tracks, the St. Johns Tank Farm which was used as a locomotive fueling station. Photographs from 1917 indicate that an oil pipeline extended east from the river across the floodplain to the tank farm. The oil pipeline later became an underground structure, and was presumably buried when the area of Slip 3 was filled and graded for development. However, the date of burial has not been verified. The pipeline alignment was along the south side of where Slip 3 would later be constructed. The oil was pumped uphill from the oil-supply dock to the tank farm.

In 1917, the site preparation for the development of Terminal 4 began. Trees and other vegetation were removed over most of the floodplain in the northern Terminal 4 area, and dredged fill material was deposited

across the low-lying ground and then leveled with horse teams. Most of lower Gatton's Slough was filled at this time as well. Beginning about the same time, fill was also placed into the offshore shallows to extend the riverbank out into the channel. The 1895 U.S. Coast and Geodetic Survey map labeled the offshore area as "Linton Shoal," with water less than a meter deep in places. Filling this area was relatively easy and provided the new Terminal 4 with a larger land base. As described in more detail below, the northern Terminal 4 facilities were Piers 1 and 2 at Slip 1 and Pier 5 at Slip 3. A Slip 2 was planned and partially excavated but never completed. The remnant Slip 2 is known today as "Wheeler Bay." Photographs taken in 1917 trace the rapid transformation of this landscape (Port of Portland, 1917).

Pre- and post-construction maps of and plans for Terminal 4 indicate substantial changes occurred in the landscape with the development of Terminal 4 from 1917 to approximately 1921 (AINW, 2003). First, construction of the terminal involved placement of fill that extended 650 to 975 feet (ft) from the original riverbank. Second, the construction of Slips 1, 2, and 3 also required excavations into the original shoreline. Slip 1 was located at the entrance to Gatton's Slough, and the head of the slip extended up to 650 ft inland from the original riverbank. These excavations probably removed much of the upriver portion of the mouth of the slough; the downriver portion of the slough entrance was covered by Houses 1 and 2 at Pier 1 and portions of the grain complex. The inland excavations for Slips 2 and 3 (although Slip 2 was never finished) extended from 440 to 565 ft back from the original shoreline. The northern portion of Terminal 4 was thus developed through a combination of fill outward from the original riverbank and excavations into the original floodplain. All traces of lower Gatton's Slough were lost either through burial under fill or removal for the creation of Slip 1 (see also Section 2.2.4).

### 2.2.3 Chronology of Ownership and Operations

#### 2.2.3.1 Property Acquisition and Development

Originally called the St. Johns Municipal Terminal, Terminal 4 was developed by the City of Portland Commission of Public Docks (City CPD) as a result of the push by the City to become a world-class shipping port and to capitalize on growth in the shipping industry following the opening of the Panama Canal in 1914 (Donovan and Associates, 1997). Following the physical preparation of the land (see Section 2.2.2), the City CPD initiated construction for development of the property as a marine terminal.

The main building construction and other physical developments at Terminal 4 are summarized in Table 2-1. Note that warehouses at Pier 1 were called "houses," while those at Pier 2 were called "warehouses."

**Table 2-1**
**Chronology of Facility Development at Terminal 4**

| Year | Entity and Event |
|---|---|
| 1906-07 | St. Johns Tank Farm (with storage tanks and a pipeline to a terminal dock) constructed by Union Pacific at the future location of Slip 3; the facility handled Bunker C fuel oil for fueling steam locomotives south of modern Slip 3. |
| 1917 | $3,000,000 bond levy approved on June 17, 1917, for land purchase and development. City CPD purchases 117.55 acres of upland and purportedly 36 acres of submerged land centered on Gatton's Slough. |
| 1917-20 | Slips 1 and 3 dredged and Pier 1 (Berths 403-405), grain elevator, operating house, storage bins, track shed, and Warehouses 1-5 constructed. Spur tracks from |

| Year | Entity and Event |
|---|---|
| | existing Union Pacific lines constructed. |
| 1919 | Liquid bulk storage facility constructed at the head of Slip 1; House 4 constructed. |
| 1919-20 | Pier 2 and Berths 406-408 constructed. Vegetable oil weighing house constructed east of Slip 1. |
| 1920 | 4.94-acre parcel acquired from Union Pacific adjacent to Slip 3; however, parcel developments (pipeline, oil supply tanks, and fuel oil dock) remained under ownership of Union Pacific. Flour mill, adjoining concrete warehouse for grain and flour, and Berth 409 constructed. Houses 1 and 2 constructed on the upstream side of Slip 1. Boiler house and service buildings (including an administration building, cafeteria/restaurant, and welfare building) constructed east of Slip 1. |
| 1920-21 | Substructure for Piers 3, 4, and 5 constructed (although Pier 3 was never completed). Quay dock, bulk handling facility, and Berths 412 and 413 completed on the upstream side of Slip 3. Union Pacific pipeline extended to service Berth 412 at Pier 5, Slip 3. |
| 1920-24 | Filling platform for liquid bulk storage facility constructed east of Slip 1. |
| 1921 | Storage bunkers constructed east of Slip 3. |
| 1921-22 | Warehouses 6 and 7 constructed on Pier 2, Slip 1 serviced by Berths 406 and 407. |
| 1922 | House 5 constructed perpendicular to House 4 along the river. |
| 1923 | Houses 6, 7, and 8 were constructed perpendicular to House 5 as a cold storage plant and ventilated warehouse. 150,000-gallon elevated water tank constructed. H.R. Leckenby fumigation plant constructed. |
| 1930 | Grain storage annex constructed north of the grain elevator. |
| 1931 | Tanks added to liquid bulk storage facility. |
| 1932 | Gearlocker building constructed north of the liquid bulk storage facility. |
| 1940-41 | Berth 401 and Airveyor system for unloading bulk grain from barges constructed on the harbor side of Houses 4 and 5 at Pier 1 for grain unloading. |
| 1942 | At the onset of WWII, the U.S. Army Transport Service (USATS) leased Terminal 4 from City CPD for Portland's Sub-Port of Embarkation. USATS added a second story to the gearlocker building. The USATS rehabilitated the loading apron at Pier 1, replaced decking and rehabilitated railroad track at Pier 2, and rehabilitated the slip side of Pier 5. |
| 1944 | Auxiliary pipeline constructed by the USATS at Slip 3 Pier 5. |
| 1946-47 | The USATS relinquished Terminal 4 to City CPD. Bulk loading facility constructed at Berth 412 on the slip side of Pier 5. |
| 1948 | 20-acre parcel south of Pier 5 acquired from Union Pacific. |
| 1951 | A railcar dumper and a hydraulic truck unloading hoist and dust collection system added to the grain facility at Pier 1. |
| 1953 | Oil packaging plant constructed and eight aboveground storage tanks (ASTs) and an underground transfer pipeline installed at the head of Slip 3 by Quaker State for oil storage. |

| Year | Entity and Event |
|---|---|
| 1954 | Eight steel ASTs for grain storage constructed east of the grain storage buildings at Slip 1. Electric elevator system at grain elevator modernized. |
| 1955 | Pier 2 rehabilitated and two gantry cranes added. Berths 410 and 411 constructed on the downstream side of Slip 3. Fumigation plant removed. |
| 1957 | Berth 401 renovated. |
| 1957-58 | 19.64-acre parcel upstream of Pier 5 acquired from Multnomah County. |
| 1958 | Second gallery for grain loading added at Pier 1. |
| 1962 | Pier 5 harbor-side wharf and Berth 409 at the head of Slip 1 removed. Dravo bulk unloader installed at Pier 4. |
| 1963 | Head of Slip 1 developed as small boat landing. |
| 1966 | Five tanks constructed by Pacific Molasses added to liquid bulk storage facility. |
| 1968 | Warehouse 4 constructed at Pier 2. Matson Navigation Co. installed 33-ton-capacity container crane on Pier 2. Three 36-ton revolver cranes purchased and installed at Pier 4. |
| 1968-69 | Berths 404 and 405 reconstructed (Berth 405 to handle offloading of barges for grain). Coal bunkers removed at Pier 5. |
| 1971 | Grain elevator remodeled; Union Pacific abandoned existing pipeline to St. Johns Tank Farm and installed a replacement pipeline; Port and City CPD consolidated; except for City's fire boat station, CPD properties and functions transferred to Port. |
| 1973 | Land purchased from Broadway Holding Company. House 8 demolished at Pier 1. Berth 417 constructed southwest and upstream of Slip 3. |
| 1975 | Berth 401 reconstructed to handle ships, adding grain loading equipment and conveyor system. |
| 1978 | Cold storage plant and ventilated warehouse (Houses 6 and 7) at Pier 1 removed. |
| 1983 | Union Pacific's operation of the St. Johns Tank Farm tanks and replacement pipeline ceased. |
| 1984 | Boat landing at the head of Slip 1 removed and ro-ro dock, called Berth 409, constructed in its place. Service buildings removed, including an administration building, cafeteria/restaurant, and welfare building. Whirley cranes removed from Berths 410 and 411. |
| 1985 | Quaker State ASTs and underground pipeline removed. |
| 1986 | City of Portland began construction of Outfall 52C and the associated storm sewer system serving Lombard Street properties. |
| 1987 | Bulk outloading facility constructed at Pier 4 by Hall-Buck Marine. Construction of City drainage system and Outfall 52C at the head of Slip 1. Tanks removed from Union Pacific's St. Johns Tank Farm. |
| 1988 | Diesel and gasoline underground storage tanks (USTs) and fueling station installed by Oregon Terminal Company. |

| Year | Entity and Event |
|---|---|
| 1989 | Second railcar dumper added to grain facility. Two pipes added at Pier 1 for liquid bulk storage facility. |
| 1990 | House 4 condemned. |
| 1991 | Guard station constructed. |
| 1992 | Four of the steel ASTs for grain storage (east of the storage bins to the north of Slip 1) modified. |
| 1992-93 | Downstream row of tanks at original liquid bulk storage facility removed. |
| 1994-95 | All but five of the tanks remaining at liquid bulk storage facility removed. |
| 1995 | Soda ash storage building constructed at Pier 4. |
| 1996 | House 6, House 7, Berth 406, and Berth 407 at Pier 2 dismantled. |
| 1996 | Oregon Terminal Company's diesel and gasoline USTs removed. |
| 1997 | Pipeline for liquid bulk storage facility rebuilt under Berth 408. |
| 1997-98 | Portions of Union Pacific's decommissioned/abandoned St. Johns Tank Farm pipeline removed from under Berth 412 and elsewhere. |
| 1999 | Houses 3, 4, and 5 and Berths 403 and 404 demolished. Mechanical/electrical building and bridge to Berth 401 constructed. |

### 2.2.3.2 Historical Terminal Operations

Tenant operations at Terminal 4 are discussed here by operating areas, further subdivided by the piers and berths the tenants used.

**Union Pacific Railroad**

Union Pacific and its predecessor, OWR&N Co., built, maintained and operated a fuel oil dock, 10-inch steel pipeline, and the St. Johns Tank Farm and tank car loading facility near Pier 5 on the south (upstream) side of Slip 3 beginning in at least 1906 to 1907. The tank farm and loading facility included two 55,000-barrel aboveground storage tanks (ASTs) for oil and associated pumping and heating facilities. The tanks and the pumping and heating facilities were adjacent to the terminal on the bluff beyond the rail trackage east of Pier 5. The pipeline was used to transfer diesel fuel and, prior to 1955, Bunker C oil from marine vessels to the storage tanks, which delivered fuel oil via a loading rack on the main rail line above the terminal to locomotive steam engines and to rail tank cars for distribution to other facilities elsewhere in Union Pacific's system. Track scales were built to avoid having to transport cars to the railroad yard, which was some distance away. The track scales were operated under the supervision of the Weighing and Inspection Department of the Transcontinental Freight Bureau.

The City CPD purchased two parcels of land from Union Pacific that contained the pipeline and dock at Terminal 4, Pier 5 but not the tank farm: approximately 5 acres in 1920 and approximately 20 acres in 1948. The 1920 and 1948 deeds retained an easement for the existing pipeline that served the St. Johns Tank Farm

on Union Pacific's property east of the terminal. The easement granted the railroad and its successors the right to operate and maintain the pipeline and associated dock.

From 1922 to 1939, General Petroleum Corporation leased the St. Johns Tank Farm from Union Pacific and operated a facility near Slip 3 for delivery of bunker fuel and unloading of fuel oil from vessels. Included in their operation was an approximately 30-ft AST used for fuel oil and two associated buildings, one of which was a designated pump house. All three structures were located along the area of the pipeline to the south of Slip 3 (Sanborn Fire Insurance Map, 1924). Neither the date of construction nor the date of demolition of these structures could be verified.

In 1952, Union Pacific requested an area for cleaning railcars and was offered the use of Track 10½ by the City CPD.

In 1969, Union Pacific leased the St. Johns Tank Farm and associated pipeline to Standard Oil Company of California (now known as Chevron). The arrangement provided that Standard Oil would supply Union Pacific with oil for its tank cars.

In 1971, Union Pacific abandoned the pipeline because of leaks. A new pipeline was then constructed parallel to the old one, but farther to the south across the adjoining 19.5-acre parcel. Standard Oil continued to operate the tank farm and replacement pipeline until 1983, when fuel transfer operations ceased altogether. The tanks were removed in 1987. In 1997, during removal of the dock at Berth 412, the under-dock portions of the pipeline were drained, cleaned, and removed. In 1998, other portions of the pipeline were drained and removed.

**Cargill Grain Facility**

The grain elevator and its operating house were completed in 1920 and were operated by the City CPD. The facility contained a conveyor belt system that carried sacked grain to the elevator for cleaning and storage. Northwest sacked wheat was susceptible to a wheat fungus known as smut. An initial lime scouring method for cleaning was later replaced when Wolf-Dawson wheat washers were installed. Dust collecting and sweeping systems controlled airborne particulates. A two-belt shipping gallery could load two vessels with bulk grain simultaneously. Track facilities were provided in the front and rear of the pier; the rear tracks had placement for 105 cars. The pier had cargo masts along its entire face, electric elevators, and electrically operated ramps for handling freight to and from river steamers and barges. The grain elevator had capacity to handle 1,053,800 bushels in eight hours. After the construction of the grain elevator annex in 1930, its grain-storing capacity of 2,000,000 bushels exceeded that of any other grain elevator on the Lower Columbia (Merchants Exchange Journals, 1932).

Barge delivery of bulk wheat to the grain elevator began to supplant sack delivery in 1939. The following year, the City CPD installed a Fuller Airveyor vacuum system for unloading grain barges in Slip 1. Another, higher-capacity vacuum system was added in 1957. Eight grain storage silos are located east of the grain terminal. When these were built and put into operation in 1954, the grain storage capacity at Terminal 4 increased to 7,400,000 bushels. To more readily accommodate grain delivery at the enhanced storage facility, a new box car unloader was added.

In 1942, Terminal 4 and operation of the grain facility were turned over to the U.S. Army Transport Service (USATS). In 1947, the facility was returned to the City CPD, which entered into a lease agreement with Kerr-Gifford. Kerr-Gifford operated the grain elevator at Pier 1 from 1947 until 1954. In 1953, Cargill agreed to purchase all of the stock of Kerr-Gifford, and in November 1954, Kerr-Gifford was merged into Cargill as the

Kerr Gifford Division. It was at that time that Kerr-Gifford's lease of the grain terminal was assigned to Cargill.

Table 2-2 summarizes the facilities Cargill used in connection with their operation of the grain facility.

**Table 2-2**
**Cargill Operating Areas at the Grain Facility at Terminal 4**

| Cargill Facility | Location(s) | Constructed | Use/Former Use | Status |
|---|---|---|---|---|
| Operating House (grain elevator) | South of Storage Annex | 1920 | Transfer of grain | Present |
| Track Shed | South of Operating House | Prior to 1953 | Cover for rail trackage | Present |
| Office Building (Building 168) | West of Flour Mill | 1975 | Administrative offices | Present |
| Conveyor Building (Building C-10) | West of Office Building | 1970s | Conveyor equipment | Present |
| Longshoremen's Lunchroom | Adjacent to Berth 401 | 1980s | Longshoremen's facility | Present |
| Truck Shed (Building 178) | North of Building C-10 | 1976 | Covered way for trucks | Present |
| Truck Dumper | East of Track Shed | Prior to 1953 | Unloading trucks | Present |
| Gearlocker | South of Railcar Tipper north of Berth 405 | Not confirmed | Storage of equipment | Present |
| Grain Storage Silos (8) | East of Operating House | Circa 1954 | Grain storage | |
| Blacksmith Shop | South of Grain Storage Silos | Not confirmed | Not yet confirmed | Removed |
| Millwright Shop | West of Operating House | 1958 | Not yet confirmed | Removed |
| Pellet Mill | East of Storage Annex | 1994 | Processing beet pellets | Present |
| Maintenance Shop | East of Operating House | 1970s | Equipment maintenance | Present |
| Oil Shack | North of Maintenance Shop | Not confirmed | Not yet confirmed | Not available |
| Bull Pen | Not yet confirmed | Not confirmed | Not yet confirmed | Unknown |
| Transformer House | Southeast of Pellet Mill between the Operating House and Storage Silos | 1917 | Transformer storage | Razed in 1977 |
| Electrical Distribution Center | Adjacent to Berth 405 | Not confirmed | Transformer storage | Removed |
| Electrical Transformers | Various locations | Varies | Energy conversion | PCB-containing transformers replaced in 1988 |
| Railcar Tipper (installed circa 1954) | South of Track Shed | Prior to 1953 | Unloading grain from railcars | Present |
| Work Pit | Beneath Railcar Tipper | Not confirmed | Not yet confirmed | Present |
| Deep Water Well | Southeast of Storage | | Turbine pump | Abandoned |

| Cargill Facility | Location(s) | Constructed | Use/Former Use | Status |
|---|---|---|---|---|
| | Annex (northeast of Operating House) | | | and filled in 1992 |
| Fueling Facility | Between Buildings 152 and 160 | Not confirmed | Fueling equipment | Removed |
| Diesel UST (1,000-gallon) (T4-20) | West of Operating House | Not confirmed | Diesel storage | Removed 1989 |
| Fuel oil UST (1,000-gallon) (T4-21) | West of Operating House | Not confirmed | Fuel oil storage | Removed 1989 |
| Fuel oil UST (500-gallon) (T4-22) | Beneath the Operating House | Not confirmed | Fuel oil storage | Removed 1993 |
| Used oil UST (T4-85) | North of Compressor House | Not confirmed | Used oil storage | Removed 1993 |
| Diesel AST (500-gallon) (T4-45) | West of Car Shed | Not confirmed | Diesel storage | Removed September 2003 |
| Diesel AST (675-gallon) (T4-47) | Southwest of Operating House | Not confirmed | Fueling locomotives and equipment | Removed September 2003 |
| Used oil AST (250-gallon) (T4-48) | North of Maintenance Shop | Not confirmed | Used oil storage | Removed September 2003 |
| Conveyor to Berth 405 | Extends south of the Operating House to Berth 405 | Prior to 1940 | Grain transport | Present |
| Conveyor to Berth 401 | Extends west from the Operating House to Berth 401 | 1975 | Grain transport | Present |
| UIC Dry Well | Near Berth 401 | 1999 | Stormwater Discharge | Present |
| Rail trackage | Throughout the leasehold | Varies | Transport of railcars and materials | Present |
| Sumps | Railcar Tipper, Building 141, Truck Dump, Building Basements | Not confirmed | Discharge | Present |
| Hydraulic equipment | Building C-10, near Track Shed, and west of Railcar Tipper | Not confirmed | Various uses | Present |

Cargill maintained preferential berthing rights throughout their occupancy at Berths 401 and 405. Cargill transported materials to and from Berth 401 via railcars that moved along trackage located between Berth 401 and the track shed. Materials were transported to and from Berth 405 utilizing the conveyor system.

Cargill is in the process of terminating its lease of the grain facility.

**Cold Storage Plant**

The cold storage plant and ventilated storage warehouse, constructed at Pier 1 in 1923, provided refrigeration space for transit shipments of apples received for export. The facility, immediately north of the Pier 1 warehouses, was a concrete and brick structure divided into three compartments (Houses 6, 7, and 8).

The 1923 addition of the cold storage plant in the eastern third of the apple storage warehouse led to a five-year storage contract with the Apple Growers Association of Hood River (City CPD, 1923). The cold storage plant was 100 ft by 200 ft and had a capacity of 105,000 boxes. The ventilated apple storage warehouse adjoined the cold storage plant and had a capacity of 350,000 boxes. The Port of Portland led the ports of the Pacific in the shipment of apples; during an average year in the mid-1920s, approximately 1 million boxes were shipped.

**H.N. Leckenby**

In 1923, H.N. Leckenby constructed a fumigation plant near the head of Slip 1 (just in front of the modern International Raw Materials [IRM] tank location, see Figure 2-2). In 1924, Mr. Leckenby began fumigating Oriental cotton received at the Port and other commodities (e.g., peanuts, rice, beans, and other foodstuffs). The plant reportedly had a capacity of 250 tons per day. City CPD minutes from the 1930s indicate that the plant operated under the name of NW Pesticide Company. During World War II, the Army may have used the fumigation plant in connection with its operations (further discussed below). According to City CPD minutes (City CPD, 1949), after the military had vacated the terminal, arrangements were made in 1946 for Mr. Leckenby to enter into a lease with the City CPD and continue operating the plant. The plant continued in operation until sometime in the mid-1950s.

**Liquid Bulk Storage**

In 1919, a liquid bulk storage facility was constructed at the head of Slip 1. By 1931, additional bulk storage tanks were added and the facility included a City CPD-operated warehouse, tank car cleaning facility, and an edible-oil cleaning pit. In 1947, the facility was leased to Pacific Molasses (which later became PM-Ag). Products handled included liquid fertilizer, molasses, molasses products, tallow, urea, caustic soda, and fats. By 1966, the liquid bulk storage facility had been upgraded to include 14 steel tanks on a concrete foundation. Liquid bulk materials were pumped directly from vessels to the tanks via one of two 8-inch pipelines at Pier 1 and Pier 2. The liquid bulks could then be weighed on a 60-ton-capacity scale and pumped into railcars at the filling platform. Up to 10 tank cars could be filled at one time. Pacific Molasses also made use of a car cleaning pit and a steam cleaning area northwest of its tanks to clean food products out of the railcars prior to their filling.

PM-Ag formerly utilized an approximately 8,000-gallon underground storage tank (UST) for storing diesel. The UST was decommissioned by removal in 1991.

Between 1992 and 1995, all of the original public tanks were removed; five private tanks remain in use at present. In 1995, the lease for the liquid bulk storage facility was assigned to IRM, which continues to operate the facility.

The Port removed an approximately 3,000-gallon diesel UST from the IRM leasehold in 1995. Based on confirmatory sampling, the DEQ subsequently issued a No Further Action determination for the UST.

IRM also utilizes an approximately 15,000-gallon heating oil UST located next to the boiler house.

**Flour Mill**

A 1919 agreement between the City CPD and the Eagle Flour Mills Company for the construction of a flour mill north of Slip 1 was transferred to Terminal Flour Mills Company in 1923. A flour production and storage

facility was completed and in operation at Terminal Flour by 1925. Terminal Flour operated the facility until 1992, at which time Terminal Flour's lease was assigned to Cereal Food Processors, which continues to operate the facility.

The mill originally consisted of a concrete building and an adjoining concrete grain and flour warehouse (Donovan and Associates, 1997). An annex was added at a later date (circa 1924 to 1950). A system of conveyors, which originally provided the mill with grain from the neighboring grain storage facility, was abandoned in 1966, and a track pit was added to the facility to accommodate hopper bottom railcars. In addition, two rail spurs running between the eight grain storage tanks served to accommodate delivery of bulk flour from the mill. Sacked flour was loaded directly onto vessels docked at Pier 1 using a conveyor belt system. In 1925, the flour mill had a capacity of 1,500 barrels a day. The output was nearly all for export. The export of flour ceased following World War II when Terminal Flour modified its operation and began milling flour for U.S. consumption. Grain was brought into the silos by rail, milled, and sold either in bulk or in sacks. At present, Cereal Food Processors mills flour for Portland-area customers and sells its product in bulk, exporting the flour from the facility via truck or rail.

Terminal Flour Mills formerly utilized an approximately 10,000-gallon fuel oil UST located north of the flour mill, an approximately 1,000-gallon diesel UST located south of the flour mill, and an approximately 1,000-gallon fuel oil UST located south of the flour mill. All three USTs were reportedly decommissioned by removal by Terminal Flour Mills. However, based on currently available information, neither the date of installation nor the date of removal of the USTs has been confirmed.

**Oregon Sulphur Company**

Oregon Sulphur Company operated on the east side of Slip 3 at Pier 5, importing bulk sulfur beginning in at least 1920. In photographs from 1920, there appears to be an open storage area, and sulfur was unloaded via clamshell bucket using a locomotive crane. The material was placed on the pier adjacent to the bunkers, where it likely remained until being loaded into railcars.

**Matson Lines**

Warehouses 6 and 7 at Pier 2, called the "Old Matson Warehouse," were constructed in 1922 and were used in Matson Navigation Company's Hawaiian trade (City CPD, 1947). Matson operated a freight dock at Slip 1 from 1955 to 1985. Matson initiated containerized cargo operations in 1964 at Berth 408, which was formerly used for the loading of scrap iron. This location fits within space designated as Berths 406 to 408. Pacific Northwest products, such as refrigerated meat, fresh fruit, potatoes, other vegetables, and canned goods, were shipped in containers to Matson's Hawaiian terminals on a biweekly basis. Return containers delivered commodities such as sugar, pineapple (fresh and canned), and tuna. Molasses shipped in vessel holds was used for ballast. Matson Navigation's agreement with the City CPD gave it preferential berthing at Pier 2 and provided for exclusive use of a paved portion of the yard south of the pier for Matson's container operations. Matson used space at Terminal 4 until expiration of the agreement in March 1982, at which time it transferred its container operations to Terminal 6 and discontinued the shipment of liquid molasses.

**Quaker State**

In 1953, Quaker State constructed an oil packaging (motor oil bottling) facility at the head (to the east) of Slip 3. The facility included an underground transfer pipeline, three 220,000-gallon tanks, one 42,000-gallon tank, four 10,000-gallon tanks, a main blending and bottling building, and a storage building. Bulk oil was brought in via railcars on the north side of the facility or via ships berthed at Pier 5, Berth 412. The oil was pumped

directly to the tanks from the railcars or directly from vessels into the transfer pipeline that traversed from Pier 5 to the eight ASTs. The tanks, which were located west of the packaging plant building, were connected to the packaging plant via pipeline. Quaker State bottled motor oil in 1-quart containers; some of the oil was blended at the facility with detergent and with motor oils of different weights. Once the oil was packaged, it was loaded onto trucks or railcars via a spur track on the north side of the packaging plant (Figure 2-3).

Port drawings indicate that Quaker State also utilized a waste oil UST and a used oil AST located southeast of their main blending and bottling building. The UST was decommissioned in 1991. The date of removal of the AST has not been confirmed.

Quaker State continued its operations through 1985, when the ASTs and the abandoned underground pipeline were removed. The building was converted in 1985 to a new gearlocker building and electrical shop for Oregon Terminal Company. Port drawings indicate that a rail-covered shop work pit was constructed west of the gearlocker building and two USTs were installed east of the gearlocker building at that time.

**Rail Development at Terminal 4**

Terminal 4 had approximately 10 miles (of a projected 17 miles) of railroad line when operations began there in 1920. After the addition of the cold storage facility in 1922, approximately 15 miles of rail trackage served the terminal. City CPD annual reports (City CPD, 1927, 1931) subsequent to 1926 described the rail network as having a working capacity of 425 cars (130 at ship side) with the ability to accommodate up to 800 cars.

The USATS made additions to the terminal's rail network during its tenure between 1943 and 1947, constructing or repairing approximately 22 miles of rail trackage. The high-capacity movement of defense materiel through the Portland Sub-Port of Embarkation created railcar holding backlogs on the main lines. The War Department responded to this by leasing land adjacent to Terminal 4 and building a railcar storage yard to accommodate cargoes awaiting transshipment.

Following the facility's return to the City CPD, improvements were made in 1947 when additional trackage was installed for the new bulk outloader built by the City CPD at Pier 5, Berth 412 for handling expected coal and phosphate cargo. Rail improvements continued at Terminal 4 in the 1950s, including a spur track constructed in 1953 to serve the Quaker State oil packaging plant at the head of Slip 3, rail modifications to accommodate the addition of the Cargill grain storage tanks in 1954, the 1959 addition of rail lines for Pier 4 when it was developed, and improvements in 1964 at the time of Matson's container terminal operation. More recently, in 1996 Hall-Buck Marine required modification of the rail network to accommodate its soda ash export facility.

In 1964, when Matson Navigation began container terminal operations at Pier 2, the rail infrastructure was assessed for container operations. In 1985, the north throat and grain leads into Terminal 4 were reconstructed. In 1987 and 1996, Hall-Buck Marine's lease operations required modification of the rail network near Slip 3. Maps depicting rail lead designations are illustrated on Figure 2-4.

Exported freight is the railroad company's responsibility until facility operators take delivery with their locomotive, as is the case with Kinder Morgan Bulk Terminals (KMBT). Responsibility remains with KMBT and the longshoremen while product is transferred to a ship's hold. When the ship's hatches are closed, responsibility for the cargo is transferred to the vessel owners and operators. The same process applies to imported cargo. While the product is in the ship's hold, it is the vessel owner/operator's responsibility. During transfer, the responsibility shifts to the terminal operator (tenant) and its agents (longshoremen). This status is in effect while the railcar is shifted to another siding and an empty car takes its place. Union Pacific,

or another railroad company, assumes responsibility when the completed load is hooked up and pulled out of the terminal.

## Army Transport Service Sub-Port of Embarkation

In January 1942, the USATS leased all of Terminal 4 for use as the Portland Sub-Port of Embarkation, and municipal shipping activities were shifted to City CPD Terminal 1 and old Terminal 2. The facility was used to embark troops for overseas, as well as to store equipment and materials, house Army personnel, refuel ships, and load ships for transport overseas. The War Department in turn leased property and buildings to subtenants (e.g., Northwestern Ice and Cold Storage Company), providing services at the Portland Sub-Port of Embarkation. During its tenure at Terminal 4, the USATS operated the facilities described below.

**Disinfestation/Fumigation Plant.** Between May and September 1943, the USATS constructed a disinfestation (fumigation) plant to the east of Warehouse 1 for delousing soldiers and prisoners of war prior to their embarkation or debarkation. (Maps and drawings from the war years refer to a House 1 on both Piers 1 and 2. A report from February 1944 notes that the disinfestation plant was located in the former Water Division repair shop, but that location has yet to be verified.) The disinfestation plant was designed to delouse 150 men and their clothing and belongings per hour. The prisoners of war were reportedly held at Warehouse 1 (including a "delousing area") prior to being transferred elsewhere. The materials used in the disinfestation process have not been confirmed. An Army directive of August 19, 1944 instructed military installations to use methyl bromide for disinfestation and fumigation.

**Salvage Yard.** The USATS established a small salvage yard at Terminal 4 for scrap metal (including scrap iron and ferrous metal) and rubber. A report from March 1943 noted the sale of more than 38,000 pounds of scrap iron and steel from salvage operations. The total tonnage of materials scrapped at the terminal during the USATS's tenure was close to 350 tons, with most of that sold in 1944. Some of the materials were sold to the Zidell Manufacturing & Supply Company, Alaska Junk Company, and California Bag & Metal Company. Aerial photographs indicate that the USATS filled the salvage yard area sometime around 1945.

**Auxiliary Oil Pipeline.** In February 1944, the USATS completed construction of an auxiliary pipeline at Pier 5, Slip 3. The pipeline extended 340 ft to the slip side of the pier. The Army also constructed two standpipes adjacent to the slip to accommodate the auxiliary pipeline. The new line was built to permit tankers to transfer oil to upland facilities while other ships took on coal from the adjacent bunkers.

**Other USATS Facilities.** Two other facilities are of potential interest: a gasoline station and a sulfur plant. The gas station was located along the south side of Carroll Road (the entrance road to the terminal) slightly northeast of the vegetable oil storage tanks east of Slip 1. The gas station utilized an approximately 2,000-gallon gasoline storage tank and pump in connection with the processing of military vehicles. It is not known whether the storage tank was above or below ground. The sulfur plant was located east of the bulk storage bunkers on Pier 5 (corresponding with the former location of the Oregon Sulphur Company).

Terminal 4 was returned to the City CPD in February 1946. In 1947, the War Assets Administration purchased the northern portion of the City CPD terminal occupied by Oregon Shipbuilding Corporation in exchange for property on the west bank of the river that the City CPD later developed as Terminal 2.

## Ore and Concentrate Handling

**Pre-1950.** From its inception, Terminal 4 was designed to handle imports and exports of bulk cargo. Rail transport by OWR&N Co. and its successor, Union Pacific, was the chief means of conveyance for import and

export cargo. Ores and concentrates were an important element of this traffic beginning in 1921 with the completion of Pier 5 on the southern edge of Slip 3. A large area for open storage, to the east and south of Pier 5, lay adjacent to eight covered concrete bunkers with sloping interiors, which were serviced by a series of belt conveyors. This was the mineral bulk-handling facility at Terminal 4, details of which are provided in Table 2-3 based on information known to date.

**Table 2-3**
**Chronology of Pre-1950 Mineral Bulk Handling at Terminal 4**

| Ore | Status | Transfer Method | Storage | Period |
|---|---|---|---|---|
| Phosphate rock | Export | Railcar from siding unloaded to either track hopper or cradle unloader to bunkers or cars; contents were discharged to open area storage. Material traveled by conveyor belt from bunkers to loading towers on the harbor face (Berth 414) of Pier 5, where it was loaded directly into ships' holds. | Open storage or covered bunker | 1921-1950 |
| Sulfur | Import | Ships unloaded by Terminal 4 locomotive crane onto Slip 3 side of Pier 5 (Berths 412 and 413). | Open storage | 1921-1945 |
| Manganese ore | Export | Same method as used for phosphate rock. | Open storage or covered bunker | 1924-1925 |
| Zinc concentrate | Export | Same method as used for phosphate rock. | Open storage or covered bunker | 1925-1928 |
| Coal | Ship fuel | Same method as used for phosphate rock. | Open storage or covered bunker | 1923-1931, 1935-1936, 1940-1950 |
| Chrome ore | Import | Same method as used for phosphate rock. Unloaded at Pier 5 in 1925 and at Pier 2 (Berths 406-408) in 1937-1941. | Open storage or covered bunker | 1925, 1937, 1940-1941 |

**Post-1950.** At the end of World War II, the City CPD regained use of Pier 5 and constructed a new bulk outloader on the Slip 3 side of the pier (Berth 412) for handling expected cargoes of coal and phosphate. Starting in 1955, lead and zinc concentrates were directly transferred from ships in Slip 1 to open Union Pacific gondola railcars by two gantry cranes at Pier 2 equipped with clamshell buckets. The transfer of lead and zinc concentrates at Terminal 4 was relocated to Slip 3 (Berths 410 and 411) in 1961 with the completion of Pier 4 and the Dravo bulk unloading tower. The Dravo unloading tower remained in service until 1998, when it was decommissioned. Soda ash, initially exported from Pier 5, Berth 412, became a major export in 1988, when loading was transferred to Pier 4, Berths 410 and 411, where a new bulk outloader was constructed by Hall-Buck. Based on currently available information, details of these operations are summarized in Table 2-4.

**Table 2-4**
**Chronology of Post-1950 Mineral Bulk Handling at Terminal 4**

| Ore | Status | Transfer Method | Storage | Period |
|---|---|---|---|---|
| Lead concentrate | Import | Gantry crane clamshell removed ore concentrate from ship hold to open railcar on Pier 2 (Berths 406-408) until 1961; Dravo unloading tower removed ore concentrates from ship hold to open railcar on Pier 4 (Berths 410 and 411) from 1961-1971. Railcars were spotted on Tracks 4-10, 4-11, 4-12, and 4-15. Cars were then pulled west to Tracks 4-2 and 4-3 for pushing under the Dravo loader. Loaded cars exited to the ladder tracks at the east of the pier for switching. | No storage | 1955-1971 |
| Coal | Export | Berth 412 bulk unloader; gantry cranes at Pier 2 also unloaded coal from barges. | Pier 5 storage bunkers | 1952-1958 |
| Zinc concentrate | Import | Same method as used for lead, same time frame. | No storage | 1955-1971 |
| Soda ash | Export | Bulk outloader; Pier 5-loaded railcars dumped soda ash into Berth 412 outloader, direct transfer to vessel. Pier 4-loaded railcars traveled along face of dock, in strings of six cars, through one of two dumper buildings. Soda ash was either transported directly to ship via conveyor or taken to storage building for later shipment. Ships could be simultaneously loaded from storage and rail. | 30,000-ton A-frame storage building at Pier 4 since 1993; no storage at Pier 5 (direct transfer from rail to ship only) | 1988-Present |
| Sulfur | Export | Transfer from railcars to barges by bulk unloader at Berth 412. After 1961, transferred by Pier 4 Dravo tower. | No storage | 1955-1967 |
| Alumina/Bauxite | Import | Gantry cranes at Pier 2 (Berths 406-408) removed ore from ship hold to Union Pacific railcars. After 1961, ships were unloaded at Pier 4 (Berths 410 and 411) by the Dravo unloading tower. | No storage | 1955-1956, 1963 |
| Ammonium sulfate | Import | Transferred from ship hold by Dravo tower into dump trucks. | Storage building south of Pier 5 | 1970 |
| Bentonite clay | Export | Direct transfer from railcar to ship via Pier 5, Berth 412 bulk outloader via conveyor belt from railcars until new outloader constructed at Pier 4. | No storage | 1967 |
| Sodium sulfate | Export | Direct transfer from railcar to ship via | No storage | Not available |

| Ore | Status | Transfer Method | Storage | Period |
|---|---|---|---|---|
| | | bulk outloader at Pier 5 until new outloader built at Pier 4. | | |
| Soybean meal | Export | Direct transfer from railcar to ship via bulk outloader at Pier 5 until new outloader built at Pier 4. | No storage | Not available |
| Chromite | Import | Gantry cranes at Pier 2 removed ore from ship holds to Union Pacific railcars. | No storage | 1956-1957 |
| Ferro-phosphorous iron ore | Export | Transferred by Pier 2 gantry cranes from railcars (originating in Idaho) to SS *Jotunfjell* for shipment to Rotterdam, Holland. | No storage | 1955-1957 |
| Limestone | Import | Transfer from barge hold to railcar. | No storage | 1966-1967 |
| Manganese | Import | Gantry cranes at Pier 2 removed ore from ships to railcars. | No storage | 1958 |
| Potash | Export | Transferred from railcars to ships at Berth 412. | Storage bunkers | 1959 |
| Rutile ore sand (titanium oxide) | Import | Transferred from ship holds by Berth 412 bulk loader. | Storage bunkers | 1970 |
| Talc | Export | Transferred from Burlington Northern railcars to ship holds by Berth 412 bulk outloader (Berth 401). | Storage bunkers | 1966 |
| Tricaphos (tri-calcium phosphate) | Import | Discharged by a marine leg and conveyor belts at Pier 1. | Storage bunkers at Pier 1 | 1961 |

The Bunker Hill Company and Hecla Mining Company's Sullivan Electrolytic Zinc Plant were the major consignees for lead and zinc ore concentrates during the 1955 to 1971 period. Anaconda Mining Co. (a former ARCO subsidiary) and American Smelting & Refining Co. (known as ASARCO) also imported ores through Terminal 4. The American National Soda Ash Consortium (known as ANSAC) has supplied Wyoming soda ash to the KMBT (formerly Hall-Buck Marine) facility at Terminal 4 from 1988 to the present day.

**Pencil Pitch Handling**

Pencil pitch is a coal tar distillate used as anode material at aluminum refineries throughout the Pacific Northwest. It is manufactured by extruding finger-width coal tar pitch "pencils." Available Port records indicate that pencil pitch was handled at Terminal 4 from 1978 to 1998. The pencil pitch was manufactured in Germany and China and purchased from Koppers Industries, Inc. Ships carrying the pencil pitch were moored at Berth 411 in Slip 3. Longshoremen removed the pencil pitch from the ships' holds by means of the clamshell-equipped Dravo unloading tower on Pier 4 and loaded it directly onto truck trailers or railcars adjacent to the pier.

In 1978, 13,161 short tons of pencil pitch arrived at the Port in several ships and were transferred to rail and truck carriers at Pier 4. In 1979, Jones Oregon Stevedoring Co. signed an agreement to handle bulk pencil pitch cargo at Terminal 4. That agreement was renewed in September 1982. In 1987, the Port leased the bulk

cargo handling operations to Hall-Buck Marine, Inc. At that time, the Port was using the Dravo unloading tower to transfer an estimated 25,000 to 35,000 tons of pencil pitch annually. Hall-Buck Marine modified the Dravo mechanism in 1988 and the rear section of the loading hopper enclosure in 1992 to improve operations. Statistics indicate that 182,748 short tons of pencil pitch were unloaded from at least 28 ships between 1978 and 1989. Port records register 11 ships calling between January 1997 and June 1998. Ten of those vessels were affiliated with General Steamship Corporation, Ltd. In 1998, Hall-Buck Marine ended bulk import of pencil pitch at Terminal 4. The Dravo unloading tower was decommissioned that same year.

**General Cargoes**

Terminal 4 was chiefly designed to handle bulk (as opposed to break-bulk) cargo. The grain elevator, vegetable oil and molasses tanks, and the bulk mineral facility at Pier 5 have been prominent elements of the bulk cargo handling at Terminal 4. Other bulk cargoes imported or exported through Slip 1 and its adjacent piers and warehouses were wool, cotton, and natural rubber. The entities handling these cargoes and the time frames involved are not presently known. Some break-bulk cargoes were processed through Terminal 4, including automobiles exported to the Far East beginning in 1925.

Prior to and during the terminal's use as a container station by Matson Navigation Company, the terminal was used to process whole log bundles for export to Japan.

In addition to the bulk storage plant for handling coal, phosphate rock, and other bulk products, the rear of the quay dock at Pier 5 had a 3.5-acre storage space available for lumber, logs, sulfur, and steel. The equipment used for loading and unloading these materials included two traveling towers, hoppers, tripper, chutes, bins, and automatic scales. The quay dock was removed from Pier 5 in 1962, and the bulk handling facility was demolished between 1968 and 1969. The bulk outloader on the slip side of Pier 5 was decommissioned and removed between 1990 and 1992.

**City of Portland**

The City of Portland owns a parcel of land adjacent to Wheeler Bay commonly known as the fire boat station parcel. When the Port and the City CPD were consolidated in 1971, the CPD's properties and functions were transferred to the Port. However, the fire boat station parcel was specifically exempted from the transfer of property. The exemption was recorded correctly, but the parcel was erroneously located on Multnomah County tax maps at Slip 1 instead of in Wheeler Bay. That error was corrected in 2002.

The City of Portland operated a fire boat station at Terminal 4 from a pier into Wheeler Bay from approximately 1960 through approximately 1986. At one point, the fire boat station was located on the upstream end of Wheeler Bay, attached to Berth 410. In approximately 1980, the Multnomah County Sheriff's Department moved a boat house and houseboat just inside the area closer to the head of the slip from the fire boat station. The City of Portland formerly utilized an approximately 1,000-gallon UST for the storage of gasoline. The former UST was decommissioned in 1995 and, following sampling of soil and groundwater, DEQ issued a No Further Action determination. The City of Portland relocated its fire boat moorage to the Port's Terminal 1 facility in 1995, at which time Carr Marine leased the ramp and floating dock to tie up barges. That lease ended in 1999. The fire boat parcel has been vacant since that time.

In 1986, the City of Portland constructed a municipal stormwater sewer conveyance system that drains properties located along North Lombard Street and North Roberts Avenue. The stormwater piping traverses the northern portion of the Slip 1 Upland Facility and ultimately discharges to Slip 1. The City of Portland refers to the outfall discharging to Slip 1 as Outfall 52C. According to City of Portland records, Outfall 52C is

a 36-inch municipal storm drain with a catchment area of approximately 24 acres located above the railroad tracks east of the terminal.

**Other Facilities**

A gearlocker building, constructed as a one-story building in 1932, housed shops for carpentry, painting, blacksmithing, and repairs. In 1942, during the USATS's tenure, an internal, second-story loft was added to the building.

**Oregon Terminal Company**

In 1988, the Port ceded control of overall operations at Pier 2 under a management agreement with Oregon Terminal Company (OTC) for operation of all break-bulk berths. OTC handled Berth 408, the ro-ro dock, and associated warehouses. In addition, OTC operated the old Quaker State building as a gearlocker. A rail-covered work pit was constructed west of the gearlocker building at that time. In addition, one 4,000-gallon UST for diesel and one 4,000-gallon UST for gasoline were installed with a fueling station on the south side of the gearlocker building. An equipment wash station was installed on the slip side of the building; the wash station drained to the sanitary sewer. Both the USTs and the wash station were removed when the management agreement ended in 1996.

### 2.2.3.3 Current Terminal Operations

Throughout the 1980s and 1990s, some of the buildings, equipment, and docks at Terminal 4 became obsolete and were removed. Slip 1 is not presently deep enough to accommodate deeper-draft modern vessels and current Port plans do not call for such deepening in the foreseeable future. In the late 1980s and early 1990s, Warehouse 4 was condemned and removed, and the original tanks at the bulk liquid storage facility near the head of Slip 1 were removed. In 1996, Berths 406 and 407 and their associated docks and warehouses were dismantled. The demolition of Berths 403 and 404 and associated Houses 3 and 4 followed in 1999. Bulk operations at Berth 412 (Pier 5) were terminated in 1989, and the wharf at Berth 412 was removed in 1997.

**Cargill**

Cargill Grain, Inc. terminated its lease for approximately 15.1 acres at the grain terminal facility in 2003 (the Port received a Notice of Early Termination on May 6, 2003). Also included in the lease are the deck and fender system for Berths 401 and 405, rail tracks from the frog, and Cargill's share of the cost for Port maintenance of common-area rail and road. Cargill is currently in "hold over" status pending final investigation and cleanup of its leasehold and is in the process of implementing an exit audit of the facility. CLD Pacific Grain was a sublessee of Cargill.

**Cereal Food Processors**

Cereal Food Processors, Inc. (formerly known as Terminal Flour Mills) is currently in the last four years of a lease for approximately 1.6 acres at the flour mill facility at Terminal 4.

## International Raw Materials

IRM is currently in year three of a 10-year lease (with two five-year option periods) for approximately 6.3 acres at the liquid bulk storage facility, excluding a Port building. The previous lease for the facility was assigned from PM-Ag to IRM in 1995.

## Rogers Terminal

Rogers Terminal & Shipping (a division of Cargill Marine) is currently in "hold over" status with a lease of improved space east of Slip 1. The lease is for less than 1 acre and encompasses an 11,712-square-ft warehouse with 406 square ft of office space and a 15,451-square-ft yard. Rogers, a terminal service company, originally leased the space for stevedoring services supplied to Cargill's operation. Since Cargill is in the process of exiting its lease and is no longer operating at Terminal 4, Rogers is currently utilizing the leasehold for storage purposes. Rogers' initial lease agreement with the Port dates from 1983.

Rogers formerly utilized an aboveground used oil tank in connection with its operations. In addition, the Port removed an approximately 10,000-gallon gasoline UST from the Rogers leasehold in 1990. Sampling during decommissioning of the UST confirmed that there were no releases associated with the UST.

## Kinder Morgan Bulk Terminals

In 1998, Hall-Buck was acquired by Kinder Morgan and renamed KMBT. KMBT continues to export soda ash through Slip 3. KMBT currently leases 6.56 acres adjacent to Berths 410 and 411 for ship loading of soda ash and/or unloading of bulk cargo from rail. The lease area includes rails, associated buildings, a storage dome, and utilities.

Additional agreements affecting Kinder Morgan's lease area include:

- a Portland General Electric easement for underground line;
- a Pipeline Crossing Agreement, Union Pacific (licensor) to Hall-Buck (licensee), allowing Hall-Buck to construct, maintain, and operate a pipeline; and
- a Revenue Sharing Agreement with Union Pacific.

KMBT currently utilizes an approximately 5,000-gallon diesel UST located north of the Rail Dump building, an approximately 675-gallon AST located in the eastern portion of the facility, and an approximately 2,000-gallon sulfuric acid AST located within Building 432. In addition, KMBT utilizes an approximately 43,000-gallon open settling tank for soda ash wash-down water.

## Schnitzer

The Port has a moorage agreement with Schnitzer Investment Corporation for a portion of the mooring dolphin that extends onto submerged lands adjacent to property owned by Schnitzer at the Berth 401 grain elevator.

## Rail Usage

The rail trackage within the confines of Terminal 4 is owned by the Port. The Port leases portions of the rail trackage to individual tenants as part of their facility leases. The Terminal 4 rail system is designated as capacity that the Port will afford a tenant under terms of the lease. Older, renewable leases, such as the one

currently in effect with KMBT, subsume the particulars of car movement and loading under the general term of "operations." Newer facility leases deal with all aspects of terminal transfer operations in detail.

Although not specifically addressed in lease language, there are recognized responsibilities regarding rail activities at Terminal 4. KMBT's soda ash operations furnish an example. Union Pacific, or any other railroad company involved in car transit and delivery, is responsible for the line haul of consigned product from origin to destination. This includes delivery of the cars to the terminal. At the point when Union Pacific pulls away from the train, the Port's lessee, KMBT, takes charge of the cargo with its own locomotive. Under KMBT's original 1987 lease agreement that governs use of the facility, longshoremen provide the labor for product movement and transfer.

### 2.2.4 Dredging and Filling History

Dredging activity at Terminal 4 began with the work that provided fill for the general terminal space and created Slips 1 and 3 between 1917 and 1921. In the process, the former Gatton's Slough and adjacent Willamette River shoreline were reconfigured (see Section 2.2.2). Port of Portland dredges provided the dredged material for the City CPD's facility. Maintenance dredging of the slips and improvements to the terminal's harbor face occurred periodically in ensuing years. Based on currently available information, Table 2-5 summarizes the chronology of dredging events at Terminal 4.

**Table 2-5**
**Chronology of Dredging Events at Terminal 4**

| Year | Location | Description |
|---|---|---|
| 1917 | St. Johns Elevator and Terminal | Slip excavation performed by Dredge Portland and "special channel" work performed by Dredge Willamette. |
| 1918 | St. Johns Terminal | Slip excavation performed by Dredge Portland and channel work performed by Dredges Columbia, Willamette, and Tualatin. |
| 1919 | Harbor Channel | Dredge Willamette dredged material from the harbor channel and applied fill to Terminal 4 during three separate time periods. |
| 1919 | Slips | Dredge Portland worked on slips during several time periods. |
| 1920 | Terminal and Harbor Channel | Dredge Willamette dredged material from the harbor channel and slips and applied fill to Terminal 4 during three separate time periods. |
| 1920 | Slips and Filling | Dredge Portland dredged material from slips and applied fill to terminal during three separate time periods. |
| 1921 | Slips and Filling | Dredge Portland dredged material from slips and applied fill to Pier 3 and Pier 4 areas during three separate time periods. |
| 1922 | Harbor Channel | Dredge Portland worked the shipping channel at Terminal 4 and deposited dredged material on an unspecified "east side" location in August. |
| 1923 | Harbor Channel | Job No. 1087: Dredged material discharged on Terminal 4 beach. |
| 1924 | Pier 5 | Job No. 1100: Dredged material discharged on bank upstream from Terminal 4. |

| Year | Location | Description |
|---|---|---|
| 1942 | Slip 1 | USATS maintenance dredging of Slip 1. |
| 1948 | Terminal 4 | Dredging of Slip 3. |
| 1957 | Slip 3 | Widening of Slip 3, dredge and fill. |
| 1962 | Slip 1 | Dredging. |
| 1968 | Slip 1 | Dredging. |
| 1975 | Slip 1 | Dredging of Berths 403-405. |
| 1977 | Slips 1 and 3 | Dredging of Berths 407-408 (Slip 1) and Berth 410 (Slip 3) |
| 1984 | Slip 3 | Maintenance dredging. |
| 1988 | Slip 1 | Maintenance dredging, Berths 403-408. |
| 1994 | Slip 3 | Dredging associated with consent decree remediation. |
| 1997 | Slip 3 | Maintenance dredging. |
| 2002 | Slip 3 | Maintenance dredging. |
| 2003 | Slip 3 | Maintenance dredging. |

### 2.2.5 Adjacent Property Ownership and Operations

Terminal 4 is bordered to the north by Schnitzer Steel Industries and Northwest Pipe and Casing; to the north/northeast by the Burgard Industrial Park; to the south by the Terminal 4 auto storage area, which is occupied by Toyota; to the east by Union Pacific rail tracks, beyond which is the Toyota processing yard and Toyota processing center; to the southeast by the Toyota upper lot; and to the west by the Willamette River. The Schnitzer Steel, Northwest Pipe and Casing, Burgard Industrial Park, and Toyota auto storage area are discussed below.

#### 2.2.5.1 Schnitzer Steel Industries

Schnitzer Steel Industries (Schnitzer), located at 12005 North Burgard Street, borders Terminal 4 on the north. Schnitzer processes, stores, and exports scrap metal (e.g., automobiles, appliances, and ferrous metal products) from its facility. Schnitzer also operates a deep marine terminal for bulk commodities. The property was the site of Oregon Shipbuilding Corporation's shipyard from approximately 1943 through 1945; from the late 1960s through 1972, Schnitzer operated a ship scrapping facility at the property. Schnitzer Steel Industries is listed as DEQ Environmental Cleanup Site Information (ECSI) #2355 and is currently under a Voluntary Cleanup Program (VCP) Agreement for remedial investigation of the site, which is ongoing.

#### 2.2.5.2 Northwest Pipe and Casing

Northwest Pipe and Casing (also known as Northwest Pipe Company), located at 12005 North Burgard Street, borders Terminal 4 on the north. Northwest Pipe and Casing operates a welded steel pipe and coating manufacturing facility. Historically, the Oregon Shipbuilding Corporation shipyard, which operated from

1943 through 1945, extended onto the Northwest Pipe and Casing property. Beall Pipe operated a pipe manufacturing facility on the property from 1945 to 1983. Northwest Pipe and Casing purchased the property in 1983. Northwest Pipe and Casing is listed as DEQ ECSI #138 and is currently under a VCP Agreement for remedial investigation of the site, which is ongoing.

### 2.2.5.3 Burgard Industrial Park

The portion of the Burgard Industrial Park that is adjacent to the north/northeast of Terminal 4 includes Boydstun Metal Works and Western Machine Works.

**Boydstun Metal Works**

Boydstun Metal Works (Boydstun), located at 9002 North Sever Court in the Burgard Industrial Park, borders Terminal 4 on the north/northeast. Boydstun fabricates and paints automobile transport trailers. Specific manufacturing activities include cutting steel and aluminum sheets and tubes, welding parts as part of trailer assembly, sandblasting, painting, and installing hydraulics and electrical control systems. Historically, the Oregon Shipbuilding Corporation shipyard, which operated from 1943 to 1945, extended onto the Boydstun property; from the late 1960s through 1972, Schnitzer operated a ship scrapping facility at the property. Boydstun is separately listed as DEQ ECSI #2362; however, the site has been incorporated into the Schnitzer Steel Industries investigation (ECSI #2355), which is ongoing.

**Western Machine Works**

Western Machine Works, located at 12005 North Burgard Street in the Burgard Industrial Park, borders Terminal 4 on the north/northeast. Western Machine Works fabricates and remanufactures components for the paper and pulp industry. Historically, the Oregon Shipbuilding Corporation shipyard, which operated from 1943 to 1945, extended onto the Western Machine Works property; from the late 1960s through 1972, Schnitzer operated a ship scrapping facility at the property. Western Machine Works is not listed in the DEQ's ECSI database; however, the site is included in the Schnitzer Steel Industries investigation, which is ongoing.

### 2.2.5.4 Toyota Auto Storage Area

Toyota Motor Sales (Toyota), which occupies properties to the east, south, and southeast of the Terminal 4 Removal Action Area, has held a long-term lease agreement with the Port since 1976 for the storage and processing of automobiles. Historically, Toyota's facilities have been at Terminal 4 and above Terminal 4 on Lombard Street; the facilities are known as the upper and lower lots.

The Toyota area south of the terminal was first developed in 1969 and paved as a large-scale automobile import facility. A floating dock (Berth 417) was constructed in 1969, and a second floating auto dock (Berth 416) was constructed in 1972. In addition, Berths 414 and 415 were completed in 1974 for the handling of steel cargo.

In 1976, Toyota leased the import facility at Berth 416, and the processing plant was expanded in 1979. Berth 417 was relocated to the Port's Terminal 6 and a general cargo auto terminal was constructed there.

In 1986, the Port purchased the St. Johns Auto Wrecking Yard on Lombard Street above Terminal 4. Toyota entered into an agreement with the Port for approximately 69.2 acres of property, buildings, improvements, and dock rights located to the east and south of the Removal Action Area. Toyota exercised an option under the terms of the 1986 lease on October 30, 1989 for an additional 12-acre parcel farther upstream. On April 3, 1990, Toyota exercised another option under the lease for an additional 8.8-acre parcel located on the corner of North Lombard and North Roberts. A recent amendment extending the term of the lease also provided for closure of the "upper property" (east of the terminal) on North Lombard, including removal of the underground fuel tanks.

In 2002, Toyota Motor Sales, U.S.A., Inc. (also known as Toyota; TLS, Logistics) entered into a separate lease agreement for approximately 82 acres south of the Terminal 4 Removal Action Area, which includes a vacated portion of North Bradford Street.

Toyota's current operations include unloading automobiles from ships that dock at Berths 414 and 415, driving the cars to designated yard areas, and storing the vehicles awaiting processing. Processing includes fueling and washing the vehicles, installing accessories, air conditioners, and radios, and making minor repairs to vehicles damaged during shipping.

## 2.3 Planned Future Land Use

The Port is currently involved in master planning to guide development and redevelopment to the year 2020. Terminal 4 will remain one of the Port's primary marine terminals for the foreseeable future. The Port's planning process is ongoing. This process, which includes discussions with existing and potential future tenants as well as overall consideration of the regional, national, and global business and trade climate, will affect the Port's plans for Terminal 4.

Options under consideration for Terminal 4 generally involve retaining the existing terminal purposes of handling grain, autos, and dry bulk and liquid bulk cargoes. To increase efficiency, most options under consideration include improvements to rail and road access to the terminal. Specific improvements include a loop track for unit trains carrying bulk commodities to the terminal and a vehicle overpass to reduce truck/auto/rail congestion. Most of the alternatives under consideration emphasize the continued use of Slip 3 and deemphasize the use of Slip 1.

## 2.4 Current Physical Characteristics

The Removal Action Area, located within the Portland Harbor Superfund Site and the Port's Terminal 4, is on the eastern shore of the Willamette River just downstream of the St. Johns Bridge and between River Miles 4 and 5 (see Figures 1-1 and 1-2 for a vicinity map and aerial photograph of the Port's Terminal 4 property). The Removal Action Area's address and boundaries are described in Section 2.1. Upland boundaries, which are depicted on Figure 2-1, are associated with a separate Port project under oversight of the DEQ, as described in Sections 1, 2.2 and 3.3.1.

Owners of property adjacent to Terminal 4 are described in Section 2.2.5. Figure 2-5 shows Port and non-Port ownership within the Removal Action Area. The Removal Action Area encompasses roughly 38 acres, of which Slip 1, Slip 3, and Wheeler Bay make up about 28 acres, while the area from the mouths of the slips to the Harbor Line encompasses approximately 10 acres. Boundaries of the Slip 1 and Slip 3 uplands, which are within Terminal 4 but are not included in the Removal Action Area, are shown on the Removal Action Area

site plan on Figure 2-6. These uplands are about 283 acres in area (Parsons Brinkerhoff, 2002), including the Toyota lease areas, and are generally flat in grade in proximity to the slips. The surface covering is primarily asphalt, with minor areas of gravel and/or ballast associated with the rail lines. At present, a relatively large volume of sand is stockpiled within the Slip 1 uplands because of recent grading of the adjacent Toyota facility.

Elevation of Terminal 4 generally ranges from 30 to 35 ft mean sea level (MSL) in proximity to the slips. The river stage (i.e., elevation) is typically between 2 and 10 ft Columbia River Datum (CRD), which equates to 3.7 to 11.7 ft MSL, with the exception of peaks in river stage. This range is generally based on information from the Morrison bridge gage (refer to Figure 2-7 for historical data and note that flood levels for river stage are not reflected in the graph). The diurnal tidal range in the St. Johns area is 2.2 ft at low river stages and becomes progressively less with higher river stages (NOAA, 2003b). East of Terminal 4, the topography is slightly sloping, but somewhat variable. The most notable nearby variation is a gradual rise in the ground surface to an elliptical hill feature about 50 ft MSL. Southeast of Terminal 4, the ground surface rises at 5H:1V or shallower to an elevation of about 100 ft MSL, corresponding to the St. Johns area of Portland. To the west of Terminal 4 and immediately west of the Willamette River channel are the Tualatin Mountains (Portland Hills), with elevation rising relatively steeply at about 1.5H:1V to 3.5H:1V to an elevation of about 1,000 ft MSL. Figure 2-8 shows Terminal 4 relative to surrounding topographic features. Figures 2-9 through 2-16 provide photographs of Slip 1, Wheeler, Bay, and Slip 3 taken during the October 16, 2003 site visit from various vantage points.

Note that the graphical datum conversion on many of the work plan figures is based on datum conversion tables available from the Port of Portland, as well as City of Portland public records. The various datums represented were included in the work plan because consultant reports, public documents, and other published information used for the work plan or the EE/CA could reference bathymetric or topographic vertical positions based on any one of these vertical datums. Therefore, for convenience, the relative positions of these datums have been provided on most figures for quick reference.

The vertical datum for the EE/CA project is the CRD, which is based on an inclined plane from sea level and is referenced according to established river miles along the Columbia River. The North American Vertical Datum (NAVD) 1988 is a "fixed" geodetic datum based on vertical leveling and other techniques that superseded the prior fixed datum, National Geodetic Vertical Datum (NGVD) 1929. The USC&GS 1947 datum is understood to be a local adjustment to NGVD 1929. Mean sea level is a tidal datum determined over a 19-year period of local sea level observations. A more detailed description of vertical datums can be found on the National Oceanic and Atmospheric Administration (NOAA) website at the following links: http://www.ngs.noaa.gov/faq.shtml and http://www.co-ops.nos.noaa.gov. Finally, also reported on the graphical datum conversion is Ordinary High Water (OHW), which is the terminology used in association with the Willamette River stage observations between River Miles 4 and 5. This simply shows the position of OHW referenced to CRD.

### 2.4.1 Slip 1 Physical Characteristics

Slip 1 is the larger of the two slips (approximately 13 acres) and is infrequently utilized. The mudline elevation ranges from about –34 ft to –38 ft CRD according to the most recent annual bathymetric condition survey by the Port (Port of Portland, 2003).

Embankment slopes above the shoreline were observed during a site visit on October 16, 2003, to be highly variable, generally ranging from very shallow to about 2H:1V or steeper. Where very shallow, the slopes

usually transition gradually to a steeper slope some distance from the water – the slope behind the pier at Berth 401 is relatively flat for about 20 to 40 ft, then transitions to a steeper slope (refer to Figure 2-10).

Slope protection consisting of variable-sized rock (having the appearance of 8-inch-minus size) was observed from the shoreline to about mid-slope on the river-facing embankment slopes, which generally have vegetation where no slope protection has been placed (refer to Figure 2-11). On the northern embankment slope near the mouth of Slip 1 are rows of remnant concrete columns from a former pier built in the same manner as the existing piers in the slip. On the embankment slope north of Berth 401 by the Schnitzer Steel property, there are a number of remnant timber piles (and concrete panels lying against the embankment slope). No slope protection is present in this area, and driftwood lines the embankment above the shoreline. More remnant square concrete columns with concrete pile caps exposed occur just south of this area on the embankment slope. The slope includes what appears to be a remnant from a tiered crib wall at the base of the slope. The opposite embankment slope west of Berth 408 does not have slope protection west of the existing pier and is showing signs of erosion in the form of scarps and surficial sloughing (refer to Figure 2-11). Factors that contribute to erosion could include undercutting resulting from propeller wash during former uses of the pier; ongoing forces such as surface currents and wind waves; and possibly cycles of soil wetting and drying that result from tidal and seasonal variations in river stage combined with the relatively steep slope.

Under-pier slopes generally range from 2H:1V to 3H:1V, with the exception of slopes near Berth 408, which range up to around 1H:1V (Port of Portland, 2003).

Two large piers exist within Slip 1, from the head of the slip to about the midpoint, on the north and south sides, providing Berths 405 and 408, respectively. The piers are timber-pile supported with concrete columns and interconnecting concrete framework built from about the shoreline and above as the support structure for the pier deck and associated structures (e.g., warehouses at Berth 405 and stationary crane at Berth 408) as shown on Figure 2-12. These pier structures are in disrepair as characterized in the Port of Portland 2020 Master Plan (Port of Portland, 2002). The Cargill grain elevator is located to the north of Slip 1.

### 2.4.2 Wheeler Bay Physical Characteristics

Wheeler Bay is the small bay (approximately 3 acres) between Slip 1 and Slip 3. Wheeler Bay was originally to become Slip 2, but Slip 2 was never completed. Wheeler Bay is immediately adjacent to Slip 3, separated by Pier 4.

The embankment slopes above the shoreline at Wheeler Bay are similar to the configuration noted for Slip 1 near Berth 401, with the exception that the very shallow, flat area abruptly transitions to a steeper slope generally 2H:1V or shallower, as observed during the October 16, 2003, site visit (refer to Figure 2-13). The transition to the steeper embankment slope is farther from the shoreline than at Slip 1, ranging from about 5 to 30 ft away. Above the mean higher shoreline, the embankment area is littered with driftwood debris such as tree stumps, logs, and scattered plant matter.

The submerged slopes are very shallow, with mudline elevations generally ranging from –6 ft to –15 ft CRD within the bay, then increasing in slope below Pier 4 to Slip 3 and toward the river.

Remnants from a partially demolished timber pile-supported structure span the relatively shallow embankment slope and remaining timber piles in the bay. Several single timber piles associated with this former structure are present.

The only current structure at Wheeler Bay is Pier 4, which separates the bay from Slip 3. A barge was docked on the Wheeler Bay side during the October 16, 2003 site visit (refer to Figure 2-14).

### 2.4.3 Slip 3 Physical Characteristics

Slip 3 is the southern and smaller (approximately 12-acre) slip in the Removal Action Area; Slip 3 is very actively used for KMBT soda ash export.

The mudline elevation ranges from about –36 ft to –50 ft CRD (Port of Portland, 2002). The shallower depths occur at the head of the slip. Maintenance dredging of Berths 410 and 411 is performed relatively frequently, and the water depth is from –40 ft to –45 ft CRD adjacent to the pier in Slip 3. The deeper portion of the slip (to –50 ft CRD) consists of a trough that extends from the east side of Pier 4 to the mouth of the slip at its center. This trough appears to be related to erosion caused by the movement of ships out of berth as part of the KMBT operations. The active berthing areas for KMBT are Berths 410 and 411, which are on the north side of Slip 3 (refer to Figure 2-15). The trough widens and deepens near the mouth of the slip.

Under-pier slopes range from about 1.5H:1V to 2.5H:1V or shallower (Port of Portland, 2002). The bathymetry includes the submerged slope at the mouth of the slip, which is about 5H:1V to the deeper channel of the Willamette River.

Embankment slopes above the shoreline and the general locations of slope protection are similar to Slip 1, with the exception that slopes on the south side of Slip 3 (north of the Toyota facility) are generally flat and have less elevation between the shoreline and upland properties. The embankment slope on the south side of Slip 3 has remnant concrete columns from a former pier structure (refer to Figure 2-16).

On the north side of Slip 3 at Berths 410 and Berth 411, a large pier structure, presently used extensively by KMBT, extends to the Harbor Line and visually separates the slip from Wheeler Bay. The structure is similar to the previously described piers, except that the structure foundation apparently included pre-stressed concrete, steel, and timber piles. A large crane is present on the deck of the pier. The remnant of a former pier with construction similar to the piers previously described occurs on the south side of Slip 3; all the above-water portions of the pier have been demolished and the timber piles remain in place, partially visible above the water line.

## 2.5 Current Ecological Characteristics

### 2.5.1 General Aquatic and Upland Habitat Potential

No specific studies of ecological conditions at the Terminal 4 Removal Action Area have been conducted. However, some studies addressing general habitat characteristics in the Lower Willamette River have included Terminal 4 (Altman et al., 1997; Ward and Nigro, 1992). In addition, sediment toxicity tests were conducted for the Slip 3 remedial investigation (Hart Crowser, 2000a), and biological tissue samples of fish and crayfish were collected from Terminal 4 during the Round 1 (2002) field investigation for the Portland Harbor Superfund Site. The following discussion summarizes the available information on the biological characteristics of the Terminal 4 Removal Action Area.

The Lower Willamette River from the Portland area to the confluence with the Columbia River is characterized by a maintained navigation channel and shoreline that is extensively modified for industrial and

commercial uses. The modification has resulted in deep (>20 ft CRD) open-water habitats in navigation areas, including much of Terminal 4. Such deep-water habitat generally provides feeding habitat for fish and wildlife that feed primarily on water-column species. Adjacent to the deep-water areas are generally shallower areas (<20 ft CRD), usually adjacent to shorelines or other areas outside the navigation channel. The shallower areas generally provide more opportunity for foraging by wading birds and semiaquatic mammals, as well as for aquatic life, including juvenile salmonids, that feeds preferentially in shallower, slack-water areas.

Benthic habitats in the river can be generally divided into three types: (1) unconsolidated sediments (sands and silts) in the deeper water and lower channel slopes; (2) unconsolidated sediments (sands and silts) in shallower areas; and (3) developed under-water structures such as rock riprap, sheet pile, and bulkheads. All three habitat types can be found at the Terminal 4 Removal Action Area. The deeper habitat with typically unconsolidated sediment tends to be in the center of Slips 1 and 3 and the outer portions of Wheeler Bay. Shallow-water areas are found at the margins of the slips and Wheeler Bay, under docks and piers, and in uncovered areas. The shallow areas also typically contain structures that include concrete and wooden pilings, riprap, and other non-native surfaces.

Farr and Ward (1993) sampled extensively in the Lower Willamette River to determine the fish species present. They identified 39 species, 19 of which were exotic. The identified species included federally listed salmon species (see below), white sturgeon, northern pikeminnow, smallmouth bass, and peamouth. During sampling conducted in 2002 to support the Portland Harbor RI/FS, reticulated and prickly sculpin, common carp, and largescale sucker were collected from Terminal 4 for tissue analysis.

Pacific lamprey are a species of concern for investigations in the Lower Willamette River. Surveys for larval ammocoetes were conducted in the Portland Harbor, although not specifically at Terminal 4. No larval or adult lamprey were identified in the harbor during the survey, but additional surveys of greater scope and frequency are needed to confirm the presence or absence of lamprey in the harbor and Terminal 4.

Upland habitat is limited because of surrounding industrial and marine facilities. Vegetated, shallow beach areas are located at the head of Slip 1 and Slip 3 and along much of the Wheeler Bay shoreline. In addition, a shallow cove area with beach shoreline is located just downstream from the mouth of Slip 1. Some revegetation has been conducted in areas at the upstream side of Slip 3.

Although habitats exist in Terminal 4, quality of the habitat is affected by the area's industrial activities. This is especially true for Slip 3, which is one of the Port's busiest berthing areas. Disturbances from ship traffic and the resuspension of sediments by propeller action limit the habitat quality in Slip 3. Far less activity occurs in Slip 1 and Wheeler Bay, but activity in Slip 3 and on adjacent uplands may adversely affect wildlife use in those areas as well.

### 2.5.2 Special Status Species

Special-status species include federal and state proposed and candidate species, federal species of concern, and state sensitive species. The following summary was taken from the draft RI/FS Programmatic Work Plan for the Portland Harbor Superfund Site. Table 2-6 summarizes the special-status species potentially occurring in the Lower Willamette River.

**Table 2-6**
**Species of Special Interest in the Portland Harbor Area, Lower Willamette River[1]**

| Common Name | Scientific Name | Federal Status | State Status |
|---|---|---|---|
| **Aquatic plants** | | | |
| Howell's bentgrass | *Agrostis howellii* | SOC | T |
| White-topped aster | *Aster curtus* | SOC | T |
| Wayside aster | *Aster vialis* | SOC | T |
| Peacock larkspur[a] | *Delphinium pavonaceum* | SOC | E |
| Willamette daisy[a] | *Erigeron decumbens* | E | E |
| Howellia[a] | *Howellia aquatilis* | T | - |
| Bradshaw's lomatium[a] | *Lomatium bradshawii* | E | E |
| Nelson's sidalcea[a] | *Sidalcea nelsoniana* | T | T |
| Hitchcock's blue-eyed grass[a] | *Sisyrinchium hitchcockii* | SOC | - |
| **Invertebrates** | | | |
| Columbia pebblesnail (spire snail) | *Fluminicola fuscus (Fluminicola columbiana )* | SOC | - |
| **Fish** | | | |
| Pacific lamprey | *Lampetra tridentata* | SOC | SV |
| River lamprey | *Lampetra ayresi* | SOC | - |
| Coastal cutthroat trout (Southwestern Washington/ Columbia River ESU) | *Oncorhynchus clarki clarki* | PT | SC |
| Chum salmon (Lower Columbia River ESU) | *Oncorhynchus keta* | T | SC |
| Steelhead (Lower Columbia River ESU) | *Oncorhynchus mykiss* | T | SU |
| Chinook salmon (Lower Columbia River ESU/Upper Willamette River ESU) | *Oncorhynchus tshawytscha* | T | SC |
| Bull trout | *Salvelinus malma* | T | - |
| **Birds** | | | |
| Aleutian Canada goose (wintering population) | *Branta canadensis leucopareia* | T | E |
| Black tern[b] | *Chlidonias niger* | SOC | - |
| American peregrine falcon | *Falco peregrinus annatum* | Delisted | E |
| Bald eagle | *Haliaeetus leucocephalus* | T | T |
| **Reptiles/amphibians** | | | |
| Painted turtle | *Chrysemys picta belli* | - | SC |
| Cope's giant salamander | *Dicamptodon copei* | - | S |
| Western toad | *Bufo boreas* | - | S |
| Tailed frog | *Ascaphus truei* | SOC | S |
| Northwestern pond turtle | *Clemmys marmorata marmorata* | SOC | SC |
| Northern red-legged frog | *Rana aurora aurora* | SOC | SU |

[1] From Portland Harbor RI/FS Programmatic Work Plan (Lower Willamette Group, 2003).

E – endangered
ESU - evolutionarily significant unit
PT - proposed threatened
S - sensitive
SC - sensitive, critical
SOC - species of concern
SU - sensitive, undetermined status
SV - sensitive, vulnerable
T – threatened

[a] The presence of these species has not been confirmed in the Superfund Site; they have been identified as species present in the Willamette Valley.

[b] This species is also on Oregon Natural Heritage Program's List 4, which contains taxa of conservation concern that require continued monitoring.

#### 2.5.2.1 Invertebrates

The Columbia pebblesnail (also known as the Columbia spire snail) is a freshwater mollusk that may occur in the Lower Willamette River. It is listed as a species of concern by the U.S. Fish and Wildlife Service (USFWS).

#### 2.5.2.2 Fish

Of the seven salmonid species reported to use the Lower Willamette River, five are listed as threatened or proposed threatened (Table 2-6). Coastal cutthroat trout, steelhead, and chum and chinook salmon are also considered sensitive species by the Oregon Department of Fish and Wildlife (ODFW). Pacific lamprey and river lamprey are recognized as species of concern at the federal level, and Pacific lamprey is recognized as a sensitive species at the state level. Pacific lamprey is an anadromous species that occurs in Portland Harbor. Little is known about the presence of river lamprey in the Lower Columbia Basin and the Willamette River. River lamprey have not been observed in these areas in recent years, but it is a rare species and difficult to find in fresh water. River lamprey have been collected in the Lower Columbia River in the vicinity of the Lower Willamette River, but their presence in the Lower Willamette River is unknown (Kostow, 2002).

#### 2.5.2.3 Birds

The status of sensitive aquatic or semiaquatic bird species is listed in Table 2-6. Aleutian Canada geese (*Branta canadensis leucopareia*) are rare but may be observed occasionally along the Lower Willamette River in winter and are considered a federal threatened species. Both Aleutian Canada geese and the American peregrine falcon (*Falco peregrinus annatum*) are protected as state endangered species. Black terns (*Childonias niger)*, a federal listed species of concern, are generally rare in the area, but were common during the summer of 2001 as a result of drought in the eastern part of the state (Nebeker, 2001). Bald eagles are known to use habitat along the Willamette River and are recognized as a threatened species both by USFWS and ODFW. Harlequin duck (*Histrionicus histrionicus*) is considered a federal species of concern, but is uncommon in the Lower Willamette Valley. On rare occasions, these ducks may be observed migrating through the area, but they would not use the area as a foraging ground (Nebeker, 2001). Any of the birds observed in the area have home ranges that extend well beyond the Superfund Site.

Breeding populations of several species present in the Lower Willamette River only during the winter have been given special status by ODFW or are considered sensitive by the Oregon Natural Heritage Program. These species include Barrow's goldeneye (*Bucephala islandica*), bufflehead (*Bucephala albeola*), horned grebe (*Podiceps auritus*), red-necked grebe (*Podiceps grisegena*), long-billed curlew (*Numenius americanus*), and greater sandhill crane (*Grus canadensis*) (ONHP, 2001).

#### 2.5.2.4 Amphibians and Reptiles

Western toad, Cope's giant salamander, tailed frog, northern red-legged frog, northwestern pond turtle, and painted turtle are all considered sensitive species by ODFW. In addition, northwestern pond turtle, tailed frog, and red-legged frog are listed as species of concern by USFWS.

#### 2.5.2.5 Aquatic Plants

Nine wetland plants that occur in the Willamette Valley and may occur within the Superfund Site are special-status species (see Table 2-6). Howell's bentgrass (*Agrostis howellii*), white-topped aster (*Aster curtus*), wayside aster (*Aster vialis*), Peacock larkspur (*Delphinium pavonaceum*), and Hitchcock's blue-eyed grass (*Sisyrinchium hitchcockii*) are all counted as species of concern by USFWS. Howellia (*Howellia aquatilis*) and Nelson's sidalcea (*Sidalcea nelsonia*) are federally threatened species, and the Willamette daisy (*Erigeron decumbens*) and Bradshaw's lomatium (*Lomatium bradshawii*) are protected federal endangered species. All of these plant species have state threatened or endangered status as well, with the exception of Howell's bentgrass, howellia, and Hitchcock's blue-eyed grass.

## 2.6 Current Engineering Characteristics

Terminal 4's current engineering characteristics are summarized below on the basis of information available from previous studies at the facility. Although the Removal Action is concerned with the engineering behavior of sediments in terms of dredging, onsite disposal, and capping, the engineering analysis of the feasibility of Removal Action alternatives requires knowledge of upland soil subsurface conditions and soil engineering properties as well. In general, the following properties of the sediment and upland soils will be used as a basis for the engineering evaluation in the EE/CA:

- density/consistency;
- plasticity characteristics;
- moisture content;
- organic content;
- gradation;
- porosity;
- consolidation characteristics;
- shear strength and "stiffness" characteristics; and
- dynamic (i.e., seismic) characteristics (i.e., shear wave velocity and shear modulus).

The engineering characteristics will be used in the following evaluations (note that other engineering activities not listed here may also be necessary):

- Conceptual designs for each of the Removal Action alternatives, which incorporate:
  - dredging volumes and sediment bulking behavior;
  - dredgeability of sediment;
  - sediment consolidation from capping;
  - slope stability of dredge slopes and under-pier areas;
  - slope stability of potential containment berms (both short-term and long-term seismic conditions); and
  - liquefaction potential and anticipated effects.
- Comparison of Removal Action alternatives, involving comparative evaluations of :
  - implementability (i.e., technical feasibility and constructability);
  - effectiveness; and
  - relative cost of Removal Action alternatives.

Engineering characteristics are available from three primary sources of existing information:

- Geotechnical Borings (or Cone Penetrometer Explorations). Typically available from such prior activities as foundation designs for pier structures and upland buildings and slip-deepening studies.

- Sediment Core or Surface Sediment Analytical Results. Typically available from laboratory testing conducted during previous environmental investigations associated with maintenance dredging or other environmental studies; typically includes grain size and moisture content data.

- Geotechnical Data. Typically available from laboratory testing associated with prior foundation design studies or other geotechnical studies that involve sample collection from borings and subsequent testing. Geotechnical data may include grain size, moisture content, plasticity, density, consolidation, and shear strength.

In addition, the present condition of and planned future uses for existing structures such as piers, utilities, and remnant piles are considered engineering characteristics because they may influence the technical feasibility of Removal Action alternatives. Information on existing structures is available from construction drawings and, in the case of piers, from inspection reports on present conditions.

### 2.6.1 Available Information Sources

#### 2.6.1.1 Geotechnical Explorations and Monitoring Wells

The Port has assembled a plan that provides the approximate location of all cataloged geotechnical borings performed at Terminal 4 through 2000. These borings provide data on deep subsurface conditions for the Troutdale Formation and typically include laboratory testing results, which provide information about the physical properties of the sediment (or soil). Of these geotechnical borings, which include information from sampling using the standard approach for geotechnical design, i.e., Standard Penetration Testing (SPT), American Society for Testing and Materials (ASTM) Method D 1586, the deep borings have been selected for specific use in identifying data gaps for the EE/CA as shown on Figure 2-17. Existing reports useful for determining currently known engineering characteristics on the basis of prior geotechnical borings and laboratory testing are:

- For Slip 1: Subsurface Conditions Below Piers 1 and 2 (Shannon and Wilson, 1962);
- For Slip 3: Test Pile Program, Including Test Borings (Gerwick, 1959);
- For Slip 3: Remedial Investigation Report (Volume I: Upland, Volume II: Sediment) (Hart Crowser, 2000a); and
- For the upland: Geotechnical Investigation for Planned Bulk Storage Facility (Dames and Moore, 1993).

Logs of geotechnical borings and monitoring wells, including any available site exploration plans and legends from the original report, are provided in Appendix C.

#### 2.6.1.2 Construction Documents

Construction documents for various structures at the Terminal 4 Removal Action Area, such as piers, and at upland properties, such as utilities and building foundations, are available for use in determining the current engineering characteristics of soil and sediment at the Terminal 4 facility. Drawings used to evaluate the condition of existing structures and other engineered aspects of Terminal 4, such as construction details, layout, and elevations for storm and sanitary sewer lines, are documented in Section 9.

### 2.6.2 Regional Geology/Current Engineering Characteristics

Terminal 4 is included in the Willamette Valley Physiographic Province and is part of the U.S. Geological Survey's (USGS's) Linnton Quadrangle, located at approximately latitude 45.59°, longitude 122.77°.

The Willamette Valley is a broad alluvial plain within a structural basin surrounded by Tertiary marine sedimentary and volcanic rocks of the Coast Range to the west and Tertiary and Quaternary volcanic and pyroclastic rocks of the Cascade Range to the east (O'Connor et al., 2001; Madin, 1990). The Portland Basin is the northern extent of the Willamette Valley. The valley has been a topographic low for millions of years, accumulating thick alluvial deposits and, in recent geologic times, experiencing episodic flooding from glacial Lake Missoula. Faulting and over 1,000 ft of uplift have exposed the Columbia River Basalt Group as the Tualatin Mountains (Portland Hills). The regional geology of the Portland Basin and Willamette Valley is made up of the following major geologic formations, listed from youngest to oldest:

- Unconsolidated Alluvial Deposits. These recent river and historical flood deposits consist of two main units:
  - Recent Alluvium. The deposition processes within the Willamette River for the last several thousand years subsequent to the glacial period have blanketed the low-lying areas in and adjacent to the river. The recent alluvium consists of deposits of silt, sand, and some gravel.
  - Glaciofluvial Flood Deposits. During the Pleistocene, several floods from the Glacial Lake Missoula, which flowed up the Portland Basin and Willamette Valley from the Columbia River, deposited a thick sequence of sand, with layers of gravel, cobbles, and boulders.
- Troutdale Formation. This deposit includes both consolidated and unconsolidated sand, gravel, and cobbles and may be on the order of 100 ft in thickness at the Removal Action Area.
- Sandy River Mudstone Formation. This deposit is predominantly fine-grained, consisting of siltstone and claystone, and thins near the Tualatin Mountains (and the Removal Action Area).

- Columbia River Basalt Group. This consists of a series of basalt flows originating from eastern Washington that spread over large areas of the Pacific Northwest. In the Portland Basin, the reported thickness is up to 1,000 ft, with individual flows ranging from 25 to 200 ft in thickness (Bridgewater Group, 2003).

As shown on Figure 2-18, surficial geology for Terminal 4 consists of recent alluvium and artificial fill. The following sediment units for anticipated depths of interest have been identified from previous studies:

- recent sediment;
- unconsolidated alluvial deposits; and
- Troutdale Formation.

Regarding recent sediment, Table 2-7 provides a tabulation of available information on the grain size distribution from samples collected in the Removal Action Area.

**Table 2-7**
**Grain Size Data**

| Sample Identification[1] | % Gravel | % Sand | % Silt | % Clay | Depth, ft |
|---|---|---|---|---|---|
| HC-S-01 | 0.1 | 19.1 | 65 | 15.8 | <12 |
| HC-S-02 | 0.3 | 54.5 | 33.1 | 12.1 | <12 |
| HC-S-04 | 0.7 | 17.7 | 66.6 | 15 | <12 |
| HC-S-05 | 0 | 39.6 | 45.8 | 14.6 | <12 |
| HC-S-07 | 0 | 12.9 | 68.3 | 18.8 | <12 |
| HC-VC-7-S2 | 0.1 | 47.8 | 36.3 | 15.8 | <12 |
| HC-S-08 | 0 | 5.6 | 73.7 | 20.7 | <12 |
| HC-S-11 | 0 | 13.4 | 69.8 | 16.8 | <12 |
| HC-VC-11-S2 | 0 | 47.8 | 39.7 | 12.5 | <12 |
| HC-S-13 | 0.1 | 39.1 | 46.4 | 14.4 | <12 |
| HC-VC-13-S2 | 0.1 | 96.9 | 2.1 | 0.9 | <12 |
| HC-S-16 | 0 | 29.6 | 55.3 | 15.1 | <12 |
| HC-VC-18-S2 | 0 | 96.8 | 2.3 | 0.9 | <12 |
| HC-S-19 | 3.7 | 64.4 | 24.4 | 7.5 | <12 |
| HC-S-22 | 0 | 39 | 46.9 | 14.1 | <12 |
| HC-S-24 | 0.7 | 58.5 | 30.4 | 10.4 | <12 |
| HC-S-26 | 0 | 76.9 | 17.4 | 5.7 | <12 |
| HC-S-28 | 0 | 16 | 65 | 19 | <12 |
| HC-S-30 | 0 | 59.2 | 30.6 | 10.2 | <12 |
| HC-S-32 | 0 | 43.8 | 38.6 | 17.6 | <12 |
| HC-VC-32-S2 | 0 | 96.5 | 2.6 | 0.9 | <12 |
| HC-S-34 | 0.1 | 38.2 | 47.2 | 14.5 | <12 |
| HC-S-35 | 0 | 35.5 | 50.2 | 14.3 | <12 |
| HC-S-36 | 0.2 | 76.4 | 17.1 | 6.3 | <12 |
| HC-S-39 | 0 | 14.9 | 69.4 | 15.7 | <12 |
| HC-S-42 | 0 | 7.1 | 78.3 | 14.6 | <12 |

| | | | | | |
|---|---|---|---|---|---|
| HC-S-44 | 0 | 11.2 | 72 | 16.8 | <12 |
| HC-S-Ref-B | 0 | 0.9 | 73.6 | 25.5 | <12 |
| HC-S-Ref-C | 1.1 | 79.1 | 16.6 | 3.2 | <12 |

| Sample Identification[2] | % Sand/Gravel >75 µm | % Silt/Clay <75 µm | Depth, ft |
|---|---|---|---|
| HC-Slip1-01 | 4.7 | 95.3 | <1 |
| HC-Slip1-02 | 93.8 | 6.2 | <1 |
| HC-Slip1-03 | 26.3 | 73.7 | <1 |
| HC-Slip1-04 | 47.7 | 52.3 | <1 |
| HC-Slip1-05 | 9.8 | 90.2 | <1 |
| HC-Slip1-06 | 3.7 | 96.3 | <1 |
| HC-Slip1-07 | 6.8 | 93.2 | <1 |
| HC-Slip1-08 | 76.9 | 23.1 | <1 |
| **Sample Identification[2]** | **% Sand/Gravel >75 µm** | **% Silt/Clay <75 µm** | **Depth, ft** |
| HC-Slip1-09 | 87.9 | 12.1 | <1 |
| HC-Slip1-10 | 70.7 | 29.3 | <1 |
| HC-Slip1-11 | 16.2 | 83.8 | <1 |
| HC-Slip1-12 | 4.2 | 95.8 | <1 |
| HC-Slip1-13 | 90.2 | 9.8 | <1 |
| HC-Slip1-14 | 11.7 | 88.3 | <1 |
| HC-Slip1-15 | 16.6 | 83.4 | <1 |
| HC-Slip1-16 | 14.3 | 85.7 | <1 |
| HC-Slip1-17 | 10.4 | 89.6 | <1 |
| HC-Slip1-18 | 16.8 | 83.2 | <1 |
| HC-Slip1-20 | 24.0 | 76.0 | <1 |

1 – Hart Crowser, 2000a.
2 – Hart Crowser, 2000b.

### 2.6.2.1 Slip 1 Engineering Characteristics

Figure 2-19 is a cross section through Slip 1 incorporating available information. The cross section provides a preliminary stratigraphic model that will be refined as supplemental information becomes available from the EE/CA field exploration program. This information has been used in concert with the other geotechnical borings to identify data gaps that will be filled prior to the evaluation of Removal Action alternatives in the EE/CA.

**Recent Sediment**

Table 2-7 provides surface sediment grain size results, indicating a predominant distribution of silt/clay-sized sediment, though a relatively high sand content is reflected in the data. The sediments in Slip 1 appear to be similar in gradation to Slip 3, though specific percentages of silt versus clay and sand versus gravel were not apparent in the available data. Samples from Slip 1 were taken from a depth of less than 1 foot.

Geotechnical borings are typically not used to sample for or accurately assess the thickness of recent sediment deposits. The sediment in Slip 1 is expected to be thicker than the sediment in Slip 3 (noted to generally range

from 2 to 6 ft in thickness) because of relatively infrequent maintenance dredging and ongoing sediment deposition.

**Unconsolidated Alluvial Deposits**

According to the deep geotechnical borings (Shannon and Wilson, 1962), which spanned the full length of the slip, the alluvial deposits are primarily black, medium dense (occasionally loose), sand to silty sand interbedded in complex layering with gray silt deposits for a depth of 80 to 100 ft below mudline, with exceptions noted below. No interbedding was evident for borings in the western portion of the slip, which could correspond with dredged fill sand placed above the former shoreline, although that could not be determined at this time. Subsurface conditions below the interbedded alluvial deposits consist of black, dense, sand with gravel. Similarly, the nearby upland study (Dames and Moore, 1993) concluded that deep alluvial deposits extend to a depth of about 160 to 180 ft below ground surface. The alluvial soils area is described as loose to medium dense sands and silty sands, to soft to medium stiff sandy to clayey silt and silty clay. The silt and clay were characterized as having moderate compressibility and low shear strength.

Shannon and Wilson (1962) also identified a considerably thicker organic deposit at the head of the slip. The deposits become more silt than sand about half the distance along Berths 405 and 408 near the head of the slip, where the deposits become thicker organic silt. It is expected that this deposit is related to the filling of Gatton's Slough. The deposit is greater than 100 ft in thickness, composed of soft to medium stiff, gray organic silt and clay, with some peat-like debris noted in one or two borings. Sediment plasticity was not determined and is an important data gap with regard to the organics and other fine-grained deposits.

Notably, the subsurface conditions below the mudline from one side of the slip to the other vary, in some cases considerably, which attests to the complexity of the subsurface conditions in the Removal Action Area.

Triaxial shear strength testing yielded the following values:

- medium sand with an internal friction angle equaling 38 degrees;
- silty fine sand with an internal friction angle equaling 33 degrees;
- organic, fine sandy silt with an internal friction angle equaling 31 degrees (cohesion equaling 0.2 ton per square ft); and
- organic clay with an internal friction angle equaling 21 degrees (cohesion equaling 0.2 ton per square ft).

These values are higher than would typically be used for design purposes and should be verified with additional testing.

**Troutdale Gravel**

The Troutdale Gravel (i.e., Troutdale Formation) was deposited within the ancestral Columbia River channel as a thick "gravel" unit typically characterized as having well-rounded gravel and cobbles derived from the Columbia River Basalt Group. The Troutdale Gravel has been estimated to be 100 ft in thickness at the Removal Action Area (Hart Crowser, 2000a), occurring below the thick sequence of unconsolidated alluvial deposits. The borings in and around Slip 1 encountered dense sandy gravel to silty sandy gravel (Dames and Moore, 1993) below the interbedded layers of sand and silt.

The top of the Troutdale Gravel generally delineates the depth of subsurface conditions of greatest impact to the engineering characteristics of Terminal 4 and will be the focus of engineering data collection to support slope and structure stability evaluations, as well as the feasibility of onsite disposal.

**Upland Fill**

Adjacent to Slip 1, Dames and Moore (1993) performed two geotechnical borings and several mechanical cone penetrometer explorations, characterizing the fill as 7- to 15-ft-thick loose, brown, silty fine sand.

### 2.6.2.2 Slip 3 Engineering Characteristics

**Recent Sediment**

Sediment physical properties in Slip 3 have been characterized (Hart Crowser, 2000a) as very soft to medium stiff, wet, brown, sandy silt to silt and organic silt. From Table 2-7, it can be seen that sediments in Slip 3 are predominantly silt and are also comprised of a lesser amount of sand and clay. Each sample has little to no gravel content. Samples from Slip 3 were taken from a depth of less than 12 feet. Organic debris such as twigs and other plant matter was noted in some of the samples.

In Slip 3, sampling appears to indicate a sediment thickness of 2 to 6 ft, although frequent maintenance dredging occurs here, particularly adjacent to the KMBT pier.

**Unconsolidated Alluvial Deposits**

Adjacent to Slip 3, Hart Crowser performed 17 monitoring well installations and numerous geoprobes, characterizing the fill as 5- to 40-ft-thick brown, medium sand (i.e., dredge fill), with the greater thickness on the western portion of the area (Hart Crowser, 2000a).

Previous monitoring wells in this same area of Slip 3 were installed by Century West (Hart Crowser, 2000a).

Deep geotechnical borings were performed in Slip 3 by Gerwick (1959) for the City CPD. The borings indicate general similarities to Slip 1, although locally the complexities of the layering and engineering properties could vary considerably.

**Troutdale Gravel**

The available information for the Troutdale Gravel below Slip 3 is similar to that of Slip 1, and the Troutdale Gravel at Slip 3 is not expected to differ dramatically in engineering properties.

### 2.6.2.3 Wheeler Bay Engineering Characteristics

No information is available on the engineering characteristics of recent sediment, unconsolidated alluvial deposits, Troutdale Gravel, or upland soil (e.g., fill) near Wheeler Bay. Note that the Troutdale Gravel is not expected to vary considerably from that of Slip 1 or Slip 3.

## 2.7 Current Hydrogeologic Characteristics

The current hydrogeologic characteristics of the Removal Action Area are summarized in this section based on available information from previous studies at Terminal 4. At present, the only available hydrogeologic information for the Removal Action Area derives from upland studies.

Site-specific hydrogeologic characteristics will be evaluated in conjunction with the upland source control evaluations. Because the Removal Action is proceeding on a separate schedule from the upland investigations, the necessary number of monitoring wells will be installed for this study, but at locations selected in coordination with the upland activities. In the EE/CA, hydrogeologic conditions will be described on both a regional and a site-specific basis.

### 2.7.1 Available Information Sources

Studies incorporating monitoring well installations and information pertaining to the hydrogeologic conditions of interest are:

- For Slip 3 Upland: Bridgewater Group, Inc., 2003, Portland Harbor Port Facility Groundwater Assessment;
- For Slip 3 Upland: Hart Crowser, 2000c, Remedial Investigation Report (Volume I: Upland, Volume II: Sediment); and
- For Slip 3 Upland: Century West, 1994 (in Hart Crowser, 2000c).

According to these studies, a considerable number of groundwater monitoring wells have been installed at Terminal 4. Most of the monitoring wells are shallow, are located on the Slip 3 uplands, and were installed beginning in early 1993 to define the lateral and vertical extent of contamination from the Union Pacific pipeline. Hart Crowser (2000c) lists the following monitoring well and geoprobe installations:

- Thirty-three geoprobes installed June through October 1998 to depths ranging from 20 to 40 ft below ground surface for groundwater sampling. These explorations were abandoned at the time of the study.
- Seventeen groundwater monitoring wells (including three shallow and deep well clusters) installed in October 1998 to depths ranging from 20 to 45 ft below ground surface. These wells are screened through the upland fill and upper portions of the alluvial deposits from 5 to 20 ft below ground surface; deeper wells are screened from about 30 to 45 ft below ground surface using 5-ft-long well screens. All monitoring wells for this study were installed to evaluate the extent of contamination or to provide groundwater flow characteristics relative to three key features identified as potential sources: the Northern Pipeline Area, the Former Rail Car Fuel Loading Area, and the Hall-Buck Quaker State/Gearlocker Area. The wells were survey-located by a licensed surveyor and referenced to Columbia River Datum.

Prior to the Hart Crowser and Bridgewater Group studies, 20 monitoring wells and 37 soil borings were drilled by Century West. The monitoring wells were installed with screen lengths ranging from 15 to 25 ft.

Figure 2-20 shows the locations of known monitoring wells on Terminal 4 that are potentially available for water-level monitoring for the EE/CA. Additional wells have been installed recently but are not depicted on this figure. A current use inventory of wells at Terminal 4 and on surrounding properties was performed by Hart Crowser (2000c). There are no known current or historical supply wells at Terminal 4. The Hart Crowser inventory identified five wells in use by Northwest Pipe, Schnitzer Steel, and Northwest Container for industrial purposes. Five additional wells installed in the 1940s were identified in the vicinity of Terminal 4. These wells were reportedly installed for industrial use, although their status (whether in use or abandoned) was not determined.

### 2.7.2 Regional Hydrogeology

Hydrogeologic (i.e., hydrostratigraphic) unit classifications differ from geologic units in that they are not only based on the geologic age and nature of the sedimentary deposit or rock formation, but also are primarily based on the function of the unit as an aquifer (i.e., coarse-grained and capable of supplying water) or confining unit (i.e., fine-grained and generally a low-permeability deposit confining a deeper aquifer). Figure 2-21 provides regional hydrogeologic cross sections near the Removal Action Area, which is located between the two cross sections, slightly closer to Section B on the figure.

Hydrostratigraphic units are categorized as:

- Unconsolidated Sedimentary Aquifer. This aquifer comprises recent alluvial deposits and primarily Pleistocene catastrophic flood deposits that mantle much of the Portland Basin.

- Troutdale Gravel Aquifer. This aquifer is a highly productive sand and gravel deposit, yielding up to 1,000 gallons per minute to wells (Bridgewater, 2003).

- Undifferentiated Fine-Grained Units. This sequence of confining units and aquifers is differentiated farther east of Terminal 4; however, at the western margin of the alluvial deposits near the Tualatin Mountains (i.e., west of Terminal 4), the alluvial deposits' sequence at depth is complicated by the relative depth to older rocks. The following subunits of the undifferentiated unit may occur at depth below the Removal Action Area:

  - Confining Unit 1. This mudstone, siltstone, and claystone unit is considered part of the Troutdale Formation, except where the Troutdale sandstone is not present, which makes it indistinguishable from the Sandy River Formation.

  - Troutdale Sandstone Aquifer. This is a sandstone and conglomerate deposit.

  - Confining Unit 2. This is mudstone, siltstone, and claystone mapped as the Sandy River Formation.

  - Sand and Gravel Aquifer. This is a silty to gravelly sand within the Sandy River Mudstone.

  - Columbia River Basalt Group. This unit is a productive aquifer to the Tualatin Mountain area and Tualatin Basin west of the mountains. Columnar jointing erosional processes between flow events create an extensive interbasalt flow network, and wells are screened at several hundred feet to intersect multiple interflow zones.

The regional drinking water aquifer supplying the City of Portland is the Troutdale Gravel Aquifer (Troutdale Formation) alluvial deposit. It is anticipated that groundwater from higher elevations flows to the Willamette River in deep circular patterns above the fine-grained deposits of the Sandy River Formation, likely creating upward gradient-dominated flow from the Troutdale Gravel Aquifer into the overlying alluvial soils.

The interbedding within the unconsolidated sedimentary aquifer, particularly fine-grained layering of silt and clay, may affect upward flow by causing vertical gradient-dominated flow to dissipate laterally before reaching the recent sediment. This may be supported by the 1999 groundwater elevation data (Hart Crowser, 2000c) at well clusters, suggesting a downward vertical gradient from the upland fill to the underlying shallow alluvial deposits at the time of measurements. However, the deeper wells were completed very shallow within the alluvial soil below the upland fill and may not represent groundwater flow conditions below the surficial unit, such that there may be some hydraulic connection or other factor influencing the result.

### 2.7.3 Terminal 4 Hydrogeology

In addition to the hydrostratigraphic units described for the regional hydrogeology, Terminal 4 includes an upland fill aquifer. This aquifer is common to the Portland Harbor and Portland Basin in general, involving reclaimed or modified land, which is highly variable in gradation, hydraulic conductivity, and water quality. The upland fill aquifer is used for infiltration of stormwater via two dry wells (Parsons Brinkerhoff, 2002).

Shallow groundwater within the upland fill at Terminal 4 typically ranges from 12 to 20 ft below ground surface to possibly 30 ft below ground surface on the western portion of the Slip 1 upland boundary (i.e., near the Willamette River), and the flow is generally toward the Willamette River from the upland areas of Terminal 4 (Hart Crowser, 2000c). However, Terminal 4's hydrogeology is a complex system influenced by the interaction of the local groundwater regime with the Willamette River hydrology. The most transient aspect of groundwater flow is expected to be the lateral component of groundwater flow, including influences from the following:

- regional groundwater flow to Terminal 4 and Portland Basin;
- seasonal river stage changes, reported to be on the order of 10 ft with short-term tidal fluctuations reported to be about 2 ft at Terminal 4 (Hart Crowser, 2000c); and
- direct precipitation that infiltrates gravel at Terminal 4 and recharges the upland fill. Average annual rainfall in Portland, Oregon is 36.99 inches (Western Regional Climate Center Period 11/1/1941 through 3/31/2003).

Seasonal water-level fluctuations are generally less than 4 ft on the eastern side of the Slip 3 upland boundary to more than 10 ft in wells closer to the river and are likely influenced by the seasonally transient conditions of the river stage.

Hydrologic testing consisting of a pumping test screened through the lower 14 ft of the upland fill has been performed by Century West (Hart Crowser, 2000c). The resulting hydraulic conductivity calculated from the test was 65 ft per day, which was influenced both by the fill and the underlying alluvial soils.

Hydrogeology for Slip 1 is expected to be influenced by the natural ravine (i.e., Gatton's Slough) filled during slip construction. However, this area appears to be in-filled with low-permeability organic silt and clay deposits, which may reduce the possible effect of channeling groundwater into the Slip 1 area.

In additional, the shallow hydrogeology near Slip 3 is expected to be influenced by a west trending depression in the alluvial deposits near Pier 5. This was identified as a preferential pathway for groundwater flow and the migration of light nonaqueous-phase liquid (LNAPL) associated with the former Union Pacific pipeline (Hart Crowser, 2000c).

## 2.8 Current Hydraulic Characteristics

The hydraulic characteristics of the Willamette River adjacent to the Removal Action Area and the hydraulic characteristics of Slips 1 and 3 are described in this section.

Flow circulation patterns and corresponding sedimentation patterns within Slips 1 and 3 are dominated by the effects of the Willamette River, although sedimentation is also affected by local depositional areas around stormwater outfalls and ship propeller scour patterns. Ship scour that redistributes sediments is an important factor in considering both recontamination potential and requirements for maintenance dredging. Published scientific studies on the bottom shear stresses generated by ship prop wash and tugboat activities will be used to assess the importance of ship scour in Slip 3. In addition, bathymetric survey maps showing localized impacts from ships will be evaluated and used to support conclusions regarding the area and spatial extent of large impacts to the sediment from ships (e.g., scour areas). Also, the near-bottom velocity meters and turbidity sensor data will be evaluated in comparison with shipping activity (times of berthing and departure) to evaluate the effect of vessel movement.

The hydraulic characteristics of the Willamette River that are of particular interest to the Removal Action include the local river bathymetry in the slips and along Terminal 4, the range of river stage fluctuations experienced in the Removal Action Area, and flow patterns, including extent and duration of flow reversals, resulting from fluctuations in the Columbia River water stage.

Recent bathymetric surveys of the Willamette River, including the Removal Action Area, provide a detailed understanding of current bathymetry in the slips and the Willamette River adjacent to Terminal 4 (Striplin Environmental Associates, Inc., 2003). Water depth at the entrance to Slip 1 is approximately 40 ft and water depth at the entrance to Slip 3 is approximately 50 ft (Figure 1-3). The river bathymetry along the Removal Action Area is characterized by steep side slopes and center channel depths of approximately 60 to 70 ft. A deep trough in the river bottom spanning most of the river's width extends from approximately 2,500 ft upstream of Slip 3 downstream to Slip 1 with maximum water depths in the trough greater than 70 ft. Within Slip 3, water depths of between approximately 30 and 40 ft occur over most of the slip with the exception of a deeper channel leading from the river to Berth 411. Within Slip 1, water depth varies between approximately 20 and 30 ft over most of the slip.

A sedimentation study conducted by the Port provides information on the sedimentation patterns and processes of the Port's terminals (Port of Portland, 2002). The ship berths in Terminal 4 experience varying sedimentation. The sedimentation analysis concluded that the two slips have more deposition occurring during lower flow conditions and that the berths running parallel to the river have more deposition occurring during high flow conditions. Although elevated sediment transport occurs during high flows, the long-term effect of low flows (which occur most of the time) can in some cases yield higher long-term deposition rates than high-flow events. High-flow events may also remobilize sediments in circulation eddies within the slips if these sediments are much finer-grained than the sediments near the berths parallel to the river. Comparison of repeat bathymetric survey data reveals local variations in sedimentation patterns along the shoreline as a result of dredging and construction and demolition activities.

The sedimentation analysis included assessment of USGS discharge records available since 1990 for the Willamette River (data primarily from the Portland gage) and the Columbia River (data primarily from the Dalles gage). The Columbia River data were included in the analysis because of the effect of Columbia River flow and stage on hydraulic conditions in the lower Willamette River. Mild flow reversals in the Willamette River occur at times due to rapid stage increases in the Columbia River, although such reversals are typically of short duration. Flows corresponding to a range of exceedance frequencies from 10% to 99% are provided for the Willamette River and Columbia River data in Tables 2-8 and 2-9, respectively, which are derived from Port of Portland, 2002.

**Table 2-8**
**Flow Exceedance Statistics for Willamette River, USGS Portland Gage, 1990 to 2001**

| Exceedance (Percent of Time) | Days/Year | Discharge (cfs) |
|---|---|---|
| Average | --- | 36,333 |
| 99% | 361 | 6,690 |
| 95% | 347 | 7,600 |
| 90% | 329 | 8,670 |
| 75% | 274 | 11,950 |
| 50% | 183 | 22,900 |
| 25% | 91 | 45,200 |
| 10% | 37 | 83,320 |
| 5% | 18 | 118,000 |
| 1% | 4 | 180,000 |

Note: cfs = cubic feet per second
Source: Port of Portland, 2002

**Table 2-9**
**Flow Exceedance Statistics for Columbia River, USGS Dalles Gage, 1990 to 2001**

| Exceedance (Percent of Time) | Days/Year | Discharge (cfs) |
|---|---|---|
| Average | - | 190,058 |
| 99% | 361 | 77,935 |
| 95% | 347 | 94,900 |
| 90% | 329 | 106,000 |
| 75% | 274 | 130,072 |
| 50% | 183 | 172,000 |
| 25% | 91 | 229,000 |
| 10% | 37 | 299,000 |
| 5% | 18 | 349,000 |
| 1% | 4 | 456,530 |

Note: cfs = cubic feet per second
Source: Port of Portland, 2002

River stage exceedance was also reported for Willamette River stage measured at the Portland gage for the same period (Table 2-10).

**Table 2-10**
**Stage Exceedance Statistics for Willamette River, USGS Portland Gage, 1990 to 2001**

| Exceedance (Percent of Time) | Days/Year | Stage (CRD) |
|---|---|---|
| Average | - | 7.4 |
| 99% | 361 | 3.4 |
| 95% | 347 | 4.1 |
| 90% | 329 | 4.5 |
| 75% | 274 | 5.4 |
| 50% | 183 | 6.7 |
| 25% | 91 | 8.6 |
| 10% | 37 | 11.4 |
| 5% | 18 | 13.2 |
| 1% | 4 | 17.6 |

Note: CRD = Columbia River Datum
Source: Port of Portland, 2002

The exceedance frequencies in Tables 2-8 through 2-10 were used by the Port to assess correlations between dredge prism volumes and the cumulative number of days where flows or stage exceeded various exceedance values (for example, the number of days for which flow was greater than a specific flow, such as the 20$^{th}$ percentile). The results of the Port's sedimentation analysis for each berth and slip are briefly summarized below, along with interpretation of spatial deposition patterns shown in survey-to-survey bathymetric changes mapped by the Port in Appendix D of the sedimentation analysis report (Port of Portland, 2002).

In Berth 401, sedimentation is reported to have occurred during high flow periods and net erosion is reported to have occurred during low flow periods. Comparison of the 1998 and 2001 bathymetric data indicates greater deposition in deeper areas away from the dock than near the dock.

In Slip 1, sedimentation rates are reported to be related to the 3% flow exceedance. Deposition is reported during low flow periods with little change or some scour during periods when high flows occurred. Spatial deposition patterns based on comparison of 2000 and 2001 bathymetric survey data were mapped by the Port. Comparison of these data indicates deposition along the downstream side of the mouth of the slip, along the center axis of the slip, and in localized areas near the southeast and northeast corners of the slip in areas corresponding to stormwater outfall locations. In particular, the area of deposition adjacent to Berth 408 appears to reflect a local deposition footprint characteristic of that produced by an outfall. The bathymetric survey comparison maps for the periods 1997 to 1998, 1998 to 1999, 1999 to 2000, and 2000 to 2001 show a consistent pattern of slope sloughing along the western half of the south shoreline of Slip 1. The bank is slowly eroding and collapsing to a more gradual slope along this section of the slip. This is apparently due to prior demolition of a berth (Port of Portland, 2002).

In Slip 3, sedimentation rates are reported to show less correlation to the 3% flow exceedance than in Slip 1. Dredge prism volumes do not show any discernable pattern over time and reported conclusions regarding flow dependency are tenuous due to the nature of the data for Slip 3. Comparison of the bathymetry changes mapped by the Port based on the May 1994 and December 1994 bathymetric surveys shows a localized area of

sedimentation in the southeast corner of the slip. This area is near two stormwater outfalls, and this deposition could be related to the outfalls. A localized depositional delta from a stormwater outfall is also apparent in the middle of the eastern shoreline of Slip 3 in comparison of the April/May 1998 survey and the June 1999 survey. Deposition due to the outfalls along the southeastern portion of Slip 1 is not evident in this survey, suggesting either that stormwater management was improved for these outfalls or that sediment sources from the outfalls are episodic (e.g., as would occur if discharges were related to periodic construction activity in the outfall drainage area).

Comparison of surveys conducted in January 1995 following a dredging event and in January 1996 indicates broader depositional areas along the southeast and northeast portions of the slip; however, the very high rates of deposition are typical of results caused by horizontal positioning error (USACE, 2002). Similarly, comparison of the January 1996 survey and the December 1997 survey shows high rates of erosion along the northeast portion of the slip on the steep slope area. These results are also suspect due to possible survey error. Another result that appears possibly affected by survey error is the June 2000 and May 2001 survey comparison, which indicates widespread erosion throughout Slip 1. Error in vertical datum control is suspected. Other survey comparisons presented by the Port for Slip 3 indicate modest rates of deposition throughout the slip.

Sediment grain size distribution in Slips 1 and 3 also provides a means to assess sedimentation patterns. Grain size measurements available for 19 surface sediment samples collected in Slip 1 indicate that the sediments are predominantly fine-grained (Hart Crowser, 2000a). Percent fines in these samples range from 96% to 6.2%, with only five samples having less than 50% fines and eight samples having greater than 85% fines. The spatial distribution of the fines shows that deposition of fines is greater at the eastern end of Slip 1 than near the mouth of the slip. The data also indicate that, in general, the sediments in the deeper portions of the slip are finer than sediments along the sides of the slip.

Twenty-nine grain size measurements available for Slip 3 show that sediments in Slip 3 also consist of predominantly fine material (Hart Crowser, 2000a). (These grain size data were derived from a NOAA database; see Section 4 for a discussion of that database.) Percent fines in these samples range from 23% to 94.5% with an average of 67% and standard deviation of 22%. Overall, Slip 3 sediments appear to contain slightly less fine-grained material than do sediments in Slip 1. The spatial distribution of percent fine values in Slip 3 does not reveal any discernable pattern, although percent fine values are generally higher in deeper areas than in shallow areas. This suggests that deposition and flow circulation patterns in Slip 3 may be quite variable under different river conditions.

## 2.9 Terminal 4 Stormwater Utilities

Stormwater runoff to the Terminal 4 Removal Action Area is derived from 15 catchment basins as illustrated in Figures 2-22 and 2-23. Figure 2-22 depicts the Terminal 4 facility-wide stormwater drainage patterns, while Figure 2-23 provides a close-up view of the Removal Action Area to illustrate details of piping, outfalls, and other specifics of the stormwater drainage system. Most of the areas represented in the figures are paved with grading to direct surface water to catch basins shown on the figures. Of these catchment basins, five drain into Slip 1, three drain into Slip 3, one drains into Wheeler Bay, and the remaining six drain into the Willamette River adjacent to the Removal Action Area site.

A total of six stormwater outfalls are located in Slip 1. As evident in Figure 2-23, the following characteristics are associated with the outfalls:

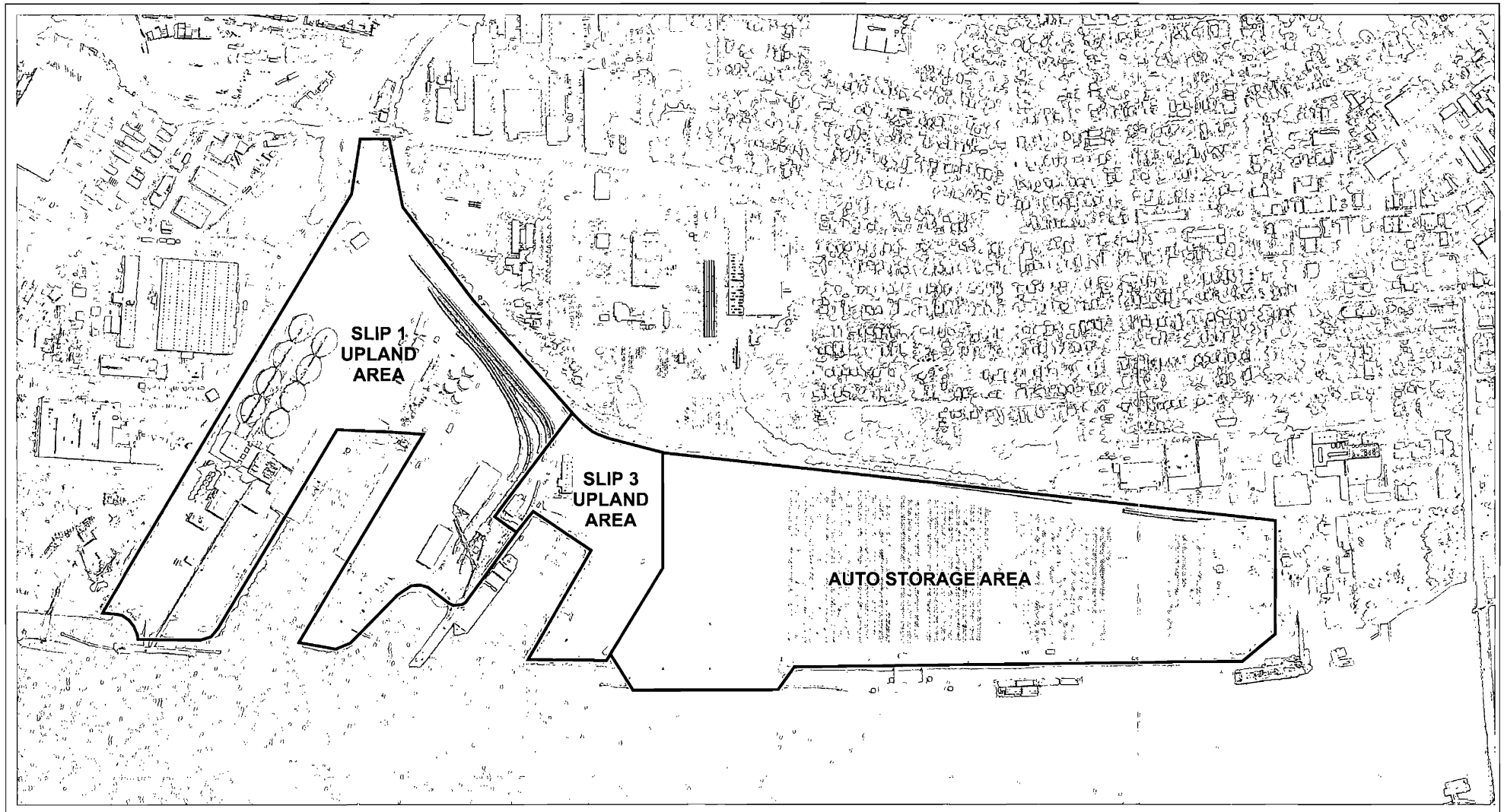
- One outfall drains stormwater runoff in a 15-inch pipe from a 17.8 acre area around the grain elevators on the former Cargill property.
- One outfalls drains stormwater runoff in an 18-inch pipe from a 13.3-acre area around the I.R.M. property to the south of Slip 1.
- Two outfalls drain stormwater runoff in 21-inch pipes from a 5.5 acre area directly east of Slip 1.
- One outfall drains a 3.6-acre piece of land just south of the previously mentioned area in a 6-inch pipe.
- The sixth outfall (52c) in Slip 1 is for the City of Portland pipeline. This 36-inch pipeline receives runoff from a 23.4-acre stormwater drainage basin approximately 1,500 feet east of Slip 1 in the Toyota Processing Yard area. On the east end of the 23.4-acre drainage basin, undetermined off-site sources of stormwater runoff exist, denoted on Figure 2-22 with a dashed line.

Slip 3 also contains a total of six stormwater outfalls. The following characteristics are associated with those outfalls, which can be seen in Figure 2-23:

- One outfall drains a 1.5-acre area at the east end of the piers in Slip 3 on the Kinder Morgan property.
- Two outfalls drain a building and the 2.6-acre area around it to the east of Slip 3.
- Three outfalls drain the 16.8-acre area south of Slip 3. An additional outfall in this area drains into the Willamette River. Two other outfalls previously drained this area into the Willamette River, but they have since been plugged and/or abandoned. Apparently, one of the two outfalls was associated with roof drainage from a former building. The building no longer exists. The abandoned outfall can be inferred to have been associated with a building from the limited distance and area coverage of piping between the outfall and terminating points of the lines.

Wheeler Bay contains one outfall which drains a 30.2-acre area, consisting of a large portion of the Kinder Morgan property as well as many of the rail lines at the site, in a 21-inch pipe.

Two outfalls drain the 16.3-acre area on the former Cargill property to the north of Slip 1 in 10-inch and 21-inch pipes, respectively. These outfalls flow into the Willamette River.




N

0 600 1200

Approximate Scale in Feet

Note: Date of Photo: July 9, 2002

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

UPLAND AREA BOUNDARIES

BBL
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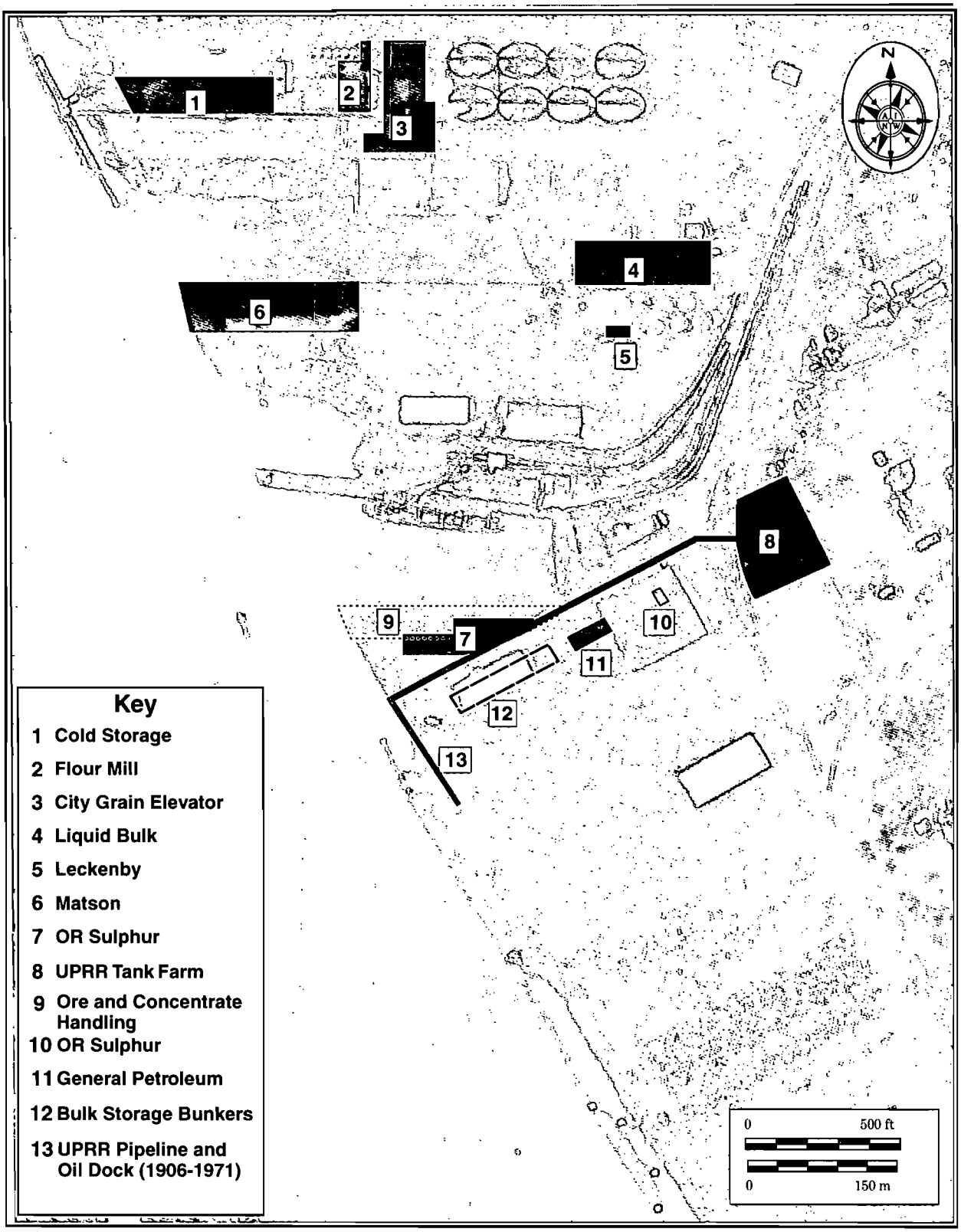
FIGURE
2-1

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PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

PRE-WORLD WAR II DEVELOPMENTS

BBL
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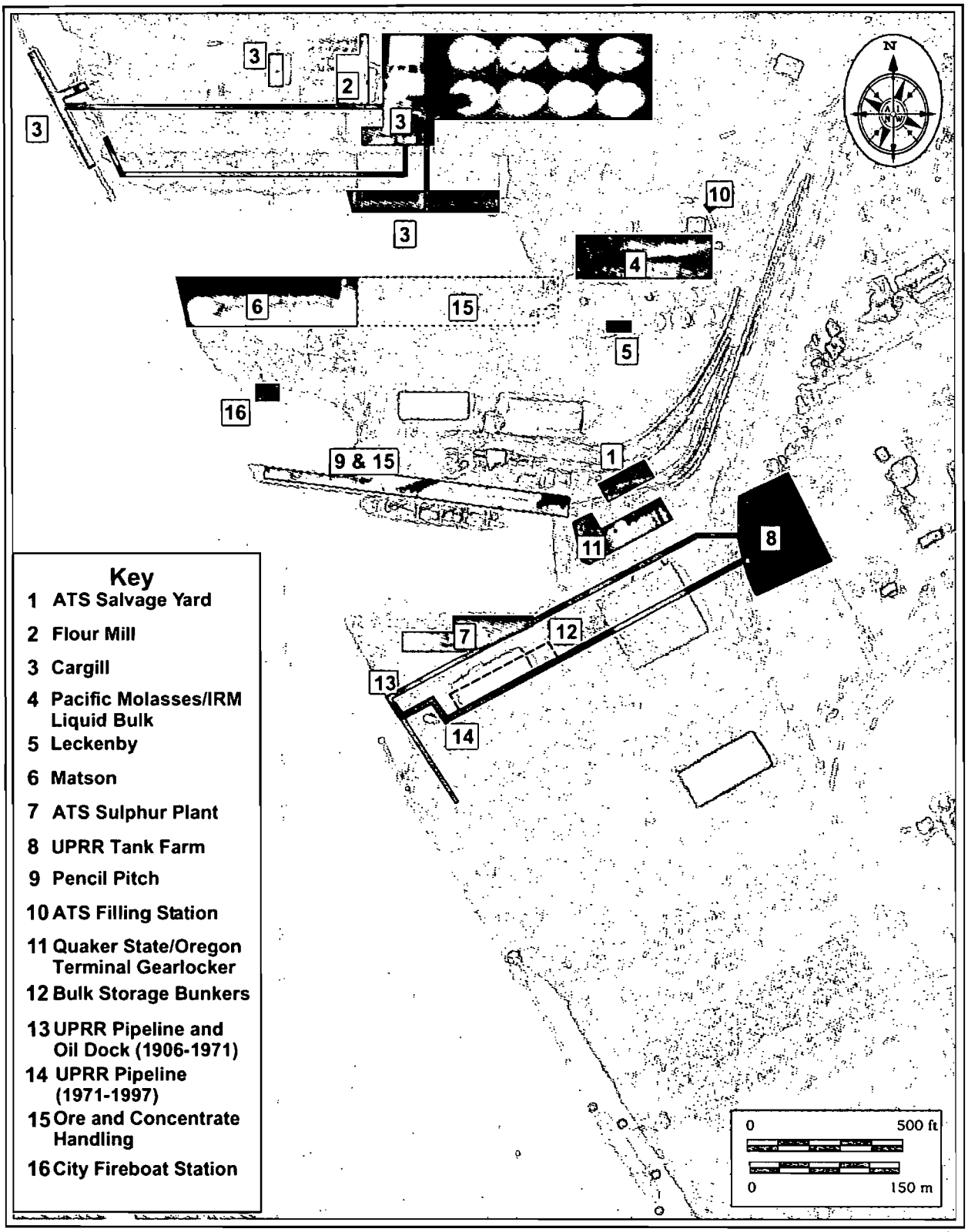
FIGURE
2-2

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PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

POST-WORLD WAR II DEVELOPMENTS

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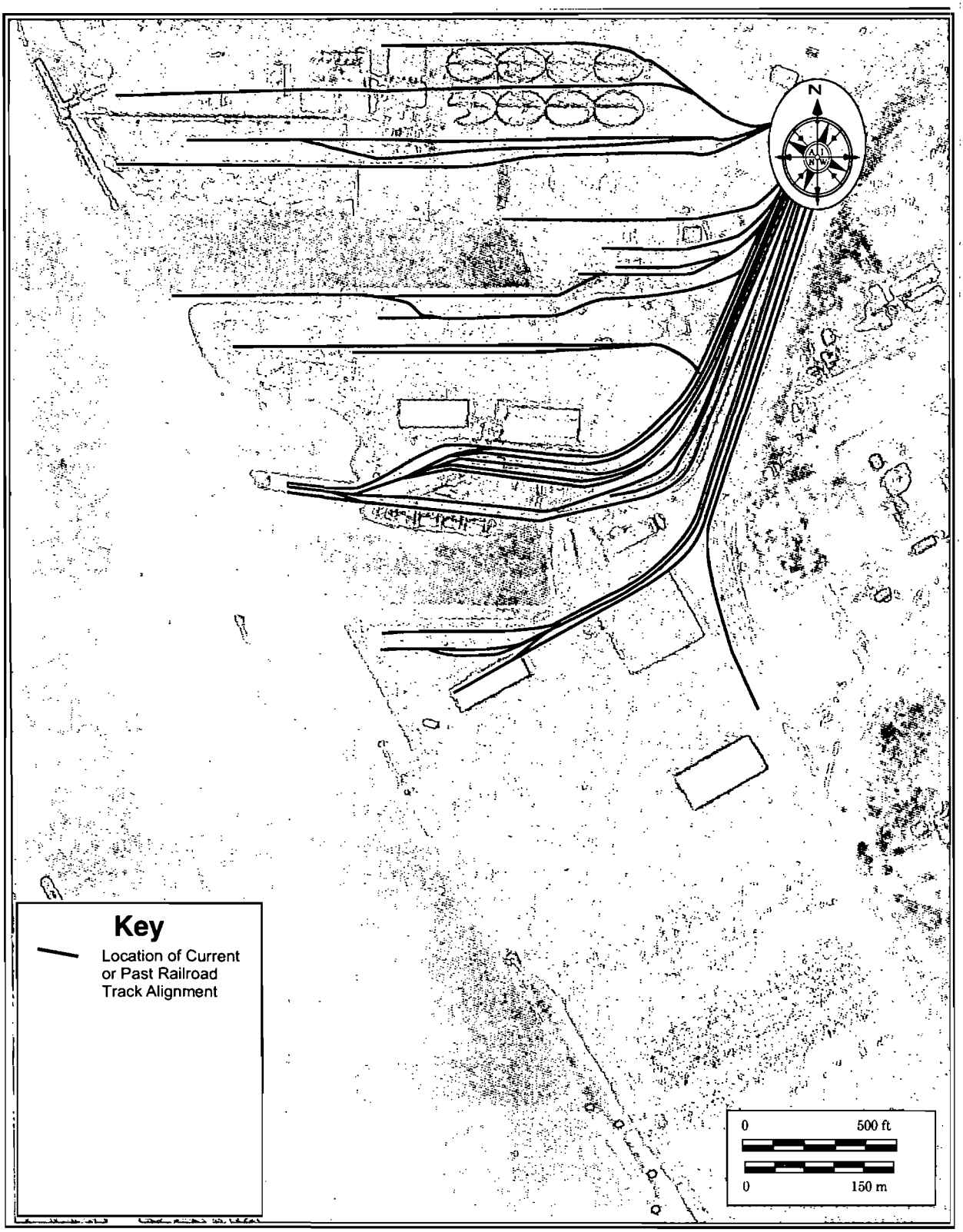
FIGURE
2-3

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TERMINAL 4 EARLY ACTION WORK PLAN

PAST AND PRESENT RAILROAD ALIGNMENTS AT TERMINAL 4

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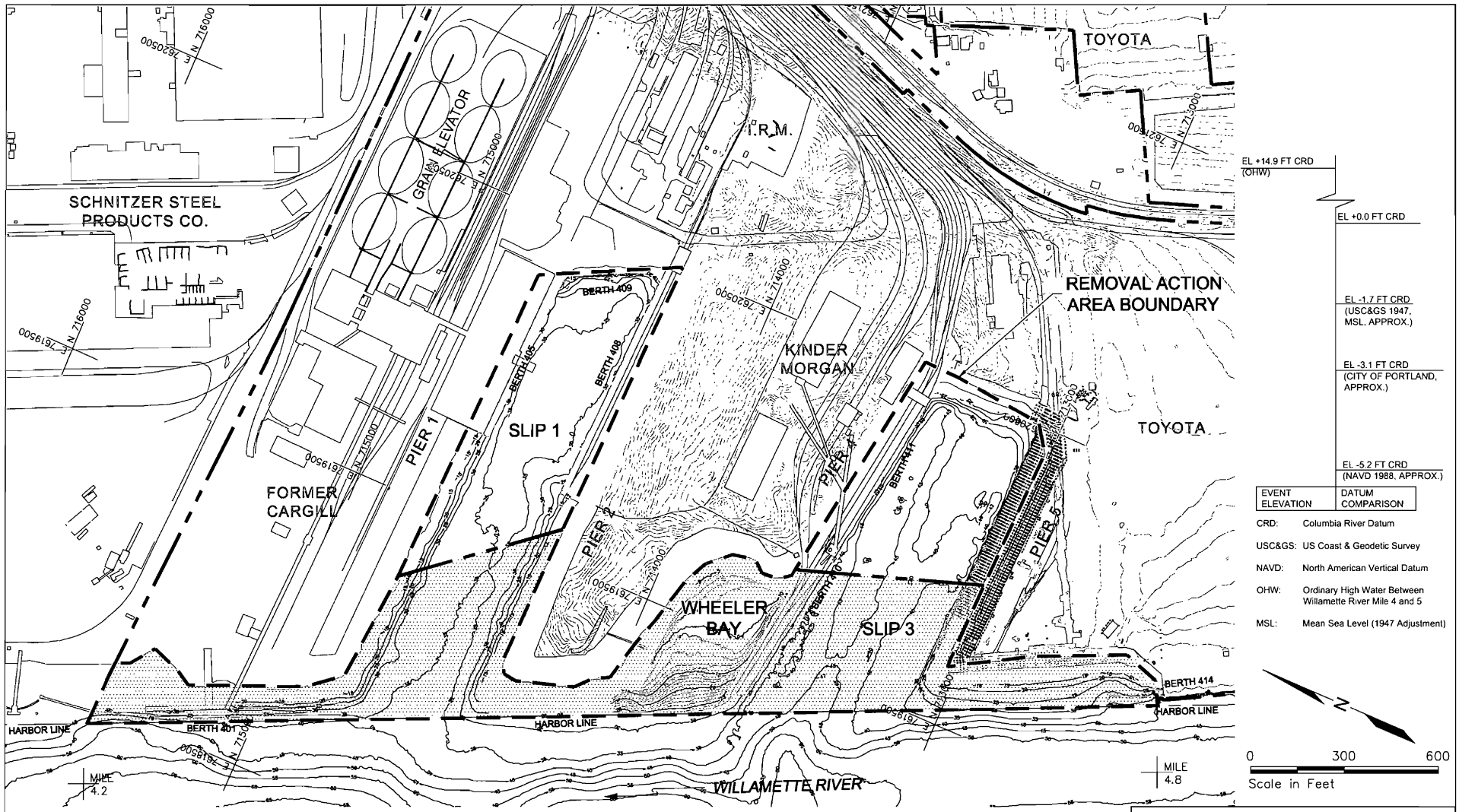
FIGURE
2-4




Ownership:

Existing Piers

Port of Portland, Area = 16.9 Acres

State of Oregon, Area = 21.9 Acres

Notes:

1. Upland topographic vertical datum is MSL, Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

OWNERSHIP

BBL BLASLAND, BOUCK & LEE, INC. engineers & scientists

FIGURE 2-5

DWG NAME: G:\project\Clients\BBL\Terminal 4\t4_009.dwg
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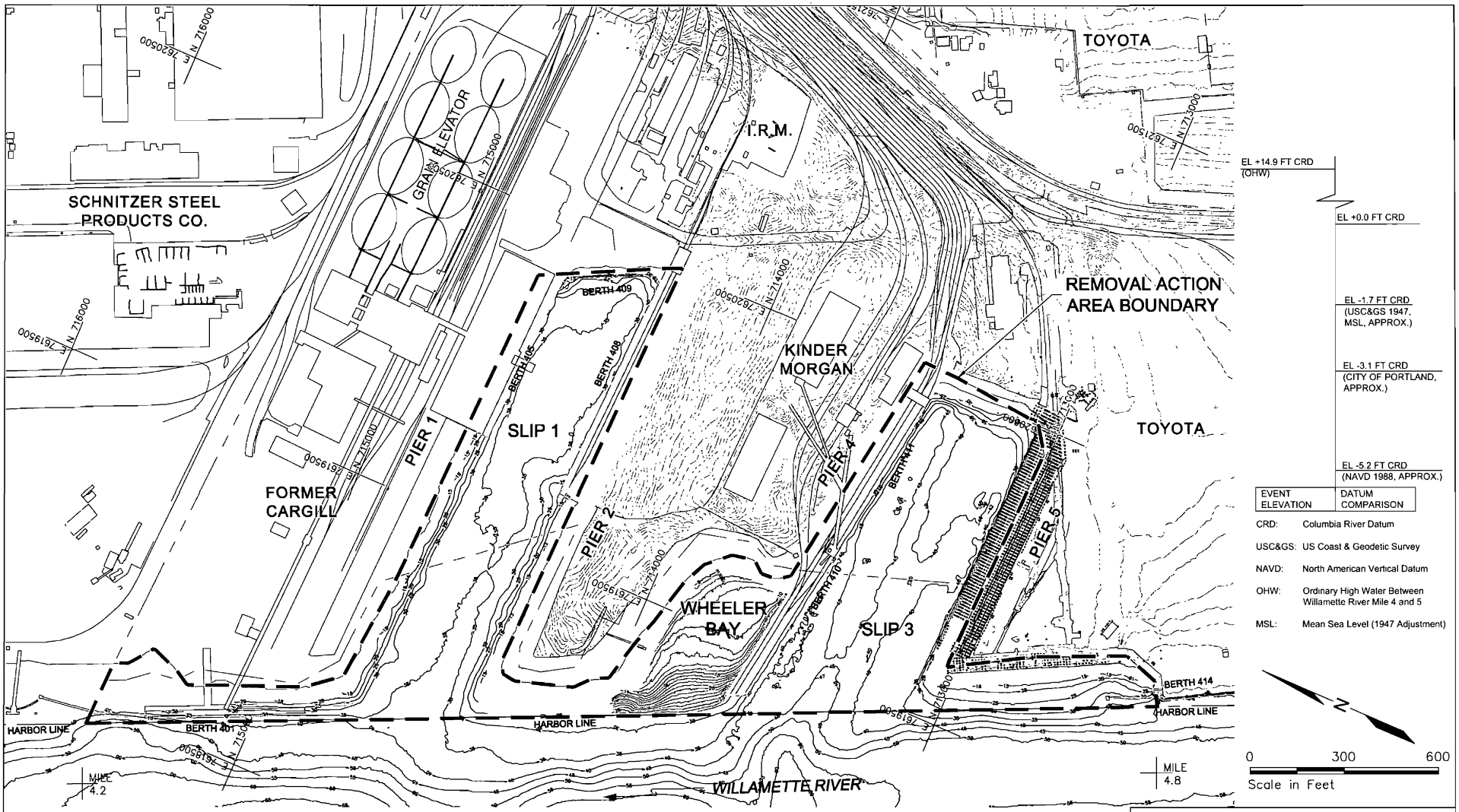


Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2 4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.

Existing Piers

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TERMINAL 4 EARLY ACTION WORK PLAN

REMOVAL ACTION AREA SITE PLAN

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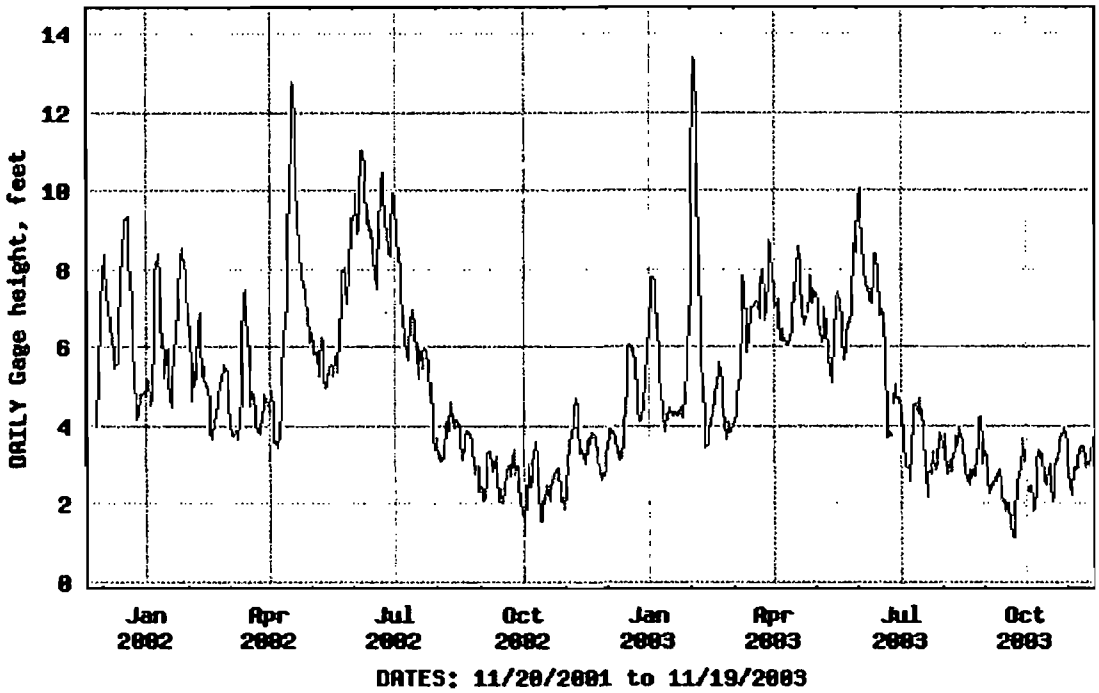
FIGURE
2-6

DWG NAME: G:\project\Clients\BBL\Terminal 4\t4_011.dwg
DATE: 02/18/04 12:19pm

## USGS 14211720 WILLAMETTE RIVER AT PORTLAND, OR




**Provisional Data Subject to Revision**

Note: Gage Height is 1.55 FT above NGVD 1929

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TERMINAL 4 EARLY ACTION WORK PLAN

RIVER STAGE ELEVATION

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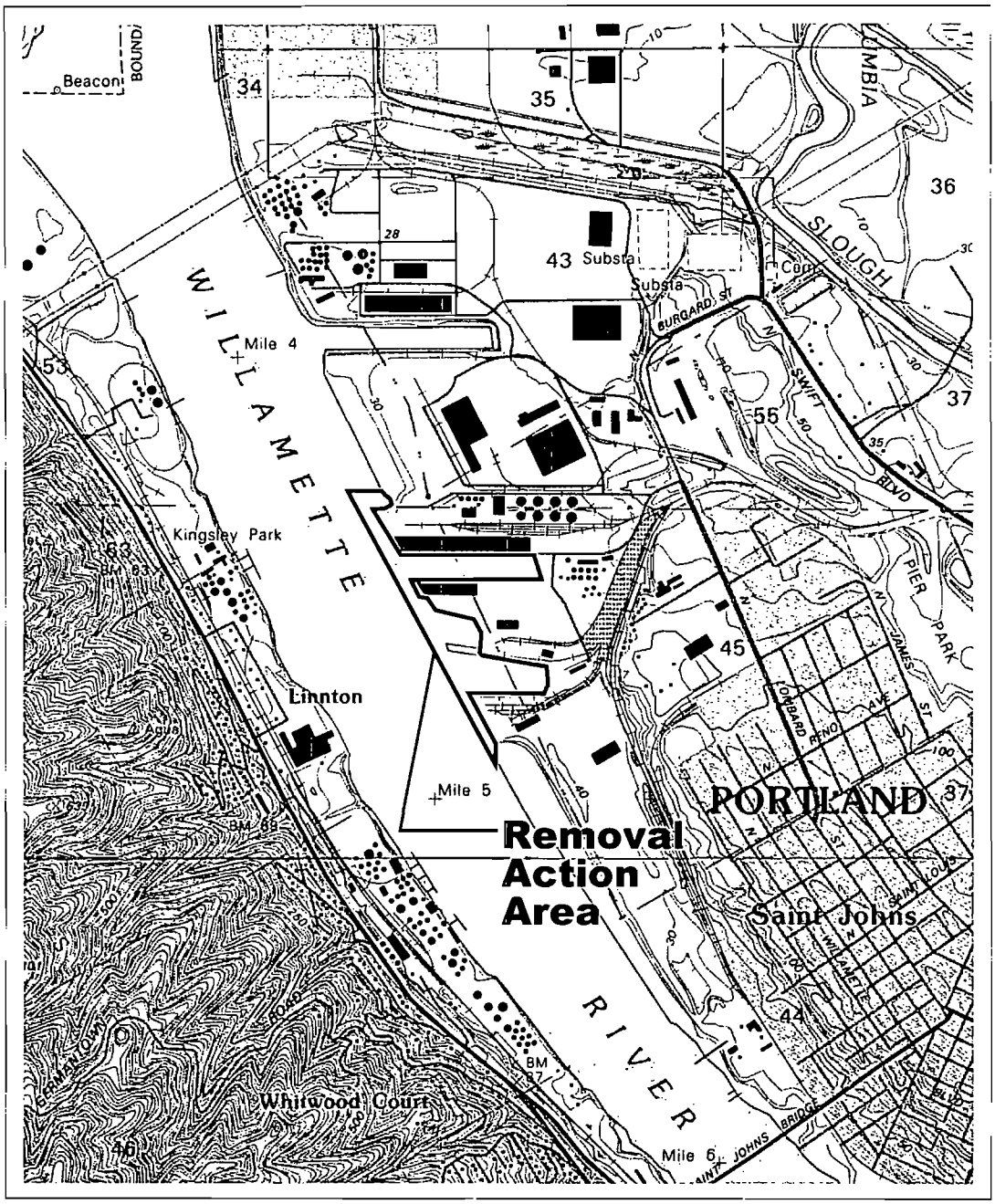
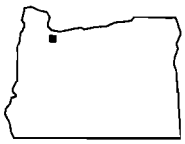
FIGURE
2-7




Note: Base map prepared from 7.5 minute USGS quadrangle map of Linnton, Oregon, dated 1990.



0 2000 4000

Scale in Feet

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

SITE LOCATION MAP

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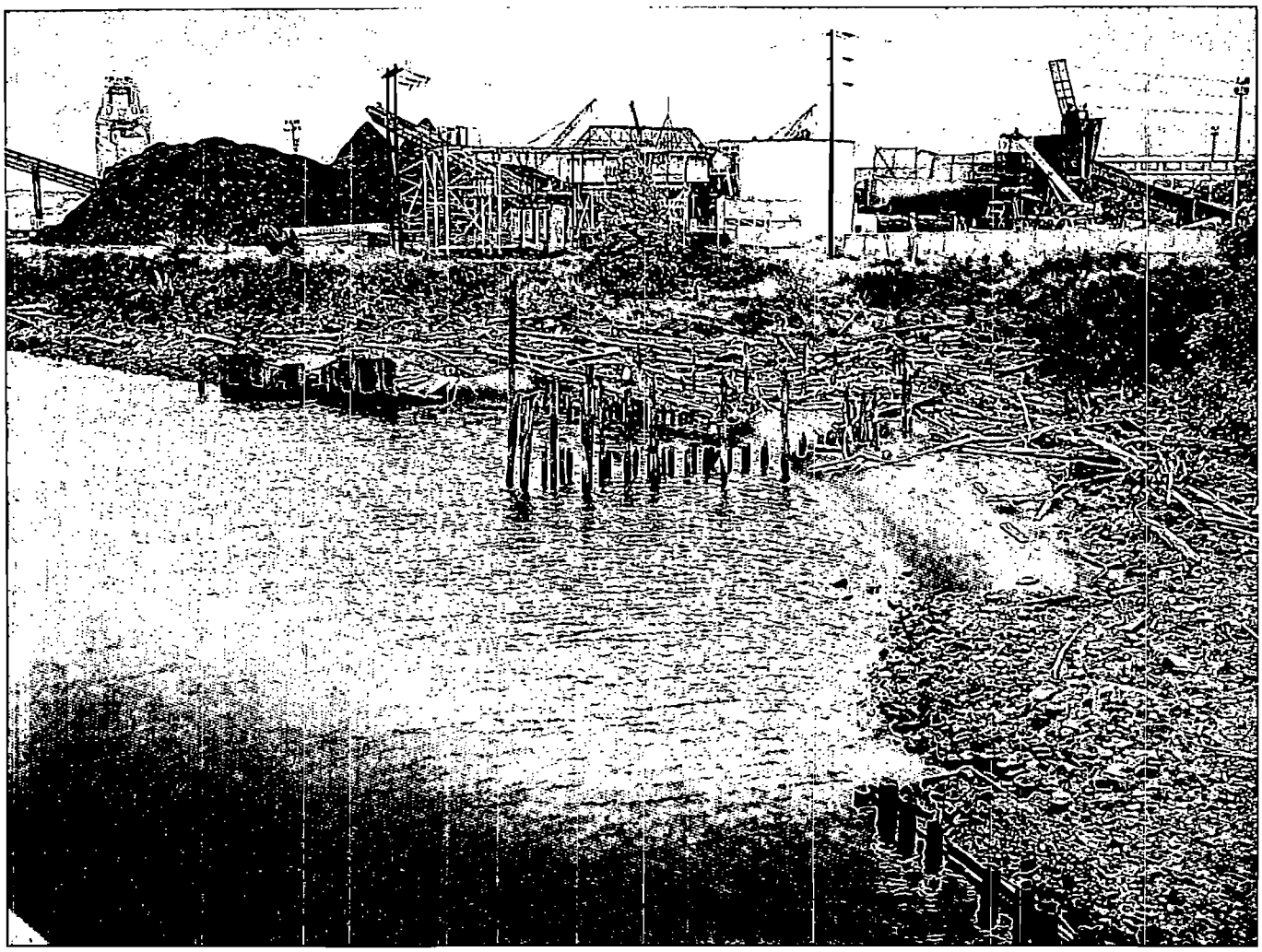
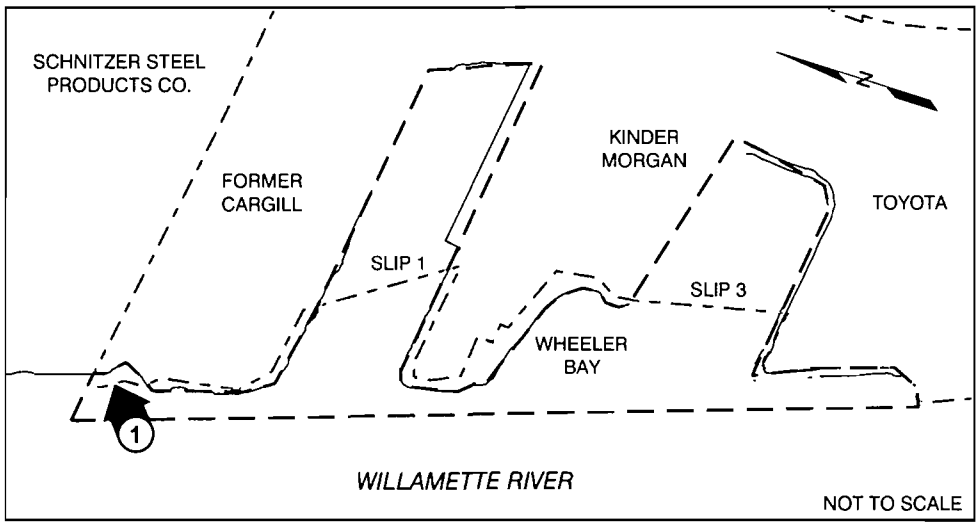
FIGURE
2-8






1 Photograph Location, Direction, and Orientation

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

SLIP 1
PHOTO 1

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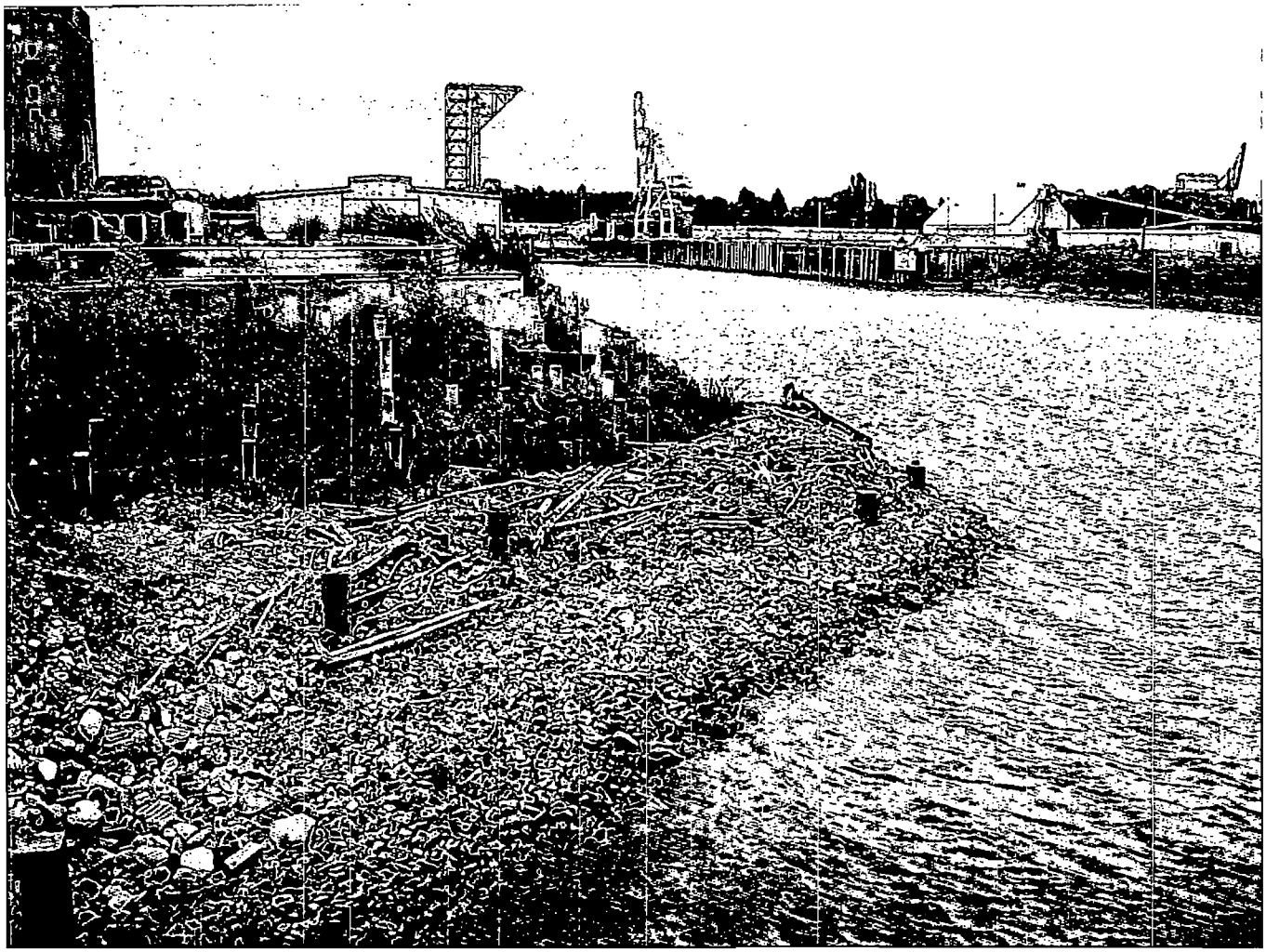
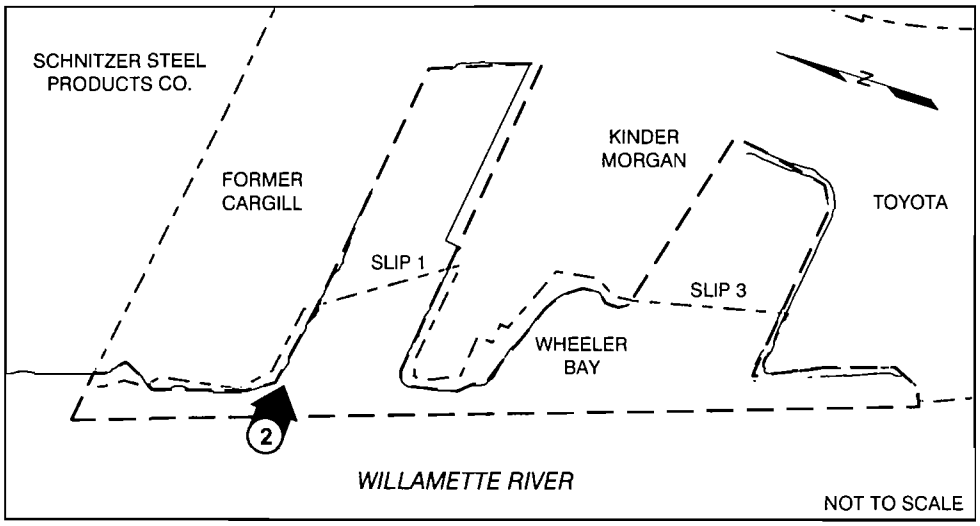
FIGURE
2-9






2 Photograph Location, Direction, and Orientation

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

SLIP 1
PHOTO 2

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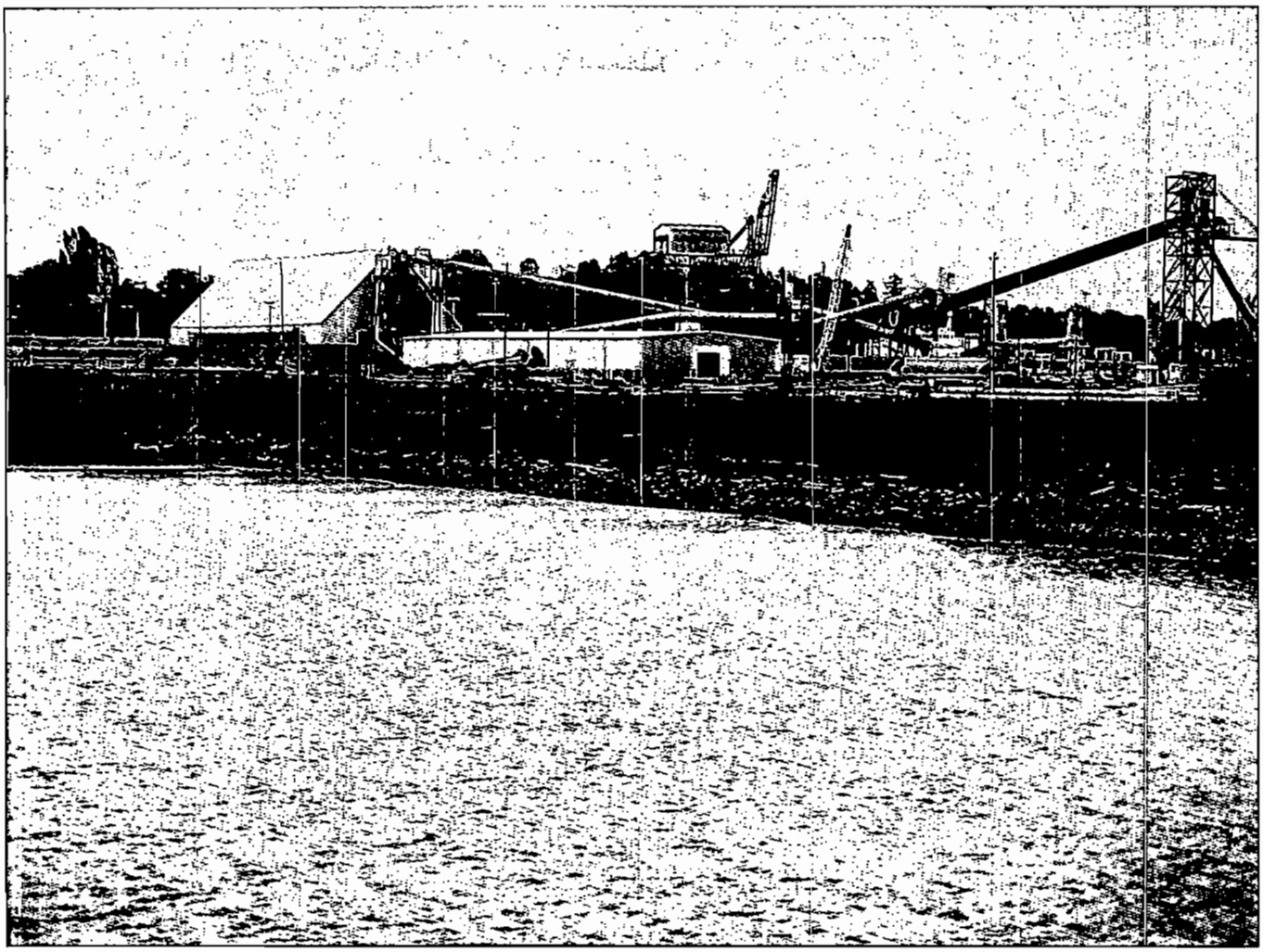
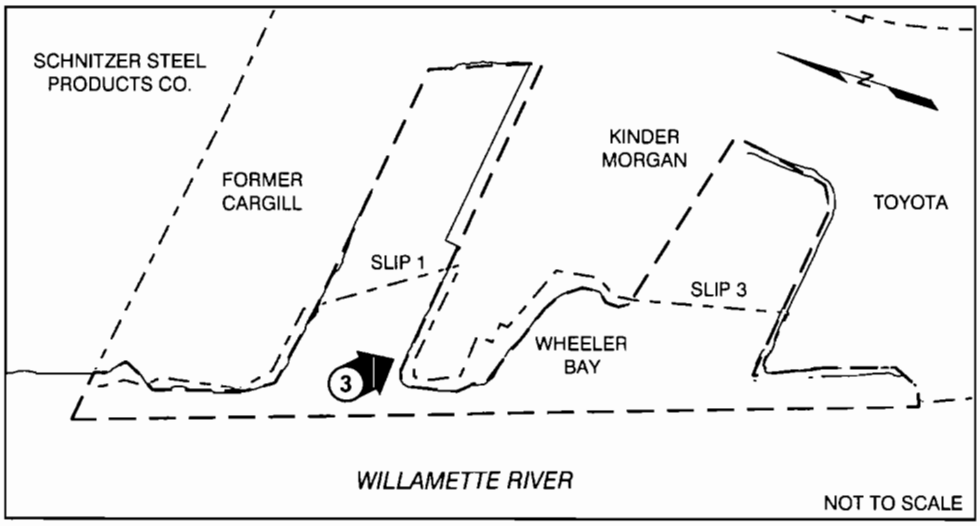
FIGURE
2-10






3 Photograph Location, Direction, and Orientation

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

SLIP 1
PHOTO 3

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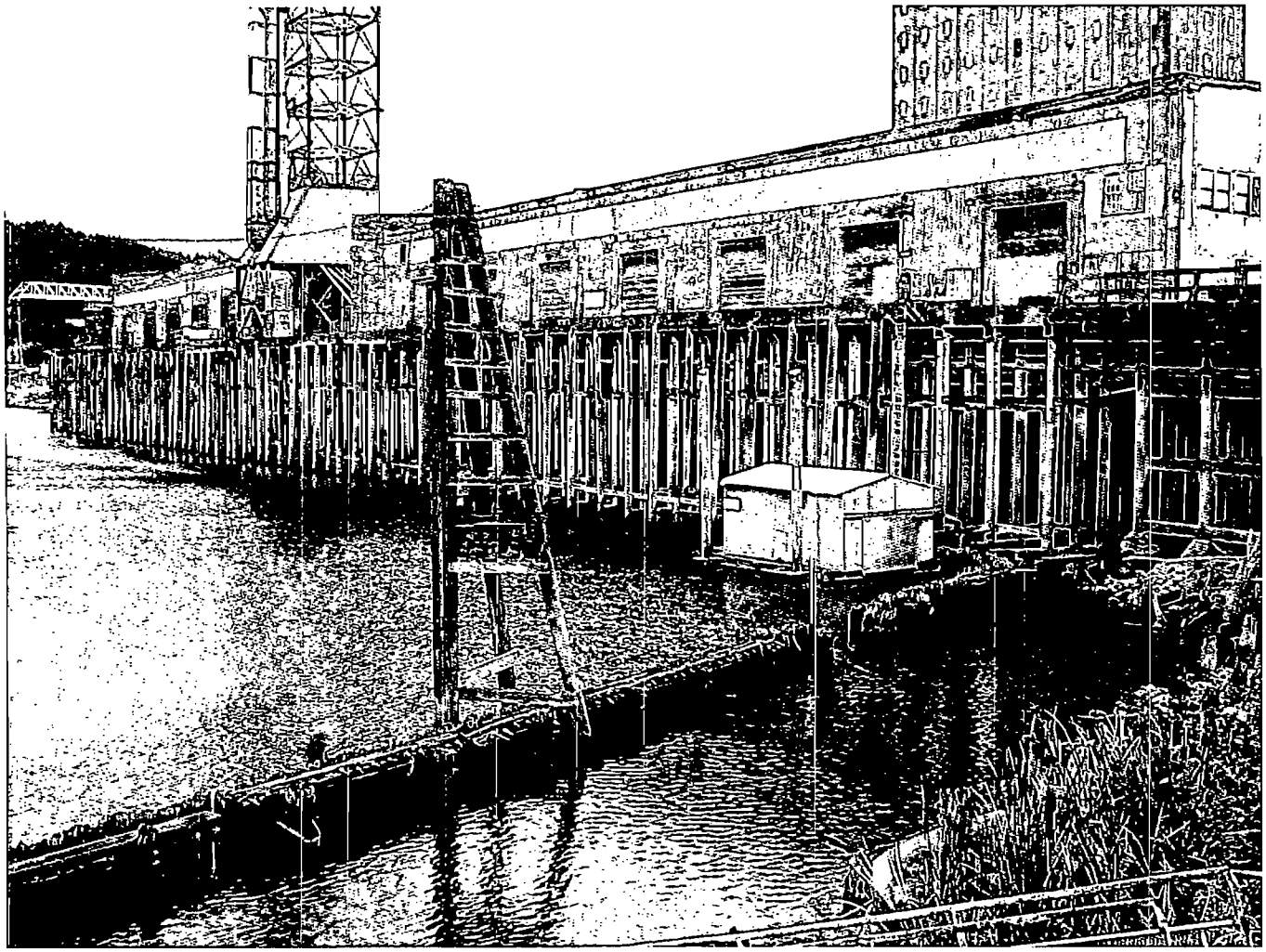
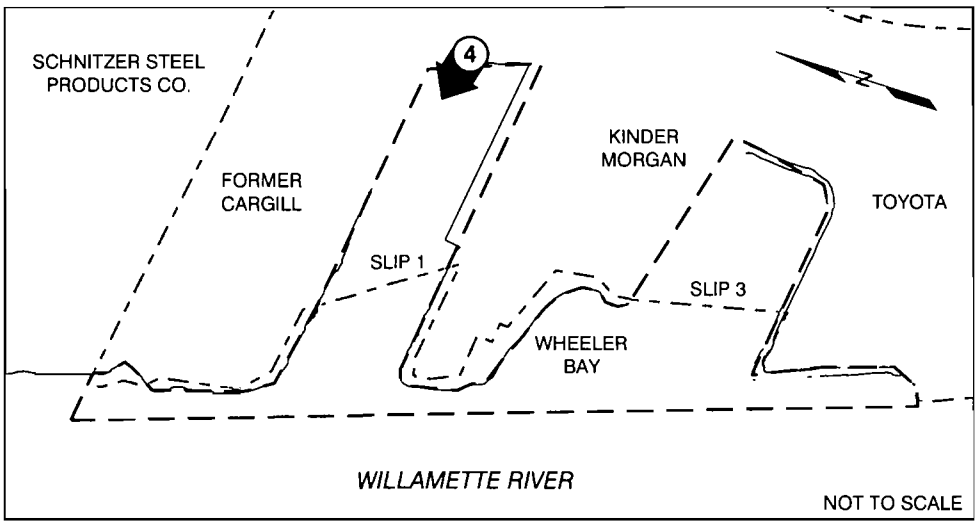
FIGURE
2-11






4 Photograph Location, Direction, and Orientation

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

SLIP 1
PHOTO 4

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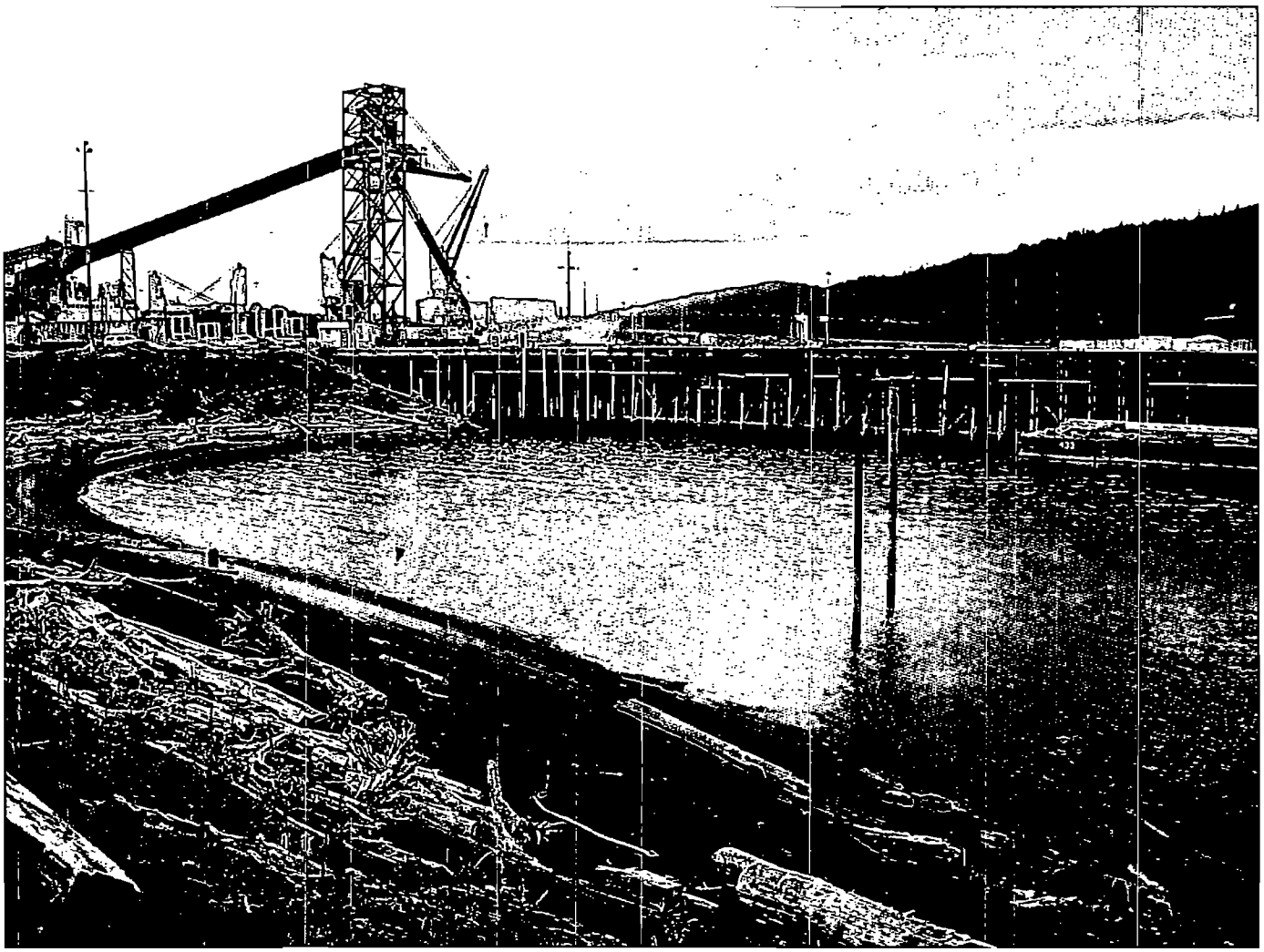
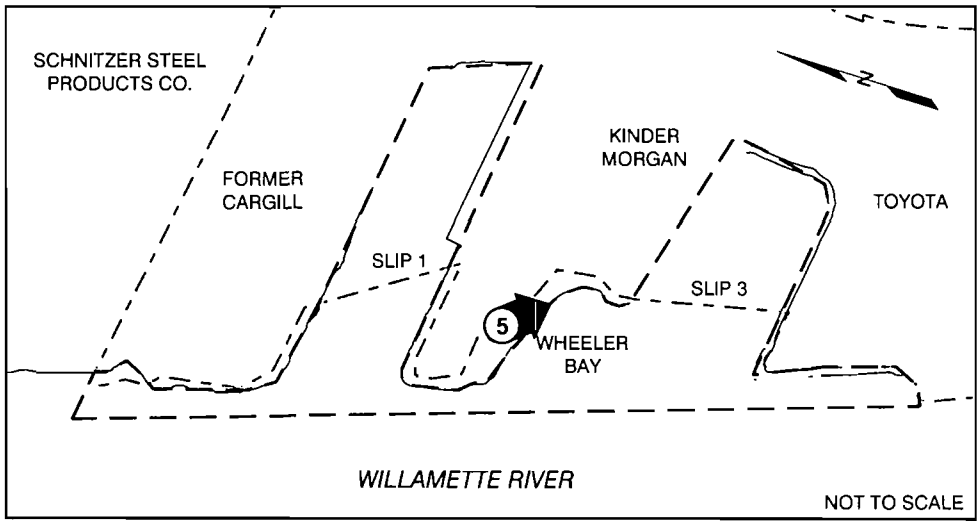
FIGURE
2-12






5 Photograph Location, Direction, and Orientation

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

WHEELER BAY
PHOTO 1

BBL
BLASLAND, BOUCK & LEE, INC
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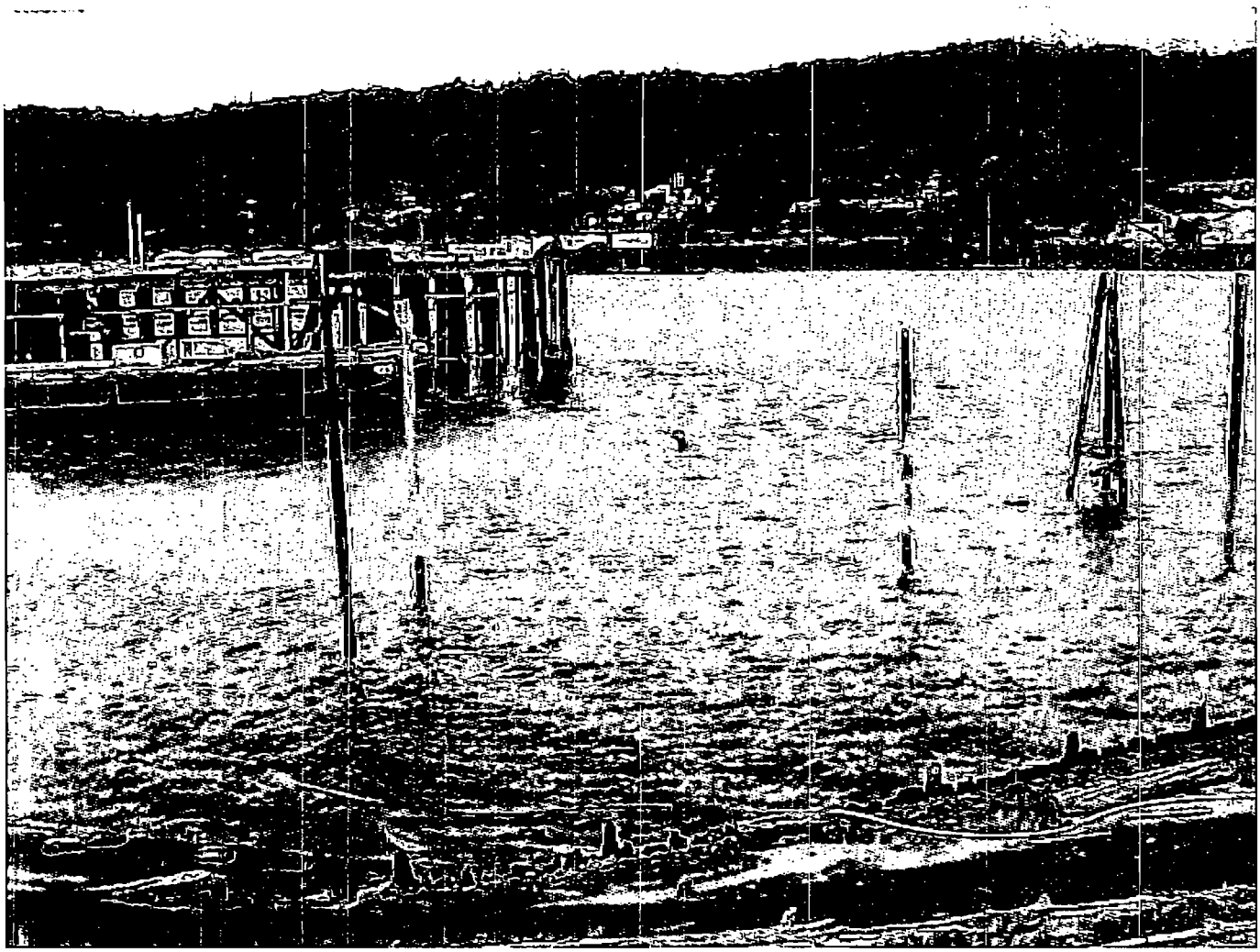
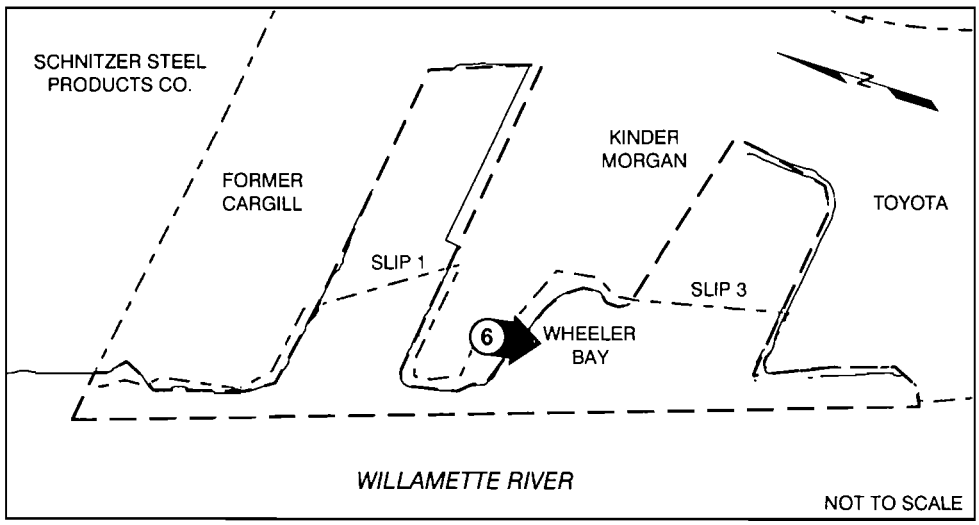
FIGURE
2-13






6 Photograph Location, Direction, and Orientation

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

WHEELER BAY
PHOTO 2

BBL
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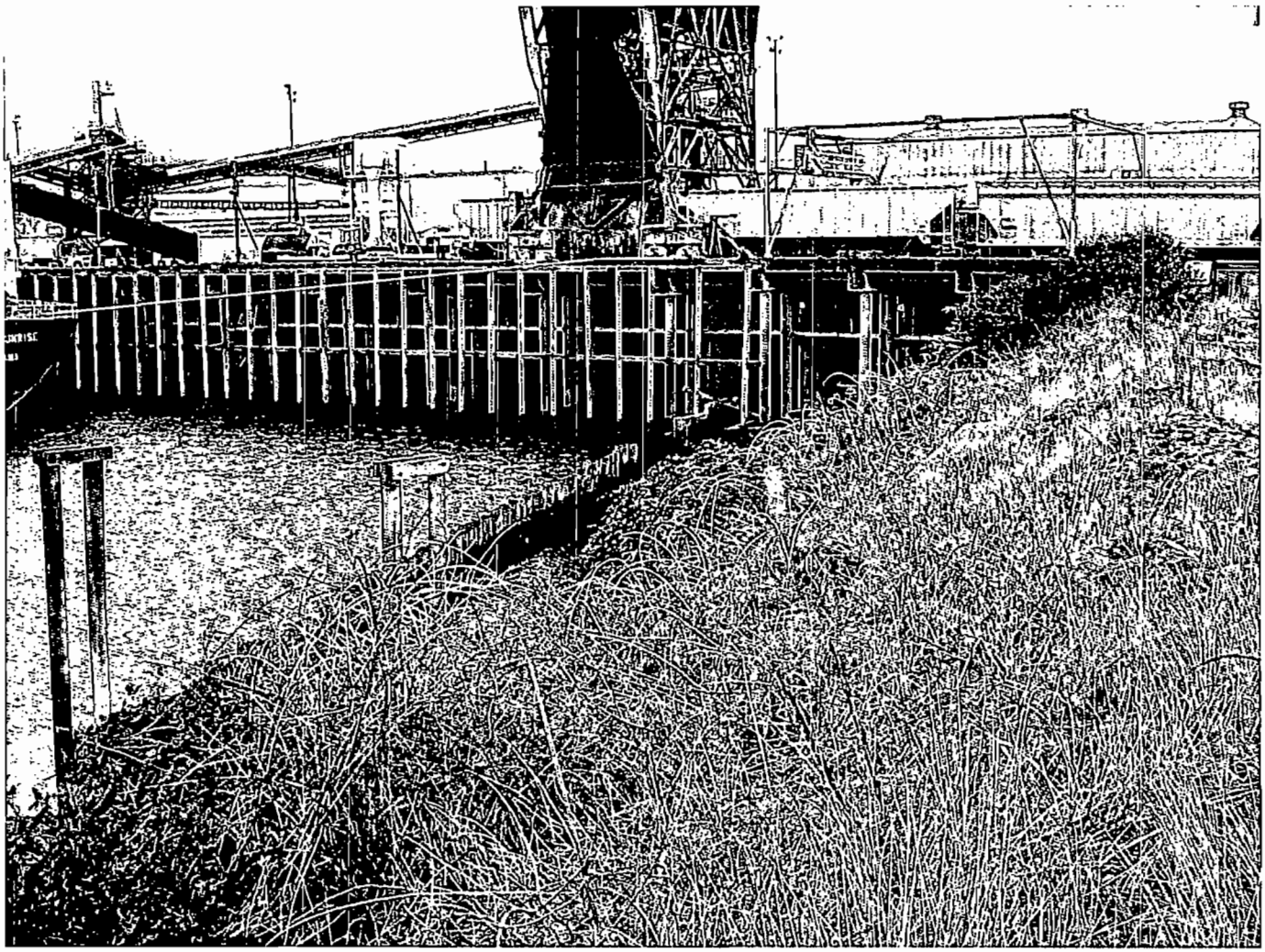
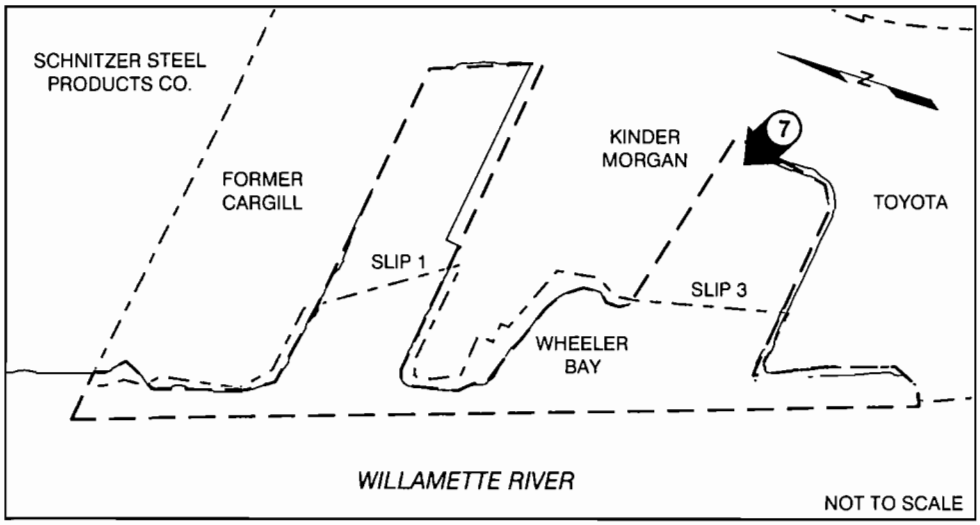
FIGURE
2-14






7 Photograph Location, Direction, and Orientation

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

SLIP 3
PHOTO 1

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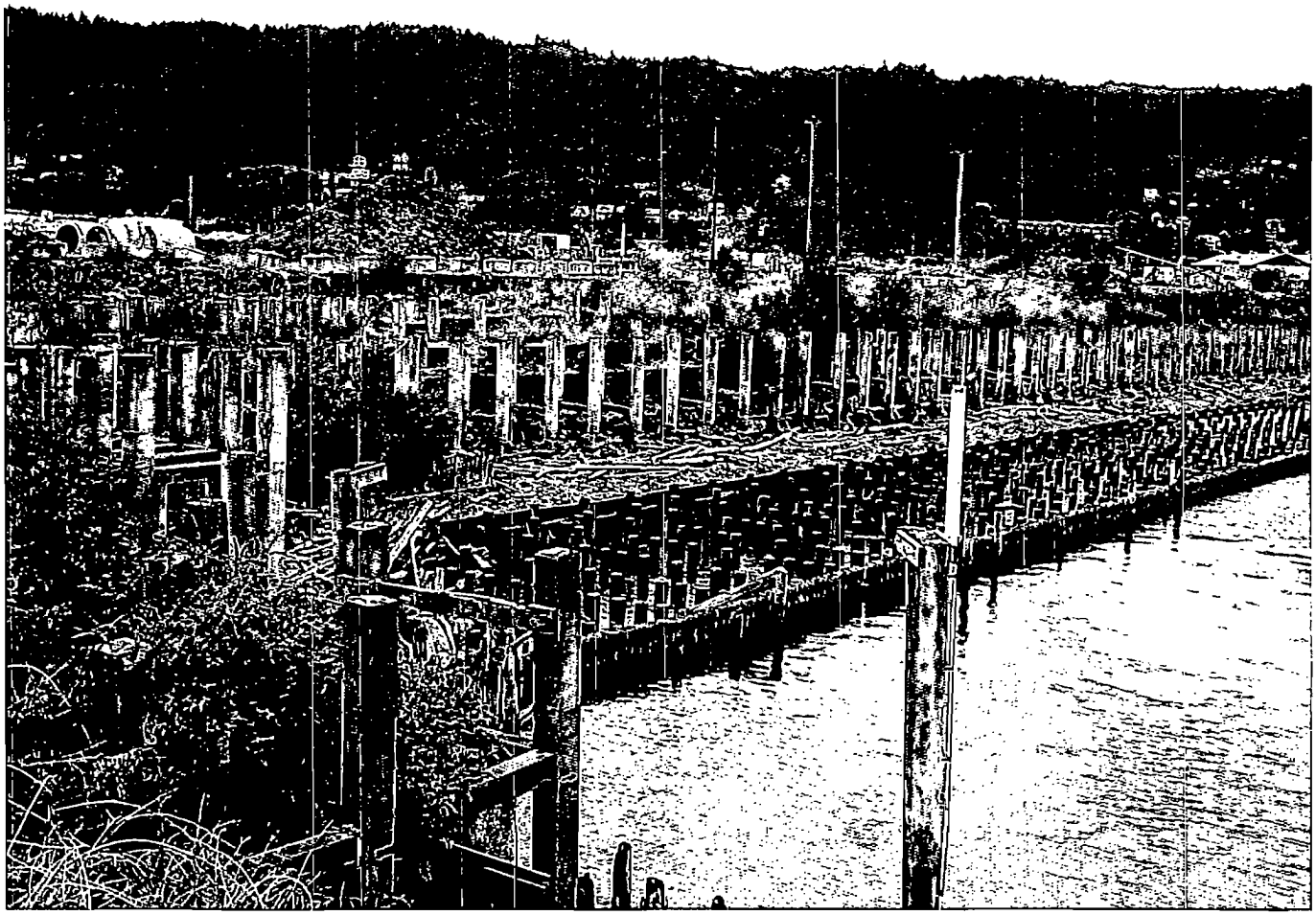
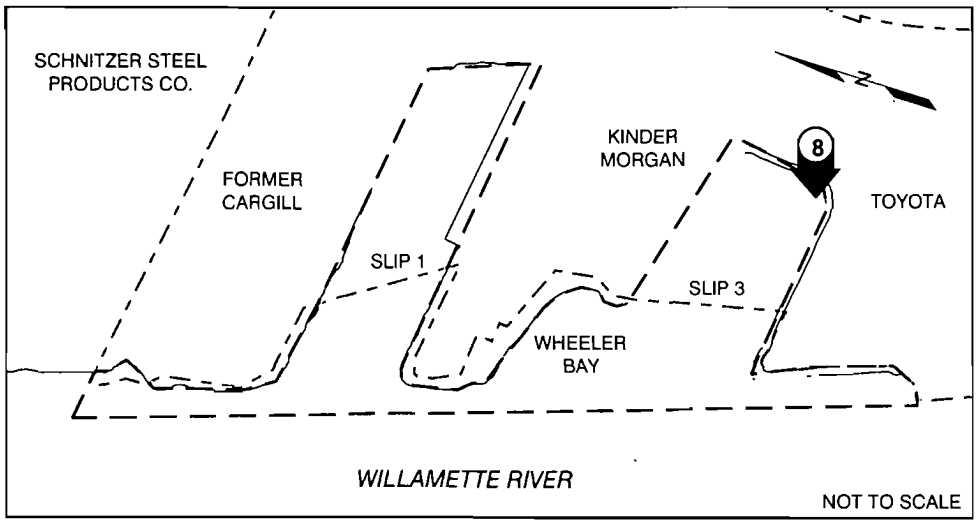
FIGURE
2-15






8 Photograph Location, Direction, and Orientation

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

SLIP 3
PHOTO 2

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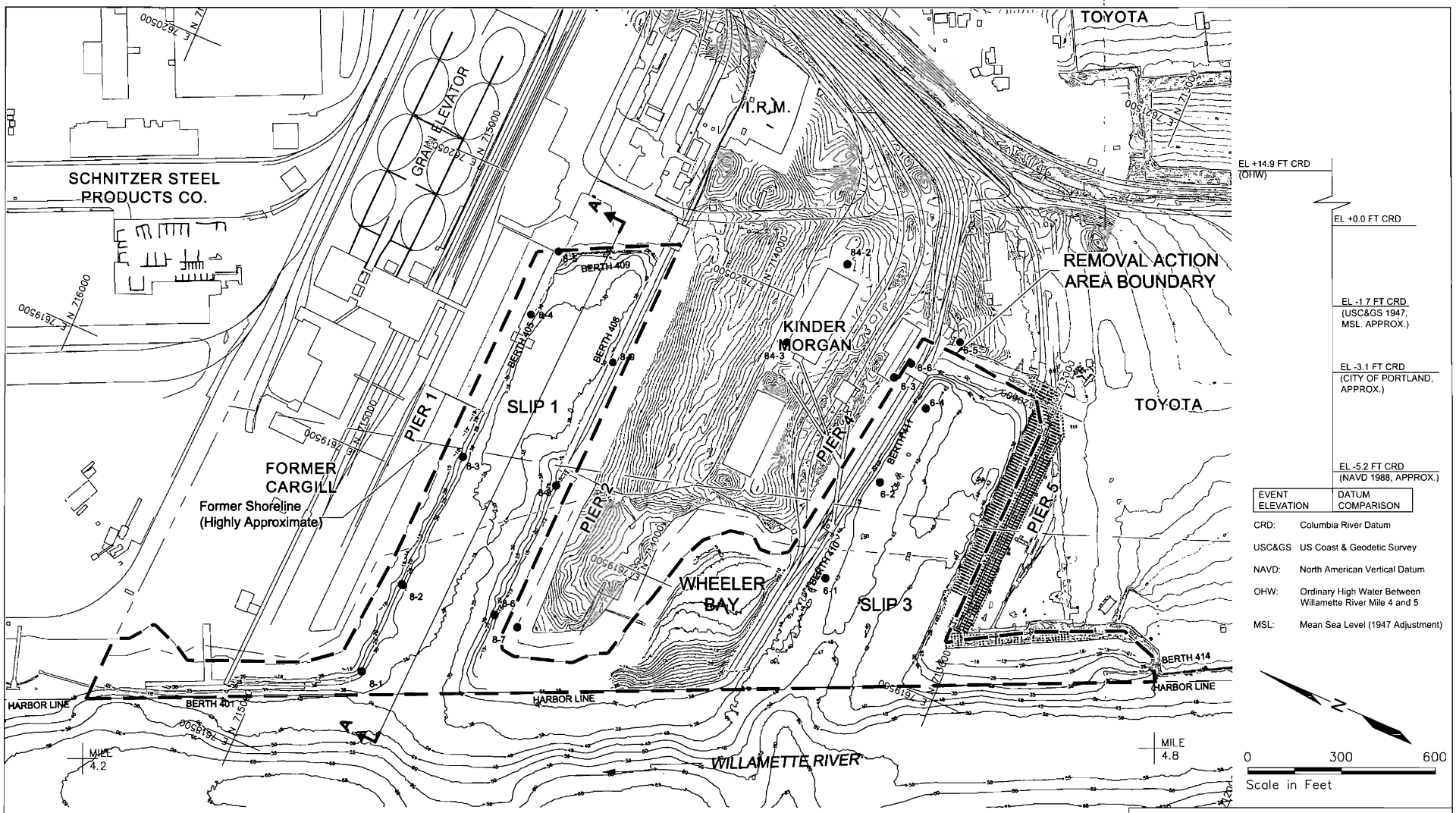
FIGURE
2-16




| EVENT ELEVATION | DATUM COMPARISON |
|---|---|
| CRD: | Columbia River Datum |
| USC&GS | US Coast & Geodetic Survey |
| NAVD: | North American Vertical Datum |
| OHW: | Ordinary High Water Between Willamette River Mile 4 and 5 |
| MSL: | Mean Sea Level (1947 Adjustment) |

Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.

● Existing Geotechnical Exploration Location

Existing Piers

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PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

EXISTING GEOTECHNICAL EXPLORATION LOCATIONS

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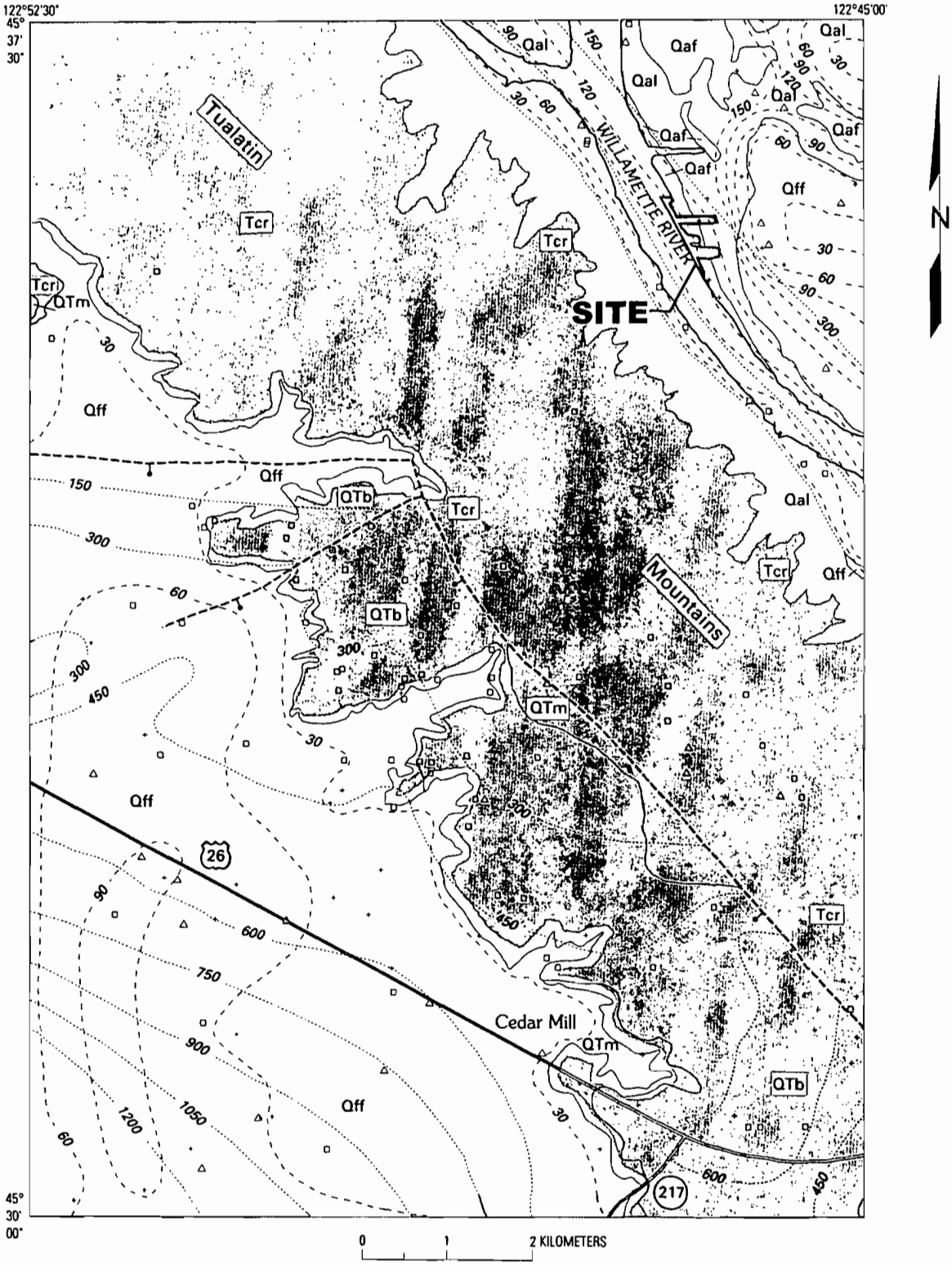
FIGURE 2-17

DWG NAME: G:\project\Clients\BBL\Terminal 4\t4_004.dwg
DATE: 02/17/04 12:42pm




Source: Geologic map of the U.S. Geological Survey's 1:24,000-series topographic Linnton quadrangle.

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TERMINAL 4 EARLY ACTION WORK PLAN

SURFICIAL GEOLOGY MAP OF THE TERMINAL 4 SITE AND VICINITY

BBL
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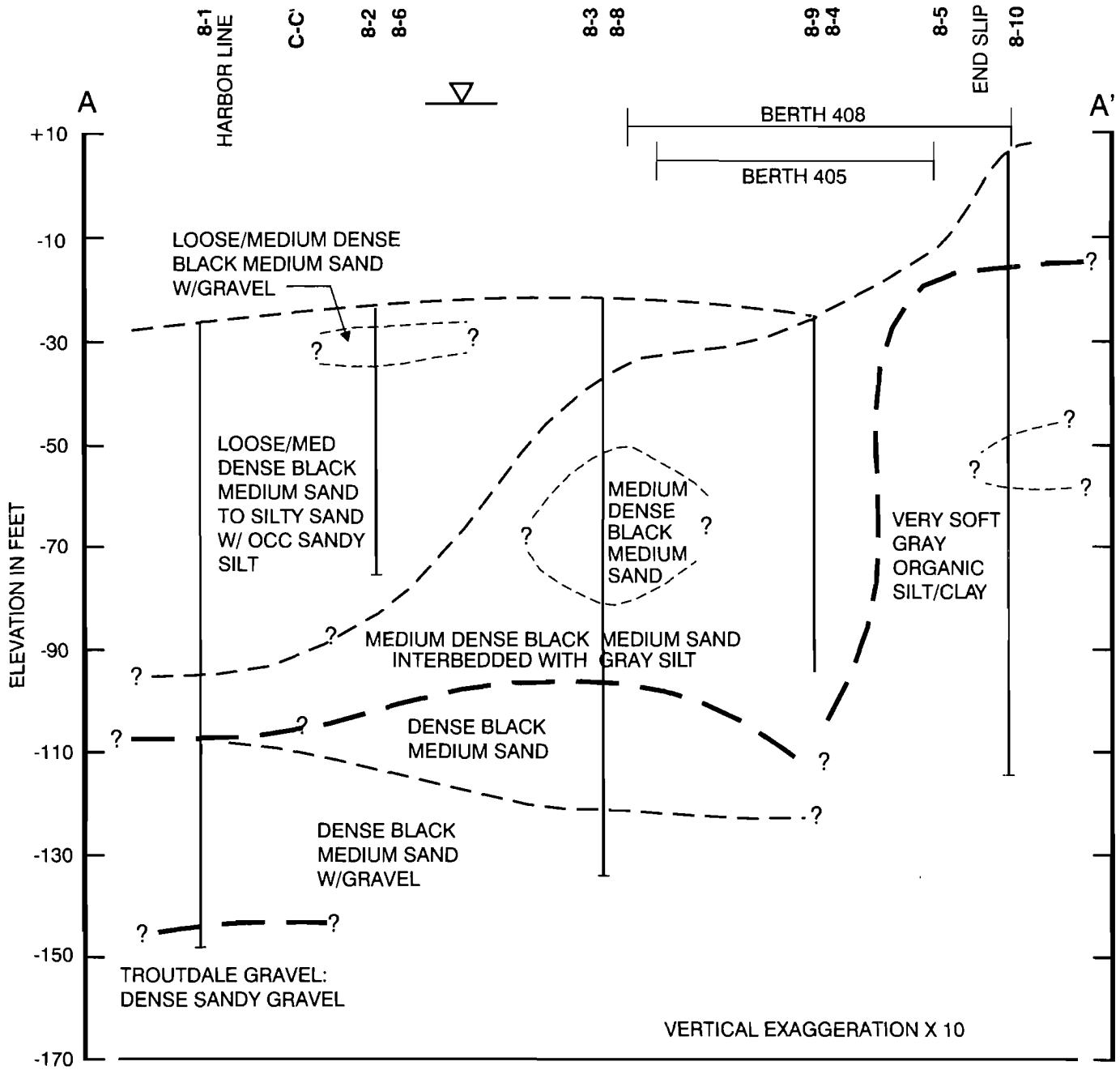
FIGURE
2-18

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TERMINAL 4 EARLY ACTION WORK PLAN

CROSS SECTION A-A'
THROUGH SLIP 1

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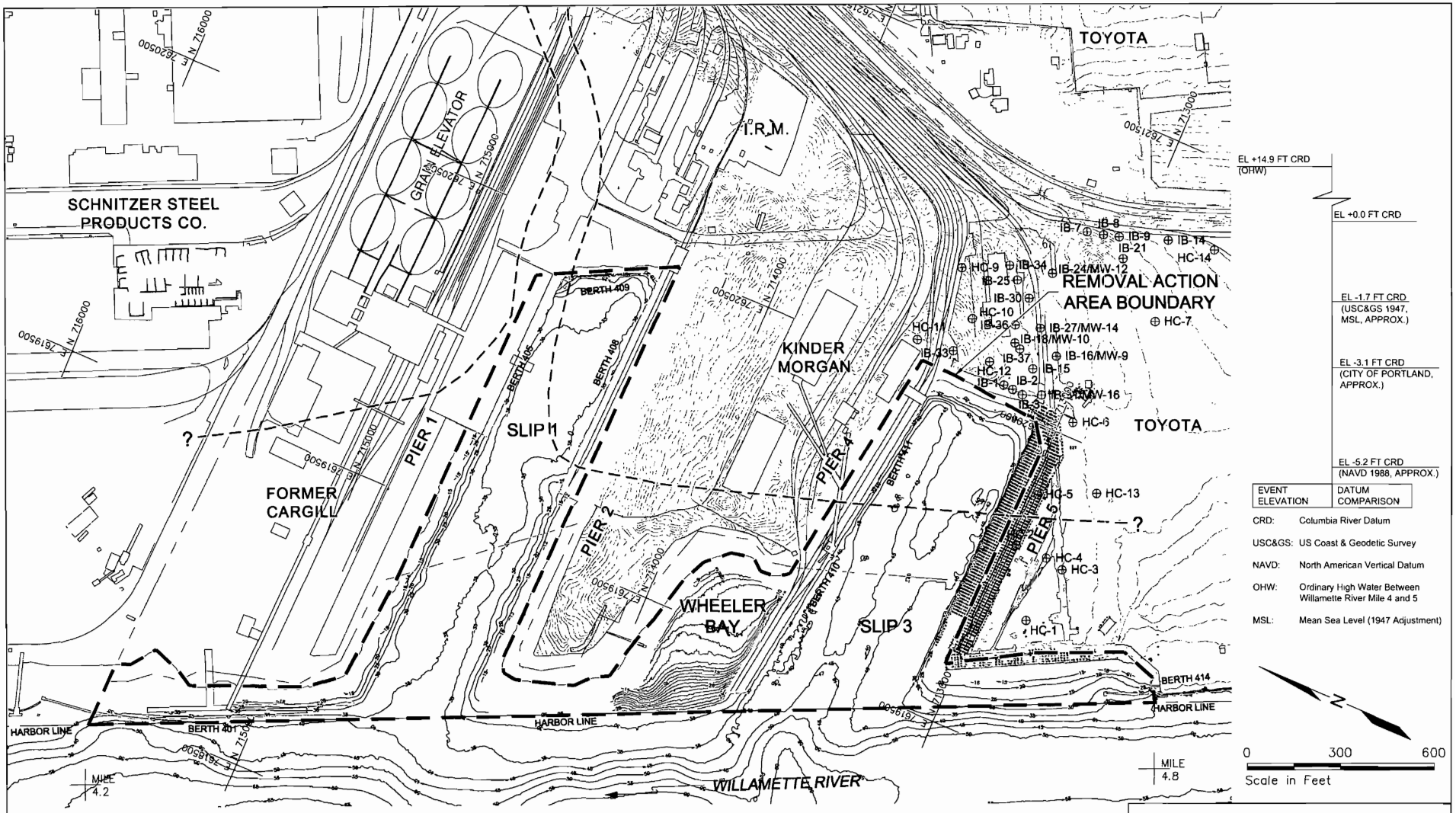
FIGURE
2-19




Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.

⊕ Existing Monitoring Well Location (RI Report, Hart Croswer, 2000)

Existing Piers

Historic Shoreline and Gatton Slough

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

EXISTING MONITORING WELL LOCATIONS

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FIGURE 2-20

DWG NAME: G:\project\Clients\BBL\Terminal 4\t4_006.dwg
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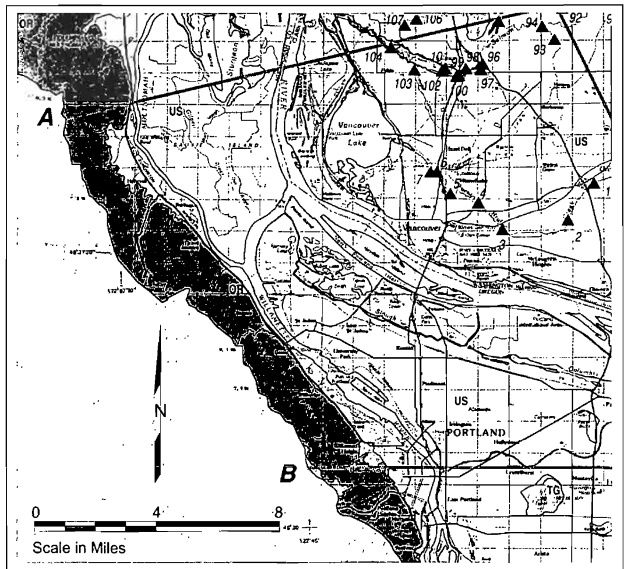
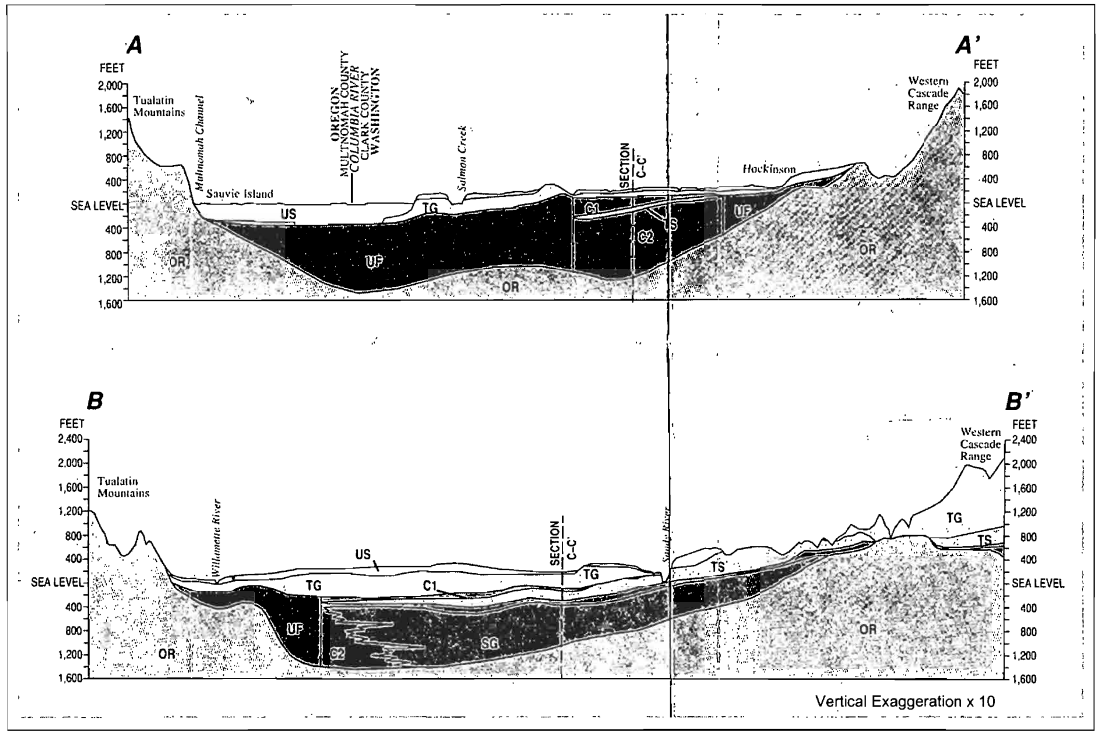



Contact—Approximately Located

A——A' Line of Hydrogeologic Section

▲3 Streamflow Measurement Site with Number

| SUBSYSTEM | SYMBOL | HYDROGEOLOGIC UNIT | DESCRIPTION |
|---|---|---|---|
| UPPER SEDIMENTARY (Quaternary and Pliocene) | US | UNCONSOLIDATED SEDIMENTARY AQUIFER | Alluvium along major rivers and Pleistocene catastrophic flood deposits that mantle much of the basin. |
| | TG | TROUTDALE GRAVEL AQUIFER | Cemented sand and gravel deposits of the Troutdale Formation. Also includes Cascadian volcanic conglomerates (Gresham, Springwater, and Walters Hill Formations). Pleistocene terrace gravel locally along rivers. Boring Lava and High Cascade volcanics. |
| LOWER SEDIMENTARY (Pliocene) | UNDIFFERENTIATED FINE-GRAINED UNIT: UF; DIFFERENTIATED UNITS: C1, TS, C2, SG | UNDIFFERENTIATED FINE-GRAINED UNITS: CONFINING UNIT 1 | Mudstone, siltstone, and claystone with some vitric sandstone. Considered Troutdale Formation; however, where the Troutdale sandstone aquifer is not present, it cannot be distinguished from Sandy River Mudstone. |
| | | TROUTDALE SANDSTONE AQUIFER | Vitric sandstone and conglomerate. Correlative with Troutdale Formation. |
| | | CONFINING UNIT 2 | Mudstone, siltstone, and claystone mapped as Sandy River Mudstone. |
| | | SAND AND GRAVEL AQUIFER | Silty to gravelly sand within Sandy River Mudstone. |
| OLDER ROCKS (Miocene–Eocene) | OR | OLDER ROCKS | Includes Skamania Volcanics, Goble Volcanics, marine sediments of the Pittsburg Bluff and Scappoose Formations, basalts of Waverly Heights, Columbia River Basalt Group and volcanic rocks of the Rhododendron Formation. |




Note:

Figure prepared from drawing entitled "Water Supply Paper 2470-A Hydrogeology, sections, and measurement sites—PLATE1 McFarland, W.D. and Morgan, D.S., 1996. Description of the ground-water flow system in the Portland basin, Oregon and Washington

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REGIONAL HYDROGEOLOGIC MAP AND CROSS SECTIONS

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FIGURE
2-21

Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.
7. Drainage basins for Outfalls 52A and 52C were provided by the City of Portland (see legend).

Existing Piers

Approximate Drainage Basin Incorporating City of Portland Stormwater Subbasin

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TERMINAL 4 EARLY ACTION WORK PLAN

EXISTING STORMWATER DRAINAGE BASINS

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FIGURE 2-22

DWG NAME: G:\project\Clients\BBL\Terminal 4\t4_012.dwg
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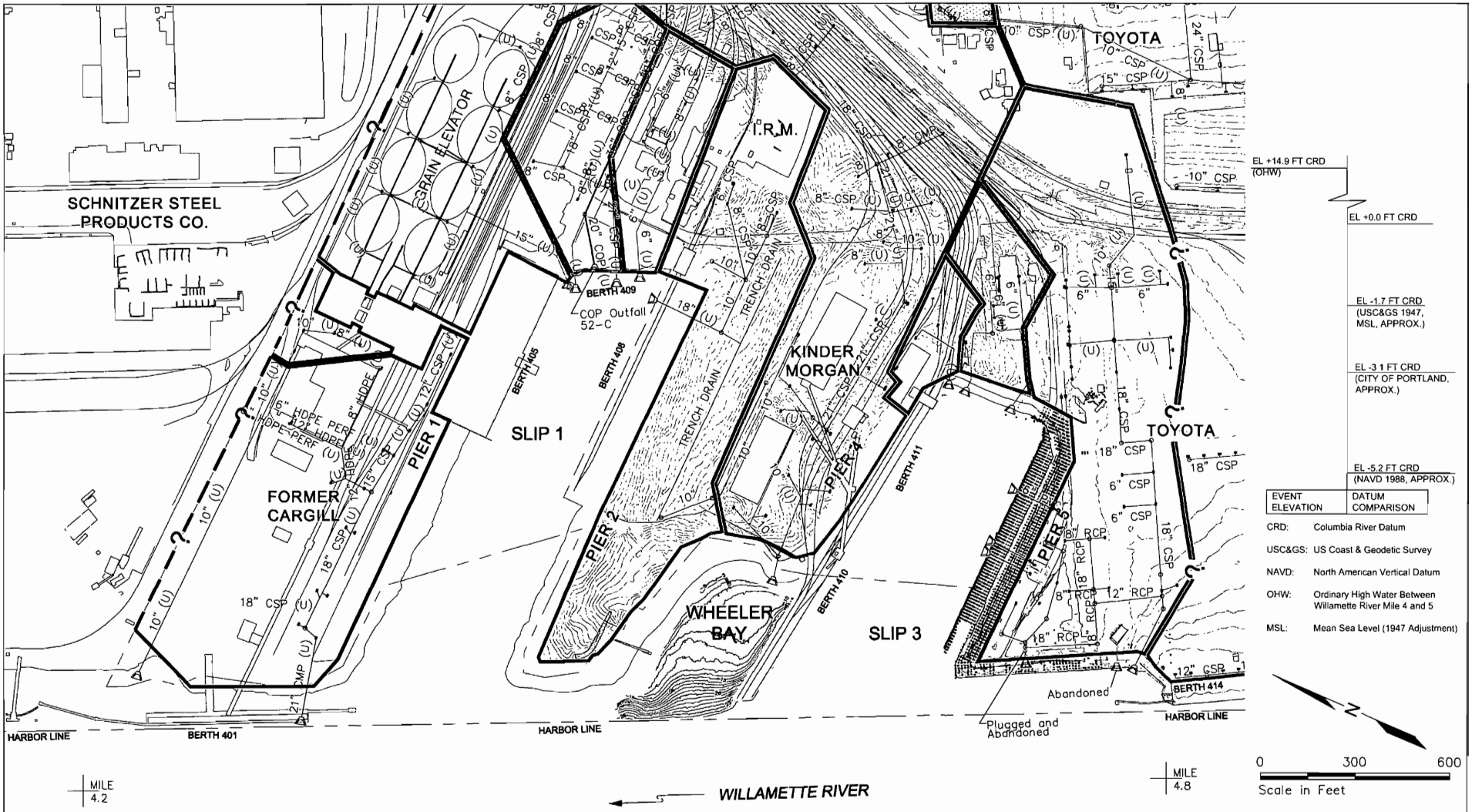


| EVENT ELEVATION | DATUM COMPARISON |
|---|---|
| CRD: | Columbia River Datum |
| USC&GS: | US Coast & Geodetic Survey |
| NAVD: | North American Vertical Datum |
| OHW: | Ordinary High Water Between Willamette River Mile 4 and 5 |
| MSL: | Mean Sea Level (1947 Adjustment) |

Notes:

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6. Datum conversion tables to CRD provided by Port of Portland.

Existing Piers

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

EXISTING STORMWATER UTILITIES AND OUTFALL LOCATIONS

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FIGURE 2-23

DWG NAME: G:\project\Clients\BBL\Terminal 4\t4_012.dwg
DATE: 02/17/04 12:30pm

Section 3

# 3. Potential Sources of Contamination

This section presents information showing how various activities and operations that took place at and near Terminal 4 may have been sources of contamination to the Removal Action Area. Existing information is generally believed to be sufficient to characterize the nature of Removal Action Area sources for the EE/CA. However, any additional or superseding information on Terminal 4 activities and contaminant sources that is developed during ongoing studies, such as those described in Sections 1, 2.2, and 3.3.1 and the Portland Harbor Superfund Site remedial investigation, will be incorporated into the EE/CA. These investigations may reveal potential contaminant sources on uplands adjacent to Terminal 4, as well as potential sources of contamination to the Willamette River, such as industrial facilities upstream and downstream from Terminal 4 and agricultural lands well upstream from Terminal 4.

## 3.1 Terminal 4 and Adjacent Property Potential Contaminant Sources

Potential sources of contamination to the Removal Action Area consist of activities and operations that have occurred or are occurring within the Removal Action Area; on Terminal 4, including Slip 1 and Slip 3 uplands; on property adjacent to Terminal 4; and on the Willamette River and property up and down river from the Removal Action Area. These activities have been described in detail in Section 2. They are summarized as potential contamination sources in Table 3-1, along with the substances potentially released by each activity. Known spills or releases associated with the activities are also included in Table 3-1, although the list is drawn only from readily available information and is not considered comprehensive. Known spills not yet associated with a particular activity are described in the text following Table 3-1.

Potential sources outside Terminal 4 include release or resuspension and transport of contaminants from upstream sediments in the river and any contaminated tributary sediments, stormwater and non-point source runoff and contributions from the urban area of Portland, runoff from other facilities along the waterfront, and point source discharges. Specific potential sources of contamination to the Willamette River currently under consideration by DEQ (Jim Anderson, personal communication, 11/5/03) include the facilities listed below. Contaminated sediments associated with these facilities could be mobilized, particularly in high flow events, and redeposited in the Removal Action Area at Terminal 4.

- Cascade General/Portland Ship Yard;
- Triangle Park – Reidel site;
- McCormick and Baxter site;
- Willamette Cove;
- Arco;
- Exxon/Mobil;
- Gasco;
- Wacker Siltronic;
- Atofina; and
- Gunderson.

DEQ has determined that the Terminal 4 auto storage area is not a source of contamination to the Willamette River. This determination is pending USEPA's concurrence.

**Table 3-1**
**Summary of Potential Contamination Sources**
**for the Terminal 4 Removal Action Area[1]**

| Potential Contaminant Source | Substances Potentially Released | Known Spills or Releases |
|---|---|---|
| Potential Contaminant Sources Located at Terminal 4 (including Slip 1 and Slip 3 Uplands) | | |
| Cargill hydraulic oil release at Conveyor Building (C-10) [2] | Hydraulic oil | • Remediation of impacted soils initiated at Building C-10 but not complete. Excavations exposed during June 2003 site walk. 11/2003 excavation left contaminated soil onsite due to inaccessibility.<br>• PAH and TPH constituents confirmed in verification samples. |
| Reported Cargill releases to Slip 1[2] | Gear grease | • In 1984, Cargill had a release of gear grease to Slip 1; cleanup was conducted by Riedel.<br>• In September 1993, approx. ½ gallon of hydraulic oil was released to Slip 1; cleanup was conducted by Riedel. |
| Cargill Fuel Storage and Handling Area near Building 152[2] | Petroleum constituents | Area groundwater discovered to contain oil in 1992. This area drains to the head of Slip 1. |
| Cargill fuel oil UST (T4-22) [1] | Fuel oil | None known. |
| Former Cargill fuel/ oil UST (T4-85) [2] | Used oil | None known. |
| Former Cargill diesel AST (T4-45) [2] | Diesel | Cat litter observed on ground near tank during October 2003 walk-through indicates past fuel spills have occurred. |
| Former Cargill diesel AST (T4-47 & 48) [2] | Diesel/used oil | Cargill discovered oil on groundwater in this area in 1992. The area drains to the head of Slip 1. |
| Cargill hydraulic pumps (west of Railcar Tipper) [2] | Hydraulic oil (staining around units observed) | None known. |
| Cargill pesticide and rodenticide applications[2] | Weed control chemicals, poisoned bait for rodent control, malathion, phostoxin, weevilcide (liquid form, including carbon tetrachloride and carbon disulfide) | Weed control chemicals applied to ground. |
| Multiple Cargill sumps[2] | Waste oil, hydraulic oil | • Sump in work pit beneath Railcar Tipper contained discolored and odorous liquid during October 2003 walk-through.<br>• In 01/1989, Spencer Environmental removed 475 gallons of waste oil pumped from the Truck Dump sump (Cargill drawing shows a hose in the Truck Dump broke).<br>• Between 1990 and 1999, Spencer pumped and disposed of approx. 2,045 gallons of oil for recycling and 32 gallon |

| Potential Contaminant Source | Substances Potentially Released | Known Spills or Releases |
|---|---|---|
| | | garbage cans of hydraulic oil-soaked wheat and absorbent pads. |
| Cargill Maintenance Shop[2] | Hydraulic oil, lube oils, lubricants, paints, thinners, solvents, antifreeze, aluminum fiberglass coating, soluble oil, industrial cleaners, epoxies, gear grease, transmission fluid, and motor oils | None known. |
| Former Cargill Transformer Building[2] | Polychlorinated biphenyls | None known. |
| Former Cargill Diesel Tanks (T4-23) [2] | Diesel | None known. |
| Waste piles[2] | Waste piles containing tires, scrap metal, railroad ties, and debris observed during the October 2003 walk-through | None known. |
| Cargill deep water well[2] | Unknown oil | • Well filled in 1992; field notes indicated 7 feet of oil on top of water between 27 and 34 feet below ground surface.<br>• Spencer Environmental removed 307 gallons of "product" from the well (PCB tests were negative). |
| Former Cargill Machinery Shop[2] | Chemical storage | None known. |
| Cargill former Blacksmith Shop[2,4] | Chemical storage | None known. |
| Cargill "Bull Pen" [2] | Trichloroethylene, primer, paint wastes | Cleanup of bull pen reportedly conducted by Van Waters and Rogers in February 1998. |
| Cargill Rail Trackage between Rail Track Shed and Berth 401[2] | Contaminants associated with locomotive maintenance operations | Stained soils observed during October 2003 walk-through and reflected in Cargill exit audit of area. Rail area drains to Slip 1. |
| Rogers AST[3] | | Soil staining was observed at the base of the AST in 1989. |
| IRM Fertilizer AST (T4-79) [3] | Liquid fertilizer | A liquid fertilizer spill from the AST located within the tank containment area occurred around 1984. In 1996, samples taken in the area of the spill revealed that nitrate levels in the soil were non-detect or below 1 mg/kg in all samples. |
| IRM Boiler Fuel UST (T4-17) [3] | Boiler Fuel | None known. |
| Former ASTs at Port Maintenance Facility (T4-81, T4-82, T4-83) [4] | Diesel, used oil | None known. |
| Former USTs at Port Maintenance Facility (T4-16, T4-26, T4-44) [4] | Diesel, gasoline | None known. |

| Potential Contaminant Source | Substances Potentially Released | Known Spills or Releases |
|---|---|---|
| KMBT UST North of Rail Dump Building (T4-43) [4] | Diesel | None known. |
| Former Tank Car Cleaning Pit at Liquid Bulk Facility[4] | Unknown | None known. |
| Ore/Concentrate Handling Areas[4] | Metals | None known. |
| Former Fumigation Plant[4] | Pesticides | None known. |
| Former USATS Disinfestation Plant[4] | Pesticides | None known. |
| Former USATS Salvage Yard[4] | Unknown | None known. |
| Former USATS gasoline fueling station along Carroll Road[4] | Petroleum constituents | None known. |
| Hazardous material storage at gearlockers and maintenance buildings[4] | Unknown | None known. |
| Hazardous material storage at former Blacksmith Shop and former Machinery Shop[4] | Unknown | None known. |
| Former below-ground gas line and fueling station at Boiler House[4] | Petroleum constituents | None known. |
| Union Pacific Pipeline[4] | Oils, fuels | • 1970 release from leaking valve seal on the Union Pacific pipeline; Standard Oil recovered about 200 gallons of diesel fuel from an overflowing manhole; four sections of piping along the northern pipeline replaced, presumably due to leaks.<br>• Five oil leaks discovered in the original Union Pacific pipeline on November 13 and December 6, 12, and 15, 1970. December 15, 1970, leak occurred during Union Pacific's pipeline repairs when oil flowed through the sand and escaped into the water.<br>• 1971 oil seep into Willamette River from southern bank of Slip 3. Union Pacific recovered some of this oil by digging a |

| Potential Contaminant Source | Substances Potentially Released | Known Spills or Releases |
|---|---|---|
| | | trench along the bank of Slip 3 at the place where the oil seepage occurred. Union Pacific also pumped oil out of the ground from several wells that it dug at Terminal 4. |
| Slip 3 slicks and seeps, possibly associated with Union Pacific pipeline[4] | Oils | • In late 1972 and early 1973, oil slicks began appearing at the head, or eastern end, of Slip 3<br>• Oil seeping from the head of Slip 3 discovered in 1991. |
| Former Pencil Pitch Handling[4] | Polycyclic aromatic hydrocarbons. | • Between 1979 and 1988, 25 illegal discharges allegedly occurred through stormwater and directly to the Willamette River when pencil pitch was unloaded by clam shell from ship holds. The Dravo clamshell's outloader protective tents were replaced in 1986. Hall-Buck modified Dravo mechanism in 1988 to better control spillage and wash water.<br>• In 1992 Jones Oregon Stevedoring Co. complained of uncontrolled pencil pitch dust generated by unloading of MV Agness on February 25; dust settled on break-bulk cargo facilities operated by Jones Oregon and interfered with ship unloading. Hall-Buck responded by improving a rear section of the loading hopper enclosure and installing a top cover.<br>• Port warned Hall-Buck in 1996 about repeated pencil pitch spills. Hall-Buck asserts existence of settling sump for capture of contaminated stormwater. |
| Oil Release at in Slip 3[5] | Oil | • According to the National Response Center, an unknown quantity of oil was released in the vicinity of Berths 410, 415, and 416 on March 18, 1985. No additional information was available. |
| Diesel Release to Willamette River[5] | Diesel | • According to the National Response Center, approximately 15 gallons of diesel was released to the Willamette River at Terminal 4 on May 2, 1985. No additional information was available. |
| Vessel Sinking at Slip 1[5] | Unknown | • According to the U.S. Coast Guard, a vessel sinking at Pier 2 on April 14, 1996 caused a sheen on the water in Slip 1. No additional information was available. |
| Vessel Astypalea, at Slip 1 | Oil | • In April 2001, approximately 50 gallons of oil were released when the Astypalea was moored at Slip 1. The U.S. Coast Guard responded and the oil was |

| Potential Contaminant Source | Substances Potentially Released | Known Spills or Releases |
|---|---|---|
| | | cleaned up using absorbent materials. The Astypalea was carrying liquid fertilizer (Port of Portland, 2001). |
| Stormwater Discharges | Unknown | • Permitted stormwater discharges from Port-owned stormwater systems at Slip 1 and Slip 3.<br>• Stormwater discharges from City of Portland-owned stormwater system at Slip 1 (outfall 52c). |
| Terminal 4 Railyard Operations | Unknown | • Not yet evaluated. |
| Potential Contaminant Sources on Upland Property Adjacent to Terminal 4 | | |
| Schnitzer Steel | Unknown | • Not yet evaluated. |
| Electrical Substation | Unknown | • Not yet evaluated. |
| Crown Cork and Seal | Unknown | • Not yet evaluated. |
| Former Union Carbide site | Unknown | • Not yet evaluated. |
| Light industrial area (Port marine facility, ChemCentral, Borden, Flint Ink) | Unknown | • Not yet evaluated. |
| Toyota facility | Unknown | • Not yet evaluated. |
| Union Pacific auto rail yard | Unknown | • Not yet evaluated. |
| Harvest Homes | Unknown | • Not yet evaluated. |
| Various wrecking yards | Unknown | • Not yet evaluated. |
| Potential Contaminant Sources on the Willamette River and Property Up and Down River from the Removal Action Area | | |
| Cascade General/ Portland Ship Yard | Unknown | • Not yet evaluated. |
| Triangle Park – Reidel site | Unknown | • Not yet evaluated. |
| McCormick and Baxter site | PAH | • Not yet evaluated. |
| Willamette Cove | Unknown | • Not yet evaluated. |
| Arco | Unknown | • Not yet evaluated. |
| Exxon/Mobil | Unknown | • Not yet evaluated. |
| Gasco | Unknown | • Not yet evaluated. |
| Wacker Siltronic | Unknown | • Not yet evaluated. |
| Atofina | DDT | • Not yet evaluated. |
| Gunderson | Unknown | • Not yet evaluated. |

**Notes:**

1 – As is true for the information discussed in Section 2.2, the information in this table is based on the best information available at the time this work plan was prepared. However, this table should be viewed as a work in progress. Additional research, such as that being conducted as part of the upland source control activities described in Sections 1, 2.2, and 3.3.1, may uncover new findings that will augment or supersede the information presented here. Such new information will be incorporated into the EE/CA.

2 – ATC Associates, Inc., 2003.

3 – Port of Portland, 2000.
4 – Slip 1 Upland Area RI Scoping Process.
5 – Lower Willamette Group, 2003.

### 3.1.1 Known In-Water Spills Not Yet Associated with a Particular Activity or Source

As described in Section 1, the Port is working with DEQ to identify contaminant sources in the Slip 1 and Slip 3 uplands and to perform appropriate source control activities. DEQ is the lead agency for such work pursuant to the Memorandum of Understanding (MOU) that the USEPA, DEQ, and other government agencies signed with regard to the Superfund Site after it was added to the NPL.

## 3.2 Completed Terminal 4 Investigative and Remedial Actions

The Port has been investigating the nature and extent of contamination at Terminal 4 since 1988. These investigations have been initiated by the Port or tenants in response to historical activities, ongoing operations, or spills of hazardous substances. A number of site investigations and remedial actions have been completed for both the upland and sediment portions of the Terminal 4 facility. Completed investigations and remedial activities for Slip 1 and Slip 3 uplands and sediments are summarized in Tables 3-2, 3-3, and 3-4. More information can be obtained about specific events from the documents referenced in the tables.

**Table 3-2**
**Chronology of Completed Slip 1 Upland and Sediment Investigations and Remedial Activities, 1998 to Present**

| Year | Event | Reference |
|---|---|---|
| 1998 | • Sediment sampling to provide preliminary dredge prism characterization to support permitting process for the dredging of the Willamette River navigational channel.<br>• Portland Harbor study included three sediment samples from Slip 1 area and one sediment sample from Berth 401. | • Volume 1: Sediment Characterization Study of Local Sponsor's Berths; Columbia and Willamette River Navigation Channel Deepening; Longview and Kalama, Washington, and Portland, Oregon (Hart Crowser, 1999)<br>• Portland Harbor Sediment Investigation Report (Roy F. Weston Inc., 1998) |
| 2000 | • Limited sediment characterization study.<br>• Preliminary assessment prepared by Port of Portland for Slip 1 uplands and submitted to DEQ.<br>• Portland Harbor Superfund Site listing for sediments. | • Terminal 4 – Slip 1 and Berth 401 Sediment Characterization Study (Hart Crowser, 2000e)<br>• Preliminary Assessment, Port of Portland, Terminal 4 – Slip 1 (Port of Portland, 2000)<br>• USEPA Administrative Order on Consent for Remedial Investigation/Feasibility Study (USEPA, 2001a) |
| 2003 | • Port entered into VCP agreement with DEQ for Slip 1 uplands (VCP investigation and remedial work is ongoing). | • Voluntary Agreement for Remedial Investigation, Source Control Measures, and Feasibility Study (Oregon DEQ, 2003a) |

| Year | Event | Reference |
|---|---|---|
| 2003 | • Cargill terminates lease of Port property. | • Environmental Site Assessment of CLD Pacific Grain/Cargill Facility (ATC Associates, Inc., 2003) |

**Table 3-3**
**Chronology of Completed Slip 3 Upland Investigations and Remedial Activities, 1991 to Present**

| Year | Event | Reference |
|---|---|---|
| 1991 | • Waste oil UST decommissioning and soil removal at gearlocker facility. | • Underground Storage Tank Decommissioning, Port of Portland Terminal 4 – OTC Gear Locker Building (Hahn and Associates, Inc., 1991) |
| 1993-1994 | • Investigation of potential oil seep sources along the former Union Pacific pipeline and Quaker State/gearlocker areas.<br>• Oil-absorbing booms placed in Slip 3 to capture seepage along the bank.<br>• Interim product recovery system installed and pumped groundwater and product from a well to an oil/water separator. Separated water was treated by carbon filtration and discharged to the Willamette River. | • Remedial Investigation Report, Terminal 4, Port of Portland (Century West Engineering Corporation, 1994) |
| 1995 | • Soil investigation at former waste oil UST location at gearlocker facility. No Further Action letter issued by DEQ. | • OTC Gear Locker Facility, Port of Portland (Century West Engineering Corporation, 1995) |
| 1996 | • Diesel and gasoline UST decommissioning and soil removal at gearlocker facility. | • Report of Underground Storage Tank Decommissioning, Terminal Four – Gear Locker Facility (GeoEngineers, Inc., 1996) |
| 1997 | • Investigations at Quaker State site and Union Pacific pipeline to assess whether former operations contributed to subsurface contamination in the vicinity of Slip 3 oil seep.<br>• Union Pacific began manually pumping product from wells and installed a 1-ft-deep interceptor trench along the eastern edge of Slip 3.<br>• Absorbent booms and pads were used to intercept seeping product. | • Former Quaker State Bottling Facility, Port of Portland – Terminal 4 (Kennedy/Jenks Consultants, Inc., 1997)<br>• Site Investigation, Port of Portland – Marine Terminal 4 (Pacific Environmental Group, 1997a)<br>• Additional Subsurface Investigation, Port of Portland – Marine Terminal 4 (Pacific Environmental Group, 1997b)<br>• Status of Interim Activities and Remedial Schedule, Port of Portland - Marine Terminal 4 (Pacific Environmental Group, 1997c) |
| 1998 | • DEQ prepared Preliminary Assessment Equivalent/Strategy Recommendation for Slip 3. The facility is given a high priority for further action.<br>• Sections of Union Pacific pipeline were drained and removed. Soil sampling was conducted. Additional soil and groundwater investigations conducted. | • Preliminary Assessment Equivalent/Strategy Recommendation, Port of Portland Terminal 4 (Oregon DEQ, 1998, DEQ Site Assessment Program)<br>• Remedial Investigation/Feasibility Study Work Plan, Terminal 4 Slip 3, Upland (Hart Crowser, 1998) |

| Year | Event | Reference |
|---|---|---|
| 1999 | • Startup of Interim Action to limit migration of petroleum hydrocarbons with groundwater to the slip. The interim action consists of pumping soil vapor, free-phase liquid petroleum hydrocarbons, and groundwater containing dissolved-phase petroleum hydrocarbons.<br>• Activities of RI work plan, initiated in 1998, concluded. | |
| 2000 | • RI report finalized and human health risk assessment and Level 1 scoping ecological risk assessment completed. | • Remedial Investigation Report Terminal 4, Slip 3 Upland (Hart Crowser, 2000c)<br>• Human Health and Ecological Baseline Risk Assessment, Terminal 4, Slip 3 Upland (Hart Crowser, 2000d) |
| 2002 | • Port entered into VCP agreement for Slip 3 uplands (VCP work is ongoing). | • Voluntary Agreement for Feasibility Study (Oregon DEQ, 2002) |
| 2002 | • Feasibility study report completed. | • Feasibility Study Report, Terminal 4, Slip 3 Upland (Hart Crowser, 2002) |
| 2003 | • DEQ issued Record of Decision for Slip 3 upland. The remedy includes:<br>o Removal and offsite disposal of shallow soil in the former Quaker State tank farm area.<br>o Groundwater pumping to remove LNAPL associated with the diesel fuel pipeline release, evaluation of dual-phase (vacuum-enhanced) LNAPL extraction, removal and offsite disposal of contaminated soil at the Slip 3 riverbank, and groundwater monitoring.<br>o An institutional control that identifies residual petroleum hydrocarbon-contaminated areas in the Slip 3 uplands and the need for appropriate contaminated soil or groundwater management. | • Record of Decision, Port of Portland, Terminal 4 Slip 3 Upland, 2003 (Oregon DEQ, 2003b) |
| 2003 | • Port entered into VCP Agreement for Slip 1 uplands. | • Voluntary Agreement for Remedial Investigation, Source Control, and Feasibility Study (Oregon DEQ, 2003a). |

**Table 3-4**
**Chronology of Completed Slip 3 Sediment Investigations and Remedial Activities, 1988 to Present**

| Year | Event | Reference |
|---|---|---|
| 1986 | • Vacuum sweeper used to clean up 75%, or about 6-8 cubic yards, of spilled pencil pitch. | |
| 1988 | • Sediment investigation included surface grabs and subsurface cores. Sediment was analyzed for pencil | • Sediment Quality Report, Sediment Test Results from Terminal 4 Slip 3, Berths 410, 411, and 412 (Port of Portland, 1994) |

| Year | Event | Reference |
|---|---|---|
| | pitch, polycyclic aromatic hydrocarbons (PAHs), metals, pesticides, oil and grease, grain size, and polychlorinated biphenyls (PCBs). | |
| 1993 – 1994 | • USEPA and State of Oregon issue Consent Decree under the Clean Water Act and state law that requires cessation of non-permitted discharges of pencil pitch and remediation of sediment above 0.5% dry weight of pencil pitch.<br>• Additional sampling conducted to delineate the depth distribution of contaminants. | • Federal Consent Decree, Case Number CV 930267 RE (USEPA, 1993a) |
| 1994 - 1995 | • Port dredges and disposes of approximately 35,000 cubic yards of sediments containing greater than 0.5% pencil pitch from Slip 3 pursuant to the 1993 consent decree between Port, USEPA and Oregon. In 1995, USEPA determines Port has met its obligations under the consent decree. | • Water Quality Monitoring During Dredging and Disposal of Sediments from Terminal 4 Slip 3 in Portland Harbor – Final Report (Hartman Associates, Inc., 1995) |
| 1997-1998 | • Sediment characterization study conducted as part of maintenance dredging requirements for Berth 410.<br>• A clamshell bucketful of pencil pitch containing an estimated 50 to 1,000 pounds of pencil pitch was spilled in the vicinity of Berth 411. Two rounds of dredging, at least one by Hall-Buck, were conducted to remove pencil pitch-contaminated sediments. DEQ provided oversight of the second round of dredging; pencil pitch handling at Terminal 4 ends with the decommissioning of the Dravo equipment.<br>• As part of the Portland Harbor study, DEQ and USEPA conducted a harbor-wide sediment characterization study that included Terminal 4.<br>• DEQ prepares Preliminary Assessment Equivalent/Strategy Recommendation for Slip 3. The facility is given a high priority for further action.<br>• Sediment sampling conducted at Slip 3 as part of a remedial investigation conducted by the Port with oversight from DEQ under the VCP. | • Sediment Characterization Study, River Terminal 4, Slip 3 (Hart Crowser, 1997a)<br>• Pencil Pitch Removal Oversight and Sediment Characterization Report, Terminal 4 Slip 3, Berth 411 (Hart Crowser, 1997b)<br>• Portland Harbor Sediment Investigation Report (Roy F. Weston Inc., 1998)<br>• Preliminary Assessment Equivalent/Strategy Recommendation, Port of Portland Terminal 4 (Oregon DEQ, 1998, DEQ Site Assessment Program)<br>• Remedial Investigation Report, Terminal 4, Slip 3 Sediments (Hart Crowser, 2000a) |
| 2000 | • Portland Harbor Superfund Site listing. | • USEPA Administrative Order on Consent for Remedial Investigation/ Feasibility Study (USEPA, 2001a) |

## 3.3 Ongoing Terminal 4 Investigative and Remedial Actions

### 3.3.1 Upland Source Control Work

An MOU regarding the Portland Harbor Superfund Site was signed by USEPA, DEQ, and other government agencies after the Site was added to the NPL. The MOU designates DEQ as the lead agency for upland source identification and control. The Port is working with DEQ to identify sources in the Slip 1 and Slip 3 uplands and, where appropriate, to perform necessary source control activities.

#### 3.3.1.1 Slip 1

In 2003, the Port and DEQ entered into a Voluntary Agreement for Remedial Investigation, Source Control Measures, and Feasibility Study (Oregon DEQ, 2003a) regarding the Terminal 4 Slip 1 uplands (see Figure 2-1 for upland area boundaries). This agreement requires the Port to investigate the property, conduct a risk assessment and a feasibility study, and identify and evaluate source control measures. Work under this agreement began in late 2003 and will be ongoing during the work specified in this work plan. The Port has arranged for close coordination between the project teams so that new information from either effort will be conveyed to the other in a timely manner.

#### 3.3.1.2 Slip 3

In June 2002, the Port and DEQ entered into a Voluntary Agreement to perform a feasibility study (Oregon DEQ, 2002) at the Slip 3 Upland Area (Figure 2-1). This agreement required the Port to conduct a feasibility study of the Slip 3 Upland Area portion of Terminal 4 to address petroleum contamination in subsurface soil and groundwater. In April 2003, DEQ issued a Record of Decision (Oregon DEQ, 2003b) requiring various cleanup actions to be performed on the Slip 3 uplands to address historical petroleum spills. These actions were to include:

- Quaker State Tank Farm excavation;
- pumping of LNAPL;
- dual-phase extraction;
- riverbank excavation and backfill;
- groundwater monitoring and compliance evaluation; and
- institutional control.

Investigation performed since the Record of Decision was issued indicates that local soil and groundwater conditions, as well as the extent of LNAPL contamination, may be different than previously assumed. Additional investigation is ongoing to assess these conditions and suggests that the volume of LNAPL may be smaller than originally reported. This new information will be incorporated into the design of the remediation system. Work under this agreement began in late 2003 and will be ongoing during the work specified in this work plan. The Port has arranged for close coordination between the project teams so that new information from either effort will be conveyed to the other in a timely manner.

### 3.3.2 Port of Portland Stormwater Management Program

The Port owns and operates its own storm sewer system at Terminal 4. This system discharges into Slip 1, Slip 3, and the Willamette River either directly or through the City of Portland's storm sewer system. Drainage areas at Terminal 4 are shown on Figure 2-22. The current configuration of the stormwater system at Terminal 4 is shown on Figure 2-23.

Marine terminal stormwater is managed through a variety of regulatory mechanisms, policies and best management practices. National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Discharge Permit No. 101314 (Municipal Permit), on which the Port and the City of Portland are co-permittees, is the foundation permit for stormwater management. The MS4 covers discharges of stormwater from the MS4 within the City of Portland Urban Service Boundary. The DEQ regulates stormwater runoff from Port properties through this permit. As co-permittees, the Port and the City of Portland are authorized to discharge stormwater to public waters while implementing a stormwater management program (SWMP) to reduce the contribution of pollutants in stormwater to the maximum extent practicable. The SWMP consists of a variety of best management practices (BMPs), such as Employee Education, Spill Prevention and Response Planning, Control of Illicit Discharges, Erosion and Sediment Control, and Landscape Maintenance Practices.

The Port's dry season monitoring effort is part of the Illicit Discharge Detection and Removal Program and is designed to detect non-stormwater discharges from Port outfalls. Dry season monitoring of Port-owned outfalls occurs on a 5-year rotation with certain priority outfalls being monitored annually. If a discharge is observed from an outfall, a sample is collected and sent to an independent laboratory for analysis. The Port uses the results of the analysis, combined with observed field conditions, to identify the discharge source and to assess associated risks.

In addition, the Port manages stormwater through Ordinance 361 Storm Water Regulation; through various environmental policies such as Commission Policy No. 6.1.11 Environmental Policy and Environmental Water Resource Policy No. 7.4.16; and through Marine Tenant Program BMPs. Marine terminal tenants are required to comply with the Port's Municipal Permit if they discharge into the system. Sources that discharge waste water to surface water, typically conveyed through the storm sewer system, must obtain an NPDES industrial wastewater permit. Sources not eligible for a general permit must apply for an individual permit. Most marine terminal tenants hold additional industrial permits. Table 3-5 lists the Terminal 4 tenants and their water quality permits.

**Table 3-5**
**Terminal 4 Tenants – Water Quality Permits**

| Tenant Name | Permit Type |
|---|---|
| Kinder Morgan Bulk Terminals | NPDES-IND (App No. 988139, File No. 100025)<br>NPDES-IW-O (Permit No. 102446) |
| International Raw Materials | 1200-Z (Permit No. 16055, File No. 110170) |
| Cargill | MS4 Permit No. 101314 |
| Cereal Food Processors | MS4 Permit No. 101314 |
| Foss Maritime | MS4 Permit No. 101314 |
| Rogers Stevedoring | MS4 Permit No. 101314 |
| Toyota Logistics Services, Inc. | 1200-Z (Permit No. 11208, File No. 100726) |
| Port of Portland | 1500-A |

The 1200-Z permits are required for point source discharges and are based on a facility's SIC code. These permits are managed through preparation and implementation of a stormwater pollution control plan (SWPCP).

The SWPCP contains a site description and site controls such as BMPs, spill prevention and response procedures, preventive maintenance procedures, and employee education requirements. The 1200-Z permits contain benchmark guideline concentrations. Sampling is required twice a year and visual monitoring is required monthly. An exceedance of benchmarks triggers a requirement to check the SWPCP and implement additional BMPs, as necessary. Table 3-6 describes the benchmarks for the required sampling parameters for the 1200-Z general industrial permits.

**Table 3-6**
**1200-Z Benchmarks**

| Parameters | Benchmark |
|---|---|
| TSS | 130 mg/L |
| pH | 5.5 - 9 S.U. |
| Oil and Grease | 10 mg/L |
| Total Copper | 0.1 mg/L |
| Total Lead | 0.4 mg/L |
| Total Zinc | 0.6 mg/L |
| Floating Solids | No Visible |
| Oil/Grease Sheen | No Visible |

Evaluation of stormwater at Terminal 4 is included in the Voluntary Agreement for the Terminal 4 Slip 1 Upland Facility and is being addressed as part of the remedial investigation. The approach to stormwater evaluation will be included in the remedial investigation work plan, which is anticipated for submittal to DEQ in May 2004.

### 3.3.3 City Stormwater Investigation

In early 2000, the City of Portland and DEQ entered into a Voluntary Cleanup Letter Agreement to address stormwater outfalls owned and operated by the City. This agreement (Oregon DEQ, 2000) requires the City to complete a preliminary assessment of certain outfalls, including Outfall 52C, which drains into Slip 1. The preliminary assessment includes the following:

- a summary of readily available current or historical information on the outfall;
- the results of database searches for facilities within the catchment area of the outfall;
- screening of existing sediment quality results in proximity to the outfall; and
- other steps to evaluate discharges from the outfall and develop priorities and recommendations for future study.

The results of this preliminary assessment were presented in July 2000 (City of Portland, 2000). Metals including cadmium, lead, and zinc as well as PAHs were detected in sediment samples immediately adjacent to outfall 52c.

The City and DEQ also entered into an Intergovernmental Agreement for Remedial Investigation and Source Control (Oregon DEQ, 2003c). This agreement requires the City to evaluate the potential for sediment contamination to result from City-owned outfalls. Work under this agreement is ongoing.

## 3.4 Summary of Potential Sources of Contamination

Sources of sediment contamination at Terminal 4 are generally understood and include various aspects of past in-river and Terminal 4 operations, including the handling of ore, ore concentrate, pencil pitch, petroleum products, and other cargo. Sediment contamination sources also include activities on the Terminal 4 and adjacent uplands which likely contributed to sediment contamination through spills, stormwater runoff, or groundwater contamination. In many cases, activities that likely contributed to sediment contamination have been discontinued. Potential ongoing sources — from ongoing operations at Terminal 4 or adjacent properties, from residual surface or subsurface contamination at Terminal 4 or adjacent properties, or from sources of contamination in the Willamette River — are currently under investigation. These sources and potential sources are considered in light of existing sediment quality data presented in Section 4 and further discussed in the preliminary conceptual model for the Removal Action Area in Section 5.

Section 4

# 4. Summary of Existing Data on Sediment Quality and Toxicity

The Port has been investigating the nature and extent of sediment contamination at Terminal 4 since 1988. Other organizations, including the U.S. Army Corps of Engineers (USACE), the USEPA, and DEQ, have investigated the nature and extent of sediment contamination in the Willamette River and have collected sediment samples from Terminal 4 as part of their investigations. The purpose of this section is to describe the existing body of sediment quality data collected at Terminal 4 through these various projects and to provide context regarding the spatial area likely to require remediation. Table 4-1 summarizes the sediment investigations that have produced data relevant to Terminal 4 sediments. Figures provided by NOAA depict surface and subsurface sediment quality exceedances for copper, lead, zinc, total polycyclic aromatic hydrocarbons (PAHs), DDT, and polychlorinated biphenyls (PCBs) (Appendix D). Because maintenance dredging has occurred periodically in Slip 1 and Slip 3 to maintain operational draft depths at the berths, data from the dredge prisms (i.e., sediment that was dredged and is no longer present at Terminal 4) are not included in Table 4-1 and are not discussed in this work plan.

Sediment chemistry data from the investigations summarized in Table 4-1 were obtained from the NOAA Query Manager 2.51 database for Terminal 4 of the Willamette River. They represent published sediment data collected in the Terminal 4 area for a variety of purposes and include different analytical detection limits and analyte lists. Different classes of constituents were analyzed in each investigation. These differences, however, are generally minor and do not limit the data set for the purposes intended here. Sufficient data exist in each analyte class and for each important constituent to evaluate fundamental statistics such as detection frequency, maximum detected concentration, and minimum detected concentration.

The Port did not compare the data in the database with data in the original reports to assess possible data entry errors. The data in the database are assumed to be entered correctly. Available sediment chemistry data consist only of bulk sediment analytical results. No analytical results are available for sediment leachates or elutriates. On the basis of a database search performed by Striplin Environmental Associates (Berger, 2003), seven subsurface sediment samples were removed from the Terminal 4 sediment database because their locations have been dredged and the data are therefore not representative of existing sediment conditions. The data removed from the Terminal 4 database are:

- For Slip 1, data associated with locations WLCT4L93T408-1T40801, WLCT4L93T408-2T40802, and WLCT4L93T408-3T40803; and

- For Slip 3, data associated with locations WR-WS198SD0290, WR-WS198SD0320, WLCDRE87.5S410.5S410, and WLCDRE87.5S412.5S412.

The remaining surface and subsurface sediment samples in the database are believed to represent sediment that has not been dredged.

This discussion of existing sediment data is categorized by surface and subsurface sediment. Under-pier sediment represents a separate category for discussion; however, no existing sediment quality data were located for under-pier samples. "Surface sediment" refers to sediment samples collected from 0 to 1 ft below mudline. The majority of surface sediment samples from the NOAA database were collected from 0 to 0.33 ft below mudline, although some were collected from 0 to 0.5 ft below mudline. "Subsurface sediment" refers to sediment samples collected below 1 ft below the mudline. The discussion of existing sediment data is further

categorized by Slip 1 and Slip 3. For the purposes of this discussion, "Slip 1" includes Slip 1 and Berth 401, and "Slip 3" includes Slip 3, Wheeler Bay, and Pier 5.

Existing sediment chemistry data, along with sediment chemistry data to be collected for the EE/CA (as discussed in Section 7.7), will be used to delineate the horizontal and vertical extent of contaminated sediment that will require removal. The SOW requires that existing sediment chemistry data be compared to the following existing sediment quality guidelines (SQGs) representing a range of levels, including low or no effects, which are:

- Threshold Effects Concentration (TEC) (MacDonald et al., 2000);
- Threshold Effects Level (TEL) (Smith et al., 1996); and
- Effects Range Low (ERL) (Long and Morgan, 1990).

In addition, the existing sediment chemistry data are to be compared to SQGs representing levels at which probable effects are expected:

- Probable Effects Concentration (PEC) (MacDonald et al., 2000);
- Probable Effects Level (PEL) (Smith et al., 1996); and
- Effects Range Medium (ERM) (Long and Morgan, 1990).

Although not required by the SOW, the existing sediment chemistry data were compared to the PELs to make the overall comparison of existing data to SQGs consistent. For example, PECs are the probable effects counterpart to the low effects TECs, and ERMs are the probable effects counterpart to the low effects ERL. The PELs were therefore included because they are the probable effects counterpart to the low effects TEL.

These SQGs are all toxicity-based SQGs. Bioacumulation-based SQGs are not widely available. The specific nature of the bioaccumulation evaluation will be identified after the removal alternatives have been through the conceptual design phase.

Existing sediment chemistry data were compared to these SQGs to evaluate the horizontal and vertical extent of contaminated sediment that requires removal. This comparison was made to fulfill requirements of the SOW and is not intended to imply that the SQGs should be used as cleanup levels for the Removal Action Area. The outcome of the comparison of existing sediment chemistry data to SQGs is discussed in Section 4.4.

## 4.1 Sediment Quality

In accordance with the SOW, existing sediment chemistry data were also reviewed to establish whether the data fall into the Category 1 or Category 2 data categories used in the Portland Harbor RI/FS Revised Draft Final Programmatic Work Plan protocols (Lower Willamette Group, 2003). Note that this document is being revised based on USEPA comments. The categories are defined as:

- Category 1 data are of known quality and are considered to be acceptable for use in decision making for the RI/FS. There is sufficient information on these data sets to confidently verify that the data, along with associated data qualifiers, accurately represent chemical concentrations present at the time of sampling.

- Category 2 data are of generally unknown or suspect quality. The quality assurance/quality control information shows that data quality is poor or suspect or that essential quality assurance/quality control

data (e.g., surrogate recoveries, matrix spike/matrix spike duplicates recoveries) are either incomplete or lacking.

The classification of data into Category 1 and Category 2 is a data quality metric used to evaluate data quality and the appropriateness of using data for decision-making. Data collected as part of the EE/CA work plan will undergo data validation, making it Category 1 data. Ten to twenty percent of the data collected as part of the EE/CA work plan will undergo Level IV data validation, and the remainder will undergo Level III data validation, in accordance with the USEPA's Functional Guidelines (USEPA, 1999, 2002). The data validation classifications of Level III and Level IV are derived from the USEPA contract laboratory program (CLP) (USEPA, 1987). Level III data validation consists of reviewing chains of custody; holding times; field, trip, and method blanks; surrogate, matrix spike/matrix spike duplicate, and laboratory control sample/laboratory control sample duplicate recoveries; field duplicate, laboratory duplicate, matrix spike/matrix spike duplicate, and laboratory control sample/laboratory control sample duplicate relative percent differences; and reporting limits. Level IV data validation consists of a full data validation, including a review of raw data.

Level III data validation is comparable to the Puget Sound Dredge Disposal Analysis quality assurance 1 (QA1) data review, and Level IV data validation is comparable to the Puget Sound Dredge Disposal Analysis quality assurance 2 (QA2) data review (Washington State Department of Ecology, 1989). For consistency with the chemistry analytical work that will be performed in accordance with CLP protocols, data collected as part of the EE/CA work plan will also be validated in accordance with CLP, i.e., Level III and Level IV data validation will be performed.

Table 4-1 identifies the data categories determined for existing sediment quality data.

The Portland Harbor RI/FS Revised Draft Final Programmatic Work Plan states that:

> *Analyses upon which project decisions will be based will utilize Category 1 data. As examples, the ecological and human health risk assessments will use Category 1 data in the risk calculations, and the definition of sediment management areas will rely on Category 1 sediment data. Category 2 data will be used during project scoping. For example, Category 2 tissue data were used to help identify chemicals of interest, and Category 2 sediment data were used in the initial assessment of trends in chemical concentrations, which was useful for defining the site characterization sampling program.*

Category 1 and Category 2 data will be used similarly for the EE/CA. Category 1 and Category 2 data are used in this section to evaluate existing sediment quality. However, additional sediment chemistry data will be collected for the EE/CA, and primarily Category 1 data will be used to delineate the horizontal and vertical extent of contaminated sediment. If existing data will be used in the Removal Action alternatives analysis, the Port will evaluate whether the existing data validation is sufficient or additional data validation is warranted.

Detection limits for the existing sediment data were evaluated, and the results of that evaluation are incorporated into the discussions that follow for each analyte group. Detection limits were evaluated for their appropriateness for the EE/CA (i.e., for delineating the horizontal and vertical extent of contaminated sediment that will require removal). Elevated detection limits could cause data to be unusable for the EE/CA. For example, if an analyte is reported as "not detected" at an elevated detection limit, there may be doubt over whether that analyte was present or not. The reported detection limits for the existing data were considered acceptable for the purposes of the EE/CA; however, as explained below, the EE/CA work plan proposes additional sediment collection to further evaluate the surface and subsurface sediment conditions in the Removal Action Area.

## 4.2 Surface Sediment

General observations of the existing surface sediment data, based on frequency of detections, range of detected concentrations, and spatial trends in concentrations, are as follows:

- Concentrations of metals, PAHs, and bis(2-ethylhexyl)phthalate (BEP) generally decreased from the head of the slip to the mouth in Slips 1 and 3.

- Concentrations of total PCBs tended to decrease from the head to the mouth of Slip 1.

The existing surface sediment data for Slips 1 and 3 are discussed in greater detail below. The data are presented by constituent class (i.e., metals, PAHs, semivolatile organic compounds, pesticides and PCBs, miscellaneous organics, volatile organic compounds, butyltins, and conventionals), as taken from the NOAA Query Manager 2.51 database. No changes were made to NOAA's categorization of particular compounds into particular constituent classes. The term "miscellaneous organics" is not meant to diminish the potential importance of compounds in that class; it simply means that those compounds were not included in other constituent class categories.

### 4.2.1 Slip 1 Surface Sediment

Twenty-six surface sediment samples were collected from throughout Slip 1, with three samples located in the vicinity of Berth 401. Figure 4-1 shows Slip 1 surface sediment sample locations. Slip 1 surface sediment sample dates and depths are presented in Table 4-2. These samples were analyzed for at least some of the following constituents: metals, PAHs, semivolatile organic compounds (SVOCs), pesticides, PCBs, miscellaneous organics, volatile organic compounds (VOCs), butyltins including tributyltin (TBT), and conventionals, including total solids, total organic carbon (TOC), and grain size. Different classes of constituents were analyzed in each investigation for Slip 1 surface sediment. Table 4-3 presents the list of constituents for which Slip 1 surface sediment samples were analyzed and summarizes Slip 1 surface sediment chemistry data, including number of samples, number of detections, minimum and maximum detected concentrations, average detected concentration, and minimum and maximum detection limit for each compound analyzed.

#### 4.2.1.1 Metals Results

Slip 1 surface sediment samples were analyzed for aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, titanium, vanadium, and zinc. However, not all Slip 1 surface sediment samples were analyzed for this full list of metals. Some Slip 1 surface sediment samples were analyzed for a subset of the full list. Table 4-3 presents the frequency of analysis for each metal. All of the metals for which the Slip 1 surface sediment samples were analyzed were detected at least once except selenium, which was not detected in any of the 15 surface sediment samples analyzed. Cadmium, chromium, copper, lead, and zinc concentrations displayed spatial trends in Slip 1 surface sediment. The maximum concentrations of cadmium, chromium, copper, and zinc occurred in the surface sediment samples collected near the head of Slip 1. The maximum concentration of lead occurred in the surface sediment sample collected near Berth 408. Surface sediment concentrations of cadmium, chromium, copper, lead, and zinc decreased from the head to the mouth of Slip 1. For the remaining metals, no spatial trend was apparent in surface sediment concentrations at Slip 1.

Metals detection limits in Slip 1 surface sediment samples are acceptable for the purposes of the EE/CA. Additional Slip 1 surface sediment samples will be collected and analyzed for a select list of metals to further delineate the horizontal extent of contaminated sediment, as discussed in Section 7.7.

#### 4.2.1.2 PAH Results

Table 4-3 summarizes the individual PAH compounds analyzed in Slip 1 surface sediment samples and their frequency of analysis. All of the PAH compounds for which Slip 1 surface sediment samples were analyzed were detected at least once except 2-nitroaniline, 3,3-dichlorobenzidine, 3-nitroaniline, 4-nitroaniline, and nitrobenzene, which were not detected. Maximum total PAH concentrations were generally observed in surface sediment samples collected at the head of Slip 1. Total PAH surface sediment concentrations tended to decrease from the head to the mouth of Slip 1.

Some detection limits for Slip 1 surface sediment results were elevated, with detection limits ranging from 10 to 35,000 µg/kg for all PAHs. The elevated detection limits for PAHs resulted from sample dilution to obtain concentrations for certain PAHs within the calibration range. Because the elevated detection limits resulted from sample dilution, PAH detection limits for Slip 1 surface sediment samples are acceptable for the purposes of the EE/CA. Additional Slip 1 surface sediment samples will be collected and analyzed for a select list of PAHs to further delineate the horizontal extent of contaminated sediment, as discussed in Section 7.7.

#### 4.2.1.3 SVOC Results

Table 4-3 summarizes the individual SVOCs analyzed in Slip 1 surface sediment samples and their frequency of analysis. Six SVOCs (4-methylphenol, benzoic acid, BEP, butylbenzyl phthalate, di-n-octyl phthalate, and di-n-butyl phthalate) were detected in Slip 1 surface sediment samples. The remaining SVOCs for which the samples were analyzed were not detected. Benzoic acid and 4-methylphenol were detected in one of 13 samples and two of 13 samples, respectively, at concentrations slightly above the detection limits. Phthalates, particularly BEP, were more frequently detected. The maximum BEP and butylbenzyl phthalate concentrations were observed in surface sediment samples from the head of Slip 1. Surface sediment concentrations of BEP decreased from the head to the mouth of Slip 1. BEP is a commonly occurring laboratory contaminant related to the use of plastics and may not represent environmental contamination.

The SVOC detection limits for some Slip 1 surface sediment results were elevated, with detection limits ranging from 0.24 to 35,000 µg/kg for all SVOCs. The elevated detection limits for SVOCs resulted from sample dilution to obtain concentrations for PAHs within the calibration range. Because the elevated detection limits resulted from sample dilution, SVOC detection limits for surface sediment samples from Slip 1 are acceptable for the purposes of the EE/CA. Additional Slip 1 surface sediment samples will be collected and analyzed for a select list of SVOCs to further delineate the horizontal extent of contaminated sediment, as discussed in Section 7.7.

#### 4.2.1.4 Pesticide and PCB Results

Table 4-3 summarizes the individual pesticides and PCBs analyzed in Slip 1 surface sediment samples and their frequency of analysis. The pesticide total DDT (tDDT, which includes 2,4'-DDD, 2,4'-DDE, 2,4'-DDT, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT) was detected in 16 of 23 samples in Slip 1 surface sediment samples. The maximum tDDT concentrations occurred in surface sediment samples from Berth 401. There was no apparent

spatial trend in tDDT concentrations in Slip 1 surface sediment samples. The pesticides aldrin, alpha-chlordane, gamma-chlordane, endosulfan sulfate, and beta-hexachlorocyclohexane were detected infrequently at concentrations slightly above the detection limit. The remaining pesticides for which the samples were analyzed were not detected.

The PCB compounds Aroclors 1242, 1254, and 1260 were detected in nine, five, and 12 samples, respectively, in Slip 1 surface sediment. Aroclor 1248 was detected in one sample. Maximum concentrations of Aroclors 1242 and 1254 were observed in a surface sediment sample collected from Berth 401. The maximum concentration of Aroclor 1260 was observed near Berth 408. Surface sediment concentrations of total PCB (tPCB, which is the sum of all available PCB data) generally decreased from the head to the mouth of Slip 1.

The pesticide detection limits for Slip 1 surface sediment samples are acceptable for the purposes of the EE/CA. PCB detection limits were elevated for five surface sediment samples collected at the head of Slip 1, with detection limits ranging from 100 to 500 µg/kg for all the Aroclors. Because these elevated detection limits resulted from sample dilution and other important constituents, such as PAHs and metals are detected, they are acceptable for purposes of the EE/CA. Additional Slip 1 surface sediment samples will be collected and analyzed for a select list of pesticides and PCBs to further delineate the horizontal extent of contaminated sediment, as discussed in Section 7.7.

#### 4.2.1.5 Miscellaneous Organic and Butyltin Results

Table 4-3 summarizes the individual miscellaneous organic and butyltin compounds analyzed in Slip 1 surface sediment samples and their frequency of analysis. Dibutyltin dichloride, which was detected in all four of the samples analyzed, was the only miscellaneous organic compound detected in Slip 1 surface sediment samples. In addition, the butyltin compounds monobutyltin chloride and TBT were detected in Slip 1 surface sediment samples. The remaining butyltins were not detected in Slip 1 surface sediment samples. There was no apparent spatial pattern in butyltin surface sediment concentrations in Slip 1.

Some miscellaneous organic detection limits for Slip 1 surface sediments were elevated, with detection limits ranging from 5 to 5,000 µg/kg. In all cases, the elevated detection limits for miscellaneous organics resulted from sample dilution to obtain concentrations for PAHs within the calibration range. Because the elevated detection limits resulted from sample dilution, miscellaneous organic detection limits for surface sediment samples from Slip 1 are acceptable for the purposes of the EE/CA. Butyltin detection limits in Slip 1 surface sediment samples are acceptable for the purposes of the EE/CA. Additional Slip 1 surface sediment samples will be collected and analyzed for petroleum hydrocarbons to further delineate the horizontal extent of contaminated sediment, as discussed in Section 7.7.

#### 4.2.1.6 VOC Results

Table 4-3 summarizes the individual VOCs analyzed in Slip 1 surface sediment samples and their frequency of analysis. The VOCs methylene chloride, toluene, and m,p-xylene were each detected once in Slip 1 surface sediment samples. The methylene chloride detection may be an artifact of laboratory method blank contamination, based on the data qualifier. Toluene and m,p-xylene were detected in a surface sediment sample collected at the head of Slip 1. The remaining VOCs for which the samples were analyzed were not detected in Slip 1 surface sediment samples.

One Slip 1 surface sediment sample had elevated detection limits for VOCs ranging from 100 to 2,000 µg/kg as a result of sample dilution to obtain concentrations for toluene and m,p-xylene within the calibration range. Because the elevated detection limits resulted from sample dilution, VOC detection limits for Slip 1 surface sediment samples are acceptable for the purposes of the EE/CA.

### 4.2.2 Slip 3 Surface Sediment

Fifty-four surface sediment samples were collected throughout Slip 3, with six surface sediment samples collected in Wheeler Bay and four collected near Berth 414. Figure 4-1 shows Slip 3 surface sediment sample locations. Slip 3 surface sediment sample dates and depths are presented in Table 4-2. These samples were analyzed for at least some of the following constituents: metals, PAHs, SVOCs, pesticides, PCBs, miscellaneous organics, VOCs, and conventionals (e.g., ammonia, total solids, total sulfide, total volatile solids, TOC, and grain size). Different classes of constituents were analyzed in each investigation for Slip 3 surface sediment. Table 4-4 presents the list of constituents for which Slip 3 surface sediment samples were analyzed and summarizes Slip 3 surface sediment chemistry data.

Because of sediment resuspension and redistribution resulting from propeller scour and other wave actions, existing surface sediment data for Slip 3 may not represent current sediment quality in the specific location where a given sample was collected. However, the data are likely representative of general surface sediment conditions in Slip 3.

#### 4.2.2.1 Metals Results

Slip 3 surface sediment samples were analyzed for aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, titanium, vanadium, and zinc. However, not all Slip 3 surface sediment samples were analyzed for this full list of metals. Some Slip 3 surface sediment samples were analyzed for a subset of the full list. Table 4-4 presents the frequency of analysis for each metal. All of the metals for which the Slip 3 surface sediment samples were analyzed were detected at least once except selenium, which was not detected in the eight samples analyzed. Cadmium, copper, lead, and zinc surface sediment concentrations displayed spatial trends, generally decreasing from the head to the mouth of Slip 3. Copper, lead, and zinc surface sediment concentrations also tended to decrease from north to south in Slip 3.

The detection limits for metals analyzed in Slip 3 surface sediment samples are acceptable for the purposes of the EE/CA. Additional Slip 3 surface sediment samples will be collected and analyzed for a select list of metals to confirm existing surface sediment quality, as discussed in Section 7.7.

#### 4.2.2.2 PAH Results

Table 4-4 summarizes the individual PAHs analyzed in Slip 3 surface sediment samples and their frequency of analysis. The only PAHs not detected in Slip 3 surface sediment samples were 2-nitroaniline, 3,3-dichlorobenzidine, 3-nitroaniline, 4-nitroaniline, and nitrobenzene. Total PAH surface sediment concentrations generally decreased from the head to the mouth of Slip 3. In Wheeler Bay, PAH concentrations tended to be highest in the southeast corner of the bay. There also appears to be a total PAH maximum adjacent to Pier 5.

Some PAH detection limits for Slip 3 surface sediment samples were elevated, with detection limits ranging from 19 to 20,000 µg/kg for all PAHs. The elevated detection limits resulted from sample dilution to obtain concentrations for certain PAHs within the calibration range. Because the elevated detection limits resulted from sample dilution, PAH detection limits for surface sediment samples from Slip 3 are acceptable for the purposes of the EE/CA. Additional Slip 3 surface sediment samples will be collected and analyzed for a select list of PAHs to confirm existing surface sediment quality, as discussed in Section 7.7.

#### 4.2.2.3 SVOC Results

Table 4-4 summarizes the individual SVOCs analyzed in Slip 3 surface sediment samples and their frequency of analysis. Of the SVOCs for which the samples were analyzed, only phenols, benzoic acid, and phthalates were detected in Slip 3 surface sediment samples. Surface sediment concentrations of BEP generally decreased from the head to the mouth of Slip 3. The remaining detected SVOCs were not detected with enough frequency to evaluate spatial trends.

Some SVOC detection limits for Slip 3 surface sediment results were elevated, with detection limits ranging from 2 to 100,000 µg/kg for all SVOCs. The elevated detection limits for SVOCs resulted from sample dilution to obtain concentrations for PAHs within the calibration range. Because the elevated detection limits resulted from sample dilution, SVOC detection limits for surface sediment samples from Slip 3 are acceptable for the purposes of the EE/CA. Additional Slip 3 surface sediment samples will be collected and analyzed for a select list of SVOCs to confirm existing surface sediment quality, as discussed in Section 7.7.

#### 4.2.2.4 Pesticide and PCB Results

Table 4-4 summarizes the individual pesticides and PCBs analyzed in Slip 3 surface sediment samples and their frequency of analysis. The only pesticides detected in Slip 3 surface sediment samples were DDD, DDE, and DDT. However, the data density for DDD, DDE, and DDT in Slip 3 surface sediment samples is not adequate for an evaluation of spatial trends.

Aroclor 1260, the only Aroclor detected in Slip 3 surface sediment samples, was detected in one sample. Data density is insufficient to evaluate spatial trends.

Some pesticide detection limits for surface sediment samples from Slip 3 were elevated, with detection limits ranging from 0.97 to 20,000 µg/kg for all pesticides. Some of the elevated detection limits (e.g., hexachlorobenzene with a maximum detection limit of 20,000 µg/kg) resulted from sample dilution to obtain concentrations for PAHs within the calibration range. One Slip 3 surface sediment sample from the northeast portion of Slip 3 had elevated detection limits for MCPA (2-methyl-4-chlorophenoxyacetic acid) of 3,300 µg/kg and for MCPP (2-[2-methyl-4-chlorophenoxy] propionic acid) of 4,600 µg/kg. Because these elevated detection limits resulted from sample dilution and other important constituents, such as PAHs and metals are detected, they are acceptable for purposes of the EE/CA. PCB detection limits in Slip 3 surface sediment samples are acceptable for the purposes of the EE/CA. Additional Slip 3 surface sediment samples will be collected and analyzed for a select list of pesticides and PCBs to confirm existing surface sediment quality, as discussed in Section 7.7.

#### 4.2.2.5 Miscellaneous Organic Results

Table 4-4 summarizes the individual miscellaneous organics analyzed in Slip 3 surface sediment samples and their frequency of analysis. Miscellaneous organic compounds and mixtures, including diesel, lube oil, pencil pitch, phytane, and pristane, were analyzed and detected in Slip 3 surface sediment samples.

Diesel detection limits for Slip 3 surface sediment samples were elevated, ranging from 25,000 to 250,000 µg/kg. The elevated detection limits for diesel resulted from sample dilution to obtain concentrations for pencil pitch within the calibration range. Because the elevated detection limits resulted from sample dilution, miscellaneous organic detection limits for Slip 3 surface sediment samples are acceptable for the purposes of the EE/CA. Additional Slip 3 surface sediment samples will be collected and analyzed for petroleum hydrocarbons to confirm existing surface sediment quality, as discussed in Section 7.7.

#### 4.2.2.6 VOC Results

Table 4-4 summarizes the individual VOCs analyzed in Slip 3 surface sediment samples and their frequency of analysis. No VOCs were detected in Slip 3 surface sediment samples. Detection limits for VOCs in Slip 3 surface sediment samples are acceptable for the purposes of the EE/CA.

## 4.3 Under-Pier Sediment

No existing data were located for under-pier sediment.

## 4.4 Subsurface Sediment

General observations of the existing subsurface sediment data, based on frequency of detections, range of detected concentrations, and vertical trends in concentrations, are as follows:

- Concentrations of lead and zinc generally increased from surface to subsurface.
- Concentrations of total PAHs tended to be greater in the surface than in the subsurface.

The existing subsurface sediment data for Slips 1 and 3 are discussed in greater detail below.

### 4.4.1 Slip 1 Subsurface Sediment

Five subsurface sediment cores were collected in and near Slip 1: one core in the southeast end of Slip 1, two cores outside the Removal Action Area in the vicinity of Berth 401, and two cores outside the Removal Action Area at the southwest end of the slip. Six subsurface sediment samples were collected from the five cores; the subsurface samples generally extended to between 2 and 6 ft below mudline and represented whole core composites. Three of the six samples included surface sediment (i.e., the top of the sample was at 0 ft below the mudline). Those three samples were neither distinctly surface nor distinctly subsurface sediment, but rather a combination of both. For the purposes of this work plan, the samples are treated as subsurface sediment

samples. Figure 4-2 shows Slip 1 subsurface sediment sample locations. Slip 1 subsurface sediment sample dates and depths are presented in Table 4-2. These samples were analyzed for metals, PAHs, SVOCs, pesticides, PCBs, miscellaneous organics, and conventionals (e.g., ammonia, total solids, total sulfide, total volatile solids, TOC, acid volatile sulfides, and grain size). Different classes of constituents were analyzed in each investigation for Slip 1 subsurface sediment. Table 4-5 summarizes Slip 1 subsurface sediment chemistry data and presents the list of constituents for which Slip 1 subsurface sediment samples were analyzed.

#### 4.4.1.1 Metals Results

Slip 1 subsurface sediment samples were analyzed for aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc. However, not all Slip 1 subsurface sediment samples were analyzed for this full list of metals. Some Slip 1 subsurface sediment samples were analyzed for a subset of the full list. Table 4-5 presents the frequency of analysis for each metal. All of the metals for which Slip 1 subsurface sediment samples were analyzed were detected at least once except thallium, which was not detected in the one sample analyzed. A sediment core collected in the vicinity of Berth 408 contained the maximum subsurface concentrations of cadmium, chromium, copper, lead, and zinc. Subsurface concentrations of lead tended to be greater than in surface sediment samples from Slip 1.

The metals detection limits in Slip 1 subsurface sediment samples are acceptable for the purposes of the EE/CA. Additional Slip 1 subsurface sediment samples will be collected and analyzed for a select list of metals to delineate the horizontal and vertical extent of contaminated sediment, as discussed in Section 7.7.

#### 4.4.1.2 PAH Results

Table 4-5 summarizes the individual PAHs analyzed in Slip 1 subsurface sediment samples and their frequency of analysis. All of the PAHs for which Slip 1 subsurface sediment samples were analyzed were detected at least once except 2-nitroaniline, 3,3-dichlorobenzidine, 3-nitroaniline, 4-nitroaniline, and nitrobenzene, which were not detected. Generally, total PAH concentrations in Slip 1 subsurface sediment samples tended to be less than in surface sediment samples.

Some PAH detection limits for Slip 1 subsurface sediment samples were elevated, with detection limits ranging from 19 to 200 µg/kg for all PAHs. The elevated detection limits resulted from sample dilution to obtain concentrations for certain PAHs within the calibration range. Because the elevated detection limits resulted from sample dilution, PAH detection limits for subsurface sediment samples from Slip 1 are acceptable for the purposes of the EE/CA. Additional Slip 1 subsurface sediment samples will be collected and analyzed for a select list of PAHs to delineate the horizontal and vertical extent of contaminated sediment, as discussed in Section 7.7.

#### 4.4.1.3 SVOC Results

Table 4-5 summarizes the individual SVOCs analyzed in Slip 1 subsurface sediment samples and their frequency of analysis. The SVOCs 4-methylphenol, BEP, and butylbenzyl phthalate were the only SVOCs detected in Slip 1 subsurface sediment samples. Butylbenzyl phthalate and 4-methylphenol were detected in one and two samples, respectively, at concentrations slightly above the detection limits. BEP was detected in one of three samples; the sample was collected near Berth 408.

Some SVOC detection limits for Slip 1 subsurface sediment samples were elevated, with detection limits ranging from 1 to 1,000 µg/kg for all SVOCs. The elevated detection limits resulted from sample dilution to obtain concentrations for PAHs within the calibration range. Because the elevated detection limits resulted from sample dilution, SVOC detection limits for Slip 1 subsurface sediment samples are acceptable for the purposes of the EE/CA. Additional Slip 1 subsurface sediment samples will be collected and analyzed for a select list of SVOCs to delineate the horizontal and vertical extent of contaminated sediment, as discussed in Section 7.7.

#### 4.4.1.4 Pesticide and PCB Results

Table 4-5 summarizes the individual pesticides and PCBs analyzed in Slip 1 subsurface sediment samples and their frequency of analysis. The pesticides methoxychlor and tDDT were detected in Slip 1 subsurface sediment samples. Methoxychlor was detected in one sample at an estimated concentration below the detection limit. Total DDT was detected in all three subsurface samples analyzed. The maximum concentration of tDDT was detected in the vicinity of Berth 401. Pesticide detection limits in Slip 1 subsurface sediment samples are acceptable for the purposes of the EE/CA.

Aroclor 1260 was detected in subsurface sediment samples collected near Berth 401 and at the southwest end of Slip 1. The remaining Aroclors were not detected in Slip 1 subsurface sediment samples. PCB detection limits for Slip 1 subsurface sediment samples are acceptable for the purposes of the EE/CA. Additional Slip 1 subsurface sediment samples will be collected and analyzed for a select list of pesticides and PCBs to delineate the horizontal and vertical extent of contaminated sediment, as discussed in Section 7.7.

#### 4.4.1.5 Miscellaneous Organic Results

Table 4-5 summarizes the individual miscellaneous organics analyzed in Slip 1 subsurface sediment samples and their frequency of analysis. Miscellaneous organics were not detected in Slip 1 subsurface sediment samples. Miscellaneous organic detection limits for Slip 1 subsurface sediment samples are acceptable for the purposes of the EE/CA. Additional Slip 1 subsurface sediment samples will be collected and analyzed for petroleum hydrocarbons to delineate the horizontal and vertical extent of contaminated sediment, as discussed in Section 7.7.

### 4.4.2 Slip 3 Subsurface Sediment

Ten subsurface sediment cores were collected throughout the Slip 3 area, with one core located in Wheeler Bay and one core located north of Berth 414. Nineteen subsurface sediment samples were collected from the 10 cores; the subsurface sediment samples generally extended to between 2 and 4 ft below the mudline and were generally sampled in 2-ft intervals (e.g., surface to 2 ft and 2 to 4 ft below mudline). Nine of the 10 cores were collected in 1998 (Hart Crowser, 2000a). The core barrels were 14 ft long. The cores generally contained good (i.e., greater than 10 ft) recovery. However, although long cores were collected, only two samples from each core representing the top 4 ft were analyzed for chemistry. Figure 4-2 shows Slip 3 subsurface sediment sample locations. Slip 3 subsurface sediment sample dates and depths are presented in Table 4-2. These samples were analyzed for metals, PAHs, SVOCs, pesticides, miscellaneous organics, VOCs, and conventionals (e.g., ammonia, total solids, total sulfide, total volatile solids, TOC, and grain size). Different classes of constituents were analyzed in each investigation for Slip 3 subsurface sediment. Table 4-6 summarizes Slip 3 subsurface

sediment chemistry data and presents the list of constituents for which Slip 3 subsurface sediment samples were analyzed.

#### 4.4.2.1 Metals Results

Slip 3 subsurface sediment samples were analyzed for aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc. However, not all Slip 3 subsurface sediment samples were analyzed for this full list metals. Some Slip 3 subsurface sediment samples were analyzed for a subset of the full list. Table 4-6 presents the frequency of analysis for each metal. All of the metals for which Slip 3 subsurface sediment samples were analyzed were detected at least once except thallium, which was not detected in the one sample analyzed. Lead and zinc concentrations tended to be greater in the Slip 3 subsurface sediment samples than in Slip 3 surface sediment.

The metals detection limits in Slip 3 subsurface sediment samples are acceptable for the purposes of the EE/CA. Additional Slip 3 subsurface sediment samples will be collected and analyzed for a select list of metals to delineate the horizontal and vertical extent of contaminated sediment, as discussed in Section 7.7.

#### 4.4.2.2 PAH Results

Table 4-6 summarizes the individual PAHs analyzed in Slip 3 subsurface sediment samples and their frequency of analysis. All of the PAHs for which Slip 3 subsurface sediment samples were analyzed were detected at least once except 2-nitroaniline, 3,3-dichlorobenzidine, 3-nitroaniline, 4-nitroaniline, acenaphthylene, and nitrobenzene, which were not detected. Generally, subsurface concentrations of total PAHs tended to be less than in surface sediment. No consistent trend was observed in total PAH subsurface sediment concentrations in the cores. The highest total PAH concentration occurred sometimes in the 0- to 2-ft interval and sometimes in the 2- to 4-ft interval. The cores containing the highest total PAH concentrations in the 2- to 4-ft interval were collected throughout Slip 3 (i.e., not located within a distinct area).

Some PAH detection limits for Slip 3 subsurface sediment samples were elevated, with detection limits ranging from 20 to 4,000 µg/kg for all PAHs. The elevated detection limits resulted from sample dilution to obtain concentrations for certain PAHs within the calibration range. Because the elevated detection limits resulted from sample dilution, PAH detection limits for Slip 3 subsurface sediment samples are acceptable for the purposes of the EE/CA. Additional Slip 3 subsurface sediment samples will be collected and analyzed for a select list of PAHs to delineate the horizontal and vertical extent of contaminated sediment, as discussed in Section 7.7.

#### 4.4.2.3 SVOC Results

Table 4-6 summarizes the individual SVOCs analyzed in Slip 3 subsurface sediment samples and their frequency of analysis. The only SVOC detected in Slip 3 subsurface sediment samples was BEP, which was detected in three of the 19 samples analyzed. Two of the three detections of BEP were at concentrations slightly above the detection limit. Because BEP is a common laboratory contaminant, it is possible that the low concentrations of BEP resulted from laboratory contamination of the samples with plasticware, such as gloves or bags.

Some SVOC detection limits for Slip 3 subsurface sediment samples were elevated, with detection limits ranging from 5 to 20,000 µg/kg for all SVOCs. The elevated detection limits resulted from sample dilution to obtain concentrations for PAHs within the calibration range. Because the elevated detection limits resulted from sample dilution, SVOC detection limits for Slip 3 subsurface sediment samples are acceptable for the purposes of the EE/CA. Additional Slip 3 subsurface sediment samples will be collected and analyzed for a select list of SVOCs to delineate the horizontal and vertical extent of contaminated sediment, as discussed in Section 7.7.

#### 4.4.2.4 Pesticide Results

Table 4-6 summarizes the individual pesticides analyzed in Slip 3 subsurface sediment samples and their frequency of analysis. Hexachlorobenzene, hexachlorocyclopentadiene, and isophorone are the only pesticides for which Slip 3 subsurface sediment samples were analyzed. These three compounds were not detected.

Some pesticide detection limits for Slip 3 subsurface sediment samples were elevated, with detection limits ranging from 20 to 4,000 µg/kg for all pesticides. The elevated detection limits resulted from sample dilution to obtain concentrations for PAHs within the calibration range. Because the elevated detection limits resulted from sample dilution, pesticide detection limits for Slip 3 subsurface sediment samples are acceptable for the purposes of the EE/CA. Additional Slip 3 subsurface sediment samples will be collected and analyzed for a select list of pesticides to delineate the horizontal and vertical extent of contaminated sediment, as discussed in Section 7.7.

#### 4.4.2.5 Miscellaneous Organic Results

Table 4-6 summarizes the individual miscellaneous organics analyzed in Slip 3 subsurface sediment samples and their frequency of analysis. Pencil pitch was the only miscellaneous organic analyte detected in Slip 3 subsurface sediment samples. The highest concentrations of pencil pitch were observed in cores from the head of Slip 3 and from the southeastern portion of Wheeler Bay.

Diesel detection limits for Slip 3 subsurface sediment samples were elevated, ranging from 25,000 to 100,000 µg/kg. The elevated detection limits resulted from sample dilution to obtain concentrations for pencil pitch within the calibration range. Because the elevated detection limits resulted from sample dilution, miscellaneous organic detection limits for subsurface sediment samples from Slip 3 are acceptable for the purposes of the EE/CA. Additional Slip 3 subsurface sediment samples will be collected and analyzed for petroleum hydrocarbons to delineate the horizontal and vertical extent of contaminated sediment, as discussed in Section 7.7.

#### 4.4.2.6 VOC Results

Table 4-6 summarizes the individual VOCs analyzed in Slip 3 subsurface sediment samples and their frequency of analysis. The only VOC detected in Slip 3 subsurface sediment samples was m,p-xylene, which was detected at the detection limit in one sample from the southeast end of Wheeler Bay. Detection limits for VOCs in Slip 3 subsurface sediment samples are acceptable for the purposes of the EE/CA.

## 4.5 Constituents of Potential Concern

Existing sediment chemistry data, along with sediment chemistry data collected for the EE/CA (as discussed in Section 7.7), will be used to delineate the horizontal and vertical extent of contaminated sediment that requires removal. To evaluate the extent of sediment that requires removal, existing sediment chemistry data were compared to the SQGs stated in the SOW (i.e., TEC, TEL, ERL, PEC, PEL, and ERM). Use of these SQGs does not imply that the SQGs should be used as cleanup levels for the Removal Action Area.

The SQGs fall into two categories: low (i.e., threshold) effects guidelines (TEC, TEL, and ERL) and probable effects guidelines (PEC, PEL, and ERM). The TEC, TEL, and ERL represent concentrations below which toxicity effects are unlikely to be observed. The PEC, PEL, and ERM represent concentrations above which toxicity effects are likely to be observed. However, these generic SQGs were developed over a variety of conditions and using mixtures of contaminants. Removal Action Area-specific conditions will determine the actual effects likely to occur. Removal Action Area sediments exhibiting concentrations below the low effects SQGs are unlikely to cause toxicity and should not require removal. Sediment chemistry concentrations that fall between the low effects and probable effects SQGs represent a gray area in which toxicity effects may occur; therefore, sediments containing chemistry concentrations above the low effects and below the probable effects SQGs may cause toxicity and may need removal. Sediments containing chemistry concentrations above the probable effects SQGs require further delineation and investigation to determine whether they are likely to cause toxicity and likely require removal. Further delineation will include a cost analysis to compare the cost of possibly dredging the sediment that contains chemistry concentrations in the "gray area" versus the cost of capping these sediments.

These SQGs are all toxicity-based. Bioaccumulation-based SQGs are not widely available. The specific nature of the bioaccumulation evaluation will be identified after the removal alternatives have been through the conceptual design phase. The maximum, minimum, and average concentrations of existing Slip 1 surface sediment, Slip 3 surface sediment, Slip 1 subsurface sediment, and Slip 3 subsurface sediment data were compared to the TEC, TEL, ERL, PEC, PEL, and ERM SQGs. This comparison is illustrated on Figures 4-3 and 4-4 for surface and subsurface chemistry, respectively. Figures 4-3 and 4-4 present the SQG comparison for a select list of constituents that, based on site history and sediment chemistry, are likely constituents of potential concern (COPCs) for the site. On the figures, the SQGs are represented by the lowest sediment quality guideline (i.e., the lowest low effects SQG) and the highest sediment quality guideline (i.e., the highest probable effects SQG).

Figure 4-3 shows that the maximum concentrations of metals and PAHs in Slip 1 surface sediment samples exceed the probable effects SQGs and that Slip 3 surface sediment samples contain average and maximum metals and PAH concentrations above the probable effects SQGs. Total DDT and tPCB results fall between the low and probable effects SQGs for Slip 1 and Slip 3 surface sediment samples.

Figure 4-4 shows that the maximum metals concentration in Slip 1 subsurface sediment samples exceeds the probable effects SQGs. PAHs, tDDT, and tPCB concentrations fall between the low effects and probable effects SQGs for Slip 1 subsurface sediment samples. However, the number of Slip 1 subsurface sediment samples analyzed for these compounds is limited. For Slip 3 subsurface sediment samples, the maximum and average metals and PAH concentrations are above the probable effects SQGs. Slip 3 subsurface sediment samples were not analyzed for tDDT and tPCB.

Compounds that were not detected or were detected only infrequently at concentrations slightly above the detection limits—e.g., pesticides except for tDDT, SVOCs except for phthalates, and miscellaneous organics

except for pencil pitch—were not carried forward as COPCs. Compounds that were occasionally detected, such as VOCs and TBT, were also not carried forward as COPCs because of the low probability that these constituents are present in sediment at concentrations of concern. The VOCs were infrequently detected; petroleum products known to have been handled at Terminal 4, such as diesel fuel, lube oil, and Bunker C fuel, generally do not contain the range of petroleum hydrocarbons that includes the VOCs. Similarly, butyltin compounds (e.g., TBT) are not expected to be common contaminants in the Removal Action Area sediments given the site history. Because TBT is an antifouling agent used in marine ship-hull paint, it is often detected in shipyard sediments impacted by paint chips from shipbuilding and ship repair. The available history indicates that shipyard activities have not occurred at Terminal 4. Although TBT may leach from ship-hull paint and become entrained in the sediment column, such an effect is not considered a likely ongoing source of contamination to sediment in the Removal Action Area because the International Maritime Organization has banned TBT antifoulants in marine paint; the ban will take effect in 2008 (http://www.imo.org/home.asp). The low frequency of detection and the low detected concentrations of pesticides (except tDDT), SVOCs (except phthalates), miscellaneous organics (except pencil pitch), VOCs, and butyltins indicate they are unlikely contaminants in the Removal Action Area and they will not drive cleanup.

Based on the existing data, metals, PAHs, phthalates, tDDT, tPCB, and petroleum hydrocarbons are the COPCs for sediment in the Removal Action Area. These COPCs were determined on the basis of frequency of detection, range of detected concentrations, lateral and vertical trends in concentrations, comparison to sediment quality guidelines, site uses, and sources. The list of COPCs may be revised when additional data proposed for collection in this work plan have been reviewed.

## 4.6 Summary of Sediment Toxicity Testing Data

Sediment toxicity testing data are available for the Removal Action Area from the Slip 3 Remedial Investigation Report (Hart Crowser, 2000a). Sixteen sediment samples from Slip 3 and the immediate vicinity were tested: 14 from Slip 3, one from Wheeler Bay, and one from the Pier 5 area just upstream of the Slip 3 mouth (Figure 4-5). In addition, two reference area samples were collected from the Columbia River downstream of the Willamette River confluence. Two reference samples were needed to account for the range in grain size of the Slip 3 sediment samples. Test sediments with less than 59.5% fines were compared to reference sample Ref-C; those with greater than 59.5% fines were compared to reference sample Ref-B. The study area and reference sampling locations were approved by DEQ.

The toxicity tests were conducted according to standard test protocols (USEPA, 1994b; ASTM, 1995). The tests employed were:

- acute 10-day amphipod survival test (*Hyallela azteca*);
- acute 10-day midge survival test (*Chironomus tentans*); and
- chronic 10-day midge growth test (*Chironomus tentans*).

Results of the tests are shown in Tables 4-7, 4-8, and 4-9 as they appeared in Hart Crowser (2000a). Decision criteria were based on the Dredge Management Evaluation Framework for the Lower Columbia River Management Area (USACE et al., 1998). For amphipod survival, tests were considered to fail if the mortality in the test samples exceeded that of reference samples by more than 15% and results in test samples were statistically different from reference (alpha $\leq$ 0.05). Similarly, midge survivorship bioassays failed if mortality in test samples exceeded reference samples by more than 20% and test sample results were statistically different from reference (alpha $\leq$ 0.05). The midge growth test failed if test sample biomass was less than 60% of reference and test sample results were statistically different from reference (alpha $\leq$ 0.05).

Tests were conducted in two phases. Phase I used samples from areas of low to moderate contamination. Phase II was conducted with samples from more contaminated areas. In general, samples from the outer (i.e., riverward) half of Slip 3 did not fail any toxicity tests (samples HCS26, HCS28, HCS30, HCS35, HCS36, HCS39, and HCS42). Six of nine (HCS01, HCS04, HCS05, HCS07, HCS16, and HCS22) samples tested from the inland half of Slip 3 failed at least one of the toxicity tests. Although correlation with contaminant concentrations were difficult to discern, test failures were more frequent in the more contaminated areas of Slip 3.

**Table 4-1**
**Summary of Existing Sediment Investigation Reports for Terminal 4**

| Date | Reference | Activity | Number of Surface Sediment Samples | | Number of Subsurface Sediment Samples | | Data Category (a) |
|---|---|---|---|---|---|---|---|
| | | | Slip 1 | Slip 3 | Slip 1 | Slip 3 | |
| 1987 | USACE, 1987b. Proposal for PCB/metal tests in Columbia/Willamette sediments. | Surface sediment samples collected in the Willamette River. | 1 | 2 | 0 | 0 | 2 |
| 1988 | USACE, 1988. Willamette River Raw Data1986-1988. | Subsurface sediment samples. | 0 | 0 | 2 | 0 | 2 |
| 1995 | Hartman Associates / Fishman Environmental Services, 1995. Chemical Characterization of Sediments Adjacent to Storm Water Discharges in the Willamette River Near Portland. | Surface sediment samples collected in the Willamette River to characterize the impact of stormwater discharge to surface sediment quality. | 5 | 0 | 0 | 0 | 1 |
| 1997 | Roy F. Weston, Inc., 1998. Portland Harbor Sediment Investigation Report, Multnomah County, Oregon. | As part of the Portland Harbor Study, USEPA and DEQ conducted a harbor-wide sediment characterization study that included Terminal 4. | 5 | 7 | 1 | 1 | 1,2 (b) |
| 1998 | Hart Crowser, 1999. Volume 1: Sediment Characterization Study of Local Sponsor's Berths; Columbia and Willamette River Navigation Channel Deepening; Longview and Kalama, Washington, and Portland, Oregon. | Sediment sampling event to provide preliminary dredge prism characterization to support permitting process for the dredging of the Willamette River Navigational Channel. | 0 | 0 | 2 | 0 | 1 |
| 1998 | Hart Crowser, 2000a. Remedial Investigation Report, Terminal 4, Slip 3 Sediments, Portland, Oregon, April 18, 2000. | Sediment sampling conducted at Terminal 4, Slip 3 as part of a remedial investigation conducted by the Port with oversight from DEQ under the Voluntary Cleanup Program. | 0 | 44 | 0 | 9 | 1 |
| 1999 | USACE, 1999. Willametter River Sediment Data - 1997 CRCD Project. | Subsurface sediment samples. | 0 | 0 | 1 | 0 | 1,2 (c) |
| 2000 | Hart Crowser, 2000e. Terminal 4 –Slip 1 and Berth 401 Sediment Characterization Study, May 31, 2000. | Limited sediment characterization study. | 10 | 0 | 0 | 0 | 2 |
| 2002 | Unknown | Round 1 sediment sampling of Portland Harbor. | 5 | 1 | 0 | 0 | 1 (d) |

a. Data categories from the Portland Harbor RI/FS Work Plan. See Section 4 for a discussion of data categories.
b. Chlorinated phenoxy herbicides were classified as Category 2. The remaining data are Category 1.
c. Grain size and total volatile solids were classified as Category 2. The remaining data are Category 1.
d. These data were not classified in the Portland Harbor RI/FS Work Plan. However, since this work was done for the Portland Harbor RI/FS, it was assumed the data are Category 1.

**Table 4-2**
**Existing Sediment Sample Depths**

| Database Station ID (a) | Database Sample ID (a) | Sample Date | Upper Sample Depth (ft) | Lower Sample Depth (ft) | Sample ID from Original Report | Source of Data (a) |
|---|---|---|---|---|---|---|
| **Slip 1 Surface Samples** | | | | | | |
| 28001 | 2801 | 12/1/1982 | 0.00 | 0.50 | 87.2/5.2.2/5.2 | USACE, 1987b |
| 51001 | 5101 | 11/19/1999 | 0.00 | 0.33 | 99lip101lip101 | Hart Crowser, 2000e |
| 51003 | 5101 | 11/19/1999 | 0.00 | 0.33 | 99lip103lip103 | Hart Crowser, 2000e |
| 51005 | 5101 | 11/19/1999 | 0.00 | 0.33 | 99lip105lip105 | Hart Crowser, 2000e |
| 51006 | 5101 | 11/19/1999 | 0.00 | 0.33 | 99lip106lip106 | Hart Crowser, 2000e |
| 51007 | 5101 | 11/19/1999 | 0.00 | 0.33 | 99lip107lip107 | Hart Crowser, 2000e |
| 51011 | 5101 | 11/19/1999 | 0.00 | 0.33 | 99lip111lip111 | Hart Crowser, 2000e |
| 51012 | 5101 | 11/19/1999 | 0.00 | 0.33 | 99lip112lip112 | Hart Crowser, 2000e |
| 51014 | 5101 | 11/19/1999 | 0.00 | 0.33 | 99lip114lip114 | Hart Crowser, 2000e |
| 51016 | 5101 | 11/19/1999 | 0.00 | 0.33 | 99lip116lip116 | Hart Crowser, 2000e |
| 51018 | 5101 | 11/19/1999 | 0.00 | 0.33 | 99lip118lip118 | Hart Crowser, 2000e |
| 75011 | 7501 | 7/18/1994 | 0.00 | 0.33 | 94J16PPA438221 | Hartman Associates / Fishman Environmental Services, 1995 |
| 75012 | 7501 | 7/18/1994 | 0.00 | 0.33 | 94J16PPB438222 | Hartman Associates / Fishman Environmental Services, 1995 |
| 75013 | 7501 | 7/18/1994 | 0.00 | 0.33 | 94J16PPC438223 | Hartman Associates / Fishman Environmental Services, 1995 |
| 75014 | 7501 | 7/18/1994 | 0.00 | 0.33 | 94J16PPD438224 | Hartman Associates / Fishman Environmental Services, 1995 |
| 75015 | 7501 | 7/18/1994 | 0.00 | 0.33 | 94J16PPE438225 | Hartman Associates / Fishman Environmental Services, 1995 |
| 76016 | 7601 | 9/18/1997 | 0.00 | 0.33 | WR-WSI98SD0160 | Roy F. Weston, Inc., 1998 |
| 76021 | 7601 | 9/18/1997 | 0.00 | 0.33 | I98SD0210000CC | Roy F. Weston, Inc., 1998 |
| 76021 | 7602 | 9/18/1997 | 0.00 | 0.33 | I98SD021000CCD | Roy F. Weston, Inc., 1998 |
| 76022 | 7601 | 9/18/1997 | 0.00 | 0.33 | WR-WSI98SD0220 | Roy F. Weston, Inc., 1998 |
| 76023 | 7601 | 9/18/1997 | 0.00 | 0.33 | WR-WSI98SD0230 | Roy F. Weston, Inc., 1998 |
| 03R004SD | C11 | 10/18/2002 | 0.00 | 0.50 | 3R004SDS015C11 | Round 1 Sediment Sampling 2002 of Portland Harbor |
| 03R004SD | C12 | 10/18/2002 | 0.00 | 0.50 | 3R004SDS015C12 | Round 1 Sediment Sampling 2002 of Portland Harbor |

**Table 4-2**
**Existing Sediment Sample Depths**

| Database Station ID (a) | Database Sample ID (a) | Sample Date | Upper Sample Depth (ft) | Lower Sample Depth (ft) | Sample ID from Original Report | Source of Data (a) |
|---|---|---|---|---|---|---|
| 03R004SD | C20 | 10/18/2002 | 0.00 | 0.50 | 3R004SDS015C20 | Round 1 Sediment Sampling 2002 of Portland Harbor |
| 03R004SD | C30 | 10/18/2002 | 0.00 | 0.50 | 3R004SDS015C30 | Round 1 Sediment Sampling 2002 of Portland Harbor |
| 04R003SD | C00 | 10/24/2002 | 0.00 | 0.50 | 4R003SDS015C00 | Round 1 Sediment Sampling 2002 of Portland Harbor |
| **Slip 3 Surface Samples** | | | | | | |
| 28002 | 2801 | 12/1/1982 | 0.00 | 0.50 | 87.5S410.5S410 | USACE, 1987b |
| 28003 | 2801 | 7/1/1983 | 0.00 | 0.50 | 87.5S412.5S412 | USACE, 1987b |
| 50001 | 5001 | 10/13/1998 | 0.00 | 0.33 | 4J98HCS01HCS01 | Hart Crowser, 2000 |
| 50002 | 5001 | 10/13/1998 | 0.00 | 0.33 | 4J98HCS02HCS02 | Hart Crowser, 2000 |
| 50003 | 5001 | 10/13/1998 | 0.00 | 0.33 | 4J98HCS03HCS03 | Hart Crowser, 2000 |
| 50004 | 5001 | 10/13/1998 | 0.00 | 0.33 | 4J98HCS04HCS04 | Hart Crowser, 2000 |
| 50005 | 5001 | 10/13/1998 | 0.00 | 0.33 | 4J98HCS05HCS05 | Hart Crowser, 2000 |
| 50006 | 5001 | 10/13/1998 | 0.00 | 0.33 | 4J98HCS06HCS06 | Hart Crowser, 2000 |
| 50007 | 5002 | 10/13/1998 | 0.00 | 0.33 | 4J98HCS07HCS07 | Hart Crowser, 2000 |
| 50008 | 5001 | 10/13/1998 | 0.00 | 0.33 | 4J98HCS08HCS08 | Hart Crowser, 2000 |
| 50009 | 5001 | 10/13/1998 | 0.00 | 0.33 | 4J98HCS09HCS09 | Hart Crowser, 2000 |
| 50010 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS10HCS10 | Hart Crowser, 2000 |
| 50011 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS11HCS11 | Hart Crowser, 2000 |
| 50012 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS12HCS12 | Hart Crowser, 2000 |
| 50013 | 5003 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS13HCS13 | Hart Crowser, 2000 |
| 50014 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS14HCS14 | Hart Crowser, 2000 |
| 50015 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS15HCS15 | Hart Crowser, 2000 |
| 50016 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS16HCS16 | Hart Crowser, 2000 |
| 50017 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS17HCS17 | Hart Crowser, 2000 |
| 50018 | 5001 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS18HCS18 | Hart Crowser, 2000 |
| 50019 | 5001 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS19HCS19 | Hart Crowser, 2000 |
| 50020 | 5001 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS20HCS20 | Hart Crowser, 2000 |
| 50021 | 5001 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS21HCS21 | Hart Crowser, 2000 |
| 50022 | 5002 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS22HCS22 | Hart Crowser, 2000 |
| 50023 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS23HCS23 | Hart Crowser, 2000 |

**Table 4-2**
**Existing Sediment Sample Depths**

| Database Station ID (a) | Database Sample ID (a) | Sample Date | Upper Sample Depth (ft) | Lower Sample Depth (ft) | Sample ID from Original Report | Source of Data (a) |
|---|---|---|---|---|---|---|
| 50024 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS24HCS24 | Hart Crowser, 2000 |
| 50025 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS25HCS25 | Hart Crowser, 2000 |
| 50026 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS26HCS26 | Hart Crowser, 2000 |
| 50027 | 5003 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS27HCS27 | Hart Crowser, 2000 |
| 50028 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS28HCS28 | Hart Crowser, 2000 |
| 50029 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS29HCS29 | Hart Crowser, 2000 |
| 50030 | 5001 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS30HCS30 | Hart Crowser, 2000 |
| 50031 | 5001 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS31HCS31 | Hart Crowser, 2000 |
| 50032 | 5002 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS32HCS32 | Hart Crowser, 2000 |
| 50033 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS33HCS33 | Hart Crowser, 2000 |
| 50034 | 5001 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS34HCS34 | Hart Crowser, 2000 |
| 50035 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS35HCS35 | Hart Crowser, 2000 |
| 50036 | 5001 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS36HCS36 | Hart Crowser, 2000 |
| 50037 | 5001 | 10/14/1998 | 0.00 | 0.33 | 4J98HCS37HCS37 | Hart Crowser, 2000 |
| 50038 | 5001 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS38HCS38 | Hart Crowser, 2000 |
| 50039 | 5002 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS39HCS39 | Hart Crowser, 2000 |
| 50040 | 5001 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS40HCS40 | Hart Crowser, 2000 |
| 50041 | 5001 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS41HCS41 | Hart Crowser, 2000 |
| 50042 | 5001 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS42HCS42 | Hart Crowser, 2000 |
| 50043 | 5001 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS43HCS43 | Hart Crowser, 2000 |
| 50044 | 5001 | 10/15/1998 | 0.00 | 0.33 | 4J98HCS44HCS44 | Hart Crowser, 2000 |
| 76025 | 7601 | 9/18/1997 | 0.00 | 0.33 | WR-WSI98SD0250 | Roy F. Weston, Inc., 1998 |
| 76027 | 7601 | 9/18/1997 | 0.00 | 0.33 | WR-WSI98SD0270 | Roy F. Weston, Inc., 1998 |
| 76029 | 7601 | 9/18/1997 | 0.00 | 0.33 | WR-WSI98SD0290 | Roy F. Weston, Inc., 1998 |
| 76031 | 7601 | 9/18/1997 | 0.00 | 0.33 | WR-WSI98SD0310 | Roy F. Weston, Inc., 1998 |
| 76032 | 7601 | 9/18/1997 | 0.00 | 0.33 | WR-WSI98SD0320 | Roy F. Weston, Inc., 1998 |
| 76033 | 7601 | 9/18/1997 | 0.00 | 0.33 | WR-WSI98SD0330 | Roy F. Weston, Inc., 1998 |
| 76034 | 7601 | 9/18/1997 | 0.00 | 0.33 | WR-WSI98SD0340 | Roy F. Weston, Inc., 1998 |
| 04R002SD | C00 | 10/16/2002 | 0.00 | 0.50 | 4R002SDS015C00 | Round 1 Sediment Sampling 2002 of Portland Harbor |

**Table 4-2**
**Existing Sediment Sample Depths**

| Database Station ID (a) | Database Sample ID (a) | Sample Date | Upper Sample Depth (ft) | Lower Sample Depth (ft) | Sample ID from Original Report | Source of Data (a) |
|---|---|---|---|---|---|---|
| **Slip 1 Subsurface Samples** | | | | | | |
| 45003 | 4501 | 9/14/1998 | 0.00 | 3.00 | 98B401C1B401C1 | Hart Crowser, 1999 |
| 45004 | 4501 | 9/14/1998 | 3.00 | 5.02 | 98B401C2B401C2 | Hart Crowser, 1999 |
| 60005 | 6001 | 3/23/1988 | 2.01 | 3.02 | R04884.3R4.3RB | USACE, 1988 |
| 60005 | 6002 | 3/23/1988 | 0.99 | 2.01 | R04884.3R4.3RM | USACE, 1988 |
| 65034 | 6501 | 7/22/1997 | 0.00 | 6.01 | 97WRGC18RGC18A | USACE, 1999 |
| 76023 | 7602 | 10/17/1997 | 0.00 | 2.97 | SI98SD0230000A | Roy F. Weston, Inc., 1998 |
| **Slip 3 Subsurface Samples** | | | | | | |
| 50007 | 5001 | 10/12/1998 | 0.00 | 1.98 | J98HCS07VC07S1 | Hart Crowser, 2000 |
| 50007 | 5003 | 10/12/1998 | 1.98 | 4.22 | J98HCS07VC07S2 | Hart Crowser, 2000 |
| 50011 | 5002 | 10/12/1998 | 0.00 | 2.11 | J98HCS11VC11S1 | Hart Crowser, 2000 |
| 50011 | 5003 | 10/12/1998 | 2.11 | 3.99 | J98HCS11VC11S2 | Hart Crowser, 2000 |
| 50013 | 5001 | 10/12/1998 | 1.98 | 3.99 | J98HCS13VC13S2 | Hart Crowser, 2000 |
| 50013 | 5002 | 10/12/1998 | 0.00 | 1.98 | J98HCS13VC13S1 | Hart Crowser, 2000 |
| 50018 | 5002 | 10/12/1998 | 0.00 | 2.21 | J98HCS18VC18S1 | Hart Crowser, 2000 |
| 50018 | 5003 | 10/12/1998 | 2.21 | 3.99 | J98HCS18VC18S2 | Hart Crowser, 2000 |
| 50022 | 5001 | 10/12/1998 | 0.00 | 1.98 | J98HCS22VC22S1 | Hart Crowser, 2000 |
| 50022 | 5003 | 10/12/1998 | 1.98 | 3.99 | J98HCS22VC22S2 | Hart Crowser, 2000 |
| 50027 | 5001 | 10/12/1998 | 1.88 | 3.50 | J98HCS27VC27S2 | Hart Crowser, 2000 |
| 50027 | 5002 | 10/12/1998 | 0.00 | 1.88 | J98HCS27VC27S1 | Hart Crowser, 2000 |
| 50032 | 5001 | 10/12/1998 | 0.00 | 1.78 | J98HCS32VC32S1 | Hart Crowser, 2000 |
| 50032 | 5003 | 10/12/1998 | 1.78 | 3.99 | J98HCS32VC32S2 | Hart Crowser, 2000 |
| 50039 | 5001 | 10/12/1998 | 0.00 | 1.98 | J98HCS39VC39S1 | Hart Crowser, 2000 |
| 50039 | 5003 | 10/12/1998 | 1.98 | 3.99 | J98HCS39VC39S2 | Hart Crowser, 2000 |
| 50042 | 5002 | 10/12/1998 | 1.98 | 3.99 | J98HCS42VC42S2 | Hart Crowser, 2000 |
| 50042 | 5003 | 10/12/1998 | 0.00 | 1.98 | J98HCS42VC42S1 | Hart Crowser, 2000 |
| 76031 | 7602 | 10/17/1997 | 0.00 | 2.97 | SI98SD0310000A | Roy F. Weston, Inc., 1998 |

a. Data from NOAA Query Manager 2.51 for Terminal 4 of the Willamette River.

Table 4-3
Summary of Slip 1 Surface Sediment Chemistry Data

| Compounds (a) | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|
| **Metals (mg/kg)** | | | | | | | |
| Aluminum | 10 | 10 | 16,400 | 44,000 | 31,150 | NA | NA |
| Antimony | 25 | 7 | 0.4 | 11 | 8.8 | 2.3 U | 10 U |
| Arsenic | 25 | 22 | 3 | 7 | 4.3 | 5 U | 5 U |
| Barium | 5 | 5 | 184 | 198 | 193 | NA | NA |
| Beryllium | 10 | 5 | 0.7 | 0.7 | 0.7 | 1 U | 1 U |
| Cadmium | 25 | 17 | 0.25 | 4 | 0.94 | 0.3 U | 1 U |
| Calcium | 5 | 5 | 8,030 | 9190 | 8,512 | NA | NA |
| Chromium | 25 | 25 | 16 | 165 | 44 | NA | NA |
| Cobalt | 5 | 5 | 18.8 | 19.4 | 19 | NA | NA |
| Copper | 25 | 25 | 15 | 151 | 44 | NA | NA |
| Iron | 5 | 5 | 42,600 | 48,000 | 45,140 | NA | NA |
| Lead | 25 | 25 | 11 | 223 | 58 | NA | NA |
| Magnesium | 5 | 5 | 7,040 | 7,440 | 7,264 | NA | NA |
| Manganese | 5 | 5 | 653 | 792 | 736 | NA | NA |
| Mercury | 15 | 8 | 0.06 | 0.2 | 0.09 | 0.1 U | 0.2 U |
| Nickel | 25 | 25 | 15 | 40 | 23 | NA | NA |
| Potassium | 5 | 5 | 1,320 | 1,500 | 1,432 | NA | NA |
| Selenium | 15 | 0 | ND | ND | ND | 0.3 U | 6 U |
| Silver | 25 | 20 | 0.06 | 0.8 | 0.34 | 2 U | 2 U |
| Sodium | 5 | 5 | 1,050 | 1,370 | 1,180 | NA | NA |
| Thallium | 10 | 5 | 6 | 10 | 8 | 1 U | 1 U |
| Titanium | 2 | 2 | 1,850 | 2,030 | 1,940 | NA | NA |
| Vanadium | 5 | 5 | 102 | 114 | 108 | NA | NA |
| Zinc | 25 | 25 | 66.5 | 655 | 201 | NA | NA |
| **PAHs (ug/kg)** | | | | | | | |
| 2-Methylnaphthalene | 25 | 3 | 36 | 80 | 61 | 10 U | 5,000 U |
| 2-Nitroaniline | 15 | 0 | ND | ND | ND | 96 U | 35,000 U |
| 3,3-Dichlorobenzidine | 15 | 0 | ND | ND | ND | 96 U | 35,000 U |
| 3-Nitroaniline | 15 | 0 | ND | ND | ND | 120 U | 35,000 U |
| 4-Nitroaniline | 15 | 0 | ND | ND | ND | 96 U | 35,000 U |

**Table 4-3**
**Summary of Slip 1 Surface Sediment Chemistry Data**

| Compounds (a) | | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|---|
| Acenaphthene | | 25 | 14 | 29 | 970 | 218 | 10 U | 5,000 U |
| Acenaphthylene | | 25 | 4 | 51 | 63 | 58 | 10 U | 5,000 U |
| Anthracene | | 25 | 18 | 22 | 1,400 | 278 | 10 U | 5,000 U |
| Benzo(a)anthracene | | 25 | 24 | 60 | 17,000 | 2,304 | 3,000 U | 3,000 U |
| Benzo(a)pyrene | | 25 | 24 | 79 | 19,000 | 2,786 | 3,000 U | 3,000 U |
| Benzo(b)fluoranthene | | 25 | 24 | 80 | 21,000 | 2,822 | 3,000 U | 3,000 U |
| Benzo(b+k)fluoranthene | | 20 | 19 | 145 | 33,000 | 6,091 | 3,000 U | 3,000 U |
| Benzo(g,h,i)perylene | | 25 | 22 | 23 | 10,000 | 1,781 | 300 U | 3,000 U |
| Benzo(k)fluoranthene | | 25 | 24 | 65 | 12,000 | 2,153 | 3,000 U | 3,000 U |
| Carbazole | | 10 | 7 | 16 | 420 | 133 | 19 U | 20 U |
| Chrysene | | 25 | 24 | 93 | 19,000 | 2,750 | 3,000 U | 3,000 U |
| Dibenzo(a,h)anthracene | | 25 | 13 | 44 | 2,300 | 544 | 10 U | 5,000 U |
| Dibenzofuran | | 25 | 7 | 30 | 290 | 119 | 10 U | 5,000 U |
| Fluoranthene | | 25 | 24 | 120 | 28,000 | 3,800 | 3,000 U | 3,000 U |
| Fluorene | | 25 | 14 | 22 | 600 | 143 | 10 U | 5,000 U |
| Indeno(1,2,3-cd)pyrene | | 25 | 24 | 28 | 17,000 | 2,207 | 3,000 U | 3,000 U |
| Naphthalene | | 25 | 9 | 21 | 140 | 67 | 10 U | 5,000 U |
| Nitrobenzene | | 15 | 0 | ND | ND | ND | 19 U | 5,000 U |
| Total PAH | (d,e) | 15 | 14 | 603 | 118,000 | 14,859 | 3,000 U | 3,000 U |
| Total PAH reported | (f) | 20 | 19 | 894 | 178,000 | 32,196 | 3,000 U | 3,000 U |
| Total HPAH | (e,g) | 15 | 14 | 512 | 106,000 | 13,133 | 3,000 U | 3,000 U |
| Total HPAH reported | (f) | 20 | 19 | 894 | 166,000 | 29,687 | 3,000 U | 3,000 U |
| Total LPAH | (e,h) | 15 | 13 | 91 | 12,000 | 1,859 | 300 U | 3,000 U |
| Total LPAH reported | (f) | 20 | 17 | 110 | 12,000 | 2,804 | 10 U | 3,000 U |
| Phenanthrene | | 25 | 22 | 69 | 12,000 | 1,772 | 10 U | 3,000 U |
| Pyrene | | 25 | 24 | 130 | 23,000 | 3,363 | 3,000 U | 3,000 U |
| **Semivolatile Organic Compounds (ug/kg)** | | | | | | | | |
| 1,2,4-Trichlorobenzene | | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |
| 1,2-Dichlorobenzene | | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |
| 1,3-Dichlorobenzene | | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |
| 1,4-Dichlorobenzene | | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |

**Table 4-3**
**Summary of Slip 1 Surface Sediment Chemistry Data**

| Compounds (a) | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|
| 2,3,4,5-Tetrachlorophenol | 3 | 0 | ND | ND | ND | 96 U | 98 U |
| 2,3,4,6-Tetrachlorophenol | 3 | 0 | ND | ND | ND | 96 U | 98 U |
| 2,3,5,6-Tetrachlorophenol | 3 | 0 | ND | ND | ND | 96 U | 98 U |
| 2,4,5-Trichlorophenol | 13 | 0 | ND | ND | ND | 96 U | 5,000 U |
| 2,4,6-Trichlorophenol | 13 | 0 | ND | ND | ND | 96 U | 5,000 U |
| 2,4-Dichlorophenol | 13 | 0 | ND | ND | ND | 58 U | 5,000 U |
| 2,4-Dimethylphenol | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |
| 2,4-Dinitrophenol | 12 | 0 | ND | ND | ND | 190 U | 35,000 U |
| 2,4-Dinitrotoluene | 13 | 0 | ND | ND | ND | 96 U | 5,000 U |
| 2-Chloronaphthalene | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |
| 2-Chlorophenol | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |
| 2-Methylphenol | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |
| 2-Nitrophenol | 13 | 0 | ND | ND | ND | 96 U | 5,000 U |
| 4-Bromylphenyl phenyl ether | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |
| 4-Chloro-3-methylphenol | 13 | 0 | ND | ND | ND | 38 U | 5,000 U |
| 4-Chloroaniline | 13 | 0 | ND | ND | ND | 58 U | 5,000 U |
| 4-Chlorophenyl phenyl ether | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |
| 4-Methylphenol | 13 | 2 | 29 | 41 | 35 | 19 U | 5,000 U |
| 4-Nitrophenol | 13 | 0 | ND | ND | ND | 96 U | 35,000 U |
| Aniline | 8 | 0 | ND | ND | ND | 19 U | 15,000 U |
| Benzoic acid | 13 | 1 | 200 | 200 | 200 | 190 U | 35,000 U |
| Benzyl alcohol | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |
| Bis(2-chloroethoxy)methane | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |
| Bis(2-chloroethyl)ether | 13 | 0 | ND | ND | ND | 38 U | 5,000 U |
| Bis(2-ethylhexyl)phthalate | 23 | 16 | 170 | 38,000 | 4,428 | 130 U | 3,000 U |
| Butylbenzyl phthalate | 23 | 5 | 31 | 3,000 | 766 | 10 U | 5,000 U |
| Di-n-octyl phthalate | 23 | 3 | 39 | 190 | 94 | 10 U | 5,000 U |
| Di-n-butyl phthalate | 23 | 2 | 27 | 61 | 44 | 10 U | 5,000 U |
| Diethyl phthalate | 23 | 0 | ND | ND | ND | 10 U | 5,000 U |
| Dimethyl phthalate | 23 | 0 | ND | ND | ND | 10 U | 5,000 U |
| Dinitro-o-cresol | 12 | 0 | ND | ND | ND | 190 U | 35,000 U |
| Dinoseb | 3 | 0 | ND | ND | ND | 3.1 U | 3.2 U |

Table 4-3
Summary of Slip 1 Surface Sediment Chemistry Data

| Compounds (a) | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|
| Hexachlorobutadiene | 13 | 0 | ND | ND | ND | 0.24 U | 5,000 U |
| Hexachloroethane | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |
| N-nitrosodi-N-propylamine | 13 | 0 | ND | ND | ND | 38 U | 5,000 U |
| N-nitrosodimethylamine | 8 | 0 | ND | ND | ND | 96 U | 35,000 U |
| N-nitrosodiphenylamine | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |
| Pentachlorophenol | 13 | 0 | ND | ND | ND | 96 U | 35,000 U |
| Phenol | 13 | 0 | ND | ND | ND | 19 U | 5,000 U |
| **Pesticides and PCBs (ug/kg)** | | | | | | | |
| 2,4,5-T | 5 | 0 | ND | ND | ND | 1.6 U | 2.6 U |
| 2,4-DB | 5 | 0 | ND | ND | ND | 31 U | 33 U |
| 2,4-D | 5 | 0 | ND | ND | ND | 6.2 U | 6.5 U |
| Aldrin | 23 | 1 | 1 | 1 | 1 | 0.19 U | 10 U |
| Aroclor 1016 | 22 | 0 | ND | ND | ND | 3.9 U | 100 U |
| Aroclor 1221 | 22 | 0 | ND | ND | ND | 7.7 U | 100 U |
| Aroclor 1232 | 22 | 0 | ND | ND | ND | 3.9 U | 100 U |
| Aroclor 1242 | 22 | 9 | 12 | 240 | 86 | 3.9 U | 100 U |
| Aroclor 1248 | 22 | 1 | 12 | 12 | 12 | 3.9 U | 500 U |
| Aroclor 1254 | 22 | 5 | 18 | 83 | 54 | 10 U | 500 U |
| Aroclor 1260 | 22 | 12 | 11 | 110 | 46 | 10 U | 500 U |
| Cis and trans-chlordane | 6 | 0 | ND | ND | ND | 39 U | 100 U |
| Alpha-chlordane | 17 | 2 | 1.1 | 2.1 | 1.6 | 0.25 U | 10 U |
| Gamme-chlordane | 12 | 4 | 2.5 | 5.8 | 3.4 | 1 U | 10 U |
| Trans-chlordane | 5 | 0 | ND | ND | ND | 0.2 U | 1 U |
| Total DDT reported (f) | 18 | 11 | 7.3 | 28.4 | 17 | 2 U | 20 U |
| Total DDT (e,i) | 5 | 5 | 6.6 | 39.7 | 18 | NA | NA |
| Dalapon | 5 | 0 | ND | ND | ND | 16 U | 69 U |
| Dicamba | 5 | 0 | ND | ND | ND | 3 U | 3 U |
| Dieldrin | 23 | 0 | ND | ND | ND | 1 U | 20 U |
| Endosulfan sulfate | 23 | 1 | 12 | 12 | 12 | 0.39 U | 20 U |
| Alpha-endosulfan | 22 | 0 | ND | ND | ND | 0.19 U | 10 U |
| Beta-endosulfan | 22 | 0 | ND | ND | ND | 0.39 U | 16 U |

**Table 4-3**
**Summary of Slip 1 Surface Sediment Chemistry Data**

| Compounds (a) | | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|---|
| Endrin | | 23 | 0 | ND | ND | ND | 0.39 U | 10 U |
| Endrin aldehyde | | 22 | 0 | ND | ND | ND | 0.39 U | 17 U |
| Endrin ketone | | 17 | 0 | ND | ND | ND | 0.39 U | 52 U |
| Heptachlor | | 23 | 0 | ND | ND | ND | 0.19 U | 10 U |
| Heptachlor epoxide | | 22 | 0 | ND | ND | ND | 0.19 U | 10 U |
| Hexachlorobenzene | | 15 | 0 | ND | ND | ND | 0.24 U | 5000 U |
| Alpha-hexachlorocyclohexane | | 22 | 0 | ND | ND | ND | 0.19 U | 10 U |
| Beta-hexachlorocyclohexane | | 22 | 1 | 2.1 | 2.1 | 2.1 | 1 U | 30 U |
| Delta-hexachlorocyclohexane | | 22 | 0 | ND | ND | ND | 0.19 U | 10 U |
| Gamma-hexachlorocyclohexane | | 22 | 0 | ND | ND | ND | 0.2 U | 10 U |
| Hexachlorocyclopentadiene | | 15 | 0 | ND | ND | ND | 96 U | 5000 U |
| Isophorone | | 15 | 0 | ND | ND | ND | 19 U | 5000 U |
| MCPA | | 5 | 0 | ND | ND | ND | 3100 U | 3300 U |
| MCPP | | 5 | 0 | ND | ND | ND | 3100 U | 5100 U |
| Methoxylchlor | | 22 | 0 | ND | ND | ND | 1 U | 70 U |
| Mirex | | 5 | 0 | ND | ND | ND | 0.39 U | 1.4 U |
| Trans-nonachlor | | 5 | 0 | ND | ND | ND | 0.39 U | 0.39 U |
| Oxychlordane | | 5 | 0 | ND | ND | ND | 0.39 U | 3.1 U |
| Total PCB | (e,j) | 13 | 6 | 51 | 369 | 225 | 39 U | 500 U |
| Total PCB reported | (f) | 17 | 8 | 11 | 135 | 63 | 20 U | 500 U |
| Silvex | | 5 | 0 | ND | ND | ND | 1.6 U | 1.9 U |
| Toxaphene | | 23 | 0 | ND | ND | ND | 19 U | 2000 U |
| Cis-nonachlor | | 5 | 0 | ND | ND | ND | 0.39 U | 1.8 U |
| o,p'-DDD | | 5 | 0 | ND | ND | ND | 0.54 U | 1.5 U |
| o,p'-DDE | | 5 | 0 | ND | ND | ND | 0.39 U | 32 U |
| o,p'-DDT | | 5 | 0 | ND | ND | ND | 0.39 U | 0.65 U |
| p,p'-DDD | | 22 | 10 | 2.6 | 12 | 6.0 | 1 U | 10 U |
| p,p'-DDE | | 23 | 11 | 3.3 | 15 | 7.2 | 2 U | 10 U |
| p,p'-DDT | | 23 | 9 | 1.2 | 11 | 6.1 | 2 U | 20 U |

Table 4-3
Summary of Slip 1 Surface Sediment Chemistry Data

| Compounds (a) | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|
| **Miscellaneous Organics (ug/kg)** | | | | | | | |
| Trans-1,2-dichloroethene | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| 2,2'-Oxybis(1-chloropropane) | 15 | 0 | ND | ND | ND | 19 U | 5,000 U |
| 2,6-Dinitrotoluene | 15 | 0 | ND | ND | ND | 96 U | 5,000 U |
| Azobenzene | 5 | 0 | ND | ND | ND | 19 U | 20 U |
| Dibutyltin dichloride | 4 | 4 | 12 | 56 | 34 | NA | NA |
| Dichloroprop | 5 | 0 | ND | ND | ND | 6.2 U | 62 U |
| Trichlorofluoromethane | 5 | 0 | ND | ND | ND | 10 U | 200 U |
| Trichlorotrifluoroethane | 5 | 0 | ND | ND | ND | 10 U | 200 U |
| Cis-1,2-dichloroethene | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| **Volatile Organic Compounds (ug/kg)** | | | | | | | |
| 1,1-Dichloroethane | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| 1,1-Dichloroethene | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| 1,1,1-Trichloroethane | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| 1,1,2,2,-Tetrachloroethane | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| 1,1,2-Trichloroethane | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| 1,2-Dichloroethane | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| 1,2-Dichloropropane | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| Trans-1,3-dichloropropene | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| 2-Butanone | 5 | 0 | ND | ND | ND | 100 U | 2,000 U |
| 2-Chloroethylvinyl ether | 5 | 0 | ND | ND | ND | 10 U | 200 U |
| Acetone | 5 | 0 | ND | ND | ND | 100 U | 2,000 U |
| Benzene | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| Bromodichloromethane | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| Bromoform | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| Bromomethane | 5 | 0 | ND | ND | ND | 10 U | 200 U |
| Carbon disulfide | 5 | 0 | ND | ND | ND | 100 U | 2000 U |
| Carbon tetrachloride | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| Chlorobenzene | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| Chloroethane | 5 | 0 | ND | ND | ND | 10 U | 200 U |
| Chloroform | 5 | 0 | ND | ND | ND | 5 U | 100 U |

**Table 4-3**
**Summary of Slip 1 Surface Sediment Chemistry Data**

| Compounds (a) | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|
| Chloromethane | 5 | 0 | ND | ND | ND | 10 U | 200 U |
| Dibromochloromethane | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| Ethylbenzene | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| Methyl butyl ketone | 5 | 0 | ND | ND | ND | 50 U | 1,000 U |
| Methyl isobutyl ketone | 5 | 0 | ND | ND | ND | 50 U | 1,000 U |
| Methylene chloride | 5 | 1 | 11 | 11 | ND | 5 U | 100 U |
| Styrene | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| Tetrachloroethene | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| Toluene | 5 | 1 | 600 | 600 | 600 | 5 U | 10 U |
| Trichloroethene | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| Vinyl acetate | 5 | 0 | ND | ND | ND | 50 U | 1,000 U |
| Vinyl chloride | 5 | 0 | ND | ND | ND | 10 U | 200 U |
| m,p-Xylene | 5 | 1 | 190 | 190 | 190 | 5 U | 10 U |
| Cis-1,2-dichloropropene | 5 | 0 | ND | ND | ND | 5 U | 100 U |
| **Butyltins (ug/kg)** | | | | | | | |
| Butyltin ion | 2 | 0 | ND | ND | ND | 5.9 U | 5.9 U |
| Dibutyltin ion | 2 | 0 | ND | ND | ND | 5.9 U | 5.9 U |
| Monobutyltin chloride | 4 | 3 | 8.2 | 28 | 15 | NA (k) | NA (k) |
| Tetrabutyltin | 6 | 0 | ND | ND | ND | 5.8 U | 5.9 U |
| Tributyltin (as TBT cation) | 6 | 6 | 20 | 63 | 41 | NA | NA |
| Tributyltin chloride | 4 | 4 | 23 | 64 | 36 | NA | NA |

**Table 4-3**
**Summary of Slip 1 Surface Sediment Chemistry Data**

| Compounds (a) | | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|---|
| **Conventionals** | | | | | | | | |
| Total Solids | (%) | 20 | 20 | 27.2 | 77.1 | 53 | NA | NA |
| Total Organic Carbon | (%) | 21 | 21 | 1.17 | 4.72 | 1.9 | NA | NA |

ND = All sample results were non-detect. There is no maximum, minimum, or average detected concentration.
NA = All sample results were detected. There is no maximum or minimum detection limit.
U = All results non-detect. Average concentration is average of detection limits.
a. Data from NOAA Query Manager 2.51 database for Terminal 4 of the Willamette River.
b. The average detected concentration calculation includes detected results only. Non-detect results are not included.
c. The maximum and minimum detection limits are for non-detect results only.
d. In the database, total PAH is the sum of total LPAH and total HPAH.
e. In the database, total concentrations were calculated using the detected values or the highest non-detect detection limit if all results were non-detect. If the highest non-detect detection limit was greater than the summed detected values, then the non-detect detection limit was used.
f. Total reported concentrations (total reported PAH, HPAH, LPAH, DDT, and PCB) were provided with the original study data.
g. Total HPAH is presented in the database and is the sum of benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, perylene, and pyrene.
h. Total LPAH is presented in the database and is the sum of acenaphthene, anthracene, biphenyl, naphthalene, 2,6-dimethylnaphthalene, fluorene, 1-methylnaphthalene, 2-methylnaphthalene, 1-methylphenanthrene, and phenanthrene.
i. Total DDT is presented in the database and is the sum of o,p'-DDD, o,p'-DDE, o,p'-DDT, p,p'-DDD, p,p'-DDE, and p,p'-DDT.
j. Total PCB is presented in the database and is the sum of the Aroclors. It appears that the same Aroclors were used for the total PCB sum in each study.
k. Three of the four samples analyzed contained detected concentrations of monobutyltin chloride. The monobutyltin chloride result in the fourth sample was rejected.

**Table 4-4**
**Summary of Slip 3 Surface Sediment Chemistry Data**

| Compounds (a) | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|
| **Metals (mg/kg)** | | | | | | | |
| Aluminum | 8 | 8 | 26,000 | 43,400 | 38,788 | NA | NA |
| Antimony | 33 | 26 | 0.1 | 13 | 3.2 | 0.1 U | 0.2 U |
| Arsenic | 33 | 28 | 3 | 14 | 6.1 | 5 U | 6 U |
| Barium | 7 | 7 | 167 | 188 | 179 | NA | NA |
| Beryllium | 7 | 7 | 0.6 | 0.7 | 0.68 | NA | NA |
| Cadmium | 33 | 33 | 0.2 | 6.6 | 1.6 | NA | NA |
| Calcium | 7 | 7 | 7,620 | 8,530 | 8,104 | NA | NA |
| Chromium | 33 | 33 | 14 | 43 | 28 | NA | NA |
| Cobalt | 7 | 7 | 18 | 20 | 19 | NA | NA |
| Copper | 33 | 33 | 15 | 134 | 52 | NA | NA |
| Iron | 7 | 7 | 41,100 | 45,400 | 42,557 | NA | NA |
| Lead | 33 | 33 | 13 | 1,160 | 228 | NA | NA |
| Magnesium | 7 | 7 | 6,910 | 7,810 | 7,307 | NA | NA |
| Manganese | 7 | 7 | 642 | 751 | 707 | NA | NA |
| Mercury | 33 | 33 | 0.02 | 0.34 | 0.1 | NA | NA |
| Nickel | 33 | 33 | 12 | 56 | 26 | NA | NA |
| Potassium | 7 | 7 | 1,240 | 1,570 | 1,386 | NA | NA |
| Selenium | 8 | 0 | ND | ND | ND | 0.3 U | 7 U |
| Silver | 33 | 33 | 0.1 | 2.1 | 0.62 | NA | NA |
| Sodium | 7 | 7 | 1,090 | 1,490 | 1,241 | NA | NA |
| Thallium | 7 | 4 | 8 | 12 | 9.3 | 5 U | 7 U |
| Titanium | 1 | 1 | 1,870 | 1,870 | 1,870 | NA | NA |
| Vanadium | 7 | 7 | 103 | 111 | 107 | NA | NA |
| Zinc | 33 | 33 | 82 | 1,330 | 349 | NA | NA |
| **PAHs (ug/kg)** | | | | | | | |
| 2-Methylnaphthalene | 8 | 5 | 26 | 540 | 238 | 19 U | 98 U |
| 2-Nitroaniline | 8 | 0 | ND | ND | ND | 95 U | 540 U |
| 3,3-Dichlorobenzidine | 8 | 0 | ND | ND | ND | 95 U | 540 U |
| 3-Nitroaniline | 8 | 0 | ND | ND | ND | 110 U | 650 U |

Table 4-4
Summary of Slip 3 Surface Sediment Chemistry Data

| Compounds (a) | | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|---|
| 4-Nitroaniline | | 8 | 0 | ND | ND | ND | 95 U | 540 U |
| Acenaphthene | | 41 | 39 | 23 | 14,000 | 1,361 | 10,000 U | 20,000 U |
| Acenaphthylene | | 41 | 20 | 20 | 3,600 | 316 | 19 U | 20,000 U |
| Anthracene | | 41 | 39 | 27 | 12,000 | 1,712 | 10,000 U | 20,000 U |
| Benzo(a)anthracene | | 41 | 41 | 170 | 81,000 | 13,713 | NA | NA |
| Benzo(a)pyrene | | 41 | 41 | 180 | 94,000 | 16,216 | NA | NA |
| Benzo(b)fluoranthene | | 41 | 41 | 150 | 83,000 | 13,922 | NA | NA |
| Benzo(b+k)fluoranthene | | 40 | 40 | 248 | 156,000 | 24,302 | NA | NA |
| Benzo(g,h,i)perylene | | 41 | 41 | 96 | 55,000 | 10,639 | NA | NA |
| Benzo(k)fluoranthene | | 41 | 41 | 98 | 76,000 | 11,349 | NA | NA |
| Carbazole | | 8 | 8 | 25 | 10,000 | 2,213 | NA | NA |
| Chrysene | | 41 | 41 | 170 | 78,000 | 14,045 | NA | NA |
| Dibenzo(a,h)anthracene | | 41 | 37 | 50 | 25,000 | 2,260 | 19 U | 20,000 U |
| Dibenzofuran | | 41 | 27 | 23 | 1,300 | 224 | 19 U | 20,000 U |
| Fluoranthene | | 52 | 52 | 280 | 130,000 | 19,910 | NA | NA |
| Fluorene | | 41 | 36 | 22 | 14,000 | 920 | 20 U | 20,000 U |
| Indeno(1,2,3-cd)pyrene | | 41 | 41 | 160 | 110,000 | 17,600 | NA | NA |
| Naphthalene | | 41 | 33 | 22 | 2,200 | 313 | 19 U | 20,000 U |
| Nitrobenzene | | 8 | 0 | ND | ND | ND | 19 U | 110 U |
| Total PAH | (d,e) | 41 | 41 | 1,493 | 585,000 | 102,528 | NA | NA |
| Total PAH reported | (f) | 40 | 40 | 2,235 | 868,000 | 167,247 | NA | NA |
| Total HPAH | (e,g) | 41 | 41 | 1,250 | 471,000 | 89,942 | NA | NA |
| Total HPAH reported | (f) | 40 | 40 | 1,976 | 765,000 | 155,065 | NA | NA |
| Total LPAH | (e,h) | 41 | 41 | 233 | 114,000 | 12,586 | NA | NA |
| Total LPAH reported | (f) | 40 | 40 | 233 | 114,000 | 12,182 | NA | NA |
| Phenanthrene | | 41 | 41 | 150 | 74,000 | 8,682 | NA | NA |
| Pyrene | | 41 | 41 | 300 | 110,000 | 22,122 | NA | NA |
| **Semivolatile Organic Compounds (ug/kg)** | | | | | | | | |
| 1,2,4-Trichlorobenzene | | 8 | 0 | ND | ND | ND | 19 U | 110 U |
| 1,2-Dichlorobenzene | | 40 | 0 | ND | ND | ND | 5 U | 110 U |

Table 4-4
Summary of Slip 3 Surface Sediment Chemistry Data

| Compounds (a) | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|
| 1,3-Dichlorobenzene | 40 | 0 | ND | ND | ND | 5 U | 110 U |
| 1,4-Dichlorobenzene | 40 | 0 | ND | ND | ND | 5 U | 110 U |
| 2,3,4,5-Tetrachlorophenol | 1 | 0 | ND | ND | ND | 540 U | 540 U |
| 2,3,4,6-Tetrachlorophenol | 1 | 0 | ND | ND | ND | 540 U | 540 U |
| 2,3,5,6-Tetrachlorophenol | 1 | 0 | ND | ND | ND | 540 U | 540 U |
| 2,4,5-Trichlorophenol | 8 | 0 | ND | ND | ND | 95 U | 540 U |
| 2,4,6-Trichlorophenol | 8 | 0 | ND | ND | ND | 95 U | 540 U |
| 2,4-Dichlorophenol | 8 | 0 | ND | ND | ND | 57 U | 330 U |
| 2,4-Dimethylphenol | 41 | 3 | 7 | 31 | 16 | 6 U | 6,000 U |
| 2,4-Dinitrophenol | 8 | 0 | ND | ND | ND | 190 U | 1,100 U |
| 2,4-Dinitrotoluene | 7 | 0 | ND | ND | ND | 95 U | 540 U |
| 2-Chloronaphthalene | 8 | 0 | ND | ND | ND | 19 U | 110 U |
| 2-Chlorophenol | 8 | 0 | ND | ND | ND | 19 U | 110 U |
| 2-Methylphenol | 41 | 2 | 17 | 51 | 34 | 6 U | 6,000 U |
| 2-Nitrophenol | 8 | 0 | ND | ND | ND | 95 U | 540 U |
| 4-Bromylphenyl phenyl ether | 8 | 0 | ND | ND | ND | 19 U | 110 U |
| 4-Chloro-3-methylphenol | 8 | 0 | ND | ND | ND | 38 U | 220 U |
| 4-Chloroaniline | 8 | 0 | ND | ND | ND | 57 U | 330 U |
| 4-Chlorophenyl phenyl ether | 8 | 0 | ND | ND | ND | 19 U | 110 U |
| 4-Methylphenol | 41 | 6 | 20 | 130 | 45 | 19 U | 20,000 U |
| 4-Nitrophenol | 8 | 0 | ND | ND | ND | 95 U | 540 U |
| Aniline | 1 | 0 | ND | ND | ND | 110 U | 110 U |
| Benzoic acid | 41 | 1 | 110 | 110 | 110 | 100 U | 100,000 U |
| Benzyl alcohol | 41 | 0 | ND | ND | ND | 6 U | 6,000 U |
| Bis(2-chloroethoxy)methane | 8 | 0 | ND | ND | ND | 19 U | 110 U |
| Bis(2-chloroethyl)ether | 8 | 0 | ND | ND | ND | 38 U | 220 U |
| Bis(2-ethylhexyl)phthalate | 41 | 29 | 50 | 550 | 327 | 91 U | 20,000 U |
| Butylbenzyl phthalate | 41 | 7 | 20 | 110 | 47 | 19 U | 20,000 U |
| Di-n-octyl phthalate | 41 | 2 | 40 | 100 | 70 | 19 U | 20,000 U |
| Di-n-butyl phthalate | 41 | 1 | 43 | 43 | 43 | 19 U | 20,000 U |
| Diethyl phthalate | 41 | 1 | 25 | 25 | 25 | 19 U | 20,000 U |

**Table 4-4**
**Summary of Slip 3 Surface Sediment Chemistry Data**

| Compounds (a) | | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|---|
| Dimethyl phthalate | | 41 | 0 | ND | ND | ND | 19 U | 20,000 U |
| Dinitro-o-cresol | | 8 | 0 | ND | ND | ND | 190 U | 1,100 U |
| Dinoseb | | 1 | 0 | ND | ND | ND | 3.3 U | 3.3 U |
| Hexachlorobutadiene | | 41 | 0 | ND | ND | ND | 2 U | 20,000 U |
| Hexachloroethane | | 8 | 0 | ND | ND | ND | 19 U | 220 U |
| N-nitrosodi-N-propylamine | | 8 | 0 | ND | ND | ND | 38 U | 220 U |
| N-nitrosodimethylamine | | 1 | 0 | ND | ND | ND | 540 U | 540 U |
| N-nitrosodiphenylamine | | 41 | 0 | ND | ND | ND | 12 U | 12,000 U |
| Pentachlorophenol | | 41 | 0 | ND | ND | ND | 60 U | 60,000 U |
| Phenol | | 41 | 2 | 55 | 110 | 83 | 19 U | 20,000 U |
| **Pesticides and PCBs (ug/kg)** | | | | | | | | |
| 2,4,5-T | | 1 | 0 | ND | ND | ND | 1.6 U | 1.6 U |
| 2,4-DB | | 1 | 0 | ND | ND | ND | 33 U | 33 U |
| 2,4-D | | 1 | 0 | ND | ND | ND | 6.5 U | 6.5 U |
| Aldrin | | 9 | 0 | ND | ND | ND | 0.97 U | 20 U |
| Aroclor 1016 | | 2 | 0 | ND | ND | ND | 3.9 U | 19 U |
| Aroclor 1221 | | 2 | 0 | ND | ND | ND | 7.9 U | 39 U |
| Aroclor 1232 | | 2 | 0 | ND | ND | ND | 3.9 U | 19 U |
| Aroclor 1242 | | 2 | 0 | ND | ND | ND | 3.9 U | 19 U |
| Aroclor 1248 | | 2 | 0 | ND | ND | ND | 7.3 U | 19 U |
| Aroclor 1254 | | 2 | 0 | ND | ND | ND | 19 U | 22 U |
| Aroclor 1260 | | 2 | 1 | 66 | 66 | 66 | 19 U | 19 U |
| Cis and trans-chlordane | | 2 | 0 | ND | ND | ND | 14 U | 450 U |
| Alpha-chlordane | | 7 | 0 | ND | ND | ND | 0.97 U | 20 U |
| Gamme-chlordane | | 6 | 0 | ND | ND | ND | 0.97 U | 20 U |
| Trans-chlordane | | 1 | 0 | ND | ND | ND | 2 U | 2 U |
| Total DDT reported | (f) | 8 | 6 | 1.2 | 39 | 16 | 12 U | 159 U |
| Total DDT | (e.i) | 1 | 1 | 6.8 | 6.8 | 6.8 | NA | NA |
| Dalapon | | 1 | 0 | ND | ND | ND | 23 U | 23 U |
| Dicamba | | 1 | 0 | ND | ND | ND | 3.3 U | 3.3 U |

**Table 4-4**
**Summary of Slip 3 Surface Sediment Chemistry Data**

| Compounds (a) | | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|---|
| Dieldrin | | 9 | 0 | ND | ND | ND | 1.9 U | 20 U |
| Endosulfan sulfate | | 9 | 0 | ND | ND | ND | 1.9 U | 23 U |
| Alpha-endosulfan | | 7 | 0 | ND | ND | ND | 0.97 U | 20 U |
| Beta-endosulfan | | 7 | 0 | ND | ND | ND | 1.9 U | 20 U |
| Endrin | | 9 | 0 | ND | ND | ND | 1.9 U | 20 U |
| Endrin aldehyde | | 7 | 0 | ND | ND | ND | 1.9 U | 20 U |
| Endrin ketone | | 7 | 0 | ND | ND | ND | 3.9 U | 20 U |
| Heptachlor | | 9 | 0 | ND | ND | ND | 0.97 U | 20 U |
| Heptachlor epoxide | | 7 | 0 | ND | ND | ND | 0.97 U | 20 U |
| Hexachlorobenzene | | 41 | 0 | ND | ND | ND | 2 U | 20,000 U |
| Alpha-hexachlorocyclohexane | | 7 | 0 | ND | ND | ND | 0.97 U | 20 U |
| Beta-hexachlorocyclohexane | | 7 | 0 | ND | ND | ND | 0.97 U | 20 U |
| Delta-hexachlorocyclohexane | | 7 | 0 | ND | ND | ND | 0.97 U | 20 U |
| Gamma-hexachlorocyclohexane | | 7 | 0 | ND | ND | ND | 0.97 U | 20 U |
| Hexachlorocyclopentadiene | | 8 | 0 | ND | ND | ND | 95 U | 540 U |
| Isophorone | | 8 | 0 | ND | ND | ND | 19 U | 110 U |
| MCPA | | 1 | 0 | ND | ND | ND | 3,300 U | 3,300 U |
| MCPP | | 1 | 0 | ND | ND | ND | 4,600 U | 4,600 U |
| Methoxylchlor | | 7 | 0 | ND | ND | ND | 10 U | 40 U |
| Mirex | | 1 | 0 | ND | ND | ND | 3.9 U | 3.9 U |
| Trans-nonachlor | | 1 | 0 | ND | ND | ND | 3.9 U | 3.9 U |
| Oxychlordane | | 1 | 0 | ND | ND | ND | 3.9 U | 3.9 U |
| Total PCB | (e,j) | 4 | 2 | 55 | 95 | 75 | 39 U | 45 U |
| Total PCB reported | (f) | 1 | 0 | ND | ND | ND | 39 U | 39 U |
| Silvex | | 1 | 0 | ND | ND | ND | 1.6 U | 1.6 U |
| Toxaphene | | 9 | 0 | ND | ND | ND | 23 U | 300 U |
| Cis-nonachlor | | 1 | 0 | ND | ND | ND | 3.9 U | 3.9 U |
| o,p'-DDD | | 1 | 0 | ND | ND | ND | 3.9 U | 3.9 U |
| o,p'-DDE | | 1 | 0 | ND | ND | ND | 3.9 U | 3.9 U |
| o,p'-DDT | | 1 | 0 | ND | ND | ND | 3.9 U | 3.9 U |
| p,p'-DDD | | 9 | 5 | 1 | 8 | 5.6 | 1.9 U | 99 U |

Table 4-4
Summary of Slip 3 Surface Sediment Chemistry Data

| Compounds (a) | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|
| p,p'-DDE | 9 | 5 | 1.2 | 5 | 3.2 | 3.9 U | 20 U |
| p,p'-DDT | 9 | 4 | 3 | 26 | 12 | 1.9 U | 159 U |
| **Miscellaneous Organics (ug/kg)** | | | | | | | |
| 2,2'-Oxybis(1-chloropropane) | 8 | 0 | ND | ND | ND | 19 U | 110 U |
| 2,6-Dinitrotoluene | 8 | 0 | ND | ND | ND | 95 U | 540 U |
| Azobenzene | 1 | 0 | ND | ND | ND | 110 U | 110 U |
| Dichloroprop | 1 | 0 | ND | ND | ND | 6.5 U | 6.5 U |
| Diesel | 44 | 10 | 230,000 | 2,100,000 | 657,000 | 25,000 U | 200,000 U |
| Lube oil | 44 | 7 | 160 | 1,100 | 479 | 100 U | 100 U |
| Pencil pitch | 44 | 37 | 310 | 14,000 | 2,274 | 100 U | 300 U |
| Phytane | 44 | 11 | 500 | 6,100 | 1782 | 500 U | 1,000 U |
| Pristance | 44 | 15 | 500 | 7,000 | 1620 | 500 U | 500 U |
| **Volatile Organic Compounds (ug/kg)** | | | | | | | |
| Benzene | 32 | 0 | ND | ND | ND | 5 U | 25 U |
| Ethylbenzene | 32 | 0 | ND | ND | ND | 5 U | 25 U |
| Tetrachloroethene | 32 | 0 | ND | ND | ND | 5 U | 25 U |
| Toluene | 32 | 0 | ND | ND | ND | 5 U | 25 U |
| Trichloroethene | 32 | 0 | ND | ND | ND | 5 U | 25 U |
| m,p-Xylene | 32 | 0 | ND | ND | ND | 5 U | 25 U |
| o-Xylene | 32 | 0 | ND | ND | ND | 5 U | 25 U |

**Table 4-4**
**Summary of Slip 3 Surface Sediment Chemistry Data**

| Compounds (a) | | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|---|
| **Conventionals** | | | | | | | | |
| Ammonia | (mg/kg) | 32 | 32 | 12 | 224 | 93 | NA | NA |
| Total Solids | (%) | 45 | 45 | 30 | 78 | 47 | NA | NA |
| Total Sulfide (S2) | (mg/kg) | 32 | 32 | 1.6 | 1,830 | 139 | NA | NA |
| Total Volatile Solids | (%) | 33 | 33 | 1.8 | 13 | 6.7 | NA | NA |
| Total Organic Carbon | (%) | 42 | 42 | 0.42 | 3.7 | 1.9 | NA | NA |

ND = All sample results were non-detect. There is no maximum, minimum, or average detected concentration.
NA = All sample results were detected. There is no maximum or minimum detection limit.
U = All results non-detect. Average concentration is average of detection limits.
a. Data from NOAA Query Manager 2.51 database for Terminal 4 of the Willamette River.
b. The average detected concentration calculation includes detected results only. Non-detect results are not included.
c. The maximum and minimum detection limits are for non-detect results only.
d. In the database, total PAH is the sum of total LPAH and total HPAH.
e. In the database, total concentrations were calculated using the detected values or the highest non-detect detection limit if all results were non-detect. If the highest non-detect detection limit was greater than the summed detected values, then the non-detect detection limit was used.
f. Total reported concentrations (total reported PAH, HPAH, LPAH, DDT, and PCB) were provided with the original study data.
g. Total HPAH is presented in the database and is the sum of benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, perylene, and pyrene.
h. Total LPAH is presented in the database and is the sum of acenaphthene, anthracene, biphenyl, naphthalene, 2,6-dimethylnaphthalene, fluorene, 1-methylnaphthalene, 2-methylnaphthalene, 1-methylphenanthrene, and phenanthrene.
i. Total DDT is presented in the database and is the sum of o,p'-DDD, o,p'-DDE, o,p'-DDT, p,p'-DDD, p,p'-DDE, and p,p'-DDT.
j. Total PCB is presented in the database and is the sum of the Aroclors. It appears that the same Aroclors were used for the total PCB sum in each study.

Table 4-5
Summary of Slip 1 Subsurface Sediment Chemistry Data

| Compounds (a) | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|
| **Metals (mg/kg)** | | | | | | | |
| Aluminum | 1 | 1 | 40,700 | 40,700 | 40,700 | NA | NA |
| Antimony | 3 | 2 | 0.03 | 6 | 3 | 0.02 U | 0.02 U |
| Arsenic | 4 | 3 | 1 | 4.5 | 2.3 | 4 U | 4 U |
| Barium | 1 | 1 | 191 | 191 | 191 | NA | NA |
| Beryllium | 1 | 1 | 0.56 | 0.56 | 0.56 | NA | NA |
| Cadmium | 4 | 4 | 0.14 | 2.8 | 0.89 | NA | NA |
| Calcium | 1 | 1 | 8,330 | 8,330 | 8,330 | NA | NA |
| Chromium | 4 | 4 | 11 | 41 | 25 | NA | NA |
| Cobalt | 1 | 1 | 19 | 19 | 19 | NA | NA |
| Copper | 4 | 4 | 14 | 64 | 34 | NA | NA |
| Iron | 1 | 1 | 42,600 | 42,600 | 42,600 | NA | NA |
| Lead | 4 | 4 | 10 | 222 | 67 | NA | NA |
| Magnesium | 1 | 1 | 7,100 | 7,100 | 7,100 | NA | NA |
| Manganese | 1 | 1 | 495 | 495 | 495 | NA | NA |
| Mercury | 4 | 4 | 0.08 | 0.21 | 0.13 | NA | NA |
| Nickel | 4 | 4 | 15 | 32 | 22 | NA | NA |
| Potassium | 1 | 1 | 1,300 | 1,300 | 1,300 | NA | NA |
| Selenium | 1 | 1 | 6 | 6 | 6 | NA | NA |
| Silver | 4 | 4 | 0.12 | 1.3 | 0.47 | NA | NA |
| Sodium | 1 | 1 | 1,200 | 1,200 | 1,200 | NA | NA |
| Thallium | 1 | 0 | ND | ND | ND | 4 U | 4 U |
| Vanadium | 1 | 1 | 107 | 107 | 107 | NA | NA |
| Zinc | 4 | 4 | 53 | 535 | 197 | NA | NA |
| **PAHs (ug/kg)** | | | | | | | |
| 2-Methylnaphthalene | 2 | 2 | 53 | 170 | 112 | NA | NA |
| 2-Nitroaniline | 1 | 0 | ND | ND | ND | 97 U | 97 U |
| 3,3-Dichlorobenzidine | 1 | 0 | ND | ND | ND | 97 U | 97 U |
| 3-Nitroaniline | 1 | 0 | ND | ND | ND | 120 U | 120 U |
| 4-Nitroaniline | 1 | 0 | ND | ND | ND | 97 U | 97 U |
| Acenaphthene | 4 | 4 | 38 | 210 | 132 | NA | NA |

Table 4-5
Summary of Slip 1 Subsurface Sediment Chemistry Data

| Compounds (a) | | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|---|
| Acenaphthylene | | 4 | 1 | 10 | 10 | 10 | 19 U | 200 U |
| Anthracene | | 4 | 4 | 46 | 250 | 127 | NA | NA |
| Benzo(a)anthracene | | 4 | 4 | 74 | 690 | 384 | NA | NA |
| Benzo(a)pyrene | | 4 | 4 | 81 | 960 | 493 | NA | NA |
| Benzo(b)fluoranthene | | 4 | 4 | 63 | 830 | 373 | NA | NA |
| Benzo(b+k)fluoranthene | | 4 | 4 | 121 | 1,500 | 700 | NA | NA |
| Benzo(g,h,i)perylene | | 4 | 4 | 56 | 560 | 284 | NA | NA |
| Benzo(k)fluoranthene | | 4 | 4 | 58 | 670 | 327 | NA | NA |
| Carbazole | | 1 | 1 | 99 | 99 | 99 | NA | NA |
| Chrysene | | 4 | 4 | 90 | 860 | 470 | NA | NA |
| Dibenzo(a,h)anthracene | | 4 | 2 | 11 | 200 | 106 | 20 U | 200 U |
| Dibenzofuran | | 4 | 2 | 42 | 85 | 64 | 20 U | 200 U |
| Fluoranthene | | 4 | 4 | 217 | 2,200 | 962 | NA | NA |
| Fluorene | | 4 | 3 | 27 | 133 | 84 | 200 U | 200 U |
| Indeno(1,2,3-cd)pyrene | | 4 | 4 | 55 | 580 | 306 | NA | NA |
| Naphthalene | | 4 | 4 | 84 | 290 | 175 | NA | NA |
| Nitrobenzene | | 1 | 0 | ND | ND | ND | 19 U | 19 U |
| Total PAH | (d,e) | 4 | 4 | 1,761 | 8,890 | 4,641 | NA | NA |
| Total PAH reported | (f) | 4 | 4 | 2,003 | 10,590 | 5,921 | NA | NA |
| Total HPAH | (e,g) | 4 | 4 | 688 | 7,040 | 3,500 | NA | NA |
| Total HPAH reported | (f) | 4 | 4 | 920 | 8,740 | 4,790 | NA | NA |
| Total LPAH | (e,h) | 4 | 4 | 466 | 1,850 | 1,142 | NA | NA |
| Total LPAH reported | (f) | 4 | 4 | 466 | 1,850 | 1,131 | NA | NA |
| Phenanthrene | | 4 | 4 | 260 | 1,100 | 590 | NA | NA |
| Pyrene | | 4 | 4 | 215 | 2,700 | 1,139 | NA | NA |
| **Semivolatile Organic Compounds (ug/kg)** | | | | | | | | |
| 1,2,4-Trichlorobenzene | | 1 | 0 | ND | ND | ND | 19 U | 19 U |
| 1,2-Dichlorobenzene | | 3 | 0 | ND | ND | ND | 1 U | 19 U |
| 1,3-Dichlorobenzene | | 3 | 0 | ND | ND | ND | 1 U | 19 U |
| 1,4-Dichlorobenzene | | 3 | 0 | ND | ND | ND | 1 U | 19 U |
| 2,4,5-Trichlorophenol | | 1 | 0 | ND | ND | ND | 97 U | 97 U |

Table 4-5
Summary of Slip 1 Subsurface Sediment Chemistry Data

| Compounds (a) | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|
| 2,4,6-Trichlorophenol | 1 | 0 | ND | ND | ND | 97 U | 97 U |
| 2,4-Dichlorophenol | 1 | 0 | ND | ND | ND | 58 U | 58 U |
| 2,4-Dimethylphenol | 3 | 0 | ND | ND | ND | 6 U | 60 U |
| 2,4-Dinitrophenol | 1 | 0 | ND | ND | ND | 190 U | 190 U |
| 2,4-Dinitrotoluene | 1 | 0 | ND | ND | ND | 97 U | 97 U |
| 2-Chloronaphthalene | 1 | 0 | ND | ND | ND | 19 U | 19 U |
| 2-Chlorophenol | 1 | 0 | ND | ND | ND | 19 U | 19 U |
| 2-Methylphenol | 3 | 0 | ND | ND | ND | 6 U | 60 U |
| 2-Nitrophenol | 1 | 0 | ND | ND | ND | 97 U | 97 U |
| 4-Bromylphenyl phenyl ether | 1 | 0 | ND | ND | ND | 19 U | 19 U |
| 4-Chloro-3-methylphenol | 1 | 0 | ND | ND | ND | 39 U | 39 U |
| 4-Chloroaniline | 1 | 0 | ND | ND | ND | 58 U | 58 U |
| 4-Chlorophenyl phenyl ether | 1 | 0 | ND | ND | ND | 19 U | 19 U |
| 4-Methylphenol | 3 | 2 | 23 | 26 | 25 | 200 U | 200 U |
| 4-Nitrophenol | 1 | 0 | ND | ND | ND | 97 U | 97 U |
| Benzoic acid | 3 | 0 | ND | ND | ND | 100 U | 1,000 U |
| Benzyl alcohol | 3 | 0 | ND | ND | ND | 6 U | 60 U |
| Bis(2-chloroethoxy)methane | 1 | 0 | ND | ND | ND | 19 U | 19 U |
| Bis(2-chloroethyl)ether | 1 | 0 | ND | ND | ND | 39 U | 39 U |
| Bis(2-ethylhexyl)phthalate | 3 | 1 | 380 | 380 | 380 | 20 U | 200 U |
| Butylbenzyl phthalate | 3 | 1 | 240 | 240 | 240 | 19 U | 20 U |
| Di-n-octyl phthalate | 3 | 0 | ND | ND | ND | 19 U | 200 U |
| Di-n-butyl phthalate | 3 | 0 | ND | ND | ND | 19 U | 200 U |
| Diethyl phthalate | 3 | 0 | ND | ND | ND | 19 U | 200 U |
| Dimethyl phthalate | 3 | 0 | ND | ND | ND | 19 U | 200 U |
| Dinitro-o-cresol | 1 | 0 | ND | ND | ND | 190 U | 190 U |
| Hexachlorobutadiene | 3 | 0 | ND | ND | ND | 19 U | 200 U |
| Hexachloroethane | 1 | 0 | ND | ND | ND | 19 U | 19 U |
| N-nitrosodi-N-propylamine | 1 | 0 | ND | ND | ND | 39 U | 39 U |
| N-nitrosodiphenylamine | 3 | 0 | ND | ND | ND | 12 U | 120 U |
| Pentachlorophenol | 3 | 0 | ND | ND | ND | 61 U | 610 U |
| Phenol | 3 | 0 | ND | ND | ND | 19 U | 200 U |

Table 4-5
Summary of Slip 1 Subsurface Sediment Chemistry Data

| Compounds (a) | | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|---|
| **Pesticides and PCBs (ug/kg)** | | | | | | | | |
| Aldrin | | 3 | 0 | ND | ND | ND | 1.7 U | 2 U |
| Aroclor 1016 | | 3 | 0 | ND | ND | ND | 10 U | 10 U |
| Aroclor 1221 | | 3 | 0 | ND | ND | ND | 10 U | 10 U |
| Aroclor 1232 | | 3 | 0 | ND | ND | ND | 10 U | 10 U |
| Aroclor 1242 | | 3 | 0 | ND | ND | ND | 10 U | 10 U |
| Aroclor 1248 | | 3 | 0 | ND | ND | ND | 10 U | 10 U |
| Aroclor 1254 | | 3 | 0 | ND | ND | ND | 10 U | 25 U |
| Aroclor 1260 | | 3 | 3 | 12 | 32 | 21 | NA | NA |
| Cis and trans-chlordane | | 1 | 0 | ND | ND | ND | 10 U | 10 U |
| Alpha-chlordane | | 2 | 0 | ND | ND | ND | 1.7 U | 2 U |
| Gamme-chlordane | | 2 | 0 | ND | ND | ND | 1.7 U | 1.7 U |
| Total DDT reported | (f) | 3 | 3 | 4.8 | 480 | 163 | NA | NA |
| Total DDT | (i) | | | | | | | |
| Dieldrin | | 3 | 0 | ND | ND | ND | 2 U | 2 U |
| Endosulfan sulfate | | 1 | 0 | ND | ND | ND | 2 U | 2 U |
| Alpha-endosulfan | | 1 | 0 | ND | ND | ND | 2 U | 2 U |
| Beta-endosulfan | | 1 | 0 | ND | ND | ND | 2 U | 2 U |
| Endrin | | 1 | 0 | ND | ND | ND | 2 U | 2 U |
| Endrin aldehyde | | 1 | 0 | ND | ND | ND | 2 U | 2 U |
| Heptachlor | | 3 | 0 | ND | ND | ND | 1.7 U | 2 U |
| Heptachlor epoxide | | 1 | 0 | ND | ND | ND | 2 U | 2 U |
| Hexachlorobenzene | | 3 | 0 | ND | ND | ND | 19 U | 200 U |
| Alpha-hexachlorocyclohexane | | 1 | 0 | ND | ND | ND | 2 U | 2 U |
| Beta-hexachlorocyclohexane | | 1 | 0 | ND | ND | ND | 2 U | 2 U |
| Delta-hexachlorocyclohexane | | 1 | 0 | ND | ND | ND | 2 U | 2 U |
| Gamma-hexachlorocyclohexane | | 3 | 0 | ND | ND | ND | 2 U | 2 U |
| Hexachlorocyclopentadiene | | 1 | 0 | ND | ND | ND | 97 U | 97 U |
| Isophorone | | 1 | 0 | ND | ND | ND | 19 U | 19 U |
| Methoxylchlor | | 1 | 1 | 1 | 1 | 1 | NA | NA |
| Total PCB | (e,j) | 3 | 3 | 12 | 32 | 21 | NA | NA |

**Table 4-5**
**Summary of Slip 1 Subsurface Sediment Chemistry Data**

| Compounds (a) | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|
| Total PCB reported (f) | 3 | 3 | 12 | 32 | 21 | NA | NA |
| Toxaphene | 1 | 0 | ND | ND | ND | 40 U | 40 U |
| p,p'-DDD | 3 | 3 | 2 | 14 | 7.0 | NA | NA |
| p,p'-DDE | 3 | 2 | 2 | 5.8 | 3.9 | 2.3 U | 2 U |
| p,p'-DDT | 3 | 2 | 0.8 | 460 | 230 | 6.7 U | 7 U |
| **Miscellaneous Organics (ug/kg)** | | | | | | | |
| 2,2'-Oxybis(1-chloropropane) | 1 | 0 | ND | ND | ND | 19 U | 19 U |
| 2,6-Dinitrotoluene | 1 | 0 | ND | ND | ND | 97 U | 97 U |

Table 4-5
Summary of Slip 1 Subsurface Sediment Chemistry Data

| Compounds (a) | | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|---|
| **Conventionals** | | | | | | | | |
| Ammonia | (mg/kg) | 2 | 2 | 154 | 209 | 182 | NA | NA |
| Total Solids | (%) | 3 | 3 | 53 | 70 | 59 | NA | NA |
| Total Sulfide (S2) | (mg/kg) | 2 | 2 | 28 | 32 | 30 | NA | NA |
| Total Volatile Solids | (%) | 2 | 2 | 2.6 | 6 | 4.4 | NA | NA |
| Total Organic Carbon | (%) | 4 | 4 | 0.53 | 2.3 | 1.6 | NA | NA |
| Acid Volatile Sulfides | (mg/kg) | 1 | 1 | 17.9 | 17.9 | 18 | NA | NA |

ND = All sample results were non-detect. There is no maximum, minimum, or average detected concentration.
NA = All sample results were detected. There is no maximum or minimum detection limit.
U = All results non-detect. Average concentration is average of detection limits.
a. Data from NOAA Query Manager 2.51 database for Terminal 4 of the Willamette River.
b. The average detected concentration calculation includes detected results only. Non-detect results are not included.
c. The maximum and minimum detection limits are for non-detect results only.
d. In the database, total PAH is the sum of total LPAH and total HPAH.
e. In the database, total concentrations were calculated using the detected values or the highest non-detect detection limit if all results were non-detect. If the highest non-detect detection limit was greater than the summed detected values, then the non-detect detection limit was used.
f. Total reported concentrations (total reported PAH, HPAH, LPAH, DDT, and PCB) were provided with the original study data.
g. Total HPAH is presented in the database and is the sum of benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, perylene, and pyrene.
h. Total LPAH is presented in the database and is the sum of acenaphthene, anthracene, biphenyl, naphthalene, 2,6-dimethylnaphthalene, fluorene, 1-methylnaphthalene, 2-methylnaphthalene, 1-methylphenanthrene, and phenanthrene.
i. Total DDT was not included in the database for Slip 1 subsurface sediment.
j. Total PCB is presented in the database and is the sum of the Aroclors. It appears that the same Aroclors were used for the total PCB sum in each study.

**Table 4-6**
**Summary of Slip 3 Subsurface Sediment Chemistry Data**

| Compounds (a) | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|
| **Metals (mg/kg)** | | | | | | | |
| Aluminum | 1 | 1 | 40,900 | 40,900 | 40,900 | NA | NA |
| Antimony | 15 | 8 | 0.2 | 8 | 1.5 | 0.1 U | 0.1 U |
| Arsenic | 15 | 15 | 2 | 15 | 5.4 | NA | NA |
| Barium | 1 | 1 | 185 | 185 | 185 | NA | NA |
| Beryllium | 1 | 1 | 0.54 | 0.54 | 0.54 | NA | NA |
| Cadmium | 15 | 14 | 0.1 | 3.3 | 1.2 | 0.1 U | 0.1 U |
| Calcium | 1 | 1 | 7,930 | 7,930 | 7,930 | NA | NA |
| Chromium | 15 | 15 | 9 | 41 | 22 | NA | NA |
| Cobalt | 1 | 1 | 20 | 20 | 20 | NA | NA |
| Copper | 15 | 15 | 13 | 103 | 47 | NA | NA |
| Iron | 1 | 1 | 44,100 | 44,100 | 44,100 | NA | NA |
| Lead | 15 | 15 | 3 | 576 | 165 | NA | NA |
| Magnesium | 1 | 1 | 7,010 | 7,010 | 7,010 | NA | NA |
| Manganese | 1 | 1 | 684 | 684 | 684 | NA | NA |
| Mercury | 15 | 13 | 0.02 | 0.18 | 0.09 | 0.02 U | 0.02 U |
| Nickel | 15 | 15 | 15 | 37 | 22 | NA | NA |
| Potassium | 1 | 1 | 1,410 | 1,410 | 1,410 | NA | NA |
| Selenium | 1 | 1 | 6 | 6 | 6 | NA | NA |
| Silver | 15 | 11 | 0.2 | 1.6 | 0.72 | 0.1 U | 0.1 U |
| Sodium | 1 | 1 | 1,230 | 1,230 | 1,230 | NA | NA |
| Thallium | 1 | 0 | ND | ND | ND | 5 U | 5 U |
| Vanadium | 1 | 1 | 106 | 106 | 106 | NA | NA |
| Zinc | 15 | 15 | 37 | 656 | 246 | NA | NA |
| **PAHs (ug/kg)** | | | | | | | |
| 2-Methylnaphthalene | 1 | 1 | 240 | 240 | 240 | NA | NA |
| 2-Nitroaniline | 1 | 0 | ND | ND | ND | 240 U | 240 U |
| 3,3-Dichlorobenzidine | 1 | 0 | ND | ND | ND | 240 U | 240 U |
| 3-Nitroaniline | 1 | 0 | ND | ND | ND | 290 U | 290 U |
| 4-Nitroaniline | 1 | 0 | ND | ND | ND | 240 U | 240 U |
| Acenaphthene | 19 | 3 | 30 | 2,200 | 913 | 20 U | 4,000 U |

Table 4-6
Summary of Slip 3 Subsurface Sediment Chemistry Data

| Compounds (a) | | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|---|
| Acenaphthylene | | 19 | 0 | ND | ND | ND | 20 U | 4,000 U |
| Anthracene | | 19 | 6 | 21 | 1,700 | 550 | 20 U | 4,000 U |
| Benzo(a)anthracene | | 19 | 17 | 190 | 20,000 | 6,334 | 20 U | 20 U |
| Benzo(a)pyrene | | 19 | 17 | 240 | 24,000 | 7,685 | 20 U | 20 U |
| Benzo(b)fluoranthene | | 19 | 17 | 180 | 21,000 | 6,430 | 20 U | 20 U |
| Benzo(b+k)fluoranthene | | 19 | 17 | 350 | 36,000 | 11,824 | 20 U | 20 U |
| Benzo(g,h,i)perylene | | 19 | 17 | 110 | 16,000 | 4,876 | 20 U | 20 U |
| Benzo(k)fluoranthene | | 19 | 17 | 170 | 17,000 | 5,394 | 20 U | 20 U |
| Carbazole | | 1 | 1 | 1,800 | 1,800 | 1,800 | NA | NA |
| Chrysene | | 19 | 17 | 190 | 20,000 | 6,369 | 20 U | 20 U |
| Dibenzo(a,h)anthracene | | 19 | 4 | 23 | 4,400 | 1,126 | 20 U | 4,000 U |
| Dibenzofuran | | 19 | 1 | 340 | 340 | 340 | 20 U | 4,000 U |
| Fluoranthene | | 19 | 17 | 350 | 28,000 | 8,929 | 20 U | 20 U |
| Fluorene | | 19 | 1 | 830 | 830 | 830 | 20 U | 4,000 U |
| Indeno(1,2,3-cd)pyrene | | 19 | 17 | 190 | 32,000 | 8,504 | 20 U | 20 U |
| Naphthalene | | 19 | 1 | 440 | 440 | 440 | 20 U | 4,000 U |
| Nitrobenzene | | 1 | 0 | ND | ND | ND | 48 U | 48 U |
| Total PAH | (d,e) | 19 | 17 | 1,481 | 124,000 | 40,925 | 20 U | 20 U |
| Total PAH reported | (f) | 19 | 17 | 2,181 | 208,000 | 66,115 | 20 U | 20 U |
| Total HPAH | (e,g) | 19 | 17 | 1,373 | 115,000 | 37,531 | 20 U | 20 U |
| Total HPAH reported | (f) | 19 | 17 | 2,073 | 198,000 | 62,735 | 20 U | 20 U |
| Total LPAH | (e.h) | 19 | 16 | 108 | 13,010 | 3,605 | 20 U | 4,000 U |
| Total LPAH reported | (f) | 19 | 16 | 108 | 12,770 | 3,590 | 20 U | 4,000 U |
| Phenanthrene | | 19 | 16 | 87 | 10,000 | 3,134 | 20 U | 4,000 U |
| Pyrene | | 19 | 17 | 320 | 24,000 | 7,949 | 20 U | 20 U |
| **Semivolatile Organic Compounds (ug/kg)** | | | | | | | | |
| 1,2,4-Trichlorobenzene | | 1 | 0 | ND | ND | ND | 48 U | 48 U |
| 1,2-Dichlorobenzene | | 19 | 0 | ND | ND | ND | 5 U | 48 U |
| 1,3-Dichlorobenzene | | 19 | 0 | ND | ND | ND | 5 U | 48 U |
| 1,4-Dichlorobenzene | | 19 | 0 | ND | ND | ND | 5 U | 48 U |
| 2,4,5-Trichlorophenol | | 1 | 0 | ND | ND | ND | 240 U | 240 U |

Table 4-6
Summary of Slip 3 Subsurface Sediment Chemistry Data

| Compounds (a) | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|
| 2,4,6-Trichlorophenol | 1 | 0 | ND | ND | ND | 240 U | 240 U |
| 2,4-Dichlorophenol | 1 | 0 | ND | ND | ND | 140 U | 140 U |
| 2,4-Dimethylphenol | 19 | 0 | ND | ND | ND | 6 U | 1,200 U |
| 2,4-Dinitrophenol | 1 | 0 | ND | ND | ND | 480 U | 480 U |
| 2,4-Dinitrotoluene | 1 | 0 | ND | ND | ND | 240 U | 240 U |
| 2-Chloronaphthalene | 1 | 0 | ND | ND | ND | 48 U | 48 U |
| 2-Chlorophenol | 1 | 0 | ND | ND | ND | 48 U | 48 U |
| 2-Methylphenol | 19 | 0 | ND | ND | ND | 6 U | 1,200 U |
| 2-Nitrophenol | 1 | 0 | ND | ND | ND | 240 U | 240 U |
| 4-Bromylphenyl phenyl ether | 1 | 0 | ND | ND | ND | 48 U | 48 U |
| 4-Chloro-3-methylphenol | 1 | 0 | ND | ND | ND | 96 U | 96 U |
| 4-Chloroaniline | 1 | 0 | ND | ND | ND | 140 U | 140 U |
| 4-Chlorophenyl phenyl ether | 1 | 0 | ND | ND | ND | 48 U | 48 U |
| 4-Methylphenol | 19 | 0 | ND | ND | ND | 20 U | 4,000 U |
| 4-Nitrophenol | 1 | 0 | ND | ND | ND | 240 U | 240 U |
| Benzoic acid | 19 | 0 | ND | ND | ND | 100 U | 20,000 U |
| Benzyl alcohol | 19 | 0 | ND | ND | ND | 6 U | 1,200 U |
| Bis(2-chloroethoxy)methane | 1 | 0 | ND | ND | ND | 48 U | 48 U |
| Bis(2-chloroethyl)ether | 1 | 0 | ND | ND | ND | 96 U | 96 U |
| Bis(2-ethylhexyl)phthalate | 19 | 3 | 36 | 420 | 212 | 20 U | 4,000 U |
| Butylbenzyl phthalate | 19 | 0 | ND | ND | ND | 20 U | 4,000 U |
| Di-n-octyl phthalate | 19 | 0 | ND | ND | ND | 20 U | 4,000 U |
| Di-n-butyl phthalate | 19 | 0 | ND | ND | ND | 20 U | 4,000 U |
| Diethyl phthalate | 19 | 0 | ND | ND | ND | 20 U | 4,000 U |
| Dimethyl phthalate | 19 | 0 | ND | ND | ND | 20 U | 4,000 U |
| Dinitro-o-cresol | 1 | 0 | ND | ND | ND | 480 U | 480 U |
| Hexachlorobutadiene | 19 | 0 | ND | ND | ND | 20 U | 4,000 U |
| Hexachloroethane | 1 | 0 | ND | ND | ND | 48 U | 48 U |
| N-nitrosodi-N-propylamine | 1 | 0 | ND | ND | ND | 96 U | 96 U |
| N-nitrosodiphenylamine | 19 | 0 | ND | ND | ND | 12 U | 2,400 U |
| Pentachlorophenol | 19 | 0 | ND | ND | ND | 60 U | 12,000 U |
| Phenol | 19 | 0 | ND | ND | ND | 20 U | 4,000 U |

Table 4-6
Summary of Slip 3 Subsurface Sediment Chemistry Data

| Compounds (a) | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|
| **Pesticides and PCBs (ug/kg)** | | | | | | | |
| Hexachlorobenzene | 19 | 0 | ND | ND | ND | 20 U | 4,000 U |
| Hexachlorocyclopentadiene | 1 | 0 | ND | ND | ND | 240 U | 240 U |
| Isophorone | 1 | 0 | ND | ND | ND | 48 U | 48 U |
| **Miscellaneous Organics (ug/kg)** | | | | | | | |
| 2,2'-Oxybis(1-chloropropane) | 1 | 0 | ND | ND | ND | 48 U | 48 U |
| 2,6-Dinitrotoluene | 1 | 0 | ND | ND | ND | 240 U | 240 U |
| Diesel | 3 | 0 | ND | ND | ND | 25,000 U | 100,000 U |
| Lube oil | 3 | 0 | ND | ND | ND | 100 U | 100 U |
| Pencil pitch | 16 | 16 | 21 | 2,300 | 703 | NA | NA |
| Phytane | 3 | 0 | ND | ND | ND | 500 U | 500 U |
| Pristance | 3 | 0 | ND | ND | ND | 500 U | 500 U |
| **Volatile Organic Compounds (ug/kg)** | | | | | | | |
| Benzene | 18 | 0 | ND | ND | ND | 5 U | 10 U |
| Ethylbenzene | 18 | 0 | ND | ND | ND | 5 U | 10 U |
| Tetrachloroethene | 18 | 0 | ND | ND | ND | 5 U | 10 U |
| Toluene | 18 | 0 | ND | ND | ND | 5 U | 10 U |
| Trichloroethene | 18 | 0 | ND | ND | ND | 5 U | 10 U |
| m,p-Xylene | 18 | 1 | 5 | 5 | 5 | 5 U | 10 U |
| o-Xylene | 18 | 0 | ND | ND | ND | 5 U | 10 U |

**Table 4-6**
**Summary of Slip 3 Subsurface Sediment Chemistry Data**

| Compounds (a) | | Number of Samples | Number of Detections | Minimum Detected Concentration | Maximum Detected Concentration | Average Detected Concentration (b) | Minimum Detection Limit (c) | Maximum Detection Limit (c) |
|---|---|---|---|---|---|---|---|---|
| **Conventionals** | | | | | | | | |
| Ammonia | (mg/kg) | 18 | 18 | 1.4 | 327 | 133 | NA | NA |
| Total Solids | (%) | 18 | 18 | 49 | 81 | 63 | NA | NA |
| Total Sulfide (S2) | (mg/kg) | 12 | 12 | 2 | 796 | 135 | NA | NA |
| Total Volatile Solids | (%) | 18 | 18 | 1.7 | 11 | 5.5 | NA | NA |
| Total Organic Carbon | (%) | 19 | 19 | 0.03 | 3.0 | 1.4 | NA | NA |

ND = All sample results were non-detect. There is no maximum, minimum, or average detected concentration.
NA = All sample results were detected. There is no maximum or minimum detection limit.
U = All results non-detect. Average concentration is average of detection limits.
a. Data from NOAA Query Manager 2.51 database for Terminal 4 of the Willamette River.
b. The average detected concentration calculation includes detected results only. Non-detect results are not included.
c. The maximum and minimum detection limits are for non-detect results only.
d. In the database, total PAH is the sum of total LPAH and total HPAH.
e. In the database, total concentrations were calculated using the detected values or the highest non-detect detection limit if all results were non-detect. If the highest non-detect detection limit was greater than the summed detected values, then the non-detect detection limit was used.
f. Total reported concentrations (total reported PAH, HPAH, and LPAH) were provided with the original study data.
g. Total HPAH is presented in the database and is the sum of benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, perylene, and pyrene.
h. Total LPAH is presented in the database and is the sum of acenaphthene, anthracene, biphenyl, naphthalene, 2,6-dimethylnaphthalene, fluorene, 1-methylnaphthalene, 2-methylnaphthalene, 1-methylphenanthrene, and phenanthrene.

**Table 4-7 - Summary of Sediment Bioassay Results - Amphipod Bioassay (Hyallela azteca)**
**Port of Portland, Terminal 4 - Slip 3**

| Sample Identification | Test Mean Mortality ($M_T$) in percent | Reference Mean Mortality ($M_R$) in percent | $M_T$-$M_R$ | P-Value | Single-Hit Criteria [1] ($M_T$ - $M_R$ > 15%) | Two-Hit Criteria [2] (significant diff. btwn $M_T$ and $M_R$) | Overall Result [3] |
|---|---|---|---|---|---|---|---|
| **PHASE 1** | | | | | | | |
| HC-S-26 | 7.5 | 1.3 | 6.2 | 0.04 | Pass | yes | **Pass** |
| HC-S-28 | 16.3 | 3.8 | 12.5 | 0.01 | Pass | yes | **Pass** |
| HC-S-35 | 5.0 | 3.8 | 1.2 | - | Pass | no | **Pass** |
| HC-S-36 | 3.8 | 1.3 | 2.5 | - | Pass | no | **Pass** |
| HC-S-39 | 6.3 | 3.8 | 2.5 | - | Pass | no | **Pass** |
| HC-S-42 | 7.5 | 3.8 | 3.7 | - | Pass | no | **Pass** |
| Ref B | 3.8 | - | - | - | - | - | - |
| Ref C | 1.3 | - | - | - | - | - | - |
| Neg. Control | 1.3 | - | - | - | - | - | - |
| **PHASE 2** | | | | | | | |
| HC-S-01 | 35.0 | 13.8 | 21.2 | 0.003 | Fail | yes | Fail |
| HC-S-04 | 37.5 | 13.8 | 23.7 | 0.002 | Fail | yes | Fail |
| HC-S-05 | 28.8 | 13.8 | 15 | 0.04 | Pass | yes | Fail |
| HC-S-07 | 20.0 | 13.8 | 6.2 | - | Pass | no | Fail |
| HC-S-11 | 18.8 | 13.8 | 5 | - | Pass | no | Pass |
| HC-S-16 | 27.5 | 13.8 | 13.7 | 0.04 | Pass | yes | Fail |
| HC-S-19 | 16.3 | 26.3 | -10 | - | Pass | no | Pass |
| HC-S-22 | 30.0 | 13.8 | 16.2 | 0.01 | Fail | yes | Fail |
| HC-S-24 | 33.8 | 26.3 | 7.5 | - | Pass | no | Pass |
| HC-S-30 | 12.5 | 26.3 | -13.8 | - | Pass | no | Pass |
| Ref B | 13.8 | - | - | - | - | - | - |
| Ref C | 26.3 | - | - | - | - | - | - |
| Neg. Control | 15.0 | - | - | - | - | - | - |

Source: Hart Crowser, 2000.

**Notes:**

[1] One Hit Required to Fail Bioassay

[2] Two Hits Required to Fail Bioassay

[3] A test fails if either of the following is true:

"Fail" of the single-hit criteria for the corresponding sample from any of the toxicity tests.

"Yes" for any two-hit criteria for the corresponding sample from any of the toxicity tests.

**Table 4-8 - Summary of Sediment Bioassay Results - Midge Acute Bioassay (Chironomus tentans)**
**Port of Portland, Terminal 4 - Slip 3**

| Sample Identification | Test Mean Mortality ($M_T$) in percent | Reference Mean Mortality ($M_R$) in percent | $M_T$-$M_R$ | P-Value | Single-Hit Criteria [1] ($M_T$ - $M_R$ > 20%) | Two-Hit Criteria [2] (significant diff. btwn $M_T$ and $M_R$) | Overall Result [3] |
|---|---|---|---|---|---|---|---|
| **PHASE 1** | | | | | | | |
| HC-S-26 | 27.5 | 20.0 | 7.5 | - | Pass | no | **Pass** |
| HC-S-28 | 40.0 | 28.8 | 11.2 | - | Pass | no | **Pass** |
| HC-S-35 | 35.0 | 28.8 | 6.2 | - | Pass | no | **Pass** |
| HC-S-36 | 26.3 | 20.0 | 6.3 | - | Pass | no | **Pass** |
| HC-S-39 | 41.3 | 28.8 | 12.5 | 0.03 | Pass | yes | **Pass** |
| HC-S-42 | 28.8 | 28.8 | 0 | - | Pass | no | **Pass** |
| Ref B | 28.8 | - | - | - | - | - | - |
| Ref C | 20.0 | - | - | - | - | - | - |
| Neg. Control | 15.0 | - | - | - | - | - | - |
| **PHASE 2** | | | | | | | |
| HC-S-01 | 47.5 | 12.5 | 35 | 0.00001 | Fail | yes | Fail |
| HC-S-04 | 30.0 | 12.5 | 17.5 | 0.03 | Pass | yes | Fail |
| HC-S-05 | 31.3 | 12.5 | 18.8 | 0.04 | Pass | yes | Fail |
| HC-S-07 | 25.0 | 12.5 | 12.5 | - | Pass | no | Fail |
| HC-S-11 | 26.3 | 12.5 | 13.8 | - | Pass | no | Pass |
| HC-S-16 | 17.5 | 12.5 | 5 | - | Pass | no | Fail |
| HC-S-19 | 12.5 | 21.3 | -8.8 | - | Pass | no | Pass |
| HC-S-22 | 33.8 | 12.5 | 21.3 | 0.007 | Fail | yes | Fail |
| HC-S-24 | 30.0 | 21.3 | 8.7 | - | Pass | no | Pass |
| HC-S-30 | 8.6 | 21.3 | -12.7 | - | Pass | no | Pass |
| Ref B | 12.5 | - | - | - | - | - | - |
| Ref C | 21.3 | - | - | - | - | - | - |
| Neg. Control | 3.8 | - | - | - | - | - | - |

Source: Hart Crowser, 2000.

**Notes:**

[1] One Hit Required to Fail Bioassay

[2] Two Hits Required to Fail Bioassay

[3] A test fails if either of the following is true:

"Fail" of the single-hit criteria for the corresponding sample from any of the toxicity tests.

"Yes" for any two-hit criteria for the corresponding sample from any of the toxicity tests.

**Table 4-9 - Summary of Sediment Bioassay Results - Midge Chronic Bioassay (Chironomus tentans)**
**Port of Portland, Terminal 4 - Slip 3**

| Sample Identification | Test Mean Individual Biomass ($B_T$) in mg | Reference Mean Individual Biomass ($B_R$) in mg | $B_T/B_R$*100 | P-Value | Single-Hit Criteria [1] ($B_T/B_R$ < 60%) | Two-Hit Criteria [2] (significant diff btwn $B_T$ and $B_R$) | Overall Result [3] |
|---|---|---|---|---|---|---|---|
| **PHASE 1** | | | | | | | |
| HC-S-26 | 2 01 | 1 73 | 116 2 | - | Pass | no | **Pass** |
| HC-S-28 | 1 32 | 1 60 | 82 5 | - | Pass | no | **Pass** |
| HC-S-35 | 1 71 | 1 60 | 106 9 | - | Pass | no | **Pass** |
| HC-S-36 | 1 50 | 1 73 | 86 7 | - | Pass | no | **Pass** |
| HC-S-39 | 1 64 | 1 60 | 102 5 | - | Pass | no | **Pass** |
| HC-S-42 | 1 46 | 1 60 | 91 3 | - | Pass | no | **Pass** |
| Ref B | 1 60 | - | - | - | - | - | - |
| Ref C | 1 73 | - | - | - | - | - | - |
| Neg Control | 1 69 | - | - | - | - | - | - |
| **PHASE 2** | | | | | | | |
| HC-S-01 | 0 19 | 1 15 | 16 5 | 0 00002 | Fail | yes | Fail |
| HC-S-04 | 0 37 | 1 15 | 32 2 | 0 00001 | Fail | yes | Fail |
| HC-S-05 | 0 51 | 1 15 | 44 3 | 0 00002 | Fail | yes | Fail |
| HC-S-07 | 0 59 | 1 15 | 51 3 | 0 0003 | Fail | yes | Fail |
| HC-S-11 | 0 81 | 1 15 | 70 4 | 0 009 | Pass | yes | Pass |
| HC-S-16 | 0 74 | 1 15 | 64 3 | 0 002 | Pass | yes | Fail |
| HC-S-19 | 1 09 | 1 37 | 79 6 | - | Pass | no | Pass |
| HC-S-22 | 1 02 | 1 15 | 88 7 | - | Pass | no | Fail |
| HC-S-24 | 0 96 | 1 37 | 70 1 | 0 08 | Pass | yes | Pass |
| HC-S-30 | 0 95 | 1 37 | 69 3 | 0 01 | Pass | yes | Pass |
| Ref B | 1 15 | - | - | - | - | - | - |
| Ref C | 1 37 | - | - | - | - | - | - |
| Neg Control | 1 46 | - | - | - | - | - | - |

Source Hart Crowser, 2000

**Notes:**

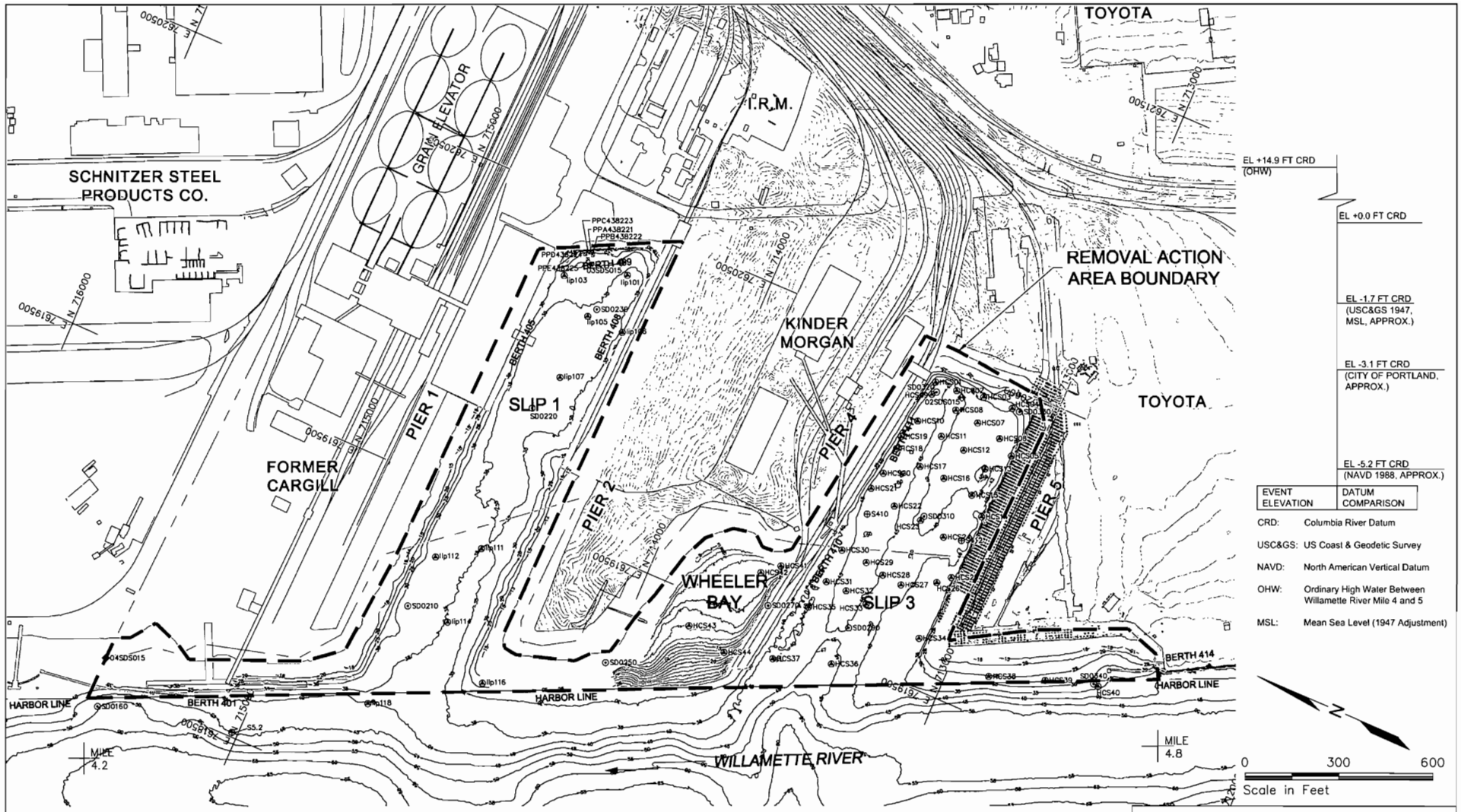
[1] One Hit Required to Fail Bioassay

[2] Two Hits Required to Fail Bioassay

[3] A test fails if either of the following is true

"Fail" of the single-hit criteria for the corresponding sample from any of the toxicity tests

"Yes" for any two-hit criteria for the corresponding sample from any of the toxicity tests




| EVENT ELEVATION | DATUM COMPARISON |
|---|---|
| CRD: | Columbia River Datum |
| USC&GS: | US Coast & Geodetic Survey |
| NAVD: | North American Vertical Datum |
| OHW: | Ordinary High Water Between Willamette River Mile 4 and 5 |
| MSL: | Mean Sea Level (1947 Adjustment) |

Existing Piers

Existing Surface Sediment Sample Location by Others

| | |
|---|---|
| SDS015 | Round 1 Portland Harbor Data |
| HCS43 | RI Report (Hart Crowser, 2000) |
| PPA438221 | Storm Water Report (Hartman Associates/Fishman Environmental Services, 1995) |
| SD0220 | Portland Harbor Sediment Investigation (Roy F. Weston, Inc., 1998) |
| S412 | Willamette Sediment Report (USACE, 1987b) |

Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.

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TERMINAL 4 EARLY ACTION WORK PLAN

EXISTING SURFACE SEDIMENT SAMPLE LOCATIONS

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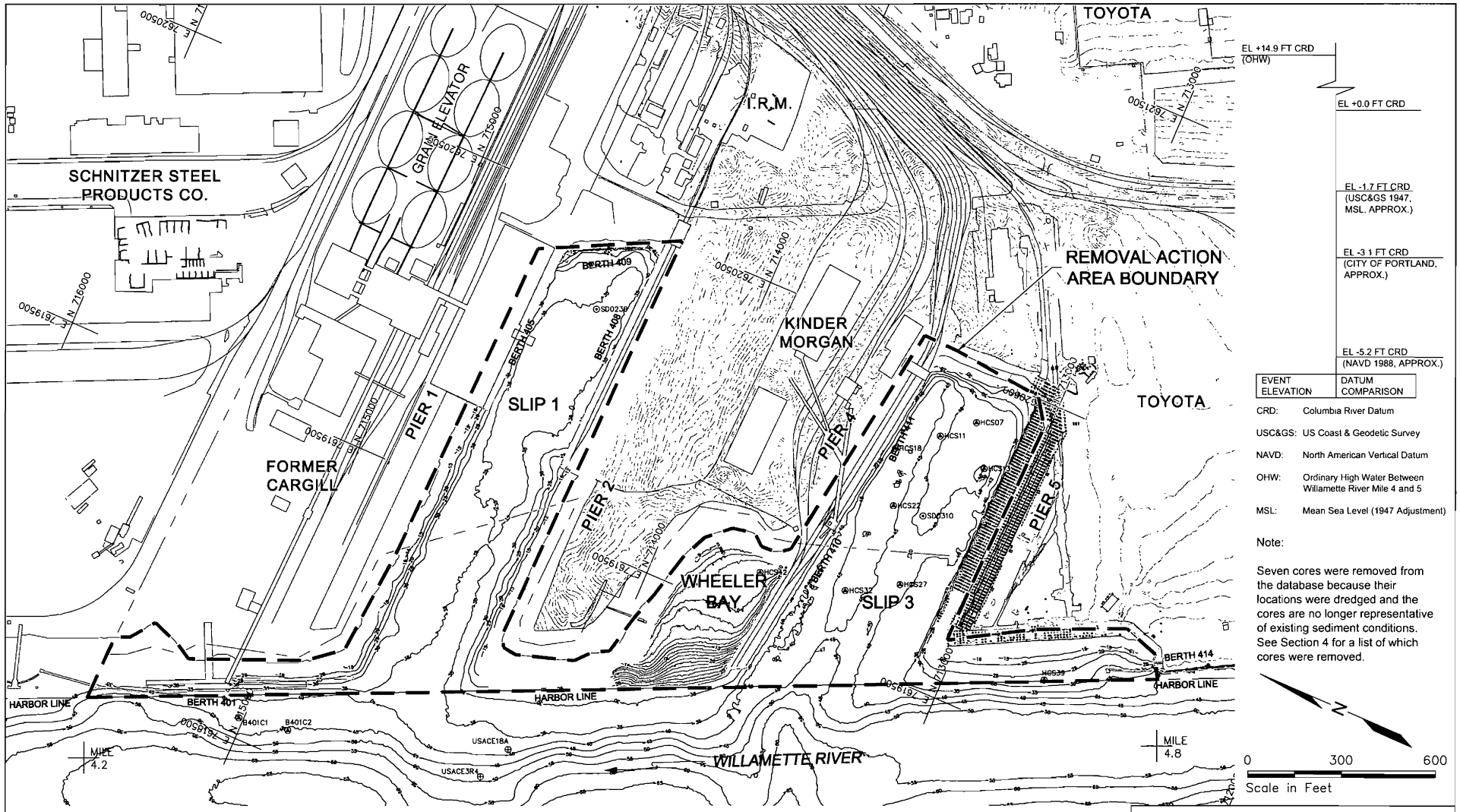
FIGURE 4-1

DWG NAME: G:\project\Clients\BBL\Terminal 4\t4_002.dwg
DATE: 02/18/04 12:21pm




| EVENT ELEVATION | DATUM COMPARISON |
|---|---|
| CRD: | Columbia River Datum |
| USC&GS: | US Coast & Geodetic Survey |
| NAVD: | North American Vertical Datum |
| OHW: | Ordinary High Water Between Willamette River Mile 4 and 5 |
| MSL: | Mean Sea Level (1947 Adjustment) |

Note:

Seven cores were removed from the database because their locations were dredged and the cores are no longer representative of existing sediment conditions. See Section 4 for a list of which cores were removed.

Existing Piers

Existing Subsurface Sediment Sample Location by Others

| | |
|---|---|
| HCS07 | Sediment Characterization Study and RI Report (Hart Crowser, 1999, 2000) |
| SD0230 | Portland Harbor Sediment Investigation (Roy F. Weston, Inc., 1998) |
| USACE18A | Willamette River Raw Data (USACE, 1988) |

Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.

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EXISTING SEDIMENT CORE SAMPLE LOCATIONS

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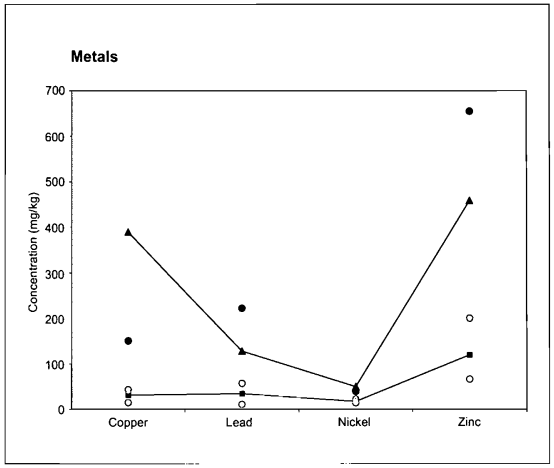
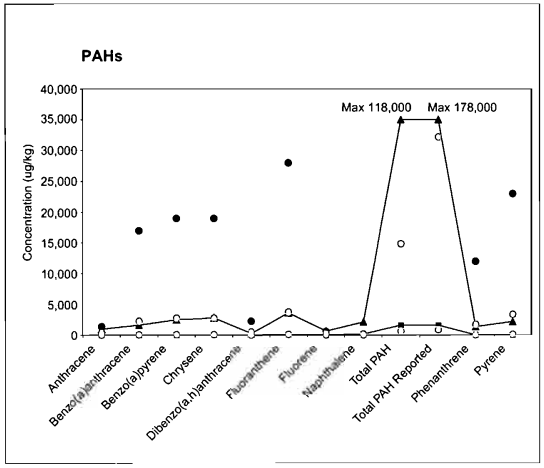
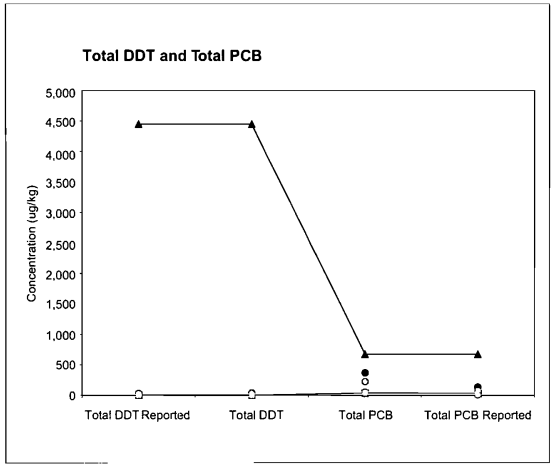
FIGURE 4-2

DWG NAME: G:\project\Clients\BBL\Terminal 4\t4_002.dwg
DATE: 02/18/04 12:21pm

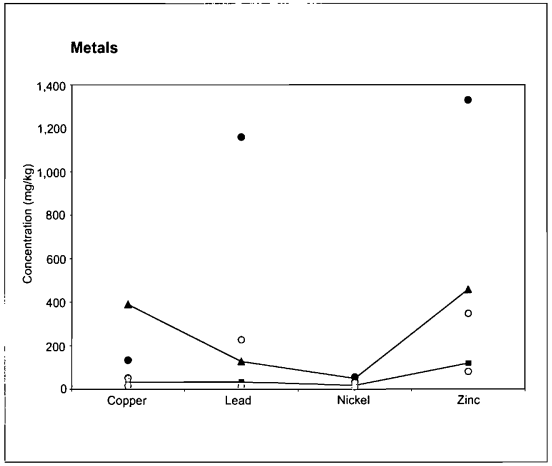
## Slip1 and Berth 401

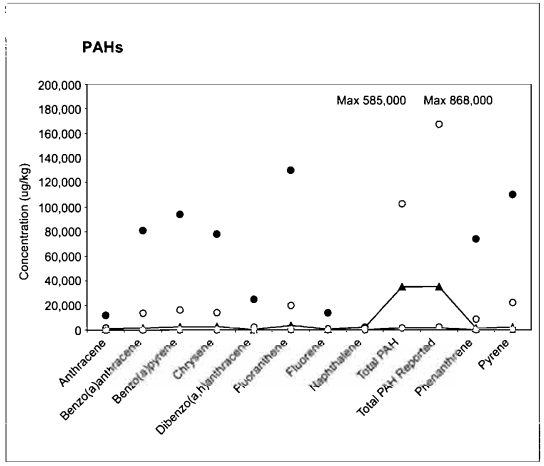


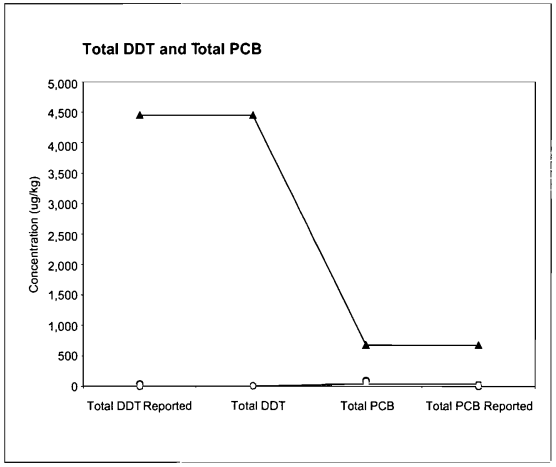




## Slip 3, Wheeler Bay, and Berth 414




## Key

- Lowest Sediment Quality Guideline
- Highest Sediment Quality Guideline
- Minimum Detected Concentration
- Maximum Detected Concentration
- Average Detection Concentration

Note: Minimum, average, and maximum surface sediment data were compared to a number of sediment quality guidelines to evaluate which areas of the removal action area require remediation. Section 4 of the text discusses which sediment quality guidelines were used. Section 4 also presents a summary of surface sediment data. The number of sediment samples for Slip 1 ranges from about 13 to 25 and for Slip 3 from approximately 33 to 41 The maximum detected concentrations for total PAH and total PAH reported in Slip 1 and Slip 3 are printed in text on the graph. These concentrations were not plotted on the PAH graphs because they fall outside of the range shown on the graphs.

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COMPARISON OF
SURFACE SEDIMENT RESULTS TO
SEDIMENT QUALITY GUIDELINES

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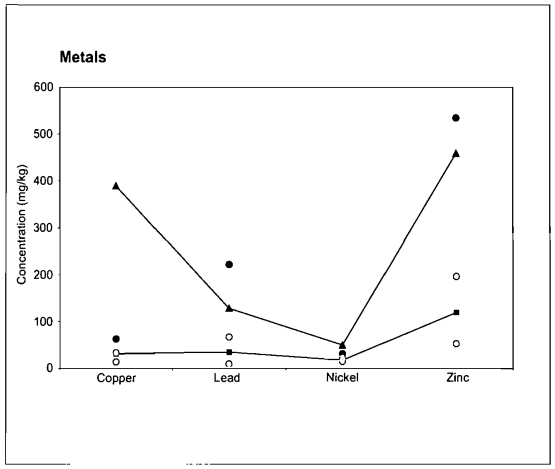
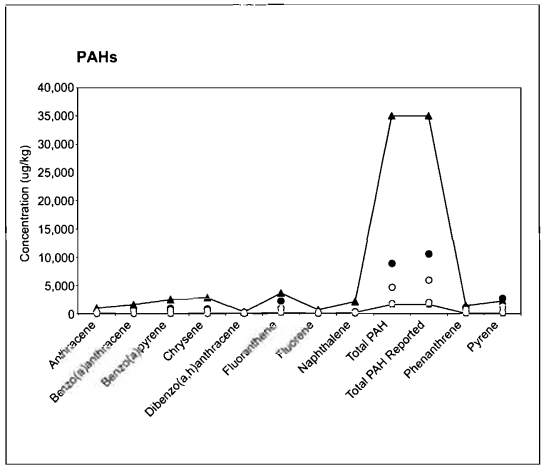
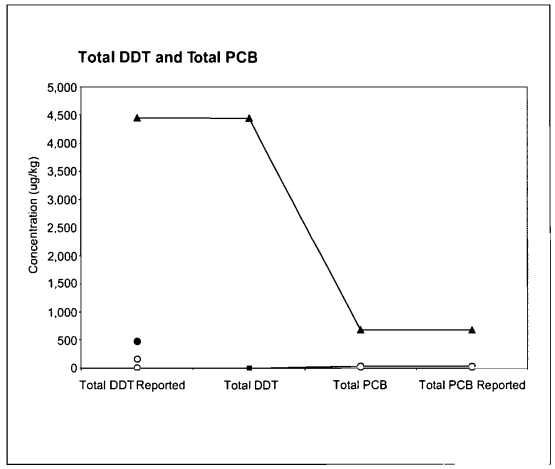
FIGURE
4-3

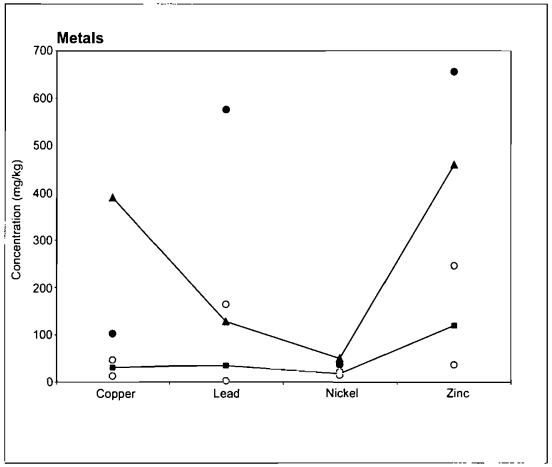
## Slip1 and Berth 401

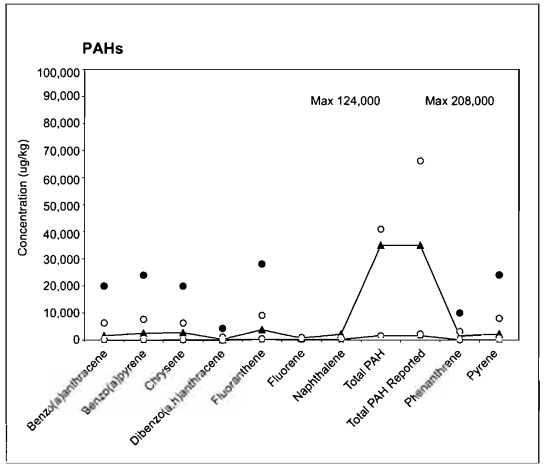



## Slip 3, Wheeler Bay, and Berth 414




## Key

- Lowest Sediment Quality Guideline
- Highest Sediment Quality Guideline
- Minimum Detected Concentration
- Maximum Detected Concentration
- Average Detection Concentration

Note: Minimum, average, and maximum subsurface sediment data were compared to a number of sediment quality guidelines to evaluate which areas of the removal action area require remediation. Section 4 of the text discusses which sediment quality guidelines were used. Section 4 also presents a summary of subsurface sediment data. The number of sediment samples for Slip 1 ranges from 3 to 4 and for Slip 3 from 15 to 19. The maximum detected concentrations for total PAH and total PAH reported in Slip 3 are printed in text on the graph. These concentrations were not plotted on the PAH graph because they fall outside of the range shown on the graph.

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COMPARISON OF
SUBSURFACE SEDIMENT RESULTS TO
SEDIMENT QUALITY GUIDELINES

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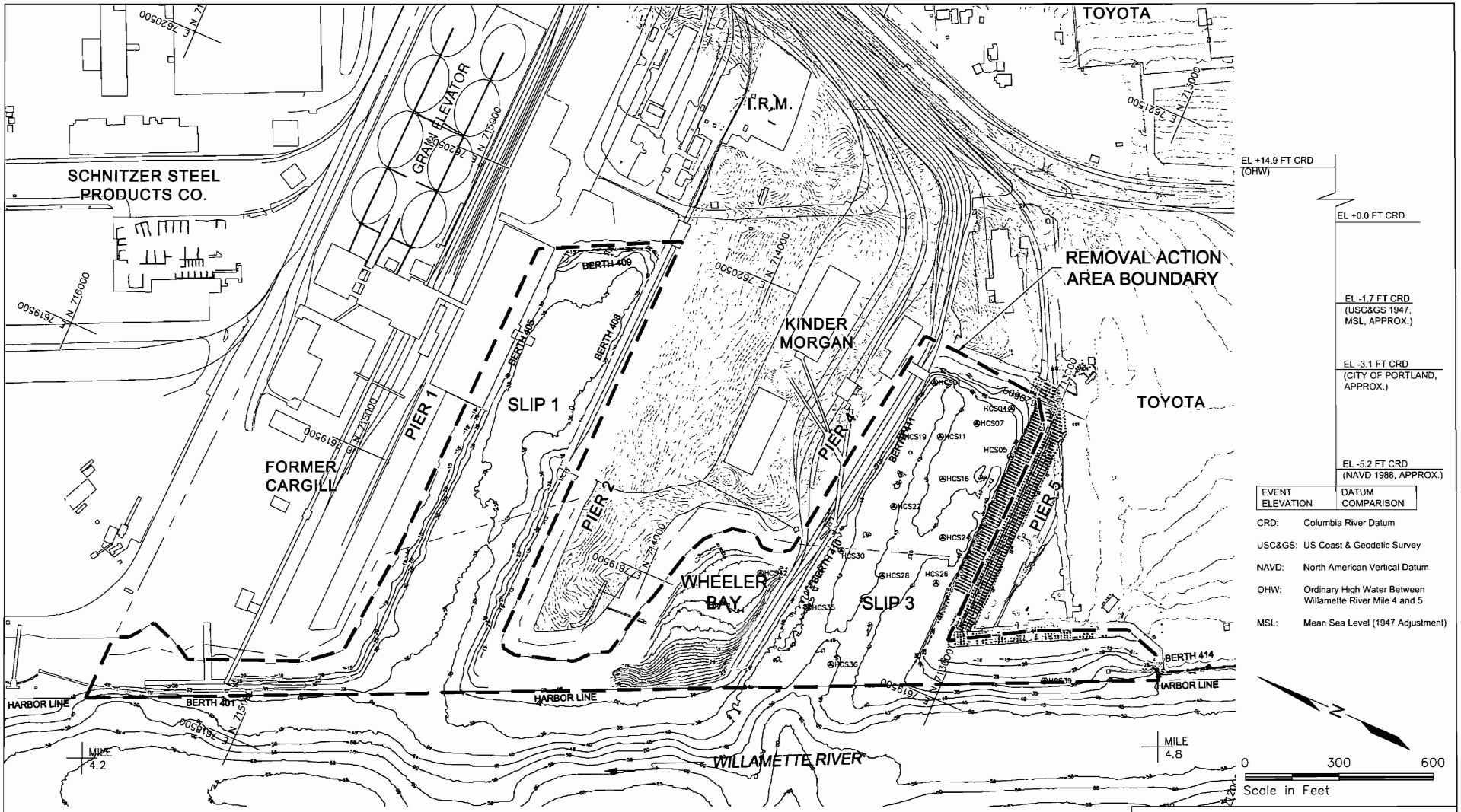
FIGURE
4-4




| EVENT ELEVATION | DATUM COMPARISON |
|---|---|
| CRD: | Columbia River Datum |
| USC&GS: | US Coast & Geodetic Survey |
| NAVD: | North American Vertical Datum |
| OHW: | Ordinary High Water Between Willamette River Mile 4 and 5 |
| MSL: | Mean Sea Level (1947 Adjustment) |

Existing Bioassay Sample Location

Existing Piers

⊕HCS01 RI Report (Hart Crowser, 2000)

Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.

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EXISTING BIOASSAY SAMPLE LOCATIONS

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FIGURE 4-5

DWG NAME: G:\project\Clients\BBL\Terminal 4\14_013.dwg
DATE: 02/18/04 12:24pm

Section 5

# 5. Preliminary Conceptual Model of the Removal Action Area

The existing sediment quality data were evaluated in concert with the ownership and operations chronology (see Section 2.2.3) and the information about known historical and potential ongoing sources (see Section 3) in order to create a preliminary model of the general relationship between the sources and contaminated sediment in Terminal 4. The discussion of sources that follows is broken into primary and secondary sources and is organized by slip. For this discussion, Slip 1 includes Slip 1 and Berth 401 and Slip 3 includes Slip 3, Wheeler Bay, and Berth 414.

Constituents of potential concern in the Removal Action Area sediment are metals, PAHs, phthalates, tDDT, tPCBs and petroleum hydrocarbons. Although other constituents, such as VOCs and butyltins, were occasionally detected in the Removal Action Area sediment, they tend to be detected infrequently and at concentrations near the detection limit (see Section 4). For that reason, the discussion of primary and secondary sources of contamination focuses on metals, PAHs, phthalates, tDDT, and tPCBs. TPH will be dealt with by individual PAH compounds.

Based on the ownership and operations history, the known physical configuration of Terminal 4, and the existing human use and ecology of the Removal Action Area, a preliminary conceptual model was developed to establish the potential linkages between known and suspected sources of contamination (see Section 3), transport mechanisms, and receptors. A pictorial representation of this preliminary conceptual model is provided on Figure 5-1.

The following discussion refers to contaminant sources and transport with respect to the in-water portion of Terminal 4 only (Removal Action Area). This perspective is necessary to focus the EE/CA on sediments, sources of contamination to the sediments, and the environmental consequences that result from sediment contamination in the Removal Action Area. In some cases, exposures may result from multiple primary or secondary sources of contamination. For example, exposure of some receptors at Terminal 4 may be affected by contaminated sediments when sediments are resuspended by propeller scour or other forces. Sediment removal would alleviate this source of adverse effect on surface water quality. However, these receptors may also be affected by other sources, including stormwater, direct spills from over-water operations, and influx of contaminated groundwater. Sediment removal in the Removal Action Area would not address exposures from such sources.

Other sources of contamination are being addressed through separate programs, such as the Upland Source Control Projects for Terminal 4 under DEQ agreements, stormwater assessment and management programs, and voluntary cleanup agreements with the DEQ. In addition, offsite sources in the Willamette River are being addressed through the Portland Harbor Superfund Site remedial investigation/feasibility study, which is providing comprehensive ecological and human health risk assessments for the river in Portland Harbor and, when completed, will result in a USEPA-sponsored plan to remediate sediments and manage risks. Figure 5-2 presents a comprehensive conceptual model for the Terminal 4 Removal Action Area. The color coding of sources and transport pathways on Figure 5-2 identifies the general programs by which various aspects are being addressed.

## 5.1 Primary Sources of Contamination

In the context of the EE/CA, primary sources of contamination are original sources from which contaminants are or were released into the environment. Each primary source is associated with a primary release mechanism by which contaminants enter the environment. Primary sources and release mechanisms include spills from ship loading and unloading, spills and leaks from historical upland operations that reach the river at Terminal 4 through runoff or leaching, leaks from petroleum storage tanks or pipelines that enter groundwater, and the range of contamination sources to the Willamette River outside the Removal Action Area.

### 5.1.1 Slip 1 Sediment

Possible primary sources of metals to Slip 1 sediment include historic spills associated with ore handling at Slip 1 and spills and releases from upland activities that drained into Slip 1 through stormwater outfalls located at the east end of Slip 1. Ore and concentrate handling occurred in the southeast area of Slip 1, including at Berth 408, from approximately 1955 to 1971. Ores that were handled at Terminal 4 include alumina bauxite; chrome ore; ferrophosphorous iron ore; and copper, lead, manganese, nickel, silver, and zinc concentrate. Surface sediment concentrations of cadmium, chromium, copper, lead, and zinc decrease from east to west. Lead concentrations in subsurface sediment tend to be greater than in surface sediment, suggesting that the source of lead to Slip 1 is historical, not ongoing.

The primary sources of phthalates, tDDT, and tPCBs to Slip 1 sediment have not been specifically identified. However, phthalates are often associated with stormwater outfalls; tDDT has multiple sources in the area, including historical application and manufacturing; and tPCB sources are abundant in the industrialized corridor.

### 5.1.2 Slip 3 Sediment

Possible primary sources of metals to Slip 3 sediment include historic spills associated with ore handling at Slip 3 and spills and releases from upland activities that drained into Slip 3 through stormwater outfalls located at the east end of Slip 3. Ore and concentrate handling occurred in the southern portion of Slip 3 from approximately 1921 to 1961. From approximately 1961 to 1988, ore handling occurred at Berths 410 and 411. Ores that were handled at Terminal 4 include alumina bauxite; chrome ore; ferrophosphorous iron ore; and copper, lead, manganese, nickel, silver, and zinc concentrate. Surface sediment concentrations of cadmium, copper, lead, and zinc decrease from east to west. Lead and zinc concentrations in subsurface sediment are generally greater than in surface sediment, suggesting that the source of lead and zinc to Slip 3 is historical, not ongoing.

Possible primary sources of PAHs to Slip 3 sediment include the activities associated with petroleum product and pencil pitch handling at Terminal 4, as well as upstream sources in the Willamette River. Petroleum-related activities at Slip 3 included the oil-supply dock, St. Johns Tank Farm, the Union Pacific pipeline, Quaker State operations, the auxiliary oil pipeline, waste oil USTs, and diesel and gasoline USTs. Pencil pitch handling at Terminal 4 occurred from approximately 1978 to 1998, generally at Berth 411. Spills of oils and pencil pitch have been documented. Possible sources to the Willamette River outside Terminal 4 include the McCormick and Baxter Superfund Site, Gasco, Arco, Mobil, and general urban stormwater runoff. These primary sources affect the sediments in Terminal 4 through secondary sources and transport. PAH concentrations in surface sediment generally decrease from east to west.

The primary sources of phthalates, tDDT, and tPCBs to Slip 3 sediment are the same as those cited for Slip 1.

## 5.2 Secondary Sources of Contamination

Secondary sources of contamination are generally environmental media that have become contaminated as a result of transport from upgradient sources and that then serve as secondary reservoirs for further release and transport or as exposure points. Examples of secondary sources and associated release mechanisms include contaminated groundwater that slowly discharges a contaminant load to surface water or sediment, upland surfaces such as parking lots or soils that release contaminants through stormwater runoff, deposition of suspended sediment from offsite sources, including the Willamette River, and sediment resuspension within Terminal 4.

### 5.2.1 Slip 1 Sediment

Possible secondary sources of metals to Slip 1 sediment include offsite, in-river sources. The trend of decreasing (from east to west) surface sediment concentrations of cadmium, chromium, copper, lead, and zinc supports the possibility that stormwater outfalls caused metals to contaminate Slip 1 sediments. As noted in Section 2.8, depositional patterns at the head of the slip appear to be typical of outfalls. In addition, the head (east end) of the slip is likely a lower-energy environment than the mouth of the slip, which is probably a higher-energy environment because of river flow and ship wake. Particulates could preferentially settle out of the water column in a lower-energy environment.

Potential secondary sources of PAHs to Slip 1 sediment include groundwater transport, stormwater, and offsite, in-river sources. Groundwater may become contaminated by migrating through soil contaminated with petroleum hydrocarbons. The contaminated groundwater may then migrate through the sediment and contaminate the sediment prior to discharging to the surface water. Stormwater may become contaminated as it encountered spilled or residual materials on the pavement surface before draining to catch basins and flowing to the Removal Action Area. Offsite releases of phthalates, tDDT, and tPCBs have resulted in contamination of sediment in the Willamette River. These sediments act as a secondary source to Slip 1 when resuspended, transported to the slip, and deposited.

### 5.2.2 Slip 3 Sediment

Possible secondary sources of metals to Slip 3 sediment include offsite, in-river sources. As in the case of Slip 1, depositional patterns appear to be influenced by sedimentation from current and historical outfalls. Deposition of sediment resulting from flow into the slip from the river is also likely.

Potential secondary sources of PAHs to Slip 3 sediment include groundwater transport, stormwater, and in-river sources. Groundwater may become contaminated by migrating through soil contaminated with petroleum hydrocarbons. The contaminated groundwater may then migrate through the sediment and contaminate the sediment prior to discharging directly to the surface water (i.e., below the waterline or through seeps that discharge onto the ground surface and flow into the water). Stormwater may become contaminated as it encountered spilled or residual materials on the pavement surface before draining to catch basins and flowing to the Removal Action Area. Offsite releases of phthalates, tDDT, and tPCBs have resulted in contamination of sediment in the Willamette River. These sediments act as a secondary source to Slip 1 when resuspended, transported to the slip, and deposited.

No existing data were located for under-pier sediment. It is unknown whether sediment contamination is present under the piers.

## 5.3 Pathways and Receptors

The focus of the EE/CA is on sediments and the exposures and risks that may result from direct or indirect contact with sediment contaminants. Sources of contamination to groundwater and surface water, and any associated exposure risks not associated with sediments, are being addressed through other activities or orders, such as those described in Sections 1, 2.2 and 3.3.1.

Exposure pathways describe the mechanisms by which a receptor becomes exposed to contaminants. At a minimum, a "complete" exposure pathway must include a source, a release mechanism, and a transport pathway (route of exposure) to the receptor. If any component is missing, the exposure pathway is likely to be incomplete. The sources, release mechanisms, and transport pathways have been described above. The following discussion identifies the exposure pathways and the receptors that may be exposed to sediment-related contaminants in the Removal Action Area. In this discussion, "sediment" is used to refer to both the solid and liquid (porewater) components of bulk sediment.

### 5.3.1 Relevant Exposure Pathways and Receptors

For human and ecological receptors, exposure to sediment contaminants may be direct or indirect. Direct exposure results from contact with contaminated sediment. Indirect exposure results from contact with contaminants that have been transferred from sediments to another exposure medium, such as water or biota.

Relevant direct exposure pathways include:

- contact between receptors' external surfaces and contaminated bed sediment, including porewater;
- ingestion of contaminated sediment by receptors, either incidentally during drinking or eating or as part of the feeding process (e.g., filter feeders); and
- contact between the receptor and resuspended sediment (e.g., ventilation of gill surfaces).

Relevant indirect exposure pathways include:

- ingestion of food that has become contaminated through contact with sediment contaminants; and
- ingestion of or contact with surface water that has become contaminated through the transfer of contaminants into the dissolved or colloidal phases.

For humans and avian/mammalian wildlife, exposure to contaminants via dermal contact with sediments is typically considered minor compared to the ingestion pathways. However, external contact with sediment (including porewater) can be important for fish and aquatic invertebrates. Figure 5-2 illustrates the exposure pathways, as well as representative ecological receptors and human receptor types.

Bioconcentration and biomagnification are processes that affect exposure, especially in aquatic-based foodwebs. Bioconcentration is the increase in concentration of a chemical in an organism resulting from tissue absorption levels exceeding the rate of metabolism and excretion. Metals and organic compounds may bioconcentrate. Biomagnification occurs when concentrations of a chemical in biota increase with successive trophic levels. Biomagnification is best known with regard to persistent organic chemicals such as DDT and PCBs, but can also occur for organically transformed metals.

As noted previously, the focus of the Terminal 4 Removal Action is in-water contaminated sediment. Therefore, the risk analysis for Terminal 4 will focus on pathways related to the effect that contaminated sediment may have on other media, such as surface water and biota. Other exposure pathways are being addressed under other regulatory programs. Exposure to beach sediment and potential exposure to shorebirds are being addressed in the harborwide RI/FS baseline risk assessment. Likewise, exposure to surface water that may have been contaminated by pathways other than Terminal 4 contaminated sediment is also being addressed for humans and ecological receptors in the harborwide RI/FS.

#### 5.3.1.1 Human Receptors

Human receptors potentially exposed at the site include (1) persons who fish in Terminal 4 and consume the fish that they catch and (2) persons engaged in activities during which they may contact sediments or surface water affected by sediments in Terminal 4. Specific receptor groups for which risk analysis will be conducted will be identified after the identification of Removal Action alternatives. Such receptor groups will probably include dockside workers and fishers/consumers (including recreational fishers, Native American fishers, and non-tribal fishers). Dockside workers could be exposed to in-water sediment-related contaminants if they contact contaminated sediment during work activities. Fishers of any group could be exposed to contaminants if they ingest fish that have absorbed contaminants from the sediment, as well as by contact with the sediment during fishing activities.

Currently, fishing exposures are assumed to occur aboard boats because federally mandated security measures for shipping ports prohibit access to the Terminal 4 shoreline and because the Port anticipates marine use of Terminal 4 for the foreseeable future. If land use of Terminal 4 changes in the future, additional risk analysis may be required, such as analysis of exposure to beach and nearshore sediment by fishers, transients or other waterfront users.

#### 5.3.1.2 Ecological Receptors

Ecological receptors potentially exposed to sediment contaminants in the Removal Action Area are listed below. The list generally follows that developed for the Portland Harbor remedial investigation/feasibility study for the entire Lower Willamette River. Because of limited habitat quality, especially in the upland adjacent to the Removal Action Area, not all of the receptor types listed here are necessarily represented in the Removal Action Area or immediate vicinity. However, the list is provided to identify the scope of species that may occur at the Removal Action Area or in the Willamette River near the Removal Action Area.

- Benthic Infauna and Epibenthic Organisms. These receptors are in intimate contact with bed sediment. Many species of infauna are also filter feeders or otherwise process sediment during feeding.

- Benthic Fish. Fish such as sculpin, catfish, and sturgeon often reside on or near the river bottom, have direct contact with sediment, and may ingest sediment as they forage. Larval lamprey (i.e., ammocoetes) live in the sediments and filter food from ingested sediments. The presence of ammocoetes has not been confirmed in Portland Harbor, but, if present, the larvae would be exposed to contaminated sediment.

- Water-Column Fish. Fish such as smallmouth bass, northern pikeminnow, and juvenile salmonids feed in the water column and so have little contact with bed sediment, but may ingest contaminated food items.

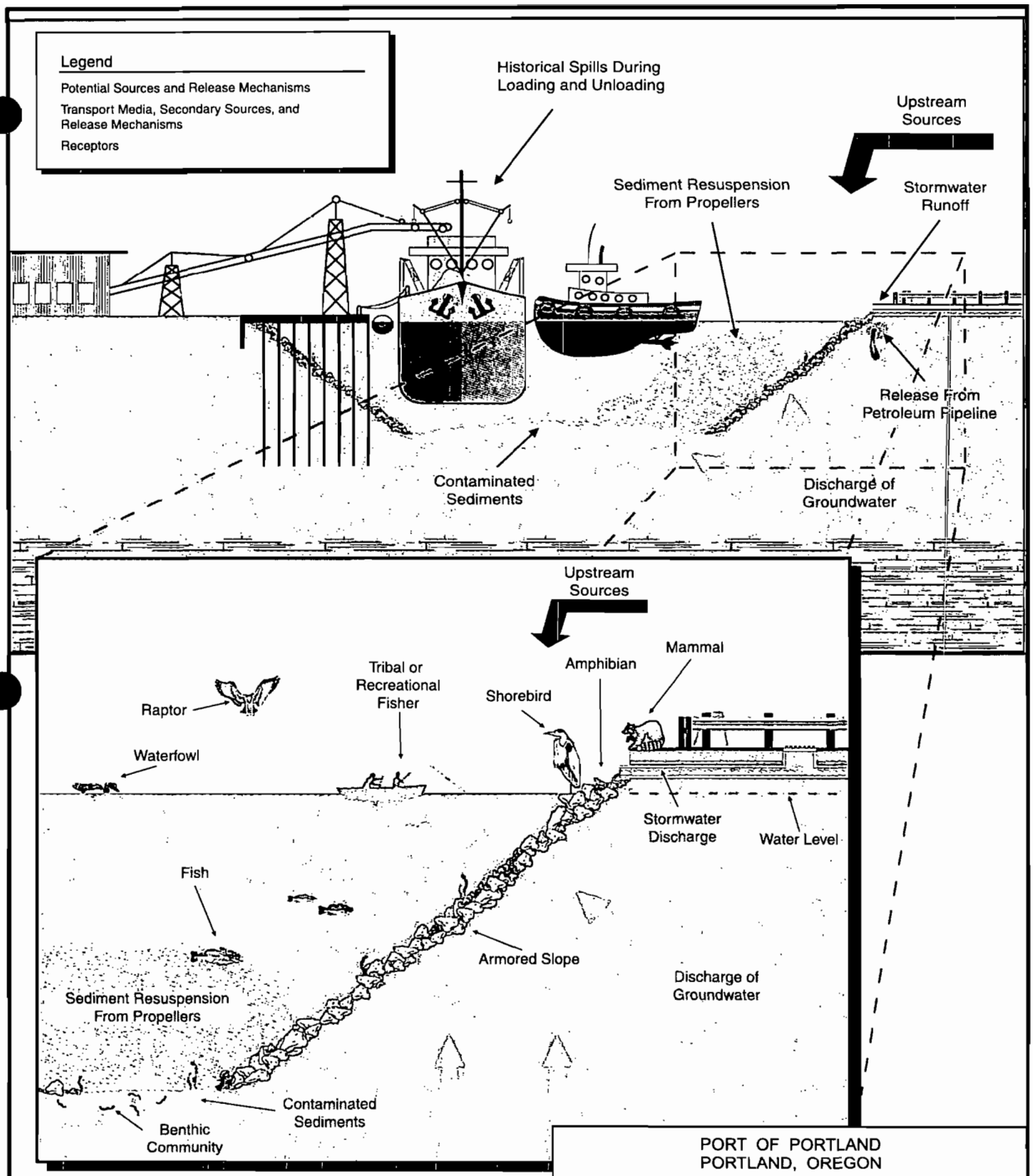
- Amphibians. Amphibians may deposit eggs on or near sediments, and adults often burrow into sediments or live in direct contact with sediments. Adults and larvae may also ingest sediments as they feed on vegetation or prey.

- Waterfowl. Waterfowl include several feeding guilds that may have contact with contaminated sediments as a result of feeding. Dabbling ducks such as mallards may be directly exposed through incidental ingestion of sediment and indirectly exposed through ingestion of contaminated prey or vegetation during feeding. Diving ducks such as mergansers may be directly exposed through incidental ingestion of sediment and indirectly exposed through ingestion of fish or amphibians that have become contaminated.

- Wading Birds. Sandpipers and related wading birds may directly ingest sediment as they probe beaches and shallow sediment for invertebrates. They may be indirectly exposed through ingestion of contaminated prey species.

- Raptors. Aquatic-feeding raptors such as osprey and bald eagles may be indirectly exposed as they ingest contaminated fish from the water column. Direct exposure through ingestion of contaminated sediments by such species is limited to the sediment contained in the gastrointestinal tract of the prey species.

- Aquatic-Feeding Mammals. Raccoons, muskrats, and river otters are examples of mammals that feed on fish, invertebrates, and amphibians from aquatic habitats. Such receptors may be indirectly exposed through ingestion of contaminated prey and directly exposed through incidental ingestion of sediments.

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# PICTORIAL CONCEPTUAL MODEL OF REMOVAL ACTION AREA

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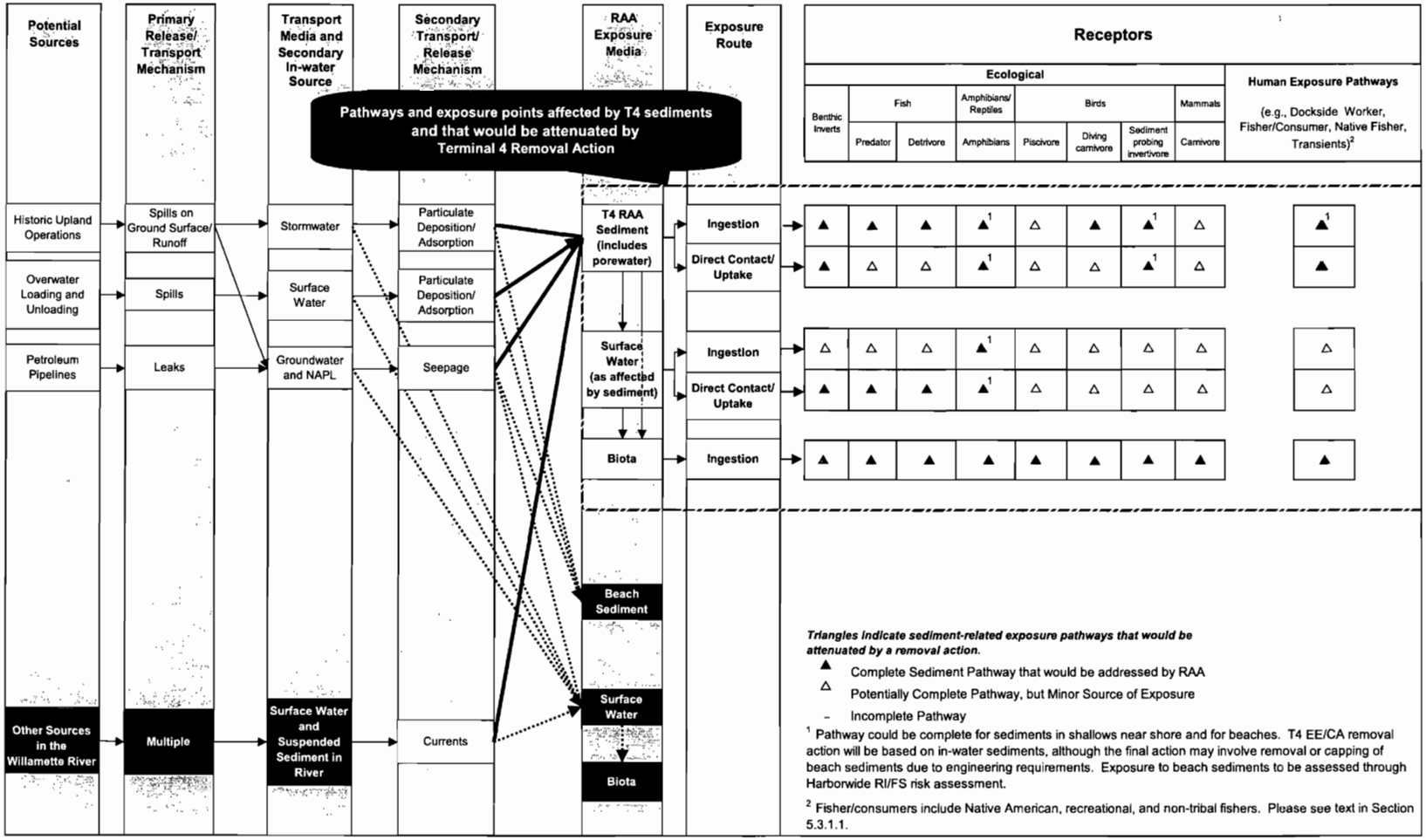
FIGURE
5-1

*NOTE: This diagram is intended to show (1) the potential pathways by which generalized receptors may be exposed to contaminants through sediment-associated pathways, and (2) those pathways that would be attenuated, in whole or in part, by sediment removal actions at T4. Due to the streamlined nature of the EE/CA process, not all pathways will be the subject of extensive risk analysis in the EE/CA.*




**Color Coding to Indicate Programmatic Relationships**

| Terminal 4 Removal Action | Terminal 4 Upland Source Control | Portland Harbor Superfund RI/FS |
|---|---|---|

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CONCEPTUAL MODEL FOR TRANSPORT AND EXPOSURE PATHWAYS RELEVANT TO THE TERMINAL 4 EE/CA

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FIGURE 5-2

Section 6

# 6. Data Gaps and Data Quality Objectives

This section evaluates whether existing data are sufficient to develop Removal Action alternatives and to allow evaluation of the Removal Action alternatives for their ability to meet the Removal Action Objectives (RAOs). If the data are found insufficient in some regard, then a data gap has been identified and must be filled. At that point, data quality objectives (DQOs) are established to ensure that new data collected to fill data gaps are of appropriate quantity and quality. In the following discussion, this process is applied to evaluate data gaps and identify DQOs in the areas of history, cultural resources, and land use; physical characteristics; ecological and human health risk characteristics; engineering characteristics; hydrogeologic characteristics; recontamination source characteristics; sediment quality characteristics; dredged sediment quality characteristics; and hydraulics and sedimentation characteristics.

## 6.1 Evaluation Process

The steps in this evaluation are to:

- introduce preliminary RAOs;
- introduce proposed Removal Action alternatives and technologies;
- assess the data needs of for each alternative and technology;
- evaluate whether the existing data are sufficient both in quantity and quality to adequately perform a comparative evaluation of the Removal Action alternatives; and
- develop DQOs for any new data that need to be collected.

## 6.2 Rationale for Data Gap Assessment

### 6.2.1 Removal Action Objectives

The RAOs for the Terminal 4 Removal Action are to:

- Reduce ecological and human health risks associated with sediment contamination within the Removal Action Area to acceptable levels.

- Reduce the likelihood of recontamination of sediments within the Removal Action Area.

The Port proposes to achieve the RAOs while allowing continued use of the marine terminal and minimizing disruption of operations.

### 6.2.2 Removal Action Alternatives and Technologies

In accordance with the USEPA guidance (USEPA, 1993b) for Non-Time-Critical Removal Actions (NTCRAs), "only the most qualified technologies that apply to the media or source of contamination" need to be considered for the development, comparative evaluation, and selection of Removal Action alternatives. On the basis of prior experience with a number of contaminated sediment projects in the Pacific Northwest, the technologies identified as likely to qualify for consideration in the EE/CA include:

- dredging of contaminated sediments, which will be followed by some or all of the following additional, auxiliary technologies:
  - transport of dredged sediments;
  - treatment of dredged sediments; and
  - disposal of dredged sediments, either onsite or offsite; and
- in-situ capping of contaminated sediments.

It is plausible to assume that the alternatives for the Terminal 4 Removal Action will include a combination of some or all of these main technology types. The technology of no action and natural attenuation are not likely to be applied in wide areas of the Removal Action Area but may be applicable to marginal areas.

Certain site-specific information is required for each of these technologies before they can be developed as Removal Action alternatives in enough detail to evaluate how each would address the RAOs and fare in a comparative evaluation of their success at meeting the criteria of effectiveness, implementability, and cost. For each of these technologies, the most important data needs are:

- Dredging
  - chemical characteristics of sediment contamination;
  - lateral extent of contamination;
  - vertical extent of contamination;
  - sediment volume to be addressed;
  - engineering properties of sediment;
  - stability of neighboring structures;
  - impacts to water quality during dredging;
  - resuspension potential of sediment;
  - remobilization of chemicals;
  - presence and nature of underwater debris;
  - disposal methodology;
  - future berth configuration considerations;
  - impacts to current tenants and operations;
  - impacts to cultural resources; and
  - impacts to environment.
- Transport
  - dredging methodology (mechanical or hydraulic);
  - sediment volume to be transported;
  - water content of sediment;
  - sediment particle size, affecting its suitability for gravity dewatering;
  - the need and type of flocculating additives to enhance gravity dewatering; and
  - distance of transport.
- Treatment
  - volume of sediment to be treated;
  - homogeneity and uniformity of sediment;
  - sediment water content;

- sediment chemical composition;
- residual sediment characteristics;
- sediment leaching potential;
- availability of site for treatment; and
- landfill waste acceptance criteria.

- Onsite disposal in a confined disposal facility (CDF)

  - strength and compressibility of subsurface sediment/soil;
  - strength of containment berm aggregate;
  - settling characteristics of dredged sediment;
  - leaching potential of sediment;
  - hydrogeological parameters;
  - hydrogeological parameters of containment berm and enclosed sediment;
  - impacts to cultural resources; and
  - impacts to environment.

- Offsite disposal

  - water acceptance criteria at disposal facility;
  - sediment chemical composition;
  - leaching potential of contaminants with respect to waste acceptance criteria;
  - sediment volume and mass;
  - water content of sediment;
  - type of transport (truck, rail, or barge);
  - impact of transport on Port operations;
  - impact of transport on community; and
  - noise and air emissions during transport.

- Capping

  - strength and compressibility of sediment;
  - sediment leaching potential;
  - hydraulic gradient across cap;
  - bioturbation depth;
  - periodic loads on cap, including seismic load, erosion (current, tides, floods), and outfall scour;
  - operational loads and impacts including spuds, anchors, and propeller-induced scour and erosion;
  - impacts to cultural resources; and
  - impacts to environment.

Along with the specific data needs mentioned above, the operational requirements of the Terminal 4 facility will factor into the analysis of technologies and Removal Action alternatives. These operational requirements include present and future vessel types, facility maintenance (pile driving, maintenance dredging) requirements, spill control and response, and debris removal.

### 6.2.3 Introduction of Data Quality Objectives Process

This section presents the procedure for a focused assessment of the gaps in existing data in terms of what is needed to evaluate the removal technologies for their effectiveness, implementability, and cost. The data needs in turn will drive the general objectives of the Removal Action Area characterization through the DQO process in accordance with USEPA guidance (USEPA, 2000). The development of DQOs for the Removal Action is outlined in detail in Table 6-1 and, for the reader's convenience, discussed briefly below. Specific methodologies for executing the Removal Action Area characterization are then outlined in Section 7.

As shown in Table 6-1, DQOs are developed through a logical process comprising the following steps:

- Step 1: State the problem.
- Step 2: Identify the decision (i.e., identify the questions that must be answered to address the problem statement).
- Step 3: Identify inputs to the decision (i.e., identify the data types required to formulate decisions to address the problem).
- Step 4: Define the boundaries of the study (i.e., define the boundaries of the data collection efforts).
- Step 5: Develop a decision rule (i.e., describe the data uses and objectives for the information needed to make the required decision).
- Step 6: Specify tolerable limits on decision errors (i.e., specify how the data will be evaluated against accepted standards, where applicable).
- Step 7: Optimize the design for data acquisition (i.e., develop data collection activities that achieve specific DQOs and can be optimized to meet multiple DQOs).

For the Terminal 4 Removal Action, the process outlined above was employed to establish DQOs and identify data gaps in nine knowledge areas:

- history, cultural resources, and land use (Section 6.3);
- physical characteristics (Section 6.4);
- ecological and human health risk assessment characteristics (Section 6.5);
- engineering characteristics (Section 6.6);
- hydrogeologic characteristics (Section 6.7);
- recontamination source characterization (Section 6.8);
- sediment quality characteristics (Section 6.9);
- dredged sediment quality characteristics (Section 6.10); and
- hydraulics and sedimentation (Section 6.11).

## 6.3 History, Cultural Resources, and Land Use

The history of Terminal 4 is sufficiently understood to allow an evaluation for purposes of the EE/CA of how terminal operations have influenced the nature and extent of contamination in the Removal Action Area. No additional data collection regarding the history of Terminal 4 is anticipated, but additional data will be incorporated into the overall data set as they become available.

Existing cultural resources information, subject to acceptance by the Tribes, is sufficient to perform the work specified for the EE/CA. However, additional cultural resources information, in the form of oral histories, will be gathered by others, independent of the Terminal 4 Removal Action. Sediment and soil samples, boreholes, and cores will also be examined during sample collection for artifacts or other archaeological deposits (see Appendix A1 for details).

No data gaps exist in the understanding of current land uses. Future land uses at Terminal 4 will remain related to marine operations. Details regarding tenants, their operations, and the Port's actions to support those operations may change. As such information becomes available, it will be incorporated into the overall data set and will be considered during the Terminal 4 Removal Action.

## 6.4 Physical Characteristics

Existing information provides a thorough understanding of the Removal Action Area's physical characteristics, with one exception: topographic information for embankment slopes above the water line; more specifically, topography from the upper extent of the June 2003 hydrographic conditions survey (Port of Portland, 2003) to the top-of-slope. (Upland topographic data are available above the top-of-slope.) Filling this data gap is necessary for characterizing embankment slope stability and stability of a slope cap or under-pier cap.

The field work to address the data gap will include:

- a topographic grid survey on slopes at low river stage conducted by a licensed surveyor; and
- a lead-line survey below piers on a 100-ft grid.

## 6.5 Ecological and Human Health Risk Characteristics

### 6.5.1 Ecological Risk Assessment

The ecological risk evaluation for the EE/CA will consist of two components. In the first component, data on existing conditions of sediment contamination and toxicity will be summarized to help in the preliminary design of Removal Action alternatives. The first component will be completed using existing data on sediment contamination and toxicity, as well as data that will be collected during the EE/CA field program. The purpose of the first component is to identify the contaminants, potentially complete exposure pathways, and exposure points and receptors in the Removal Action Area. Assessment of risk in this component will be limited to a comparison of sediment data to SQGs, where available.

The second component will be specific characterization of the residual risk for each of the Removal Action alternatives proposed in the EE/CA. This characterization will be used to demonstrate each alternative's protectiveness of the environment and to compare the relative protectiveness of the alternatives. To the extent

practicable, residual risks will be evaluated by comparing SQGs to sediment chemistry data. However, if risk calculations being developed by the Lower Willamette Group are approved by the USEPA and its partners during this process, those values will be used instead of SQGs. The specific methodology for the risk analyses will be determined in consultation with USEPA personnel after specific Removal Action alternatives have been identified. The methodology for evaluating residual risk will be documented during the Technical Briefing that will initiate the EE/CA process.

The conceptual site model (Section 5) shows potentially complete pathways for exposure of aquatic and terrestrial receptors to contaminated sediments in the Removal Action Area (Figure 5-2). Past data from Slip 3 show toxicity to test organisms in standard sediment toxicity tests (Hart Crowser, 2000d). Data from Slip 1, Slip 3, and Wheeler Bay indicate concentrations of COPCs (e.g., PAHs, zinc, and DDT) in surface sediments that exceed commonly used SQGs. Therefore, data from the Removal Action Area (sediment suggest that unacceptable risk exists in Slip 3 and is likely in Slip 1 and Wheeler Bay. Ecological risk evaluation is necessary to (1) help in designing preliminary Removal Action alternatives and (2) evaluate and compare the environmental protectiveness of the Removal Action alternatives.

For comparison of sediment chemistry to SQGs, the Removal Action Area data needs include:

- historical surface and subsurface data on sediment chemistry;
- data from the EE/CA field program documenting existing surface sediment chemistry;
- data on subsurface chemistry to (a) help in the design of Removal Action alternatives and (b) determine risks associated with Removal Action alternatives that may result in exposure of currently buried sediment horizons; and
- data from sediment elutriate testing to evaluate the effects of resuspended bed sediment on water quality.

### 6.5.2 Human Health Risk Assessment

The conceptual model introduced in Section 5 shows potentially complete pathways for exposure of humans to sediment contaminants at the Removal Action Area (Figure 5-2). Exposure pathways include direct exposure to sediments (i.e., incidental ingestion, dermal absorption) and indirect exposure through ingestion of surface water, fish, or shellfish that may have absorbed contaminants. While available information is insufficient to assess whether associated risks are acceptable, elevated concentrations of contaminants have been documented for the Removal Action Area. Data are needed for each Removal Action alternative to help determine whether residual risk to human health will acceptable after implementation of the Removal Action.

The approach to assessing human health risks includes two components. The first component focuses on existing conditions and is limited to identifying complete exposure pathways from sediment to humans and areas where elevated contaminant concentrations are known. Historical data and data from the EE/CA field program will be used in this assessment. Results will be used to help identify Removal Action alternatives that eliminate potentially complete pathways for exposure to humans.

As with the ecological risk assessment, the second component will evaluate the residual human health risks specific to each Removal Action alternative for the ingestion of biota and direct contact with in-water sediments. The specific risk questions and method for accomplishing this cannot be identified until the characteristics of each alternative have been identified. To the extent necessary, risk analysis procedures for human health will be consistent with those being used in the Portland Harbor Superfund Site remedial investigation/feasibility study.

The specific methods will be developed in consultation with USEPA risk assessors and formally documented in the Technical Briefing.

The information needed to support these decisions will include existing and new data on contaminant concentrations in surface and subsurface sediments; estimates of post-Removal Action concentrations; and, if bioaccumulation-based SQGs are not available, estimates of contaminant intake from fish or shellfish using existing data. However, information needs beyond sediment chemistry cannot be identified at this time.

The anticipated sediment chemistry data needs for the human health risk assessment are similar to those anticipated for the ecological risk assessment:

- historical surface and subsurface data on sediment chemistry;
- data from the EE/CA field program documenting existing surface sediment chemistry; and
- data on subsurface chemistry to (a) help in the design of Removal Action alternatives and (b) determine risks associated with Removal Action alternatives that may result in exposure of currently buried sediment horizons.

Additional data needs will be identified once Removal Action alternatives have been characterized and specific risk assessment methods have been approved.

## 6.6 Engineering Characteristics

Engineering characteristics of the Removal Action Area should be understood sufficiently well so that the Removal Action alternatives can be adequately developed and comparatively evaluated. Only a certain number of Removal Action technologies and alternatives will be considered to achieve the RAOs. These technologies have unique data needs. Data needs for engineering characteristics fall into three categories:

- Capping/dredging data needs
  - laboratory testing of sediments from core samples generally collected from soil strata near the surface and surface samples for engineering properties; and
  - additional information, such as the refusal depth for coring and other behaviors noted during the sampling process.

- Onsite disposal data needs
  - laboratory testing of sediments from core samples generally collected from soil strata near the surface and surface samples for engineering properties;
  - laboratory testing of sediments from core samples collected from soil strata at greater depth;
  - Standard Penetration Testing (SPT) blow counts in accordance with ASTM D 1586-99;
  - structure details and properties of structural elements;
  - monitoring wells installed using SPT sampling methodology;
  - seismic cone penetrometer tests (SCPT) or other CPT technology in accordance with ASTM D 5778-95 (2000);
  - seismic testing (e.g., shear wave velocity profile); and
  - additional information, such as the refusal depth for coring and other behaviors noted during the sampling process.

- Slope and adjacent structure stability data needs

- laboratory testing of sediments from core samples collected from soil strata at greater depth;
- SPT blow counts in accordance with ASTM D 1586-99;
- structure details and properties of structural elements;
- monitoring wells installed using SPT sampling methodology;
- SCPT or other CPT technology in accordance with ASTM D 5778-95 (2000); and
- seismic testing (e.g., shear wave velocity profile).

Figure 2-17 shows the locations of existing over-the-water geotechnical explorations. As the figure indicates, some geotechnical data are available, but not to the extent in quantity and distribution that would be sufficient to develop and compare the Removal Action alternatives. Although not shown on the figure, shallow upland borings and monitoring wells performed using SPT methodology are available and will be used during the EE/CA to the extent practical.

To locate additional exploration locations, design cross sections have been developed (Figure 6-1) and will likely be utilized during the development and evaluation of the Removal Action alternatives. These cross sections identify the most efficient number and locations of geotechnical explorations for gathering sufficient data. Field activities to fill data gaps will include:

- installing five geotechnical borings;
- installing 10 seismic cone penetrometer explorations; and
- installing one seismic properties boring.

The specific locations of and methodology for executing the data collection are described in Section 7.4.

## 6.7 Hydrogeologic Characteristics

Available information regarding hydrogeologic characteristics is summarized in Section 2.7. Additional data needs revolve around the following analysis requirements:

- development of a general hydrogeologic model for the Terminal 4 Removal Action Area; and
- support groundwater flow and contaminant transport modeling.

Activities to fill data gaps and support the EE/CA will include:

- installing three monitoring well clusters near the Willamette River, screened within each hydrostratigraphic unit influencing contaminant transport characteristics for sediments residing at the base of the slips;
- installing one intermediate/shallow well cluster at the Gatton's Slough organic silt/clay in Slip 1, with one screen in lower elevations of recent alluvial deposits at or slightly below elevation of Slip 3, the other within the Gatton's Slough soils if a saturated sand layer is encountered;
- installing two monitoring well clusters upgradient of the slips screened within each hydrostratigraphic unit; and
- surveying monitoring well top-of-casing elevations and ground surface elevations.

Subsequent data collection and testing will include:

- performing laboratory testing of long-term sediment leaching characteristics using thin-column leaching tests (TCLTs);
- performing laboratory testing of sediment sorption/desorption characteristics to provide site-specific values for contaminant transport modeling if TCLT results indicate that contaminant mass loading from sediment to surface water would occur;
- performing a limited groundwater monitoring study that incorporates extrapolated data on seasonal trends and existing data from Hart Crowser, 2000c and includes pressure transducers to measure real-time variation in water level, with periodic monitoring of conventional parameters; and
- performing grain-size testing for correlations to determine hydrogeologic parameters.

## 6.8 Recontamination Source Characterization

Potential sources of recontamination should be understood sufficiently well so that their impact can be incorporated in the development and comparative evaluation of the Removal Action alternatives.

A conceptual model for potential sources of sediment recontamination at the Terminal 4 Removal Action Area is shown on Figure 6-2. Sources at Terminal 4, such as ongoing operations, stormwater, and groundwater, will be considered. Sources outside Terminal 4 and the Removal Action Area, such as neighboring upland facilities, discharges or releases to the river, and sediment transport from elsewhere in the river, will also be considered.

The Port has, under the DEQ Voluntary Cleanup Program, established two initiatives to address the upland sources of contamination at Terminal 4: one for the Slip 1 area and one for the Slip 3 area specifically aimed at nonaqueous-phase liquid contamination. The Port's efforts, which are summarized in Section 3 and include remedial investigation, feasibility study, source control measures evaluation, and remedial action, will likely identify and control remaining sources at Terminal 4. The Port has also established a detailed stormwater management program for the entire Terminal 4 facility. Details of the Port's stormwater program are discussed in Section 3.3.2. Finally, the Port is a member of the Lower Willamette Group, which is the PRP group to address the contaminated sediment issues for the entire Portland Harbor Superfund Site.

Information from these efforts should provide the foundation for evaluation of source control and recontamination. In particular, the following information is expected:

- estimates of groundwater-related flux of contaminants to the Removal Action Area;
- estimates of the stormwater-related flux of contaminants into the Removal Action Area; and
- sediment quality and grain size measurements in Willamette River sediments near the Removal Action Area.

The approach to acquisition of these data is discussed in Section 7.7.

## 6.9 Sediment Quality Characteristics

The sediment quality characteristics of the Removal Action Area should be sufficiently well understood so that the lateral and vertical extent (area and volume) of sediment requiring remediation can be established in order to develop and evaluate the Removal Action alternatives.

Sediment quality data needs required for evaluation of Removal Action alternatives are:

- nature and lateral extent of contamination;
- under-pier sediment quality; and
- nature and vertical extent of contamination.

These sediment quality data needs are generally associated with the sediment in its **present place** and relate primarily to assist in establishing the extent of the sediment to be remediated. These data will also be used to estimate residual contamination (if any) and thus will serve as important inputs to the streamlined ecological and human health risk assessments to be performed as part of the evaluation of the long-term effectiveness of the Removal Action alternatives.

Different sediment characteristics data will be needed to describe sediment behavior for dredging and transportation to onsite or offsite disposal. These sediment quality data needs are discussed in the following sections.

### 6.9.1 Nature and Lateral Extent of Contamination

Surface sediment chemistry data will be used to evaluate the nature and lateral extent of contamination in the Removal Action Area. Insufficient surface sediment data are currently available for Slip 1 to allow delineation of the lateral extent of contamination, so additional surface sediment samples will be collected. Information for Slip 3 is insufficient to evaluate the lateral extent of contamination. Because bathymetry data from Slip 3 indicate that surface sediment may be resuspended and deposited in different areas as a result of propeller scour, additional surface sediment samples will be collected in Slip 3 to confirm surface sediment quality. Section 7.8.2 describes the number and locations of surface sediment samples that will be collected and the analyses to be performed.

### 6.9.2 Under-Pier Sediment Quality

Surface sediment chemistry data from under the piers is needed to determine whether action is required under the piers, as well as to determine the potential lateral extent of contamination under the piers. There are no available under-pier sediment data; therefore, under-pier sediment samples will be collected. There are no data available for the sediment in the pilings of the former Pier 5. Under-pier sediment samples will also be collected from this area. Section 7.8.3 describes the number and locations of under-pier surface sediment samples and the analyses to be performed.

### 6.9.3 Nature and Vertical Extent of Contamination

Subsurface sediment chemistry data will be used to determine the nature and vertical extent of contamination in the Removal Action Area. Insufficient subsurface sediment data are currently available to allow evaluation of the vertical extent of contamination in Slips 1 and 3, so additional subsurface sediment samples will be collected in Slips 1 and 3 to evaluate the vertical extent of contamination. Section 7.8.4 describes the number of cores, the locations of the cores, and the subsampling scheme for the cores, as well as the analyses to be performed.

## 6.10 Dredged Sediment Quality Characteristics

Dredged sediment quality characteristics should be understood sufficiently well to assist in the development and evaluation of Removal Action alternatives that involve dredging, i.e., the removal of sediment from its present place and subsequent transportation and onsite or offsite disposal of the sediment.

These data needs include the following:

- data needed to assess impacts to water quality during dredging;
- data needed to assess onsite disposal; and
- data needed to assess offsite disposal.

### 6.10.1 Water Quality Impacts During Dredging

Dredging elutriate data will be required to assess the water quality impacts during dredging so that the short-term effectiveness of Removal Action alternatives involving dredging can be evaluated. Dredge elutriate data will be collected from composite (surface and subsurface) sediment samples. No dredge elutriate data are currently available for the sediments that may require dredging. Therefore, composite samples will be collected for laboratory dredging elutriate tests.

Section 7.8.2 details the number of dredging elutriate tests that will be performed. The dredging elutriate samples will be analyzed for the same list of constituents as surface and subsurface sediment samples.

### 6.10.2 Sediment Quality Characteristics Impacting Onsite Disposal

Certain sediment quality characteristics need to be understood sufficiently well so that Removal Action alternatives involving onsite disposal can be adequately developed and evaluated. These characteristics are:

- settling velocity of the dredged material;
- short-term water quality impacts from a CDF; and
- long-term water quality impacts from a CDF.

No such data are currently available, so column settling, modified elutriate, and column leachate data will be collected from composite (surface and subsurface) sediment samples. Settling velocities will be evaluated with column settling tests, short-term water quality impacts will be evaluated with modified elutriate tests, while long-term water quality impacts will be evaluated with thin-column leaching tests. Section 7.8.3 discusses the number of composite sediment samples, their composition, and the analyses to be performed.

### 6.10.3 Sediment Quality Characteristics Impacting Offsite Disposal in a Subtitle D Landfill

Certain sediment quality characteristics need to be understood sufficiently well so that Removal Action alternatives involving offsite disposal can be adequately developed and evaluated. These data needs include:

- chemical data with respect to hazardous waste determination;

- chemical data with respect to Toxic Substances Control Act (TSCA) waste determination; and
- chemical and physical data with respect to landfill acceptance criteria.

The assessment of offsite disposal of dredged sediment assumes that the dredged sediment is suitable for disposal at a Subtitle D landfill. The assessment will be performed using the following landfill acceptance criteria:

- hazardous waste determination;
- toxicity characteristics leaching procedure (TCLP) testing;
- a TSCA determination;
- data on the generation and loss of free liquid; and
- any additional landfill-specific acceptance criteria.

Because existing data are insufficient for this analysis, new surface and subsurface sediment chemistry data and composite (surface and subsurface) sediment samples will also be collected. Section 7.8.4 details the number of samples, their composition, and the analyses to be performed.

## 6.11 Hydraulics and Sedimentation

The degree to which the Terminal 4 shoreline and local bathymetry influence river stage in the Willamette River should be sufficiently well understood so that potential changes to river flood stages as a result of berth modification necessitated by a Removal Action alternative can be adequately evaluated.

The data types of interest are:

- basin hydrology data;
- water stage measurements and corresponding flow measurements;
- upstream flow data; and
- any available velocity measurements or model computations in the river reach of interest.

Basin hydrology data such as monthly flow statistics, the effect of any upstream dams on flow, and similar information will allow an assessment of the range of flow conditions that might be experienced during the Removal Action.

Specific data needs include:

- cross-sectional river velocity measurements to calibrate a local hydrodynamic model;
- velocity measurements at several locations within the slip areas to characterize eddy circulation and differentiate between the following situations:
  - low or moderate river flow and no vessel activity;
  - high river flow and no vessel activity; and
  - vessel activity.
- river stage measurements at the Removal Action Area and near the mouth of the Willamette River or at some downstream location during high flow periods that can be correlated in time to USGS flow measurements; and
- characterization of the river bottom over the model domain.

The methodology and procedures for gathering and using these data are presented in Section 7.10.

**Table 6-1**
**Data Quality Objectives Development**

| Data Type | Problem Statement | Required Decision | Decision Inputs | Study Boundaries | Decision Rule | Decision Error Limits | Design for Obtaining Data |
|---|---|---|---|---|---|---|---|
| History | The history of Terminal 4 should be sufficiently understood to evaluate for EE/CA purposes the influence of Terminal 4 operations on the nature and extent of contamination in the Removal Action Area. | Determine what activities could have contributed contamination and where. | Decision will require understanding of Terminal 4 history. | Terminal 4 property. | Terminal 4 history should be understood well enough to leave no substantial gaps in chronological continuity. | Not applicable. | None required. Existing information is sufficient. |
| Cultural Resources | The history of Terminal 4 should be sufficiently understood to evaluate the potential impact of the removal action on cultural resources within the Removal Action Area. | Determine what operational or spatial controls might be necessary during implementation of the removal action. | Decision will require understanding of Terminal 4 history. | Terminal 4 property. | Terminal 4 history should be understood well enough to leave no substantial gaps in chronological continuity. | Not applicable. | Oral histories may be required and would be gathered by others, independently from the Terminal 4 Removal Action. Samples, boreholes, and cores will be examined during collection for artifacts. |
| Land Use | The current and potential future land use of Terminal 4 should be understood well enough to identify potential constraints on the removal action. | Determine if current and potential future Terminal 4 land use could limit the type or location of removal action planned. | Decision will require a planning-level understanding of potential future land use and a thorough understanding of current land use at Terminal 4. | Terminal 4 property. | Current and potential future land use at Terminal 4 should be understood well enough to avoid conflicts with the removal action. | Not applicable. | Current Port operations and potential future Terminal 4 uses are subject to ongoing business planning processes. |
| Physical Characteristics | The physical configuration of the Removal Action Area should be sufficiently understood to safely and effectively explore the area and propose a removal action. | Determine the dimensions and other physical parameters of the Removal Action Area. | The decision will require bathymetric, topographic, geologic, and built structure information. | The Removal Action Area and the immediately adjacent slopes and upland areas. | The physical configuration of the Removal Action Area will need to be known well enough to support alternative evaluation and ultimately design. | Standard survey limits will apply. | Existing topography and bathymetry are sufficient for EE/CA except topographic information for above water line embankment slopes to be gained by topographic surveys. |

| Data Type | Table 6-1<br>Data Quality Objectives Development | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Problem Statement** | **Required Decision** | **Decision Inputs** | **Study Boundaries** | **Decision Rule** | **Decision Error Limits** | **Design for Obtaining Data** |
| **Ecological Health** | The potential exposure pathways from sediment to ecological receptors should be sufficiently understood to confirm that they will be sufficiently attenuated by the removal action or, if not, that residual risk is acceptable. | Slip 3 and Wheeler Bay: Determine whether post-removal action risks are acceptable.<br><br>Slip 1. Determine (1) extent of removal action needed in slip and (2) whether post-removal action risks are acceptable. | For the analysis of alternatives in the EE/CA, comparison will require data on the projected surface sediment chemistry to relevant sediment criteria. Once the selected Removal Action has been implemented, but prior to closure, confirmation sampling will be used to assess the actual residual risk. | Removal Action Area. | Benthos and Fish: UCL95 for mean post-action surface sediment concentration in each unit, or other appropriate exposure unit, should not exceed chemical-specific SQGs.<br><br>Upper Trophic Level Consumers: Aggregate exposure from T4 sediment should not exceed chemical- and receptor-specific LOAEL-based reference dose. (Based on UCL95 exposure point concentrations). | Implied error rate is 5% or less chance that mean exposure will exceed relevant criterion. | Evaluation of existing habitat data and coordination with collection and evaluation of sediment chemistry data. |
| **Human Health** | The potential exposure pathways from sediment to human users should be sufficiently understood to confirm that they will be sufficiently attenuated by the removal action or, if not, that residual risk from sediment is acceptable. | Determine whether post-removal action risk is acceptable for removal action alternatives. | Decision will require (1) data on surface sediment chemistry (projected post-Removal Action), AND (2) data on other exposure parameters (bioaccumulation, intake parameters, etc.) OR site-specific SQGs from harborwide risk assessment if available. | Removal Action Area | Remediate contaminated sediment to ensure that contaminant levels are not above ARARS or above risk-based goals when ARARS are not available or are not protective. Other factors (e.g., detection limits, background) and uncertainties may also be considered. For carcinogenic effects in humans, USEPA's Superfund program uses $10^{-6}$ to $10^{-4}$ as an acceptable cancer risk range; for non-cancer effects, the goal is to limit exposures to levels below the RfD. Protective is defined as a cancer risk of less than or equal to $10^{-4}$; for non-cancer effects, protective is defined as exposures equal to or less than the RfD. | Implied error rate is 5% or less chance that mean exposure will exceed relevant criterion. | Sediment sampling and development of exposure scenarios appropriate to removal action alternatives. |

**Table 6-1**
**Data Quality Objectives Development**

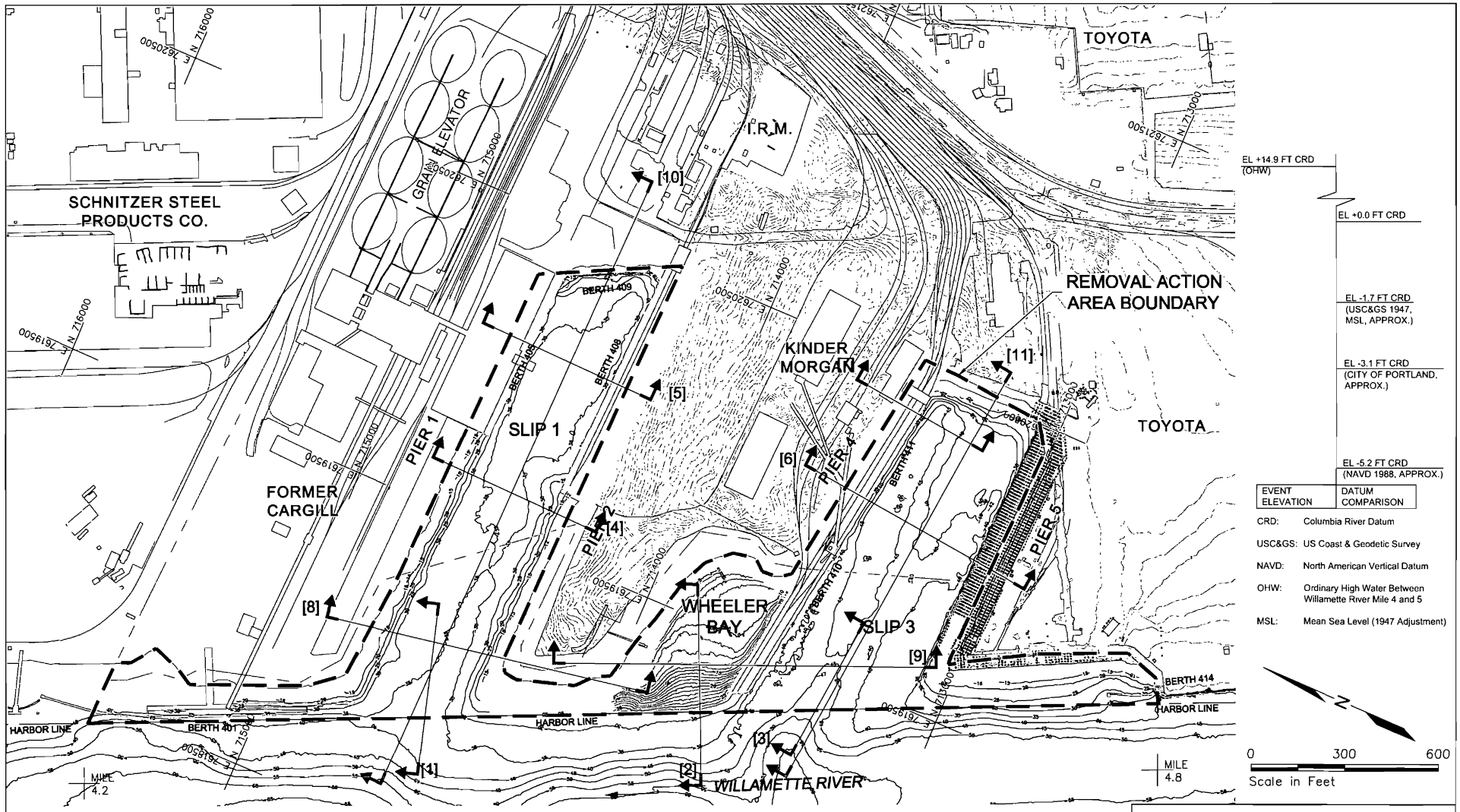
| Data Type | Problem Statement | Required Decision | Decision Inputs | Study Boundaries | Decision Rule | Decision Error Limits | Design for Obtaining Data |
|---|---|---|---|---|---|---|---|
| Engineering Characteristics | The engineering properties of the sediments should be sufficiently understood to evaluate short-term effectiveness of removal actions such as capping or dredging. | Determine if the sediments in the Removal Action Area can be effectively dredged using available equipment and/or capped using accepted technology. | Decision will require knowledge of physical properties of the sediments including standard penetration test, grain size, moisture content, Atterberg limits, organic content, bulk density, specific gravity, consolidation, and shear strength. | Removal Action Area. | The engineering properties of the sediments should be known at a level consistent with standard of practice in the Pacific Northwest for sediment remediation and other shoreline projects. | Accuracy of the individual geotechnical tests is set forth in the appropriate ASTM. | For sediment, utilize 10% to 20% of all vibracore sampling locations to obtain samples. Drill 3 geotechnical borings over the water. Perform 7 seismic cone penetrometer tests (SCPT) in-water. Laboratory testing to be comprised of particle size distribution test, Atterberg limits test, moisture content test, specific gravity test, organic content, triaxial testing (shear strength), and consolidation testing (compressibility). Obtain tip resistance, sleeve friction and pore pressure parameters as well as shear wave profiles from SCPTs. |
| | The properties of sediments within the Removal Action Area and the properties of soils in the vicinity of the Removal Action Area should be sufficiently understood to evaluate the interaction of sediments and nearby slopes, structures and fixtures caused by removal action. | Determine the maximum practical dredging elevation adjacent to existing slopes and structures. | Decision will require geotechnical borings and related standard penetration tests as well as index testing of selected samples. | The Removal Action Area and immediately adjacent slopes and upland areas. | The engineering properties of the soils on the margins of the Removal Action Area should be known at a level consistent with the standard of practice for evaluation of slope stability using models such as Plaxis. | Accuracy of the individual geotechnical tests is set forth in the appropriate ASTM. | Drill boreholes at 6 locations. These boreholes will be completed as clustered monitoring wells. Drill 1 deep geotechnical boring for upland shear wave velocity profile testing. Drill 2 geotechnical borings. Laboratory testing to be comprised of particle size distribution test, Atterberg limits test, moisture content, specific gravity test, organic content, triaxial testing (shear strength), and consolidation testing (compressibility). |
| | The Removal Action Area itself should be sufficiently understood to evaluate the feasibility of onsite disposal of contaminated sediments. | Determine the feasibility of construction of a disposal facility within the Removal Action Area. | Decision will require geotechnical borings and related standard penetration tests as well as index testing of selected samples. | The Removal Action Area in general and critical areas such as those where closure berms or adjacent structures could present feasibility limitations for onsite disposal. | The engineering properties of the sediments within the Removal Action Area and in immediately adjacent areas should be known to a level consistent with the standard of practice for evaluation of onsite disposal. | Accuracy of the individual geotechnical tests is set forth in the appropriate ASTM. | Utilize 10% to 20% of samples at vibracore locations. Drill 2 geotechnical borings. Perform 7 SCPT within the slips and 3 SPCT in front of the slips. Collect in-situ soil parameters using the SPT test. Laboratory testing to be comprised of particle size distribution test, Atterberg limits test, moisture content test, specific gravity test, organic content, triaxial testing (shear strength), and consolidation testing (compressibility). Obtain tip resistance, sleeve friction and pore pressure parameters as well as shear wave profiles from SCPTs. |
| Hydrogeologic Characteristics | The Removal Action Area should be sufficiently understood to evaluate the feasibility of onsite disposal or in-situ capping of contaminated sediments. | Will contaminated sediments disposed of onsite be effectively contained for the long term? | Decision will require knowledge of hydrogeologic regime and groundwater quality. | Terminal 4 property surrounding Removal Action Area as necessary. | Hydrogeologic regime and groundwater quality information should be sufficiently understood to provide inputs to typical models such as ModFlow and MT3D. | Accuracy based on appropriate laboratory standards. | Perform elutriate testing to assess partitioning of absorbed contaminants into liquid phase during removal action. Perform TCLT laboratory testing to assess the long-term leaching potential of sediment to be disposed at disposal facilities or capped in situ. |

Table 6-1
Data Quality Objectives Development

| Data Type | Problem Statement | Required Decision | Decision Inputs | Study Boundaries | Decision Rule | Decision Error Limits | Design for Obtaining Data |
|---|---|---|---|---|---|---|---|
| Recontamination Source Characterization | Sources within and immediately adjacent to Removal Action Area could contribute contaminants in sufficient mass to ultimately recontaminate the Removal Action Area. | Determine if sources on or immediately adjacent to the Removal Action Area may result in recontamination. | Decision will require knowledge of contaminant mass loading from sources such as stormwater and groundwater. | Terminal 4 property surrounding the Removal Action Area as necessary. | Mass loadings should be sufficiently understood to assess the potential for recontamination using models such as WASP, if necessary, or more simple approaches, if possible. | Mass loadings will need to be quantified such that analysis of recontamination within a 50- to 100-year design life will be possible. | Collect stormwater samples from outfalls, install monitoring wells and collect groundwater quality samples. (Note: these samples to be collected by others under Terminal 4 Slip 1 upland study.) |
| | Other sources of contamination to the river could contribute contaminants in sufficient mass to ultimately recontaminate the Removal Action Area. | Determine if other sources will result in contamination. | Decision will require knowledge of contaminant mass loading from offsite sources such as nearby facilities, upriver industrial and agricultural sources. | The Willamette River upstream and in the vicinity of Terminal 4. | Mass loadings should be sufficiently understood to assess the potential for recontamination using models such as WASP, if necessary, or more simple approaches, if possible. | Mass loadings will need to be quantified such that analysis of recontamination within a 50- to 100-year design life will be possible. | Analyze existing information for river water quality, analyze existing information on Willamette River sedimentation and sediment chemistry, and analyze suspended and bedload transport rates. Collect additional chemistry information on suspended sediment. |
| | Historical and existing sources of contaminants may be declining and future recontamination potential could be significantly lower than historical or present day potential. | Evaluate historical concentration trends in sediment to determine whether or not sources are declining and whether or not present-day measured recontamination potential will be representative of the future trends. | Determination will require obtaining data on historical sediment concentration trends from sediment core profiles. | Removal Action Area. | Sediment cores must be obtainable from long-term depositional areas in the removal action area. Detailed core chemistry profiles will also be needed. | Approximately +/- 2 ft vertically. | Qualitatively evaluate core chemistry profiles for better determination of change in sediment concentrations with depth. |
| Sediment Quality | The areal extent of surface sediment contamination should be delineated to determine the areal extent of sediment that requires remediation. | Determine areal extent of surface sediment contamination. | Decision will require evaluation of existing surface sediment chemistry data and collection of surface sediment samples for chemistry analysis to provide adequate coverage of the Removal Action Area. | Removal Action Area. | Surface sediment quality should be sufficiently understood to assess the areal extent of sediment contamination. | Approximately +/- 50 to 100 ft horizontally, the assumed length and width of a dredge sub-prism. | Collect surface sediment samples in the Removal Action Area and analyze for chemistry. |
| | The quality of surface sediment under the piers should be evaluated to determine if remediation is required for under-pier sediment. | Determine under-pier surface sediment quality. | Decision will require collection of under-pier surface sediment samples for chemistry analysis. | Under-pier areas within Removal Action Area. | Under-pier surface sediment quality should be sufficiently understood to assess the need for under-pier sediment remediation. | Approximately +/- 50 to 100 ft horizontally. | Collect under-pier surface sediment samples in the Removal Action Area and analyze for chemistry. |
| | The vertical extent of subsurface sediment contamination should be delineated to determine the depth and volume of sediment that requires remediation. | Determine vertical extent of subsurface sediment contamination. | Decision will require evaluation of existing subsurface sediment chemistry data and collection of subsurface sediment samples for chemistry analysis to provide adequate coverage of the Removal Action Area. | Removal Action Area. | Subsurface sediment quality should be sufficiently understood to assess the vertical extent of sediment contamination. | Approximately +/- 1 ft vertically, the assumed allowable amount of overdredge. | Collect subsurface sediment samples in the Removal Action Area and analyze for chemistry. |

**Table 6-1**
**Data Quality Objectives Development**

| Data Type | Problem Statement | Required Decision | Decision Inputs | Study Boundaries | Decision Rule | Decision Error Limits | Design for Obtaining Data |
|---|---|---|---|---|---|---|---|
| Dredged Sediment Transport and Disposal | The onsite transport and disposal characteristics of the sediments within the Removal Action Area should be understood. | Determine the effectiveness of onsite transport and disposal technologies. | Decision will require physical and chemical analysis of the contaminated sediments. | Removal Action Area. | Settling behavior, elutriate concentration, and leaching behavior should be understood at a level necessary to evaluate on-site disposal technologies. | Corps of Engineers protocols will apply. | Sediment samples will be tested for settling velocity, dredging and modified elutriate behavior, and column leaching behavior. |
| | The offsite transport and disposal characteristics of the sediments within the Removal Action Area should be understood. | Determine the effectiveness of offsite transport and disposal technologies. | Decision will require physical and chemical analysis of the contaminated sediments. | Removal Action Area. | Dewatering behavior, water treatment requirements, and disposal facility-specific testing requirements should be understood at a level sufficient to evaluate offsite disposal. | Facility-specific. | Sediment samples will be tested for generation and loss of free liquids, pore water quality, and disposal facility-specific tests. |
| Hydraulics and Sedimentation | Velocity and associated bed shear stress patterns in the Removal Action Area will likely control sedimentation rates important to evaluating recontamination potential. | Identify what areas will be most subject to sedimentation and how sedimentation will vary spatially in the Removal Action Area. | Decision will require an understanding of the spatial (two-dimensional) variation in flow velocities and associated bed shear stresses for a range of flow conditions. | Terminal 4 project area and section of Willamette River bounded by the project area. | Velocity patterns (location, direction and magnitude) and bed shear stresses (location and magnitude) should be measured and/or computed on a grid or scale of sufficient resolution to resolve the main flow circulation pathways and bathymetric variations. | Desired accuracy of velocity predictions or measurements - approximately +/- 0.2 ft/sec. | Measure velocity profiles along transects within Slips 1 and 3 of the Terminal 4 project area and across the Willamette River at the upstream, mid point, and downstream boundary of the removal area. Compute velocities and shear stresses using the RMA2 hydrodynamic model, utilizing measured values for model calibration. |
| | The degree to which the Terminal 4 shoreline and local bathymetry influence river stage should be understood so that potential changes to river flood stages as a result of berth modifications can be predicted. | Determine if flood stage will be appreciably impacted by activities in the Removal Action Area. | Decision will require flood stage simulations for existing conditions and post-remediation conditions (and potentially during remediation of local flow constrictions are put in place such as sheet pile). | Main channel of the Willamette River to a distance upstream where changes in the local river geometry can be shown to have a minimal impact on river stage. | Terminal 4 modifications as a result of remediation action should not have any appreciable impact on upstream or downstream flood stage. | Predicted flood stage for existing conditions and modified conditions using a river hydraulics model with accuracy of at least +/- 0.5 ft, or equal to accuracy of existing, accepted flood stage models for the Willamette River. | Obtain model inputs for existing flood stage simulations for the Willamette River, simulate existing conditions for the 100-yr flood, and modify river cross sections to reflect remedial actions at the Terminal 4 area and then repeat the 100-yr flood simulation. Compare water surface elevation predictions for each case. |




Notes

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.
7. Analysis Cross Section Locations may change depending on the outcome of the field program and course of the EE/CA Process in general.

Existing Piers

[9] Potential EE/CA Analysis Cross Section

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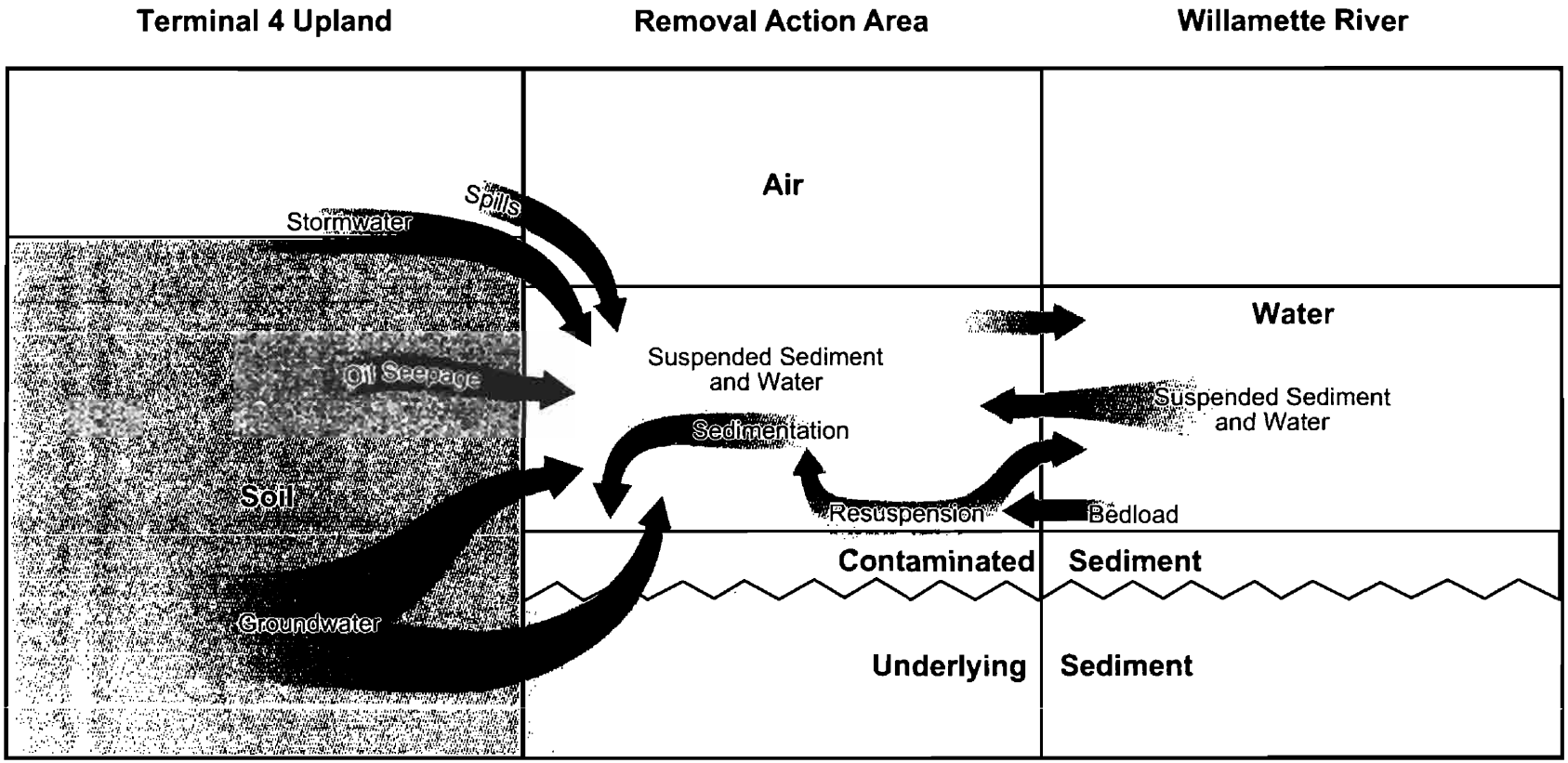
GENERALIZED ANALYSIS CROSS SECTIONS

BBL BLASLAND, BOUCK & LEE, INC. engineers & scientists

FIGURE 6-1

DWG NAME: G:\project\Clients\BBL\Terminal 4\t4_008.dwg
DATE: 02/18/04 12:26pm




PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

GEOCHEMICAL CONCEPTUAL MODEL

BBL
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
6-2

Section 7

# 7. Removal Action Area Characterization Activities

This section describes the methodologies, procedures, and protocols to be used in collecting data to fill the data gaps identified in Section 6. Filling these data gaps will provide the additional information needed to complete the Removal Action Area characterization.

## 7.1 Summary of Data Sufficiency

Available data in several areas were found to be insufficient to adequately develop and evaluate Removal Action alternatives, as summarized below.

- History, Cultural Resources, and Land Use — available data, subject to acceptance by the Tribes, are sufficient;
- Physical Characteristics — available data are nearly sufficient;
- Ecological and Human Health Risk Characteristics — available data are insufficient, additional data required;
- Engineering Characteristics — available data are insufficient, additional data required;
- Hydrogeologic Characteristics — available data are insufficient, additional data required;
- Recontamination Source Characterization — available data are insufficient, additional data required;
- Sediment Quality Characteristics — available data are insufficient, additional data required;
- Dredged Sediment Quality Characteristics — available data are insufficient, additional data required; and
- Hydraulics and Sedimentation Characteristics — available data are insufficient, additional data required.

## 7.2 History, Cultural Resources, and Land Use

No additional data collection regarding Terminal 4 is required in the knowledge areas of history, cultural resources, and land use; existing information is sufficient, subject to the Tribes' acceptance. Oral histories, while not necessary for the EE/CA, will be gathered by others independent of the Removal Action project. Historical Terminal 4 data that become available will be incorporated into the EE/CA.

## 7.3 Physical Characteristics

The physical characteristics data gaps for the Removal Action Area consist only of topographic information on the embankment slopes above the water line, from the upper extent of the available hydrographic surveys to top-of-slope, above which upland topographic surveys are available. The field work will consist of a topographic grid survey on slopes at low river stage and a lead-line survey below piers on a 100-ft spacing.

Once the grid survey is performed for the embankment slope to the top-of-slope, the information will be converted to CRD and incorporated into the base map for the Removal Action Area prior to analysis of cross sections. The lead line surveys will be indicated as numeric elevation values (i.e., CRD) shown on the correction horizontal position according to digital global positioning system measurements taken during data collection activities.

## 7.4 Ecological and Human Health Risk Characteristics

An important motivation for performing the Removal Action is the known unacceptable ecological risk as evidenced in some sediment samples that show toxicity to benthic organisms and contaminant concentrations that exceed risk-based SQGs. A streamlined risk evaluation will be conducted for the EE/CA to aid in selection of a Removal Action alternative for the Removal Action Area. In accordance with USEPA guidance for NTCRAs (USEPA, 1993b), the risk assessment will be streamlined to identify exposure pathways of potential concern and provide a screening-level assessment of potential risk associated with complete pathways.

The overall EE/CA risk analysis approach includes two components. The first component is intended to simply identify the contaminants, potentially complete exposure pathways, and exposure points in the Removal Action Area and compare sediment data to SQGs to provide a preliminary characterization of risk. The first component will be completed using existing data on sediment contamination and toxicity, as well as data that will be collected during the EE/CA field program. The results will be used to aid in preliminary design of alternatives to help ensure that exposure pathways of interest are addressed.

The second component will be specific characterization of the residual risk for each of the Removal Action alternatives proposed in the EE/CA. As noted above, this characterization will be used to demonstrate the protectiveness of human health and the environment for each alternative and to compare the relative protectiveness of the alternatives. Once Removal Action alternatives have been identified, risk analysis procedures that are specific to assessing residual risks for each alternative will be proposed in the Technical Briefing on Removal Action Alternatives (Technical Briefing) to be submitted for USEPA review and approval prior to the EE/CA report.

Section 5 describes the preliminary conceptual model for the site, including the important sources and media to which human and ecological receptors may be exposed. The risk analyses will focus on the pathways relevant to each receptor type.

### 7.4.1 Human Health Risk Assessment

As noted above, the human health risk assessment (HHRA) will have two components. The first component will focus on identifying potential exposure pathways currently existing at the Removal Action Area and the human uses of the Removal Action Area that might result in exposure. Data on contaminant concentrations in sediment will be used to identify the areal extent of potential exposures. Removal Action alternatives will then be developed to address the areas of exposure.

The objective of the second component is a specific analysis of residual human health risk associated with each Removal Action alternative. Proposed methods for the analysis will be documented in the Technical Briefing document and submitted to USEPA for review and approval. The extent of the analysis will depend on the nature of the Removal Action. For example, if Slip 3 alternatives prescribe pathway elimination (e.g., through extensive capping with clean materials), the remaining surface that is not capped will be the focus of the analysis.

The HHRA is expected to include one or more exposure scenarios reflecting expected human use of the Removal Action Area following the Removal Action. The scenarios will allow identification of the appropriate frequency and duration of exposure. To the extent applicable, the scenarios will be consistent with those to be used in the Portland Harbor Superfund Site RI/FS. Human uses that result in potentially complete exposure pathways are expected to include fishers that consume fish caught in and around Terminal 4, occupational

exposures for dock workers, and trespasser/transient scenarios. The exposures are expected to include consumption of fish and, therefore, will include assessment of bioaccumulative compounds as appropriate. This may require use of SQGs based on bioaccumulation. If agency-approved bioaccumulative SQGs are available from the Portland Harbor RI/FS, they will be used in the EE/CA process. If not available, site-specific SQGs may be developed if necessary to support removal decisions. Direct contact with in-river sediments will also be considered for scenarios for which it is applicable. The long-term plans for land use at Terminal 4 will be used to adjust the frequency and intensity of exposures considered in the risk analyses. For example, marine operations and security measures may minimize access to the water from land at Terminal 4, reducing fishing opportunities and catch. Ongoing marine activities may limit Terminal 4 as a significant source of food to subsistence fishers.

As noted, specific methods for exposure analysis will be consistent with those used for the Portland Harbor Superfund Site RI/FS. However, the EE/CA field data collection is not expected to include fish or invertebrate tissue beyond that collected for the RI. Therefore, assumptions regarding exposure may be adopted, including use of data on fish species that are not normally important in human consumption and use of biota-sediment accumulation factors (BSAFs) to estimate uptake into consumed fish and invertebrate species. Exposure and risk calculations will be consistent with USEPA guidance.

### 7.4.2 Ecological Risk Assessment

The following discussion presents general ecological characteristics of the Removal Action Area followed by an approach for the risk evaluation for Slip 1, Slip 3, and Wheeler Bay. Because the approach will utilize SQGs to evaluate risk potentials, a discussion of the SQGs is also presented. As for the HHRA, specific ecological risk analysis processes will be proposed in the Technical Briefing once Removal Action alternatives have been identified. However, SQGs for evaluating potential toxicity to benthic invertebrates and fish are available for use in preliminary risk characterization during alternative development. SQGs will be used to provide a preliminary estimate of ecological risk for Terminal 4 sediments.

#### 7.4.2.1 Ecological Characterization

The Removal Action Area consists of a highly modified habitat; its quality is limited by past and present industrial and maritime land uses, and it has been modified by dredging and shoreline development for marine operations. No native habitat or shoreline currently exists in the Removal Action Area. Some shallow-water habitat (<20 ft) does exist at edges and margins of the Removal Action Area, both under piers and in open water. Wheeler Bay has the most extensive uncovered, nearshore shallows, with beach areas where wildlife can feed. Some shoreline and upland areas have been replanted at the north side of Slip 3. Given the past operations at Terminal 4 and the current understanding of habitat characteristics, no additional habitat characterization is needed to support Removal Action decisions.

**Threatened and Endangered Species**

A search of the existing literature to determine the presence of threatened and endangered species will be conducted. This will include the general scientific literature, information obtained from the USFWS, the DEQ, and other federal, state, and local agencies. Table 2-6 summarizes the results of a recent search conducted for the Portland Harbor Superfund Site RI/FS. As required, a complete biological assessment will be performed (see Section 8.6.2) to evaluate the effects of the preferred Removal Action alternative on any threatened or endangered species that may be present in the Removal Action Area.

**Benthic Resources**

Because the sediment in Slips 1 and 3 is of a highly disturbed nature as the result of maritime operations and maintenance dredging, the development of benthic communities in some areas of the slips may be limited. However, Sediment Profile Imaging (SPI) showed a functional benthic community in Slip 3 and at the head of Slip 1. Benthic organisms may exist in the shallow-water habitat within the slips and in Wheeler Bay.No specific, added studies will be conducted to characterize benthic communities in Terminal 4. Benthic resources will be addressed in the ecological risk assessment through the use of specific SQGs for benthic organisms.

**Fish Resources**

Due to the size of Terminal 4 and the highly mobile nature of fish resources in the Willamette River, it is unlikely that fish resources in the harbor will be significantly affected by actions identified in the EE/CA. Fish resources in Terminal 4 probably include resident species (e.g., sculpin) as well as species that may spend only a portion of their time there (e.g., smallmouth bass, juvenile salmonids). Individual fish in Terminal 4 could be adversely affected by sediment contamination. However, it is unlikely that contamination in Terminal 4 would by itself significantly affect fish populations in the Lower Willamette River. Risks to fish will be evaluated through the use of SQGs to address food-chain effects for the post-Removal Action analysis; water-column effects (i.e., through resuspension of sediment) will be addressed for possible risks as part of the evaluation of long-term effectiveness during the Removal Action (see Section 8.5.1.5).

**Other Ecological Receptors**

Additional ecological resources present in the Removal Action Area, such as amphibians, birds, and small mammals, will be evaluated in the ecological risk assessment through use of SQGs (see Section 8.5.1.5).

### 7.4.2.2 Ecological Risk Assessment Approach

As noted above, the ecological risk assessment will have two components. The first is primarily intended to characterize existing conditions through comparison of sediment quality data to SQGs for the contaminants relevant to the EE/CA. This process has been initiated with the comparison of existing sediment data to SQGs and the summary of toxicity testing data, both presented in Section 4 of this work plan. Additional characterization of existing conditions will be conducted using surface sediment and surface water data collected during the EE/CA field program. This information will be used to help design Removal Action alternatives and will be presented in the EE/CA report.

The second component will focus on evaluating residual risks associated with each of the Removal Action alternatives. The approach will also be primarily based on comparison of sediment chemistry data to SQGs. For each alternative, the analysis will focus on the surface conditions expected following implementation. This includes evaluation of:

- newly exposed sediment that may result from dredging operations;
- existing surface sediment conditions that may be left undisturbed; and
- risks that may be associated with potential sources of recontamination to surface materials.

The analysis will include the SQGs presented in Section 4. However, subject to approval from USEPA, Portland Harbor-specific SQGs that become available from the Portland Harbor Superfund Site RI/FS will be

substituted for literature-based SQGs where applicable. This will help ensure consistency of the Terminal 4 Removal Action with the harbor-wide remedial action(s) that will be identified in the Record of Decision. Use of such criteria may be adopted at several points in the EE/CA process, including assessment of residual risk and/or final identification of Removal Action areas. Where such criteria are not available, specific risk-analysis procedures will be proposed in the Technical Briefing.

Supplemental information is also available for risk analysis if needed to support Removal Action decisions. These data include contaminant concentrations in a few fish species and some crayfish samples that are available from harbor-wide sampling for the RI/FS (Lower Willamette Group, 2003). Much of the available data are from Slip 1, with fewer samples available from Wheeler Bay and Slip 3. These data may aid in evaluating risk from sediments that would remain undisturbed by Removal Action alternatives or in assessing the relative importance of offsite sources to risk in the Removal Action Area.

In addition to the residual long-term risks associated with each alternative, the short-term risks during alternative implementation will be assessed. Of primary concern is the resuspension of bed sediments during dredging or other disturbances. The effects of suspended sediment on water quality will be evaluated using results of elutriate testing and other analyses.

## 7.5 Engineering Characteristics

As discussed in Section 6.6, available information is insufficient to adequately develop and evaluate Removal Action alternatives. Therefore, additional geotechnical explorations are proposed with associated laboratory testing. The following sections discuss the methodology, protocols, and procedures of the exploration and laboratory testing. The methodology of sampling and testing somewhat depends on the analytical tools to be used for the development and evaluation of the Removal Action alternatives. Therefore, where this is the case, the analytical method is also presented and its special data input needs are discussed.

### 7.5.1 Geotechnical Field Exploration

Six geotechnical borings and 10 SCPTs are proposed to address engineering characteristics. Geotechnical borings will be completed in accordance with OAR 690 Division 240 Construction, Maintenance, Alternation, Conversion and Abandonment of Monitoring Wells, Geotechnical Holes, and Other Holes in Oregon. Hollow-stem auger borings will be completed for geotechnical borings and monitoring wells in general accordance with ASTM D 1452, Standard Practice for Soil Investigation and Sampling by Auger Drilling. SCPT technology involves a less invasive, temporary installation of a probe that is grouted upon retraction. SCPT explorations will be performed in general accordance with ASTM D 5778, Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils. The proposed locations of these explorations are shown on Figure 7-1.

The field sampling plan provides additional details pertaining to the geotechnical explorations (both borings and SCPTs). Details for the proposed geotechnical borings, including anticipated depths and number of samples, are shown in Table 7-1, which indicates laboratory testing to be performed for the combined purposes of engineering and hydrogeologic characterization. Testing will be performed in accordance with the ASTM standards indicated in Table 7-1.

Regarding analysis of engineering characteristics, this section further elaborates on the analysis methods and models that will be used in the EE/CA. The analyses described in this section will either be completed to

support the screening of technologies during development of Removal Action alternatives or performed after the technologies have been assembled into Removal Action alternatives to aid in determining technical feasibility.

### 7.5.2 Sediment Physical Properties

Laboratory testing of sediment physical properties will provide input to the assessment of sediment engineering characteristics. Sediment physical properties can be generally categorized into the following subgroups:

- Physical properties (for characterization of sediment and upland soil)
  - moisture content;
  - grain size;
  - organic content; and
  - specific gravity.

- Consolidation properties (for characterization of sediment and upland soil)
  - 1-dimensional consolidation; and
  - Atterberg limits.

- Shear strength properties (for testing of deep "sediment" and upland soil)
  - UU triaxial test. This is a rapid shear test (unconsolidated, undrained) that gives a general idea of the undrained strength characteristics of the sample in its disturbed condition following extrusion from a thin-walled sample liner.

  - CU triaxial test. This is a more representative and time-consuming shear strength test that involves consolidating the soil to its in-situ stress conditions (i.e., compressed axially and laterally to represent in-situ stress regime, then sheared undrained). The test allows an approximation of the drained shear strength properties of the sediment/soil by measuring pore-pressure during the shear.

Seismic properties will not be determined based on laboratory testing. Alternatively, SCPT and the seismic properties borings will also provide shear wave velocity profiles that will become inputs for the analysis of seismic stability and liquefaction potential.

### 7.5.3 Slope Stability Assessment Methodology

A commercially available software package, SLOPE/W v5.0 (GEO-SLOPE, 2002) will be used to assess the stability of slopes affected by the Removal Action. This software package is based on the limit equilibrium method and the Spencer's calculation methodology commonly used in geotechnical engineering practice for slope stability analyses. Its use has been accepted and approved for contaminated sediment remediation projects by USEPA Region 10.

Cross sections 1 through 7 shown on Figure 7-1 will be used to select representative analysis sections for evaluating slope stability of potential containment berms (i.e., cross sections 1, 2, and 3) and impact to adjacent structures from dredging and stability of under-pier slopes subject to capping (i.e., cross sections 4, 5, 6, and 7). From subsurface information, "worst-case" soil conditions profiles will be modeled for slope stability using conventional means (i.e., SLOPE/W). Engineering properties obtained either directly or by empirical correlations/published values will be used to develop input parameters for the analyses.

Analysis conditions to be tested in the modeling, depending upon the Removal Action alternative, will consist of the following (to be further discussed in the EE/CA):

- Short-term (undrained). Represents conditions during or immediately after construction of the Removal Action alternative.
- Long-term (drained). Represents the long-term, static equilibrium condition long after construction of the Removal Action alternative.
- Pseudo-static. Represents a quasi-seismic evaluation methodology that adds an inertial horizontal force to simulate the increase driving force from earthquake shaking.
- Post-liquefaction (residual shear strength). Represents the case where applicable sediments/soils have liquefied and undergone loss of shear strength following the liquefaction event.

To assess the additional complexity of determining "impacts to adjacent structures" from dredging adjacent to piers, as well as the additional complexity of seismic stability of potential containment berms, Plaxis v8 will be used in the EE/CA as needed. Plaxis will supplement SLOPE/W to support the determination of technical feasibility and cost of a particular Removal Action alternative. Plaxis v8 (Plaxis, 2002) is a finite element model capable of simulating the interaction of soil and structures subject to changed loading and/or stress state conditions, including the capability to consider a number of construction steps and the incremental effects on stability. Rather than predicting a factor of safety, this model provides output indicating the deformation characteristics of the soil and resulting stress/moment conditions and deflection of the adjacent structure elements. This analysis will be needed for evaluating dredging immediately next to the piers. Dredging will likely require the addition of a sheet pile wall to maintain the stability of under-pier slopes and the stability of the pier itself (depending on the nature and extent of contamination to be removed and the Port's planned facility use). The representative size and type of structural reinforcement will be needed to establish a reasonably representative and comparable cost for the EE/CA.

### 7.5.4 Settlement and Consolidation Assessment Methodology

Settlement (elastic compression and consolidation) below caps, under-pier caps, and containment berms may be severe enough to limit the effectiveness or even nullify the technical feasibility of Removal Action alternatives. The EE/CA will include analyses using both standard 1-Dimensional Consolidation Theory and the USACE's ADDAMS model PSDDF (Primary-Secondary Consolidation, and Desiccation of Dredged Fill) (Stark, 1996). The latter will be used only as part of the assessment of effectiveness of onsite disposal. For PSDDF, a portion (or all) of cross sections 8 through 11 (particularly 10 and 11), shown on Figure 6-1, could be modeled for consolidation behavior. The settlement and consolidation behavior of the Removal Action Area will not only involve the amount (i.e., magnitude) of settlement, but also the length of time (i.e., time rate) of settlement, which will likely factor into the evaluation process.

### 7.5.5 Liquefaction Potential/Seismic Strength Assessment Methodology

The behavior of the Removal Action Area or a Removal Action alternative in response to earthquake effects may be severe enough to limit the effectiveness or nullify the technical feasibility of a given Removal Action alternative. Liquefaction analyses will be performed based on the standard of practice approach by Seed et al. (1985) and the National Center for Earthquake Engineering Research Workshop (NCEER, 1996) to define the extent of liquefaction predicted and potential impacts to the Removal Action alternatives. To accomplish this analysis, the shear wave velocity profiles collected during the field program will be used to perform a ProSHAKE (or equivalent) analysis, which calculates a site-specific peak ground acceleration that may occur

for a particular representative set of seismic conditions. For liquefaction, a portion (or all) of cross sections 8 through 11 (particularly 10 and 11), shown on Figure 6-1, could be modeled for this condition when evaluating Removal Action alternatives.

The peak ground acceleration determined from ProSHAKE (or equivalent) will also be used as an input to the pseudo-static seismic stability analyses. Additionally, post-liquefaction residual shear strength to support the slope stability analyses will be determined from methods presented in Kramer (1996) and Seed and Harder (1990).

## 7.6 Hydrogeologic Characteristics

As discussed in Section 6.7, available information is insufficient to adequately develop and evaluate Removal Action alternatives. Therefore, additional hydrogeologic investigations are proposed with associated laboratory testing. The following sections discuss the methodology, protocols, and procedures of the hydrogeologic data collection.

Six monitoring well clusters are proposed to address hydrogeologic characteristics. Monitoring wells will be completed in accordance with OAR 690 Division 240 Construction, Maintenance, Alternation, Conversion and Abandonment of Monitoring Wells, Geotechnical Holes, and Other Holes in Oregon and in conformance with DEQ guidance (see http://www.deq.state.or.us/wmc/tank/documents/monwell.pdf). The field sampling plan provides additional details pertaining to well completion and well development. Details for the proposed monitoring wells (anticipated depths and number of samples) are provided in Table 7-1, which indicates laboratory testing to be performed for the combined purposes of engineering and hydrogeologic characterization. Grain size tests will be used to determine hydrologic parameters based on empirical relationships and published values in the technical literature. Testing will be performed in accordance with relevant ASTM standards. The locations of the proposed explorations are shown on Figure 7-2.

Monitoring well clusters will comprise shallow, intermediate, and deep intervals, corresponding to the three primary hydrogeologic units to be characterized, which were introduced in Section 2. The exception to this may be the MW03 series of wells, which is specifically for monitoring groundwater flow conditions associated with Gatton's Slough. All three depths of the cluster are indicated, but based on a geotechnical study (Shannon and Wilson, 1962) of Slip 1, which discovered organic clay and silt that may be associated with Gatton's Slough in-filling, there may be limited flow through these fine-grained deposits with low hydraulic conductivity. Unless layers of saturated sand are encountered within the in-filled deposits that would justify a well, the deep location will be completed as the sole well below the in-filled soils. Each well within a cluster will be completed within 10 to 20 ft of an adjacent well for predicting vertical gradients. Wells will be screened within the zone of interest using 10-ft screens or 5-ft screens if applicable for thin layers.

As described in Section 6, a limited groundwater monitoring study will be performed within the data collection time frame allowed by the EE/CA schedule and will be extrapolated based on historical trends to infer seasonal characteristics.

Regarding hydrogeologic characteristics relevant to the analysis of disposal technologies, the following tasks will be performed:

- Develop conceptual site hydrogeologic model (in coordination with the Port's Upland Source Control Project where applicable, primarily for shallow wells).

- Determine hydraulic connectivity of upland fill aquifer to recent alluvial deposits (may differ from Slip 1 to Slip 3).

- Determine groundwater contour maps for each of three units (upland fill; recent alluvial deposits; Troutdale Gravel).

- Determine seasonal changes within each of the three units by water-level monitoring by extrapolating data collected within the EE/CA data collection period based on seasonal trends and existing data from Hart Crowser, 2000a. This activity includes field monitoring of pH, temperature, specific conductance, and dissolved oxygen.

- Determine vertical groundwater flow gradients between hydraulically separate units (and horizontal flow gradients).

- Determine groundwater flow characteristics of in-filled Gatton's Slough.

- Verify upland gradients from Troutdale Gravel Aquifer.

- Develop groundwater flow model using Visual MODFLOW, which includes each hydrostratigraphic unit encountered in explorations.

- Assess the effectiveness of onsite disposal and capping of sediment. Both require that contaminated sediment remain in place. Modeling of contaminant transport through sediment using MT3D will be used in conjunction with the results of laboratory testing described in Section 7.9 to assess sediment leaching characteristics.

## 7.7 Recontamination Source Characterization

### 7.7.1 Sources at Terminal 4

Work to be conducted pursuant to the Port's Terminal 4 Slip 1 source control agreement (Oregon DEQ, 2003b) includes installation of groundwater monitoring wells and sampling of stormwater. Details of these proposed studies will be provided separately.

### 7.7.2 Sources Outside Terminal 4

Sources outside Terminal 4 include contaminants transported in dissolved phase, attached to suspended particles, or attached to bed load sediment particles. Dissolved phase transport is not of high concern for the Removal Action Area, as sediment recontamination will be governed by deposition of particle-bound contaminants. Assessment of recontamination potential resulting from offsite, in-river sources should include:

- quantification of levels of contaminants in recently deposited sediments;
- characterization of the uncertainty range about the quantifications;
- estimation of the time trend in historical and current sources for projections into the future; and
- estimation of the amount of deposition likely to occur in the Removal Action Area of particles borne by the upstream flow .

There are several possible approaches to assessing recontamination potential associated with current offsite, in-river sources, including direct measurement of the sources (e.g., outfalls or tributaries), measurement of water quality or sediment quality transported to the Removal Action Area from offsite, and estimation based on available data. Recontamination potential can be assessed by assuming that the highest concentrations measured in the river will be transported without dilution to the boundary of the Removal Action Area. An estimate of the potential impact of current sources can be obtained by measuring water quality and transported sediment quality (suspended sediment and bed load sediment) immediately outside the Removal Action Area.

In-river source characterization activities will include:

- measurement of particle-phase concentrations of constituents of interest on sediments collected through deployment of sediment traps and bed load samplers; and
- measurement of contaminant concentrations in water quality samples collected upstream of the Removal Action Area during stormwater runoff events.

Sediment trap and bed load sampling will also provide an indication of sediment transport rates. Once in-river source characterization activities are completed, recontamination potential will be assessed by estimating sediment deposition in the Removal Action Area. For example, if the suspended sediment concentration is X, the deposition rate is Y, and the bioturbated sediment layer is Z, the time rate of recontamination of the surface sediment layer can be estimated. The deposition rate can be estimated based on the sediment trap data, or computed with the SED2D model.

## 7.8 Sediment Quality Characteristics

As discussed in Section 6.9, available sediment quality information is insufficient to adequately develop and evaluate Removal Action alternatives. Therefore, additional sediment chemistry sampling and analysis are proposed. The following sections discuss the methodology, protocols, and procedures of the sediment sampling and analysis.

The sediment quality data required for evaluation of Removal Action alternatives are:

- nature and lateral extent of contamination;
- under-pier sediment quality; and
- nature and vertical extent of contamination.

The lateral extent of contamination will be evaluated with surface sediment chemistry data. Under-pier surface sediment quality will be assessed to determine whether removal is required for under-pier sediment. Subsurface sediment chemistry data will be used to determine the vertical extent (i.e., depth) of contamination.

### 7.8.1 Sampling Methods and Data Validation

Sediment samples will be collected in accordance with USEPA's Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual (USEPA, 2001b). Sediment chemistry analyses will be performed in accordance with CLP or equivalent methods, such as SW-846, Test Methods for Evaluating Solid Waste (USEPA, 1994). Laboratories performing chemistry analyses will be certified by the National Environmental Laboratory Accreditation Program (NELAP). Analytical

methods, target detection limits, and sample requirements for chemical analyses are specified in the QAPP (Appendix A). All analytical results will undergo data quality validation performed by an independent third party; approximately 90% of analytical results will undergo a Level III data quality validation, and 10 to 20% of the results will undergo a Level IV data quality validation (CLP). Data quality validation will be performed in accordance with USEPA Contract Laboratory Program National Functional Guidelines for Organic and Inorganic Data Review (USEPA, 1999, 2002).

The proposed sampling design is stratified. Samples from Slip 1 and Slip 3, as well as Wheeler Bay and the Willamette River portion of the Removal Action Area will be obtained. A high degree of judgment has been applied to the particular sampling locations within each strata.

### 7.8.2 Surface Sediment Chemistry

Thirty-two surface sediment samples will be collected for the EE/CA: 17 in Slip 1 and 15 in Slip 3. Proposed surface sediment sampling locations are shown on Figure 7-3. Sampling locations were selected based on the existing data and to provide adequate coverage to evaluate the nature and lateral extent of contamination. Surface sediment samples will be collected from the top 1.0 ft in accordance with the surface sediment interval used for the Portland Harbor Superfund Site surface sediment sampling protocol. Surface sediment samples will be analyzed for metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc), SVOCs (including PAHs and phthalates), tDDT, PCBs (as Aroclors), total petroleum hydrocarbons (TPH), TOC, and grain size. Although pesticides, besides DDT, are not COPCs, a contingency plan has been developed at the request of USEPA for the possible analysis of a few sediment samples from Slip 1 for pesticides. Sediment samples for tDDT will be extracted and analyzed for the list of pesticides presented in Table A2-1 of the QAPP but only DDT will be reported. DDT and PCB results will be evaluated in Slip 1 for possible reporting of the full suite of pesticides. If elevated tDDT is observed in sediment samples from Slip 1, a select number of samples from Slip 1 will have the full pesticide list reported. Figure 7-4 outlines the sediment sample handling and analytical framework for the EE/CA.

### 7.8.3 Under-Pier Sediment Chemistry

Fifteen under-pier surface sediment samples will be collected for the EE/CA. Proposed under-pier surface sediment sampling locations are shown on Figure 7-3. Sample locations were selected to provide adequate coverage to evaluate the nature and lateral extent of potential contamination. Under-pier surface sediment samples will be collected by SCUBA divers using hand-held core tubes. Divers will target any available surface sediment under the piers. Under-pier surface sediment samples will be analyzed for metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc), SVOCs (including PAHs and phthalates), tDDT, PCBs (as Aroclors), TPH, TOC, and grain size. In addition, the divers will probe the surface sediment within the pilings of the former Pier 5 to evaluate the depth of soft sediment as opposed to riprap. Figure 7-4 outlines the sediment sample handling and analytical framework for the EE/CA.

### 7.8.4 Subsurface Sediment Chemistry

Thirty-two sediment cores will be collected for the EE/CA: 17 cores in Slip 1 and 15 cores in Slip 3. Proposed core locations are shown on Figure 7-5. Sample locations were selected based on the existing data and to provide adequate coverage to evaluate the extent of contamination. Cores will be collected with a vibracore. Target core length will be 15 ft or the point of refusal. The top 1 ft of each core will be collected for the surface

sediment sample. The remainder of the core will be subdivided into 2-ft intervals (i.e., 1 to 3 ft below mudline, 3 to 5 ft, 5 to 7 ft, 7 to 9 ft, 9 to 11 ft, 11 to 13 ft, and 13 to 15 ft). Each interval will be homogenized and subsampled for analysis The subsamples representing the top 11 ft of sediment below the mudline will be submitted for analysis of metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc), SVOCs (including PAHs and phthalates), tDDT, PCBs (as Aroclors), TPH, TOC, and grain size. Although pesticides, besides DDT, are not COPCs, a contingency plan has been developed at the request of USEPA for the possible analysis of a few sediment samples from Slip 1 for pesticides. Sediment samples for tDDT will be extracted and analyzed for the list of pesticides presented in Table A2-1 of the QAPP but only DDT will be reported. DDT and PCB results will be evaluated in Slip 1 for possible reporting of the full suite of pesticides. If elevated tDDT is observed in sediment samples from Slip 1, a select number of samples from Slip 1 will have the full pesticide list reported. A representative subsample of each remaining core section will be placed in a frozen archive for possible future analysis. Where necessary, analytical groups (e.g., organic analyses) will be extracted and the extract held in archive for future analysis. The archived samples may be submitted for analysis depending on the chemistry results for the top 11 ft of each core. Figure 7-4 outlines the sediment sample handling and analytical framework for the EE/CA.

## 7.9 Dredged Sediment Quality Characteristics

As discussed in Section 6.10, available information is insufficient to adequately develop and evaluate Removal Action alternatives. Therefore additional sediment quality characteristics pertaining to the dredging and subsequent transport and disposal of the dredged sediment are proposed. The following sections discuss the methodology, protocols, and procedures of the exploration and laboratory testing.

The data needs include:

- data to assess impact to water quality during dredging;
- data to assess onsite disposal; and
- data to assess offsite disposal.

Potential water quality impacts during dredging will be evaluated using dredging elutriate data. Settling velocity, modified elutriate, and column leachate data will be used to assess onsite disposal in a CDF. The assessment of offsite disposal in a Subtitle D landfill will be performed with landfill-specific acceptance criteria. These criteria may include hazardous waste determination, TCLP tests, TSCA determinations, data on the generation and loss of free liquid, and other landfill-specific acceptance criteria.

### 7.9.1 Water Quality Data Need

Assessment of water quality impacts for the implementation of dredging technologies will be performed with dredging elutriate data. The dredging elutriate test (DRET) simulates the release of sediment-bound and porewater constituents into the receiving water column at the point of dredging. Two DRETs will be performed for the EE/CA in accordance with Dredging Elutriate Test (DRET) Development (DiGiano et al., 1995). Two composite sediment samples will be created for the DRETs: one composite of the cores collected from Slip 1 and the other of the cores from Slip 3 (Slips 1 and 3 core sampling locations are discussed in Section 7.8). The composite sediment samples will consist of representative subsamples of the top 11 ft (i.e., 0 to 11 ft below mudline) of each core. Figure 7-4 outlines the sediment sample handling and analytical framework for the EE/CA. The DRET samples will be analyzed for the same list of constituents as surface and subsurface

sediment samples (metals, SVOCs, tDDT, PCBs, and TPH). Additionally, elutriate ammonia and hydrogen sulfide content will be measured in each sample.

### 7.9.2 Sediment Quality Characteristics Impacting Onsite Disposal

Data needed to evaluate the onsite disposal of dredged material include:

- settling velocity of dredged material placed in a CDF;
- short-term water quality impacts from a CDF; and
- long-term water quality impacts from a CDF.

A column settling test (CST) will be performed to evaluate the settling velocity of dredged material placed in a CDF. The CST simulates the settling chacteristics of hydraulically transported and placed sediment. The CST will be performed in accordance with Confined Disposal of Dredged Material (USACE, 1987). The CST will be performed on a composite sediment sample consisting of the cores from Slip 3. Figure 7-4 summarizes the sediment sample handling and analytical framework for the EE/CA. The composite sediment sample will consist of the 0- to 11-ft below mudline length of each core. Column settling samples will analyzed for total suspended solids.

A modified elutriate test (MET) will be performed to evaluate short-term water quality impacts from a CDF. The MET simulates the release of sediment-bound and porewater constituents. The MET will be performed in accordance with Environmental Effects of Dredging, Technical Notes, Interim Guidance for Predicting Quality of Effluent Discharged from Confined Dredged Material Disposal Areas—Test Procedures (Palermo, 1985). The MET will be performed on a composite sediment sample consisting of cores from Slip 3. The composite sediment sample will consist of the 0- to 11-ft below mudline length of each core. The MET elutriate will be analyzed for metals, SVOCs, tDDT, and PCBs.

A thin-column leaching test (TCLT) will be performed to evaluate long-term water quality impacts from a CDF. The TCLT will be performed in accordance with Leachate Testing and Evaluation for Estuarine Sediments (Myers et al., 1996). The TCLT will be performed on a composite sediment sample consisting of cores from Slip 3. The composite sediment sample will consist of the 0- to 11-ft below mudline length of each core. The TCLT leachate will be analyzed for metals, SVOCs, tDDT, and PCBs. Figure 7-4 outlines the sediment sample handling and analytical framework for the EE/CA.

### 7.9.3 Sediment Quality Characteristics Affecting Offsite Disposal

Two composite sediment samples will be analyzed for hazardous waste determination, TCLP, generation and loss of free liquid, and landfill-specific acceptance criteria. One composite sediment sample will consist of the cores collected from Slip 1, and the other will consist of the cores from Slip 3. The composite sediment samples will consist of the 0- to 11-ft below mudline length of each core.

For hazardous waste determination, the two composite sediment samples will be analyzed for ignitability, corrosivity, and reactivity. TCLP tests will be performed on the two composite sediment samples and the TCLP leachate will be analyzed for metals, pesticides, herbicides, VOCs, and SVOCs. The two composite sediment samples will also undergo paint filter tests to evaluate the generation and loss of free liquid.

The existing and new surface and subsurface sediment PCB data will be evaluated as part of the TSCA determination. The new surface and subsurface sediment TPH data will be evaluated against landfill TPH acceptance criteria. Figure 7-4 outlines the sediment sample handling and analytical framework for the EE/CA.

### 7.9.4 Sampling Methods and Data Validation

Sediment samples will be collected in accordance with USEPA's Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual (USEPA, 2001b). Laboratories performing chemistry analyses will be certified by NELAP. Elutriate, leachate, and other tests will be performed in accordance with the methods specified above. All analytical results will undergo data quality validation; 90% of analytical results will undergo a Level III data quality validation, and 10% of the results will undergo a Level IV data quality validation (CLP). Data quality validation will be performed in accordance with USEPA Contract Laboratory Program National Functional Guidelines for Organic and Inorganic Data Review (USEPA, 1999, 2002).

## 7.10 Hydraulics and Sedimentation Characteristics

As discussed in Section 6.11, available information is insufficient to adequately develop and evaluate Removal Action alternatives. Therefore, additional hydraulic and hydrodynamic data collection is proposed. The following sections discuss the methodology, protocols, and procedures of the data collection.

The interaction between river and berth hydraulics in the Removal Action Area will be simulated with the RMA-2 two-dimensional hydrodynamic model to predict flow circulation and sedimentation patterns. Simulation will be performed for a range of conditions, including high and low flow scenarios, to assess the spatial variation in velocity and bed shear stresses. Flow velocity and bed shear stress patterns will be mapped for each scenario. Sedimentation patterns will be simulated using the SED2D model, which is designed to directly use the hydrodynamic simulation results obtained from RMA-2.

The data required to successfully run the RMA-2 and SED2D models include bathymetric data, river elevations and flow rates for simulation conditions, and suspended sediment concentrations carried by the river. Calibration data are also needed, including velocity data, water surface elevations, and sedimentation measurements. The calibration data can also be used to empirically assess sedimentation behavior outside of the modeling analysis.

The following data collection activities will be conducted to support evaluation of river and berth hydraulics and sedimentation patterns:

- Three rounds of velocity measurements will be collected along eight transects running halfway across the river adjacent to the Terminal 4 Removal Action Area and along four transects across Slip 1 and Slip 3 using a boat-mounted Acoustic Doppler Current Profiler (ADCP).

- Four moored oceanographic arrays consisting of an Acoustic Doppler Current Meter (ADCM), turbidity sensor, and tubular sediment traps will be deployed as vertical in-line arrays within each slip to collect time series near-bottom velocity, turbidity, and sedimentation data.

- Willamette River water surface elevations will be measured with three tide gages deployed near Berth 414 and at an upstream and a downstream location. The upstream gage will be installed near the St.

Johns Bridge. The downstream gage will be installed at a location approximately 3 miles downstream of the Removal Action Area near the confluence with the Columbia River to provide a downstream elevation for the hydrodynamic model.

### 7.10.1 Transect Velocity Measurements

Cross-sectional river velocity measurements will be obtained from measurement of velocity depth profiles along eight transects running part way across the river from the Terminal 4 shoreline and across each of the slips. These measurements will provide "snapshots" of the magnitude and direction of flow velocities adjacent to the terminal and within the slips that can be used to calibrate the hydrodynamic model simulations of flow and circulation patterns in the river and adjacent slips.

These data will be collected by a qualified hydrographic surveying contractor using RD Instrument's 1,200 kHz ADCP (or comparable) positioned below a differential global positioning system (DGPS) receiver using trackline control instrumentation. The transects will be run from the Terminal 4 shoreline halfway across the river (i.e., to the channel midpoint). Three transects will be run in Slip 3, two in the Wheeler Bay area, and three in Slip 1. ADCP transect lines in the Slip 3 area will take off from the upstream end of Slip 3 (at the shoreline corner entering the slip), from the midpoint of the eastern edge of the slip, and from the downstream edge of the slip (from the shoreline corner at the mouth of the slip). ADCP transect lines in the Wheeler Bay area will take off from the midpoint of the eastern shoreline of Wheeler Bay and from the downstream edge of Wheeler Bay. The transects in Slip 1 will take off from the upstream edge, midpoint of the eastern edge, and the downstream edge (similar to Slip 3). The trackline and measurement points for each transect will be recorded using DGPS equipment.

Transects will also be run north-south in the slips. Three north-south transects will be run in Slip 3 (from the head, midpoint, and mouth of the slip). Three north-south transects will be run in Slip 1 (from the head, midpoint, and mouth of the slip).

### 7.10.2 Moored Arrays

Four arrays consisting of a near-bottom ADCM will be moored within the slips. One array will be placed near the mouth of Slip 1, two arrays will be placed within Slip 3, and one array will be placed just upstream of the Removal Action Area. The arrays will be deployed as in-line vertical moorings composed of an anchor, a sufficient length of jacketed wire cable, and a subsurface floatation buoy. A surface buoy will be linked to the top of the subsurface sphere with a tether. The two moorings in Slip 3 will include a single sediment trap mounted 2 to 3 ft above the sediments and a Nortek Aquadopp® (or comparable) sensor mounted 3 ft above the sediment trap. The remaining two arrays will just have Aquadopp® sensors. The Aquadopp® sensors will record turbidity and current velocity. Sediment traps of typical design will be constructed or purchased. Sediment traps will generally consist of a series of three tubes capped on one end and positioned around the vertical mooring cable. A hexcel baffle composed of numerous individual cells will placed in the opening of each tube or cone to reduce turbulence around the mouth of the trap.

The array in Slip 1 will be situated approximately 30% of the distance from the mouth of the slip to the eastern end at approximately the east-west centerline of the slip. The two arrays in Slip 3 will be positioned, with one array positioned at one-third of the distance from the mouth of the slip to the eastern end of the slip; and the other array at a distance approximately two-thirds of the distance from the mouth of the slip to the eastern end. This configuration is designed to provide information on flow circulation and sedimentation patterns caused by eddies in the slip from the Willamette River flow.

The sensors may also record influences of vessel movement and ship propellers. Kinder Morgan, the tenant of Slip 3, will be contacted in order to prepare a schedule of vessel movement in and out of Slip 3 during the sampling time frame. Our current understanding is that approximately 100 ships per year, typically of the 50,000-ton class and never more than one ship at a time, are serviced at Slip 3. Ships are berthed bow toward the river and are maneuvered with tugboat tenders during berthing and departure. When sensor readings are made, the time of vessel movement, type and size of vessel, and other pertinent information will also be recorded, and the relationship of this information to the sensor readings will be evaluated.

Sampling locations will be recorded using DGPS equipment and marked with high-visibility buoys to minimize disruption by ship traffic. Prior to array deployment, ship activities will be reviewed with the Port and, if necessary, locations will be adjusted and/or diver installation and retrieval of the arrays will be used to avoid placing buoys in ship traffic.

Following installation, the arrays will be retrieved at 30 days and 60 days for data collection. Data will be downloaded each time and samples retrieved from the sediment traps for analysis.

In addition to the collected data, published scientific studies on the bottom shear stresses generated by ship prop wash and tugboat activities will be used to assess the importance of ship scour in Slip 3. Bathymetric survey maps showing localized impacts from ships will be evaluated and used to support conclusions regarding the areas and spatial extent of large impacts to the sediment from ships (e.g., scour areas).

### 7.10.3 Stage Recorders

Water surface elevations will be recorded with tide gages installed near the downstream end of Slip 3 and approximately 1.25 miles downstream of the Removal Action Area.

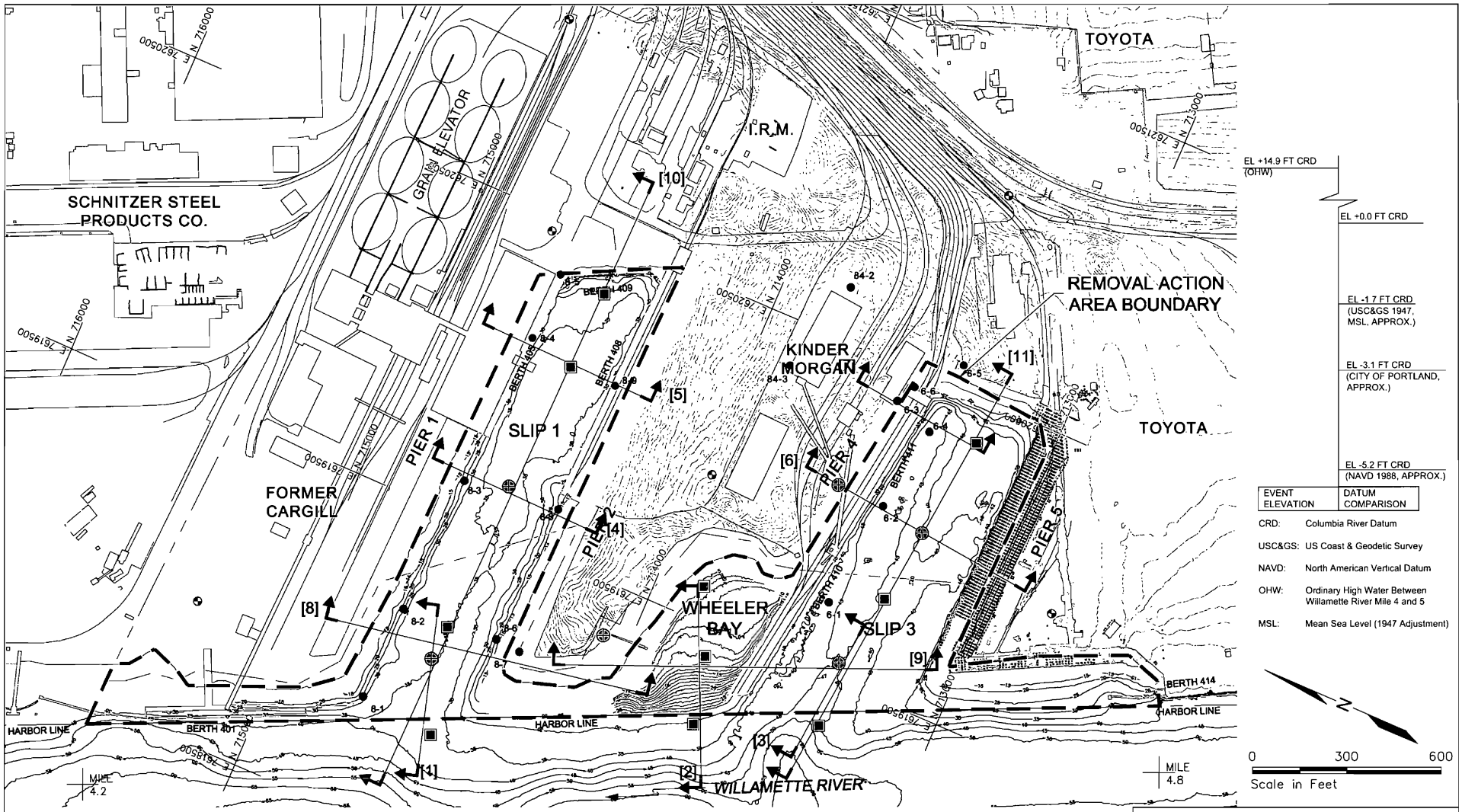
The gage locations will be established to the Columbia River datum, which will be programmed into the gages so that water depth measurements recorded by gage are automatically converted and stored as elevation. Water level recording will be initiated after the gage elevations have been established through field survey with accuracy to at least 0.1 ft.

The gages will be installed for a 60-day period and data downloads will be conducted at 20 days, 30 days, and 60 days following installation. Water levels will be recorded at 15-minute intervals.

**Table 7-1**
**Estimated Number and Type of Engineering (and Hydrogeologic) Characteristics Explorations and Laboratory Tests**

| Exploration ID | Anticipated Depth, Ft.[1] | Anticipated No. (Disturbed) SPT Samples | Anticipated No. ("Undisturbed") Piston Samples | Anticipated No. of Surface/Subsurface Sediment Samples | Composited Sample (Core Samples Only) | Moisture Content, ASTM D 2216 | Grain Size, ASTM D 422 | Atterberg Limits, ASTM D 4318 | Organic Content, ASTM D 2974 | Specific Gravity, ASTM D 854 | Consolidation, ASTM D 2435 or 4186 | Sample Bulk Density (Coordinated with Laboratory) | UU Triaxial Test (Shear Strength), ASTM D 2850 | CU Triaxial Test (Shear Strength), ASTM D 4767 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G01W | 120 | 27 | 4 | N/A | N/A | 27 | 5 | 5 | 1 | 2 | 2 | 4 | 4 | 1 |
| G02W | 80 | 21 | 2 | N/A | N/A | 21 | 4 | 4 | 1 | 1 | 1 | 2 | 0 | 0 |
| G03L | 160 | 26 | 4 | N/A | N/A | 26 | 5 | 5 | 1 | 0 | 0 | 4 | 0 | 0 |
| G04L | 90 | 18 | 4 | N/A | N/A | 18 | 4 | 4 | 1 | 0 | 0 | 4 | 4 | 1 |
| G05W | 140 | 29 | 4 | N/A | N/A | 29 | 6 | 6 | 1 | 2 | 2 | 4 | 4 | 1 |
| G06W | 70 | 19 | 2 | N/A | N/A | 19 | 4 | 4 | 1 | 1 | 1 | 2 | 0 | 0 |
| MW01S | 30 | 1 | 0 | N/A | N/A | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW01I | 60 | 1 | 0 | N/A | N/A | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW01D[4] | 180 | 28 | 0 | N/A | N/A | 28 | 6 | 6 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW02S | 30 | 1 | 0 | N/A | N/A | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW02I | 60 | 1 | 0 | N/A | N/A | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW02D | 180 | 28 | 0 | N/A | N/A | 28 | 6 | 6 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW03I | 80 | 16 | 0 | N/A | N/A | 16 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW03D[5] | 130 | 23 | 0 | N/A | N/A | 23 | 5 | 5 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW04S | 30 | 6 | 1 | N/A | N/A | 6 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW04I | 80 | 16 | 2 | N/A | N/A | 16 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW05S | 30 | 1 | 0 | N/A | N/A | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW05I | 60 | 1 | 0 | N/A | N/A | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW05D | 180 | 28 | 0 | N/A | N/A | 28 | 6 | 6 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW06S | 30 | 1 | 0 | N/A | N/A | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW06I | 60 | 1 | 0 | N/A | N/A | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| MW06D | 180 | 28 | 0 | N/A | N/A | 28 | 4 | 4 | 1 | 0 | 0 | 0 | 0 | 0 |

**Notes:**
(1) Anticipated depths are presently estimated. These will be refined before the field program and further altered depending on the conditions encountered in the field.
(2) Number of laboratory tests indicate represent approximate values to be verified based on conditions encountered in the field.
(3) This table does not include proposed Seismic Cone Penetrometer explorations, as these do not involve sample collection.
(4) For monitoring well series explorations, the deep boring of a cluster will be sampled at the interval specified in the Field Sampling Plan. Shallow and Intermediate wells will only be sampled in the screened interval for the purpose of grain size analysis, etc.
(5) This well is not intended for installation into the Troutdale Gravel, but for installation in a permeable unit below Gatton Slough fine-grained organic silt/clay soils.




Existing Piers

Existing Geotechnical Exploration Location

Proposed Geotechnical Exploration Location

Proposed Seismic Properties Boring Location

Proposed Seismic Cone Penetrometer Explorations

Proposed Monitoring Well Cluster Location

[9] Potential EE/CA Analysis Cross Section

Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.
7. Analysis Cross Section Locations may change depending on the outcome of the field program and course of the EE/CA Process in general.

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PROPOSED GEOTECHNICAL EXPLORATIONS

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FIGURE 7-1

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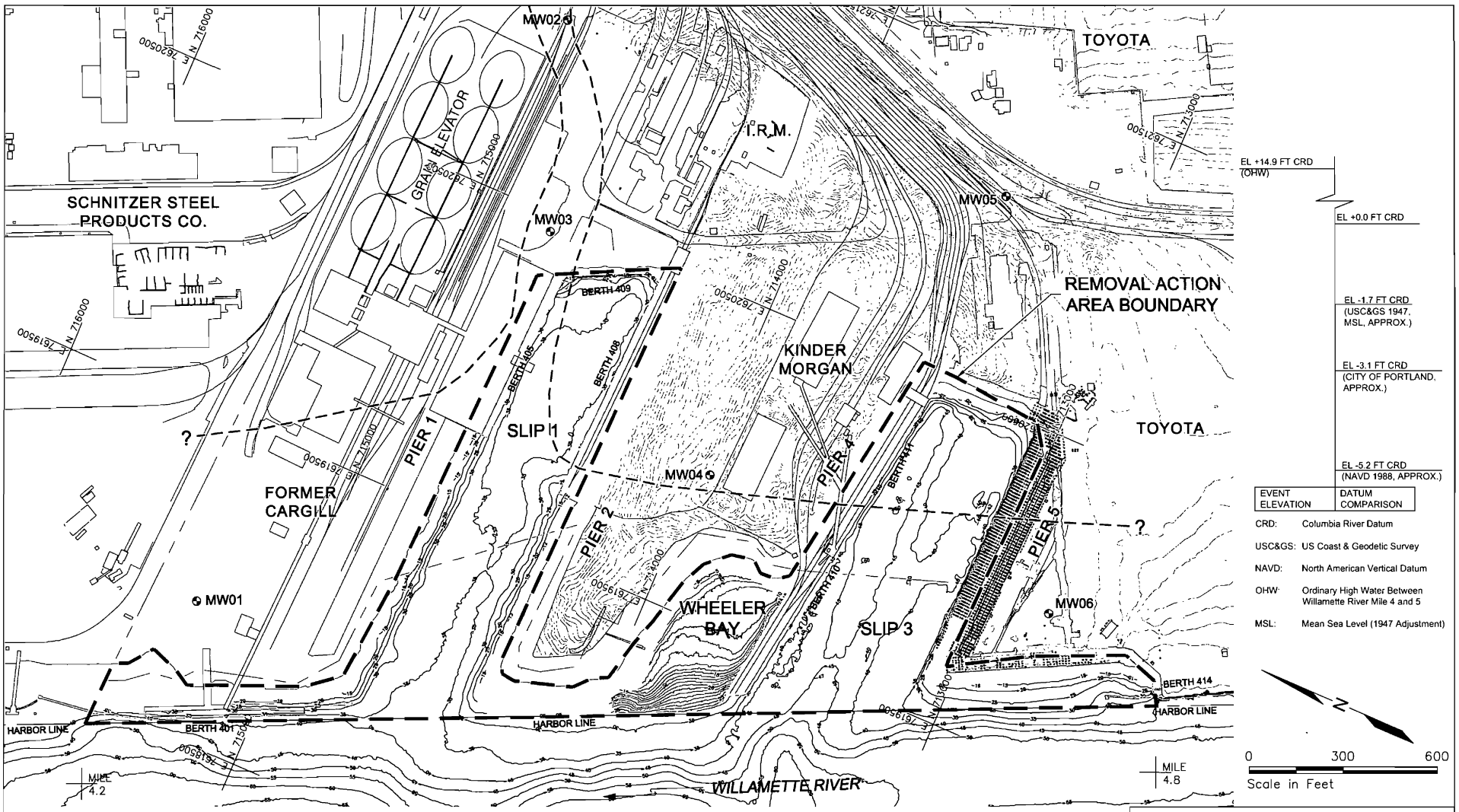


Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.

Proposed Monitoring Well Cluster Location

Existing Piers

Historic Shoreline and Gatton Slough

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PROPOSED MONITORING WELL CLUSTER LOCATIONS

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FIGURE 7-2

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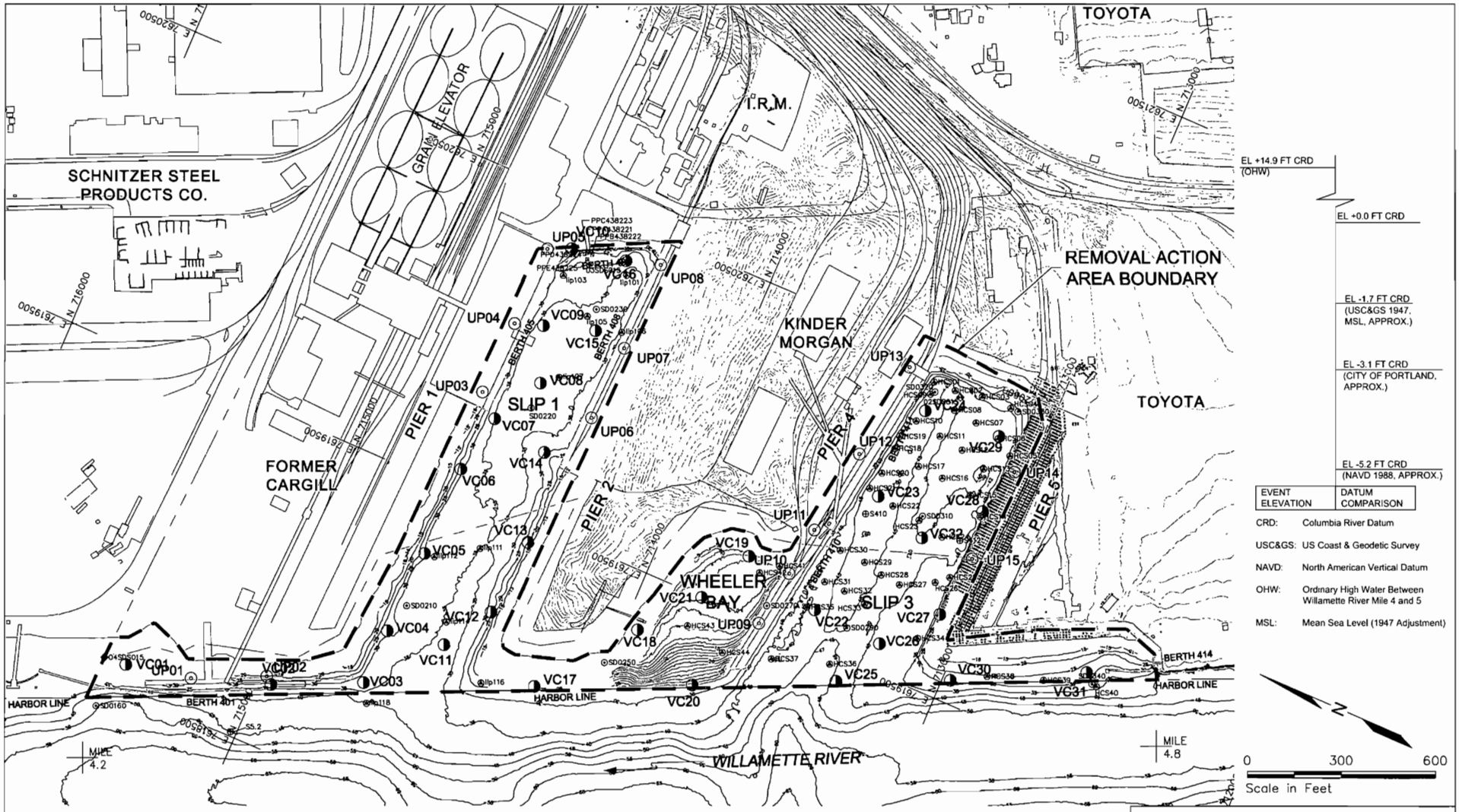


| EVENT ELEVATION | DATUM COMPARISON |
|---|---|
| CRD: | Columbia River Datum |
| USC&GS: | US Coast & Geodetic Survey |
| NAVD: | North American Vertical Datum |
| OHW: | Ordinary High Water Between Willamette River Mile 4 and 5 |
| MSL: | Mean Sea Level (1947 Adjustment) |

Existing Piers

Proposed Sediment Core Sample Location

Proposed Under-Pier Surface Sediment Sample Location

Existing Surface Sediment Sample Location by Others

| | |
|---|---|
| SDS015 | Round 1 Portland Harbor Data |
| HCS43 | RI Report (Hart Crowser, 2000) |
| PPA438221 | Storm Water Report (Hartman Associates/Fishman Environmental Services, 1995) |
| SD0220 | Portland Harbor Sediment Investigation (Roy F. Weston, Inc., 1998) |
| S412 | Willamette Sediment Report (USACE, 1987b) |

Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.

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EXISTING AND PROPOSED SURFACE SEDIMENT SAMPLE LOCATIONS

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FIGURE 7-3

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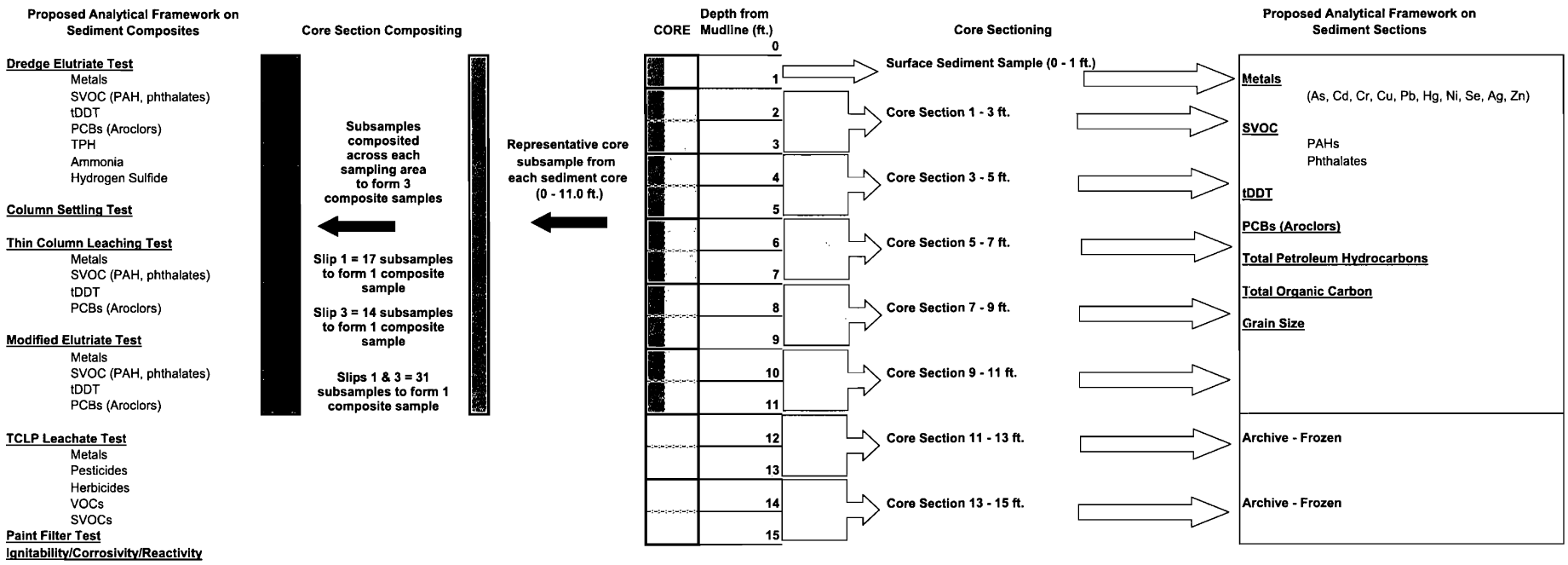


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SUMMARY OF PROPOSED SEDIMENT SAMPLES AND ANALYSES

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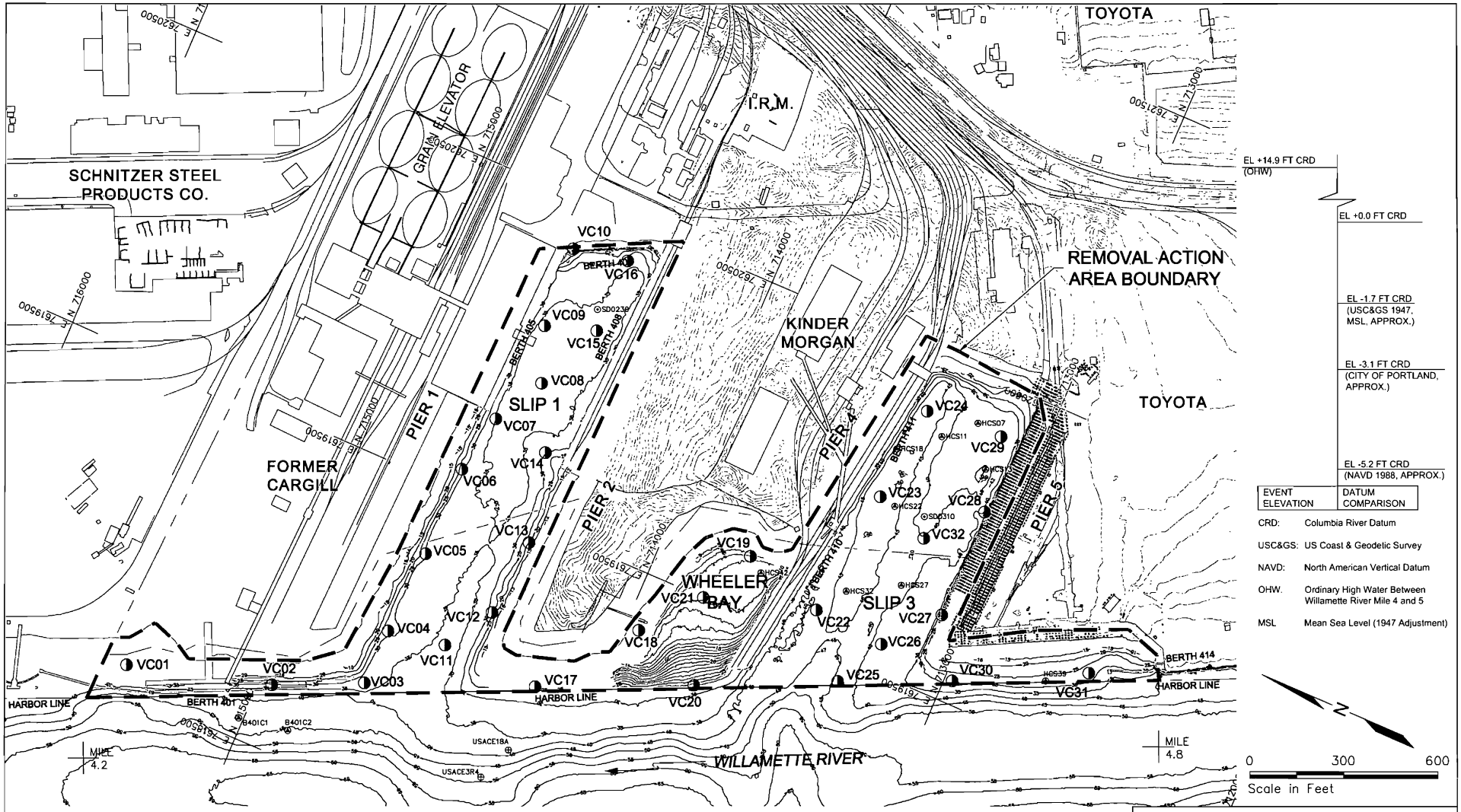
FIGURE 7-4




Existing Piers

Proposed Subsurface Sediment Sample Location

Existing Subsurface Sediment Sample Location by Others

HCS07 Sediment Characterization Study and RI Report (Hart Crowser, 1999, 2000)

SD0230 Portland Harbor Sediment Investigation (Roy F. Weston, Inc., 1998)

USACE18A Willamette River Raw Data (USACE, 1988)

Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6 Datum conversion tables to CRD provided by Port of Portland.

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EXISTING AND PROPOSED SUBSURFACE SEDIMENT SAMPLE LOCATIONS

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FIGURE 7-5

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Section 8

# 8. Removal Action Evaluation Approach

This section describes how Removal Action alternatives will be developed and how the alternatives will then be compared and ranked to assess their relative performance at meeting specific objectives associated with the evaluation criteria of effectiveness, implementability, and cost. This section also describes how the preferred Removal Action alternative will be identified, as well as the steps that will be taken to conduct a biological assessment of the effects of the preferred alternative on species listed and proposed for listing under the Endangered Species Act.

## 8.1 Removal Action Objectives

The RAOs were introduced in Section 6.1 and are repeated here in accordance with the NTCRA guidance (USEPA, 1993b). RAOs for the Terminal 4 Removal Action Area are to:

- Reduce ecological and human health risks associated with sediment contamination within the Removal Action Area to acceptable levels..

- Limit the likelihood of recontamination of sediments within the Removal Action Area.

The Port proposes to achieve the RAOs while allowing continued use of the marine terminal and minimizing disruption of operations.

## 8.2 Potential ARARs and TBCs

Federal and Oregon potentially applicable or relevant and appropriate requirements (ARARs) will be compiled and used as one element in the Removal Action evaluation. On-Site actions (i.e., those taken within the Portland Harbor Superfund Site) must comply with the substantive requirements of any identified ARARs, to the extent practical considering the circumstances of the situation, or receive an ARAR waiver allowed by USEPA guidance under certain circumstances. On-Site actions do not have to comply with the corresponding procedural ARAR requirements, such as permit applications, reporting obligations, and record keeping requirements. Off-Site actions must comply with all substantive and procedural ARAR requirements.

Potential ARARs are divided into the following categories:

- Chemical-Specific Requirements. These are health- or risk-based concentration limits or ranges for specific hazardous substances, pollutants, or contaminants in various environmental media. An example is the maximum contaminant levels established by USEPA as safe levels in drinking water.

- Action-Specific Requirements. These are controls or restrictions on particular types of activities such as hazardous waste management or wastewater treatment. Examples of action-specific requirements are state and federal air emissions standards as applied to an in-situ extraction treatment unit.

- Location-Specific Requirements. These are restrictions on activities based on the characteristics of a site or its immediate environment. The restrictions on work performed in wetlands or wetland buffers provide an example. In this example, the location-specific requirements may require restoration of wetlands.

The potential chemical- and location-specific ARARs are summarized in Table 8-1, which provides citations and brief synopses of the ARARs. Chemical- and location-specific ARARs will be reevaluated subsequent to data collection described in this work plan. Action-specific ARARs will be identified after Removal Action alternatives and cleanup technologies are chosen for analysis in the EE/CA. However, evaluation and tracking of certain action-specific ARARs, such as the Flood Insurance Act and related cut and fill issues, will be undertaken prior to development of Removal Action alternatives to allow for an appropriate level of analysis. A complete list of potential chemical-, location-, and action-specific ARARs and To Be Considereds (TBCs) will be developed following the selection of Removal Action alternatives for the EE/CA.

## 8.3 Screening of Technologies

In accordance with the USEPA guidance (USEPA, 1993b) for NTCRAs, "only the most qualified technologies that apply to the media or source of contamination" need to be considered for the development, comparative evaluation, and selection of Removal Action alternatives. On the basis of prior experience with a number of contaminated sediment projects in the Pacific Northwest, the technologies identified as likely to qualify for consideration in the EE/CA include:

- Dredging, followed by additional, auxiliary technologies:
  - transport of dredged sediments;
  - treatment of dredged sediments; and
  - disposal of dredged material onsite or offsite; and
- In-situ capping of contaminated sediment.

### 8.3.1 Dredging Technologies

Dredging technologies are used to remove contaminated sediment from its original place for subsequent treatment, transportation, or disposal. Dredging removes the sediment and associated contamination, thereby reducing or eliminating its volume and toxic effects.

The EE/CA will briefly review dredging technologies (primarily grouped as either mechanical or hydraulic) and introduce a range of dredging equipment that is both available and potentially suitable for the Removal Action. The screening criteria that will be used to narrow a presumably broad range of dredging technologies to those most practical and qualified for the Removal Action will include, but not be limited to:

- resuspension of sediment during dredging;
- dredging accuracy;
- production rate;
- volume of water generated while dredging;
- equipment availability;
- type of and need for supporting equipment;
- ability to handle underwater obstructions, logs, riprap, boulders, and other debris; and
- site constraints, slopes, including water depths, slip size, and presence of piers (i.e., access).

Following this screening, a short list of dredging technologies will be developed and will serve as the basis for developing Removal Action alternatives.

### 8.3.2 Dredge Material Handling Technologies

The following is a brief summary of technologies likely to be considered for the handling, transportation, and disposal of dredged sediment.

#### 8.3.2.1 Transport Technologies

The EE/CA will discuss the various alternatives for dredged material transport and their applicability to the Removal Action. Transport methods such as pipelines, barges (of various types and configurations), and transloading to truck and rail will be reviewed. A table or flowchart illustrating the relationship of the transport technologies to the dredging and disposal technologies will be developed to demonstrate the interrelationships among the various transport, dredging, and capping technologies, which are closely linked.

#### 8.3.2.2 Treatment Technologies

The USEPA guidance for conducting NTCRAs (USEPA, 1993b) indicates that, to the extent practicable, EE/CA alternatives should consider the CERCLA preference for treatment over containment or land disposal. The EE/CA will identify technologies, process options, and alternatives for evaluation that include treatment of contaminated sediments. Based on a preliminary evaluation, treatment of sediment may include:

- Physical or chemical treatment; or
- Thermal treatment.

Physical treatment involves operations in which change to the medium is brought about by means of or through the application of physical forces (e.g., separation technologies such as gravity separation or filtration).

Chemical treatment brings about change to the sediment by means of or through chemical reaction. Chemical treatment is typically used in conjunction with physical treatment to enhance contaminant removal, immobilization, or degradation. Physical/chemical treatment technologies likely to be considered potentially applicable to the Removal Action Area sediments include:

- Sediment Washing. Sediment washing is a physical or physical/chemical process that reduces the volume of material requiring further treatment or disposal by separating and/or removing organic contaminants that adhere to organic matter and fine particles within a soil/sediment matrix. The water used in sediment washing normally requires additional handling and treatment to meet applicable discharge criteria.

- Stabilization/Solidification. Stabilization/solidification is a treatment process that immobilizes contaminants in sediments using chemical treatment (addition of cement, pozzolanic material) while potentially improving the handling characteristics of the material.

Thermal treatment technologies use heat as the primary mechanism for removal/volatilization and/or destruction of chemical compounds in sediments. Thermal treatment technologies include:

- Incineration. Incineration is a treatment technology that uses a controlled, high-temperature combustion process to destroy contaminants, reducing the volume and/or toxicity of the contaminated sediments.

- Thermal Desorption. Thermal desorption is a treatment technology that separates the contaminants from the sediment matrix at a lower temperature than incineration, causing the contaminants to volatilize.

On the basis of past experience with sediment remediation projects in the Northwest (and elsewhere), it is anticipated that treatment will consist only of dewatering.

### 8.3.3 Disposal Technologies

Sediment dredged from the Removal Action Area may be disposed of onsite or offsite. The onsite disposal of dredged sediment is typically implemented by the construction of a nearshore confined disposal facility (CDF). Nearshore CDFs are essentially lagoons surrounded by berms into which the dredged sediment is placed. The berms are designed and constructed to reduce the likelihood of migration of leachable contaminants into the groundwater or to the adjacent water body. After a CDF is filled, it is capped with an engineered layer that prevents the infiltration of precipitation and other surface water and that can also facilitate the use of the CDF area for beneficial purposes. Upland CDFs were not considered because sufficient land is not available at the Terminal 4 facility.

Offsite disposal of the sediment dredged from the Removal Action Area will likely be implemented via disposal at a Subtitle D solid waste landfill. Typically, disposing of dredged material in this manner requires that the dredged material be dewatered, loaded, and transported for disposal. Loading into a barge, railcar, or truck may occur at the Removal Action Area or loading into a railcar or truck could occur at another location, depending on the disposal facility selected. Transport to the disposal facility may be by barge, truck, railcar, or a combination, depending on the disposal facility selected. The selected disposal facility must be permitted to accept the types and concentrations of contaminants found in the dredged material.

Pacific Northwest landfills have developed several approaches to managing the relatively high water content found in dredged material. Landfills may apply for a research, development, and demonstration (RD&D) permit or may add a byproduct to the dredged material to dry the waste. An RD&D permit waives specific requirements (such as the paint filter test) for municipal solid waste landfills in order to promote innovative landfill technologies and operating processes. The landfill operator must demonstrate that these technologies and operating processes will not result in increased risk to human health and the environment. Under this program, certain landfills may accept liquid wastes for disposal to enhance waste decomposition. Liquid wastes are wastes that do not pass the paint filter test (USEPA Method 9095). Alternatively, a landfill operator may add a byproduct to dry the waste so that the waste will meet the permit conditions of the landfill (i.e., pass the paint filter test).

The EE/CA will summarize the disposal technologies determined to be most practical for the sediment in the Removal Action Area, as well as the waste disposal requirements and current and projected capacities of the likely upland disposal facilities.

### 8.3.4 Capping Technologies

Capping technologies isolate contaminated sediment in place, thereby reducing the mobility of contaminants, i.e., the ability of contaminants to reach ecological and human receptors and the water body.

The EE/CA will briefly review capping technologies, including caps constructed using earthen materials, such as sand and gravel, and caps constructed using man-made materials, such as reinforced mattresses, concrete filled mattresses, and armoring. The advantages and disadvantages of the capping technologies will be described. The EE/CA will also discuss the various placement techniques that can be used to install caps. The screening criteria that will be used to narrow a presumably broad range of capping technologies to those most practical and qualified for the Removal Action will include, but not be limited to:

- strength and compressibility of sediments;
- stability of sediment slopes to be capped;
- impacts to water quality during cap placement;
- the presence of underwater debris;
- potential interference of the cap with navigation;
- the presence of piers, piles, and under-pier areas to be capped; and
- periodic external loads on the cap, including seismic forces, erosion, propeller wash, and ice, as appropriate.

Following this screening, a short list of capping technologies will be developed and will serve as the basis for developing Removal Action alternatives.

### 8.3.5 Technology Summary

The EE/CA will summarize the limited number of dredging technologies (including auxiliary treatment, transport, and disposal technologies), capping technologies, options, and facilities that will be considered in developing Removal Action alternatives. In accordance with NTCRA guidance, "only the most qualified technologies that apply to the media or source of contamination" (USEPA, 1993b) will be evaluated in the EE/CA.

## 8.4 Development of Alternatives

The EE/CA will introduce a limited number of Removal Action alternatives based on the short list of technologies discussed in Section 8.3. In compliance with the National Contingency Plan, a No Action alternative will be used as a baseline for evaluating and comparing the alternatives. The alternatives will be built on the selected technologies, the results of the Removal Action Area characterization, the RAOs, and future land use requirements.

It is likely that different removal technologies will be considered for Slip 1, Slip 3, and Wheeler Bay. Therefore, the alternatives likely will include a combination of technologies.

Anticipated alternatives to be developed in the EE/CA include:

- No Action;
- removal by dredging (either mechanical or hydraulic), followed by onsite disposal;
- removal by dredging (either mechanical or hydraulic), followed by upland disposal; and
- capping in place.

A flow chart of the development of these alternatives using the various technologies introduced above is shown on Figure 8-1.

So that each alternative can be considered for further evaluation, the following information will be provided in the EE/CA:

- a brief summary of the rationale behind development of the alternative;
- the alternative's removal scope;
- the alternative's removal schedule; and
- a brief description of the technologies involved and planned removal activities, including:

  - quantification of the volume or areal extent of sediment to be addressed with the technology(ies);
  - a general description of the type of equipment to be used for in-water work;
  - a general description of shoreline equipment for the handling, pre-treatment, treatment, and hauling of sediment (as applicable); and
  - requirements for an onshore staging area and access to support implementation of the technology(ies).

It is envisioned that each Removal Action alternative will be introduced at a conceptual design level (approximately 15% completion), with figures and tables (as necessary) to support the narrative description.

The EE/CA will also evaluate the developed alternatives against the criteria of effectiveness, implementability, and cost, as discussed below.

In the assessment of effectiveness, each alternative will be evaluated for:

- how well it meets RAOs, i.e., protects the public health and the environment and provides a permanent, long-term solution;
- whether and to what extent it meets the ARARs;
- whether and to what extent it meets the criteria of reducing mobility, volume, and toxicity of contaminants; and
- whether and how it provides safety to workers, the public, and the environment during implementation.

In the assessment of implementability, each alternative will be evaluated with regard to its technical feasibility, the availability of the necessary resources to support the alternative, and its administrative feasibility.

The cost of the alternatives will be determined by establishing the present worth of each alternative's implementation by looking at capital costs and the costs of post-removal control (if any). The capital costs include direct and indirect capital costs. Typical cost considerations include:

- Direct capital costs
  - construction costs;
  - mobilization and demobilization costs;
  - equipment and material expenses;
  - land and site acquisition costs;

- buildings, services, utilities, and relocation costs;
- treatment costs;
- transport and disposal costs;
- analytical costs; and
- contingency.

- Indirect capital costs
  - engineering and design fees;
  - legal fees, permits and licenses; and
  - startup and shakedown costs.

- Annual post-Removal Action control costs
  - operational costs;
  - maintenance;
  - auxiliary materials and energy;
  - monitoring costs;
  - disposal of residuals;
  - support cost; and
  - insurance and other risk-related cost.

The accuracy of EE/CA-level cost estimates is in the range of -30% to +50%, in accordance with USEPA guidance (USEPA, 1993b).

The Port may also factor in other financial considerations including but not limited to risk management, insurance costs, and costs associated with interruptions in marine operations.

## 8.5 Comparative Evaluation of Alternatives

The EE/CA will present a comparative evaluation of the relative performance of each alternative in relation to the evaluation criteria. The purpose of the comparative evaluation is to identify the advantages and disadvantages of each alternative so that key tradeoffs affecting selection of the Removal Action alternative can be identified. In this evaluation, the No Action alternative will be used as a baseline.

In the comparative evaluation, the alternatives will be scored (ranked) for how well each meets each criterion. Alternatives that meet all the requirements of a criterion will be ranked "high." Alternatives that meet most, but not all, the requirements of a criterion will be ranked "medium." Alternatives that meet only some of the requirements of a criterion will be ranked "low." Alternatives that do not meet the requirements of a criterion will be ranked "does not meet."

For example, when evaluating alternatives from the aspect of the "reduction of mobility, volume, and toxicity of contaminants," a capping alternative that achieves the RAOs by isolating the contaminated sediment and so meets only the reduction of mobility component of the criterion may be scored as "medium." This alternative may then be compared to another alternative, such as dredging followed by treatment and upland disposal, that achieves the RAOs and meets all the criterion's requirements by reducing mobility, volume, and toxicity, thereby receiving a score of "high."

The EE/CA will also discuss the process used to evaluate the criteria and to develop a comparative ranking of the Removal Action alternatives, as outlined below.

### 8.5.1 Effectiveness

Under this criterion, the Removal Action alternatives will be comparatively evaluated against the factors discussed below.

#### 8.5.1.1 Overall Protection of Public Health and the Environment

This evaluation will assess the extent and effectiveness of controls at managing the risk posed by exposure to residual sediment contaminants and untreated wastes in the Removal Action Area. The following factors will be considered:

- the extent to which the alternative addresses potentially complete and significant exposure pathways for human and ecological risk;
- the magnitude of residual risk, i.e., the effectiveness of the alternative and the residual risk from waste and residuals remaining after the Removal Action. This factor also looks at whether the alternative contributes to future cleanup objectives. Since the Removal Action is the last action anticipated for the Removal Action Area, the magnitude of the risk will be fully evaluated; and
- the adequacy and reliability of controls, i.e., the need for, extent of, and effectiveness of post-removal controls, if required.

Exposure and risk calculations as described in Section 7.4 will be used to estimate relative exposure and risk for the alternatives. As noted in Section 7.4, the specific methods to be used in estimating human health risk will be proposed when the Removal Action alternatives have been identified. For ecological risk, the analysis will depend primarily on a comparison of contaminant concentrations in sediments to SQGs appropriate to the pathways and receptors identified. However, if risk calculations being developed by the Lower Willamette Group are approved by the USEPA and its partners during this process, those values will be used instead of SQGs.

#### 8.5.1.2 Compliance with ARARs

The evaluation criteria will include potential location-, chemical-, and action-specific ARARs and TBCs. The comparative evaluation and ranking of the Removal Action alternatives will assess whether and to what extent the alternatives meet the potential ARARs and TBCs.

As part of the evaluation of ARARs, each alternative will be evaluated for compliance with the standards and criteria of Clean Water Act Section 404 (b) (1). The criteria and standards are outlined in 40 CFR 230 Subparts B-H. This information will be included as an appendix to the EE/CA report and will fulfill the Scope of Work requirement for "a draft memorandum that provides sufficient information to demonstrate compliance with substantive requirements of Section 404 (b) (1) of the Clean Water Act."

The highest score will be assigned to those Removal Action alternatives that meet all potential ARARs and TBCs.

#### 8.5.1.3 Short-Term Effectiveness

The evaluation criteria for short-term effectiveness will include:

- worker health and safety;
- public health and safety;
- impacts to water quality;
- impacts to quality of life in terms of noise, vibrations, dust, emissions, and odor;
- impacts to offsite aquatic and terrestrial biota during implementation; and
- impacts on the ongoing operations of Terminal 4 and general navigation.

The highest score will be assigned to those Removal Action alternatives that represent the least risk to workers and will have the fewest impacts on water quality, quality of life, biota, and Terminal 4 operations.

#### 8.5.1.4 Reduction of Mobility, Volume, and Toxicity of Contaminants

The evaluation criteria for reduction of mobility, volume, and toxicity of contaminants will include:

- the alternative's effectiveness at reducing the ability of contaminants to move by advection or diffusion;
- the alternative's effectiveness at reducing the volume of contaminated sediment in the Removal Action Area upon implementation; and
- the alternative's effectiveness at reducing the harmful effects (i.e., toxicity) of contaminants in the sediment on ecological or human receptors.

In making this evaluation, the following factors will be considered:

- the process (if any) by which the mobility, volume, and toxicity of contaminants in the sediment are affected;
- the extent to which the mobility, volume, and toxicity of contaminants will be reduced;
- the degree to which the effect on mobility, volume, and toxicity of the contaminants is irreversible;
- the type and quantity of residuals that will remain after implementation of the alternative; and
- whether the alternative will satisfy the CERCLA preference for treatment.

The highest score will be assigned to those Removal Action alternatives that provide the greatest reduction (collectively) in the mobility, volume, and toxicity of contaminants.

#### 8.5.1.5 Long-Term Effectiveness – Residual Risk Assessment Approach

The long-term effectiveness of the Removal Action alternatives will be evaluated by assessing factors such as permanence of the actions proposed, the stability of the sediments, and the potential for recontamination from offsite sources.

NTCRA guidance (USEPA, 1993b) identifies two basic components to this evaluation: (1) the magnitude of (residual) risk and (2) the adequacy and reliability of controls.

An assessment of the magnitude of risk that is residual to the action is necessary to characterize the effectiveness of the action at reducing risk and protecting public health and the environment. The Terminal 4 Removal Action is being performed as an interim measure and as part of the overall cleanup of Portland Harbor. However, the extent of the action is intended to represent the final action in the Removal Action Area. In this respect, the effectiveness of the alternatives at addressing health risks will be compared using the risk analysis framework that will be developed once the alternatives have been identified. As noted in Section 7.4, the USEPA-approved framework will be documented in the Technical Briefing on Proposed Removal Alternatives as required by the AOC. For both human health and ecological receptors, risk-based sediment criteria established for the Portland Harbor Superfund Site remedial investigation/feasibility study will be used where available and applicable to ensure consistency with the site-wide remedy. Where Removal Action Area-specific risk analyses are necessary, the Technical Briefing on Proposed Removal Alternatives will describe methods and data needs.

The adequacy and reliability of controls will be compared based on whether the alternatives provide a permanent, irreversible technical solution or whether the alternatives carry the risk that protectiveness will deteriorate.

The highest score will be assigned to those Removal Action alternatives that provide irreversible, permanent protectiveness and result in the least residual risk to human and ecological receptors.

### 8.5.2 Implementability

Under this criterion, the Removal Action alternatives will be comparatively evaluated against the factors discussed below.

#### 8.5.2.1 Technical Feasibility

The EE/CA will assess the ability of the technology components to implement the Removal Action alternative. Three principal aspects of the technical feasibility will be assessed:

- Construction and Operational Considerations. The alternatives will be compared from the aspect of assembling, staffing, and operating within the time allotted by the Removal Action schedule.

- Demonstrated Performance. The alternatives will be compared from the aspects of technical maturity, prior use under similar conditions, reliability, and possible issues related to difficulty or complexity of their implementation at the Removal Action Area. In addition, the technology components of each alternative will be evaluated for their availability from multiple sources on a competitive basis.

- Schedule. The overall schedule for implementing each alternative will be carefully considered taking into account the potential for shutdowns, since technical problems may adversely affect the schedule.

The highest score will be assigned those the Removal Action alternatives that exhibit the most successful project performance, are available from multiple vendors, and offer the highest reliability and the least risk of delay.

#### 8.5.2.2 Administrative Feasibility

The EE/CA will address the activities needed to coordinate with other offices and agencies prior to and during the implementation of a Removal Action alternative, including any offsite permits, adherence to non-environmental laws, and concerns of other regulatory agencies; for example, ecological considerations for threatened and endangered species. Other factors to be considered include easements, right-of-way agreements, and zoning requirements.

Since the Removal Action is funded by the Port, the statutory limits otherwise applicable to agency-funded NTCRAs are not applicable.

The highest score will be assigned to those Removal Action alternatives that require the least amount of agency coordination and the least amount of additional regulatory action (e.g., building permit, zoning, right-of-way).

#### 8.5.2.3 Availability

The EE/CA will assess whether and to what extent the technology components of the Removal Action alternatives are available within a time frame that maintains the Removal Action schedule. The availability of funds to meet the requirements of the post-removal controls will also be assessed. Important availability factors include:

- the availability of the technologies, as well as the availability of labor, skilled labor, and professional labor to implement the alternatives;
- the capacity, adequacy, and availability of offsite disposal facilities (if required for an alternative), with special emphasis on certain waste disposal requirements (e.g., all wastes from the Removal Action Area are considered CERCLA wastes, the potential for PCB-contaminated waste streams, and the high moisture content of the waste stream);
- the availability of necessary laboratory services and onsite facilities such as light, electricity, sewer, and other utilities; and
- the time frame required to implement full-scale use of an innovative, prospective technology (if required for an alternative), including pilot-scale studies or demonstrations.

The highest score will be assigned to those Removal Action alternatives that are readily available, preferably from multiple vendors and suppliers; for which the need for labor, laboratory services, and onsite services can readily be met in the vicinity of Terminal 4; and that can be implemented in the shortest time.

#### 8.5.2.4 State and Tribal Acceptance

During preparation of the EE/CA, the concerns of DEQ and tribal entities will be solicited and carefully considered. The Removal Action alternatives will be compared as to whether and to what extent DEQ and tribal concerns can be addressed by implementing an alternative.

The highest score will be assigned to those Removal Action alternatives that best address DEQ and tribal concerns.

#### 8.5.2.5 Public Acceptance

During preparation of the EE/CA, the Port will implement a community outreach program to actively seek input from members of the community and gather their concerns. The Removal Action alternatives will be compared as to whether and to what extent community concerns can be addressed by implementing an alternative.

The highest score will be assigned to those Removal Action alternatives that best address community concerns.

### 8.5.3 Cost

The Removal Action alternatives will be compared with respect to their projected full implementation costs, including the costs of mitigation, disposal, and long-term monitoring. The costs for individual alternatives will be established based on the present worth method, so that alternatives with significantly different implementation time frames can be compared.

The highest score will be assigned to those Removal Action alternatives that have the lowest present worth implementation cost.

### 8.5.4 Ranking of Alternatives

The EE/CA will summarize the results of the comparative evaluation. A table will be prepared to summarize the comparison and scoring. A narrative will discuss the tradeoffs associated with implementation of the various Removal Action alternatives. The Removal Action alternative that best satisfies the evaluation criteria will be identified, as will the justification for its selection.

## 8.6 Preferred Alternative

### 8.6.1 Description of the Preferred Alternative

The EE/CA will describe the preferred Removal Action alternative, i.e., the alternative determined to best satisfy the evaluation criteria.

The preferred Removal Action alternative will be described in some detail, providing a basis for preparation of the Action Memorandum and a more detailed presentation to the public, the State, tribal entities, and other stakeholders, as well as providing a foundation document for development of the biological assessment and the Clean Water Act, Section 401.b.1 evaluation. It is envisioned that the preferred alternative will be described at the 20% to 25% level of design detail.

### 8.6.2 Biological Assessment of the Preferred Alternative

A professional biologist will complete a biological assessment (BA) of the effects of the preferred alternative on species listed and proposed for listing under the Endangered Species Act. The BA will analyze the potential direct, indirect, and cumulative effects of the preferred Removal Action alternative on species and their habitat. The best available scientific and commercial data and reports will be used for the BA, including agency species reviews, basin assessments, and species narratives.

Preparation of the BA will require a field review and compilation and review of all existing habitat and species information relevant to the Removal Action Area. It is likely that no primary data collection will be necessary. The BA will include the following information:

- Introduction and Background
  - purpose of the BA, including legal and other directions;
  - project setting and legal description of the Removal Action Area;
  - a summary of listed species and their habitats; and
  - other species present.

- Consultation to Date
  - information on the analysis to be used in the BA; and
  - documentation of field reviews, meetings with agencies, and other efforts to support the analysis and conclusions contained in the BA.

- Preferred Alternative
  - all details of the preferred Removal Action alternative, including mitigation measures and all measures to be used to minimize adverse effects to species and their habitats.

- Species Account
  - a general species account, including life history and biological requirements;
  - known current limiting factors for the species; and
  - species presence in the Removal Action Area or location relative to the Removal Action Area.

- Existing Habitat Conditions/Environmental Baseline
  - formal habitat designations (federal and State) in the Removal Action Area;
  - environmental baseline of habitat (defined as conditions at the time of listing), current conditions, limiting factors, and habitat capabilities in the context of existing conditions; and
  - the relative contribution or value of habitat in the Removal Action Area.

- Effects of the Preferred Alternative
  - effects of the preferred Removal Action alternative, organized using accepted indicators of habitat quality including water quality, channel physical attributes, streambank conditions, and riparian conditions; and
  - discussion of potential direct, indirect, and cumulative effects to species and their habitats for each indicator.

- Determination
  - succinct conclusions regarding the effects of the preferred Removal Action alternative on species and their habitats.

- References
  - a complete list of references used to support the BA's analysis and conclusions.

- Appendices
  - a project area map;
  - maps of species distribution; and
  - a checklist summarizing the effects of the preferred Removal Action alternative.

| Table 8-1<br>Proposed Chemical- and Location-Specific ARARs<br><br>Chemical-Specific ARARs | | | |
|---|---|---|---|
| **Regulation** | **Citation** | **Criterion/Standard** | **Applicability/Appropriateness** |
| **Federal ARARs** | | | |
| Clean Water Act, Ambient Water Quality Criteria | 33 USC 1314<br>40 CFR Part 131 | Provides minimum standards for water quality programs established by states. Two kinds of water quality criteria exist: one for protection of human health, and one for protection of aquatic life. | Relevant and appropriate |
| Water Pollution Control Act, Total Maximum Daily Loads | 33 USC 1313 (d)<br>40 CFR Part 130 | Provides for development of TMDLs. | Relevant and appropriate |
| Resource Conservation and Recovery Act | 42 USC 6901 et seq<br>40 CFR 260, 261 | Establishes management standards for solid and hazardous waste. | Relevant and appropriate |
| **State ARARs** | | | |
| State Water Quality Criteria | ORS 468.735, 720, 990, 992<br>OAR 340-41-0442 and 0445 | Provides Willamette Basin beneficial uses and water quality standards. | Relevant and appropriate |
| Total Maximum Daily Loads | ORS 468.020, 030, 468(B).030, 035, 110<br>OAR 340-042-0025 | Provides for development of TMDLs. | Relevant and appropriate |
| Solid Waste Management Regulations | ORS 459.005-418<br>OAR 340-93 | General provisions for storing, collecting, transporting, treating and disposing of solid waste. | Relevant and appropriate |
| Hazardous Waste Regulations | ORS 466.005-225,<br>OAR 340-101-0033 | General provisions for distinguishing between solid waste and hazardous waste. Identifies residues that are subject to regulation as hazardous waste. | Relevant and appropriate |
| Oregon Hazardous Substance Remedial Action Rules | ORS 465.200-465.420,465.900, 466.995<br>OAR 340-122-010 et seq. | Establishes cleanup authority and objectives; regulations establish cleanup standards. | Relevant and appropriate |

| Table 8-1<br>Location-Specific ARARs | | | |
|---|---|---|---|
| **Regulation** | **Citation** | **Criterion/Standard** | **Applicability/Appropriateness** |
| **Federal ARARs** | | | |
| Fish and Wildlife Coordination Act Requirements | 16 USC 662, 663<br>40 CFR 6 302 (g) | Requires consultation with appropriate agencies to protect fish and wildlife when federal actions may alter waterways Must develop measures to prevent and mitigate potential loss to the maximum extent possible. | Applicable |
| National Historic Preservation Act | 16 USC 470 et seq<br>36 CFR Part 800 | Establishes requirements for the recovery and preservation of historical and archaeological data. Also requires measures to minimize harm to historic resources. | Potentially applicable |
| Native American Graves Protection and Reparation Act | 25 USC 3001-3013<br>43 CFR 10 | Prevents willful removal of cairn, burial, human remains, funerary object, sacred object or object of cultural patrimony. Provides for reinterment of human remains or funerary objects under the supervision of the appropriate Indian tribe | Potentially applicable |
| Archaeological Resources Protection Act | 16 USC 470aa<br>43 CFR 7 | Archaeological sites on public lands are under the stewardship of the people of the United States and are to be protected and managed in perpetuity | Potentially applicable |
| Endangered Species Act | 16 USC 1531 et seq. | This act requires action to avoid jeopardizing the continued existence of listed endangered or threatened species or destruction or adverse modification of critical habitat. Also must consult with Department of Interior | Applicable |
| Executive Order for Wetlands Protection | Executive Order 11990 (1977) | Requires measures to avoid adversely impacting wetlands whenever possible, | Potentially applicable |

| Table 8-1<br>Location-Specific ARARs | | | |
|---|---|---|---|
| **Regulation** | **Citation** | **Criterion/Standard** | **Applicability/Appropriateness** |
| | 40 CFR 6.302 (a)<br>40 CFR Part 6, App. A | minimize wetland destruction, and preserve the value of wetlands. | |
| Executive Order for Floodplain Management | Exec. Order 11988 (1977)<br>40 CFR Part 6, App. A<br>40 CFR 6.302 (b) | Requires measures to reduce the risk of flood loss, minimize impact of floods, and restore and preserve the natural and beneficial values of floodplains. | Applicable |
| Clean Water Act Section 404 Requirements | 33 USC 1344<br>33 CFR Parts 320-323<br>40 CFR 230 | For discharge of dredged or fill material into water bodies or wetlands, there must be no practical alternative with less adverse impact on ecosystem; discharge cannot cause or contribute to violation of state water quality standard or toxic effluent standard or jeopardize threatened and endangered species; discharge cannot significantly degrade waters of U.S.; must take practicable steps to minimize and mitigate adverse impacts; must evaluate impacts on flood level, flood velocity, and flood storage capacity. | Applicable |
| Rivers and Harbors Act | 33 USC 403<br>33 CFR 320-330 | Regulates activity that may obstruct or alter a navigable waterway. Activities controlled include construction of piers and berms, installation of piling, or sheet pile walls. | Applicable |
| **State ARARs** | | | |
| State Removal Fill Operations | ORS 274.040, 0.43,.922, .944<br>OAR 141-85-001 et seq | Regulates all activities associated with removal and fill operations in state waters. | Applicable |
| Certification of Compliance with Water Quality Requirements and Standards | ORS 468b.035<br>OAR 340-048- | Outlines review process between state and federal agencies regarding compliance with water quality requirements and standards for projects that discharge into navigable waters or impact water quality. | Applicable |
| Lower Willamette River | ORS 273.045 | Regulates leasing, license, and permit | Relevant and appropriate |

| Table 8-1<br>Location-Specific ARARs | | | |
|---|---|---|---|
| **Regulation** | **Citation** | **Criterion/Standard** | **Applicability/Appropriateness** |
| Management Plan | OAR 141-0105 | activities in the lower 18 miles of the Willamette River, which includes Terminal 4. The plan describes allowable activities and conditions for waterway management areas based on public trust values (fisheries, recreation, or navigation). | |
| Willamette River Greenway Plan/City of Portland Greenway Overlay Zones | ORS 390.318, 322<br>OAR 736-003-005<br>Title 33 Chapter 44.440 | Outlines boundaries for land acquired or to be acquired or for acquisition of a scenic easement for Willamette Greenway. The City of Portland implements the Willamette Greenway Plan and is responsible for consistency between greenway overlay zones and local zoning codes. | Potentially relevant and appropriate |
| Willamette Basin Program | ORS 536.300, 340<br>OAR 690-52 | Requires development of plans to maintain stream flow, promote in-stream uses and values, and meet public needs. | Relevant and appropriate |
| Indian Graves and Protected Objects | ORS 97.740-760 | Prevents willful removal of cairn, burial, human remains, funerary object, sacred object or object of cultural patrimony. Provides for reinterment of human remains or funerary objects under the supervision of the appropriate Indian tribe. | Potentially applicable |
| Archaeological Objects and Sites | ORS 358.905-955 | Archaeological sites on public lands are under the stewardship of the people of Oregon and are to be protected and managed in perpetuity by the state. | Potentially applicable |
| Permit and Condition For Excavation or Removal of Archaeological or Historical Material on Public Lands | ORS 390.235<br>OAR 736-051-0080 | Provides for permits and conditions for excavation or removal of archaeological or historical materials. | Potentially applicable |

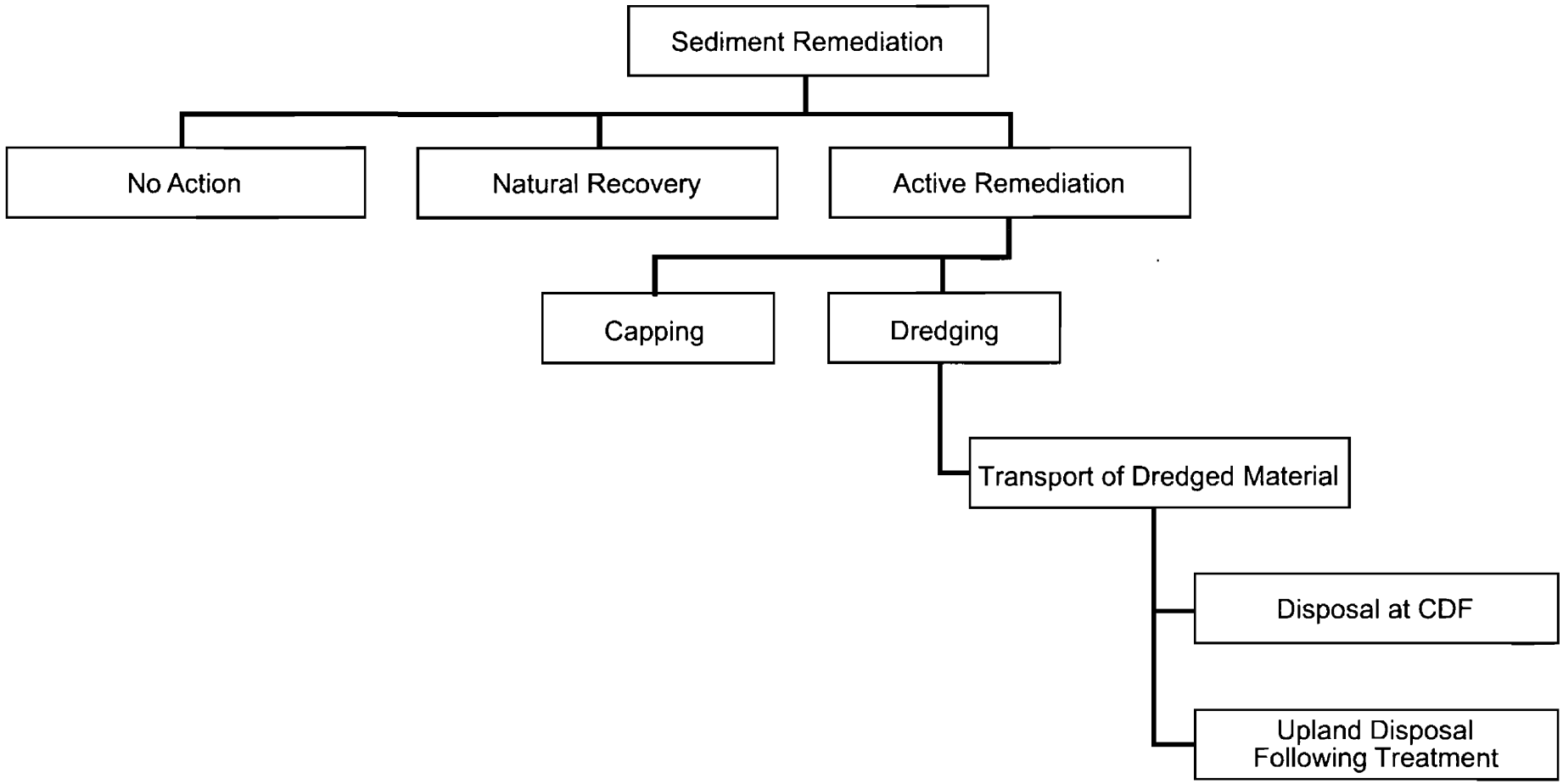


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FIGURE
8-1

Section 9

# 9. References

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# Appendix A
# SAP

# *Appendix A*

# Sampling and Analysis Plan

**Note: Appendix A consists of two parts: A1 which is the Field Sampling Plan, and A2 which is the Quality Assurance Project Plan. These documents are intended for use with one another and should not be used separately.**

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# Appendix A1
# FSP

# *Appendix A1*

# Field Sampling Plan

**Approved by:**

, February 23, 2004

**Project Manager (date)**

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# A1-1. Introduction and Scope of Document

This field sampling plan (FSP) has been prepared as an appendix to the Port of Portland (Port) Terminal 4 engineering evaluation/cost analysis (EE/CA) work plan. The FSP addresses the collection of data required to fill gaps in the existing data for the Removal Action at Terminal 4. The data will be used to evaluate Removal Action alternatives.

This FSP has been prepared in accordance with the U.S. Environmental Protection Agency's (USEPA's) *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988) and USEPA's *Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analyses* (USEPA, 2001). It has also been prepared in accordance with the Oregon Department of Environmental Quality (DEQ) and USEPA's *Archaeological Monitoring Protocol, McCormick and Baxter Creosoting Company Superfund Site* document (DEQ and USEPA, 2002) and with Blasland, Bouck and Lee's (BBL's) Quality Assurance Procedure 3.04, *Requirements for Field Sampling Plans*. Additionally, all sampling activities described in the FSP will be performed within the guidelines of the site-specific health and safety plan (HASP) (see Appendix B of the work plan).

A discussion of existing information relevant to the Terminal 4 Removal Action is presented in the work plan, including information on the Removal Action Area characteristics, existing sediment quality data, and an evaluation of data gaps. The work plan also provides the rationale for activities planned for characterization of the Removal Action Area.

The FSP addresses the following areas:

- sediment sampling (both surface and subsurface);
- preparation of composite samples;
- geotechnical sampling;
- hydrogeologic sampling;
- hydrology/hydraulics monitoring;
- decontamination;
- sampling documentation, sample handling, and chain-of-custody procedures;
- quality assurance and quality control requirements; and
- waste management.

Field sampling activities will be performed in accordance with the DEQ and USEPA's *Archaeological Monitoring Protocol, McCormick and Baxter Creosoting Company Superfund Site* document (Archaeological Monitoring Protocol) (DEQ and USEPA, 2002). There is a possibility that archaeological resources may be encountered during field sampling activities. It is important that any "discovered" human remains and associated cultural materials and deposits be treated with care and respect and protected from further disturbance and exposure to weather, as outlined in the Archaeological Monitoring Protocol.

The on-site procedures from the Archaeological Monitoring Protocol assure compliance with the National Historic Preservation Action (16 USC 470) and applicable Oregon statutes (ORS 97.740 et seq., 358.905 et seq., and 390.235 et seq.) to address potential inadvertent discoveries of cultural materials and deposits (including sacred objects, funerary objects, and objects of cultural patrimony as defined in ORS 358.905) and Indian burials and human remains (as defined in ORS 358.905) during ground disturbing activities. The Archaeological Monitoring Protocol is briefly summarized here.

- Pre-field sampling ceremonies. Tribal governments may desire to perform pre-field sampling ceremonies at the removal action area. The Port will give two weeks notice, by email, of the construction start date. Tribes will coordinate with the Port so that scheduling and logistics of pre-field sampling ceremonies will not delay the sampling schedule.

- Notification of ground disturbing work. The Port will notify the tribes by email in advance of any ground disturbing field sampling. The ground disturbing activities anticipated to occur during the field sampling activities include: sediment vibracores, under-pier sediment samples, geotechnical borings, and monitoring wells.

- Professional archaeologist on-site. The Port will retain the services of a professional archaeologist, as defined in ORS 97.740 and ORS 390.235(6) (b). The professional archaeologist will provide on-site monitoring when ground disturbing work is conducted within the boundaries of the archaeological sensitivity area as determined in the cultural resource survey of the removal action area (Archaeological Investigations Northwest, Inc., 2003).

- Tribal representative on-site. Interested Tribes are welcome to provide Tribal monitors during field sampling activities. Since the site is contaminated with hazardous substances, Tribal representatives will be required to comply with Occupational Safety and Health Administration requirements provided in 29 CFR 1910.120. The application of these requirements will vary, depending on the type of activity at the site and the proximity of the monitors to the activity. The requirements may include: supervision by someone who is appropriately trained for hazardous substance sites, restriction from the immediate work area, prohibition of handling contaminated material, use of personal protective equipment, and 24 or 40 hour hazardous waste operations health and safety training. Also, all on-site personnel, including Tribal monitors, are subject to the directions of the Health and Safety Supervisor at all times.

- Discovery. At the discretion of the monitoring archaeologist, ground disturbing activities may be slowed or halted at any time a suspected archaeological object or archaeological site (as defined in ORS 358.905) is encountered. Discovery will be performed in accordance with the Archaeological Monitoring Protocol.

The Port shall make its best efforts, in accordance with State and Federal law, to ensure that its appropriate personnel and contractors keep the discovery of any found or suspected human remains, other cultural items, and potential historic properties confidential. Contractors and Port personnel are prohibited from contacting the media or any third party or otherwise sharing information regarding the discovery with any member of the public, and to immediately notify the Port of and direct any inquiry from the media or public. Prior to any release, the Port and the Tribes shall concur on the amount of information, if any, to be released, to the public, any third party, and the media and the procedures for such a release, to the extent permitted by law.

# A1-2. Sediment Sampling

## A1-2.1 Station Positioning

The objective of location control is to accurately determine horizontal and vertical positioning of sampling locations. To achieve this objective, each sample location will be referenced to known survey control points using the methods described below. The following tables give the station coordinates for the various sampling activities:

- Table A1-1: vibracore sample locations;
- Table A1-2: under-pier sample locations;
- Table A1-3: geotechnical boring locations;
- Table A1-4: cone penetrometer locations; and
- Table A1-5: monitoring well locations.

The following parameters will be documented at each sampling location in accordance with Section A1-8.1 (Documentation):

- location coordinates (Oregon state plane north zone, North American Datum 83, international survey feet);
- vertical elevation in feet (CRD, including mudline and tidal elevation above mudline);
- actual water depth;
- time and date; and
- tidal elevation referenced to mean sea level (MSL).

These parameters will be measured using pre-surveyed visual horizontal triangulation to known control points and/or landmarks on shore if necessary, a differential global positioning system (DGPS), and weighted tape measures. A grid system will be established for locating field activities before field work commences.

### A1-2.1.1 Differential Global Positioning System

Location control will be performed with a DGPS unit onboard the sampling vessel. DGPS coordinates for each sampling location will be recorded at the time of sampling.

### A1-2.1.2 Visual Horizontal Triangulation Methods

Visual horizontal triangulation methods will be used as a backup method to the DGPS. This system will use pre-surveyed markers and established landmarks on shore. This method determines sampling locations based on horizontal distances to survey control points and/or landmarks identifiable on base maps. Locations will be identified by measuring the horizontal distance from the actual sampling location to the known control point or landmark to the nearest foot (ft) using a tape measure. Horizontal measurements can be calculated from registered base maps so field measurements can be translated to state plane coordinates. Buoy markers may be used to mark the sampling location.

### A1-2.1.3 Vertical Control

The vertical control parameters measured will be depth to sediment (mudline), tidal elevation, and land surface elevation. The depth to sediment will be measured during each sampling event using a hand-held weighted tape (lead line). The tape will be dropped from the work platform to the bottom, pulled taut, and read to the nearest 0.1 ft. This observation will be cross-checked against the onboard depth sounder.

Tidal readings will be taken periodically from a tide board installed onsite and checked against daily tide charts for the Terminal 4 vicinity. Tidal elevations and time will be monitored and recorded before each sample is collected to the nearest 0.1 ft. Sample elevations will then be corrected to MSL. Monitoring wells will be surveyed by a professional surveyor to MSL.

## A1-2.2 Vibracore Samples

Sediment core samples collected from the Removal Action Area will be used to:

- evaluate the lateral extent of contamination;
- evaluate the vertical extent of contamination;
- assess dredging technologies;
- assess onsite disposal in a confined disposal facility (CDF);
- assess offsite disposal in a Subtitle D landfill; and
- determine engineering characteristics of the sediments.

Sediment cores will be collected to obtain both surface and subsurface sediment samples. Continuous cores will be collected from 32 locations within the Removal Action Area. Of these, 17 cores will be taken in Slip 1 and 15 cores will be taken in Slip 3. Figure A1-1 shows the target core locations in the Removal Action Area. The target core depth is 15 ft below mudline or to core refusal. The vibracore will be equipped with aluminum core barrels. Multiple cores may be collected at each location to obtain adequate sediment volume. All coring procedures will be performed in accordance with BBL's Standard Operating Procedure (SOP) for Vibracore Sediment Collection.

### A1-2.2.1 Equipment List

The following general equipment will be required during collection procedures:

- personal protective equipment (PPE), as required by the HASP;
- navigation and site maps;
- aluminum decked boat equipped with outboard motor;
- vibracore device;
- aluminum tubing with end caps;
- calibrated rod for sediment depth measurement;
- weighted tape measure calibrated in 0.1 ft increments;
- duct tape;
- camera; and
- field notebook.

### A1-2.2.2 Vibracore Collection Procedure

1. Maneuver the sampling vessel to the target sample location. Secure the vessel in place using spuds, anchors, or tie lines.

2. Once the targeted area is deemed suitable for core collection, select an appropriate 3-inch (outside diameter) core tube type (aluminum) and length based on the probing information. Mount a clean coring tube into the vibracore device.

3. Lower the coring apparatus with the core tube attached vertically through the water column, tube end first, until the river bottom is reached.

4. Vibrate the core into the sediment to the point of refusal. Measure and record the depth of core tube penetration into the sediments in the field notebook.

5. Pull the apparatus upward out of the river bottom (using a winch) and raise it to the surface while maintaining the core in a vertical position.

6. Allow water overlying the core tube in the coring apparatus to drain prior to removing the core tube.

7. Estimate the recovered length of the sediment core and record it in the field notebook.

   - The length of the cores recovered in aluminum tubing will be determined indirectly by tapping the core with a metal rod from top to bottom. The spot where the pitch of the sound changes corresponds to the approximate top of the recovered core.

   - The distance between the top of the sediment in the core tube and the bottom of the coring tube corresponds to the estimated length of the recovered core.

8. Compare the length of the recovered core with the core penetration depth.

   - If the recovered length of the sediment core is more than 60% of the penetration depth, keep the core.

   - If an insufficient amount of material is recovered, discard the core over the side of the sampling vessel. Rinse the core tube with river water and prepare to make an additional attempt.

     - An additional attempt will be made at a minimum distance of 10 ft from the previously attempted location.

     - A maximum of three attempts to collect a core will be made for a given location ID.

     - Rinse the core tubes with river water between consecutive attempts.

     - If all three attempts to collect a core are unsuccessful based on recovery alone (i.e., less than 60% recovery), retain the final core for analysis and indicate that the targeted recovery was not achieved.

9. After successful core recovery, enter the following information into the field notes:

   - date;

- time of recovery;
- sample position;
- water depth (ft);
- core tube material (aluminum);
- core penetration depth (in); and
- observations, including probing results.

10. Remove the core tube from the vibracore device and place a second cap on top of the core tube. Secure the cap in place with duct tape. Rinse the outside of the core tube with a small amount of river water.

11. Section acceptable cores into 4-ft lengths on the vessel. Cover each end of the core sections, top and bottom, with aluminum foil. Place a plastic cap firmly over the aluminum foil to keep the core intact until processing. Secure the plastic caps with duct tape.

12. Label each core section with the station identification, sample depth, and an arrow indicating the top of the core. Label the core by scratching into the surface of the core barrel and with an indelible marker.

13. Store the core vertically while on the vessel and transport to the processing area.

### A1-2.2.3 Processing Cores

Cores will be processed on shore in the Removal Action Area. Processing will occur using an electric saw to cut along the length of the core in two places, forming two D-shaped core halves. Only the barrel, not the sediments, will be cut by the saw. When sediment is collected from the core, care will be taken not to collect sediment in contact with the core barrel. Any excess sediment that may come loose will be collected on plastic sheeting so that it may be disposed of properly (see Section A1-10, Waste Management Plan).

For evaluating lateral and vertical contamination, the following subsampling scheme will be used for the cores. The top 1 ft of the core will be collected as the surface sample. The vibracore subsurface sample will be subsampled at 2-ft intervals beyond the top 1 ft used for the surface sample. Therefore, the first subsample will be the 1- to 3-ft section below mudline, and the subsamples will continue in 2-ft segments (i.e., 3 to 5 ft, 5 to 7 ft, and so on). The subsamples representing the top 11 ft of sediment below the mudline will be submitted for analysis. A representative sample of each remaining core section will be placed in a frozen archive for possible future analysis. Where necessary, analytical groups will be extracted and the extract archived for future analysis. These additional subsurface subsamples may be submitted for analysis depending on the chemistry results for the top 11 ft of each core. Sample handling will be performed in accordance with BBL's Chain of Custody, Packing, Handling, and Shipping SOP (see Section A1-8). Figure A1-2 shows the sediment subsampling scheme and analysis of subsamples.

For assessing dredging technologies, onsite disposal in a CDF, and offsite disposal in a Subtitle D landfill, composite sediment samples will be created from the vibracores. Composite sampling is discussed in Section A1-3. Geotechnical sampling (i.e., to determine engineering characteristics) is discussed in Section A1-4.

After the cores are sectioned, the subsamples will be homogenized until the sediment is of uniform color. This will be done in a stainless steel bowl with either a stainless steel mixing spoon or drill paddle. Proper decontamination procedures will be followed between the mixing of each subsample (see Section A1-7). Once homogenized, the subsamples will be placed in appropriate containers (Table A1-6) and properly labeled. The

samples will be submitted for laboratory analysis following appropriate handling and chain-of-custody requirements (see Section A1-8).

The surface sediment samples and the subsurface sediment samples will be analyzed for the following chemical constituents:

- metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc);
- semivolatile organic compounds (SVOCs);
- total DDT (tDDT);
- polychlorinated biphenyls (PCBs);
- total petroleum hydrocarbons (TPH);
- total organic carbon (TOC); and
- grain size.

Sediment samples for tDDT will be extracted and analyzed for the list of pesticides presented in Table A2-1 of the Quality Assurance Project Plan but only DDT will be reported. DDT and PCB results will be evaluated in Slip 1 for possible reporting of the full suite of pesticides. If elevated tDDT is observed in sediment samples from Slip 1, a select number of samples from Slip 1 will have the full pesticide list reported. Analytical methods and detection limits are presented in Table A2-1 of the quality assurance project plan (QAPP), which is also contained within this appendix.

Some of these samples will also be used for the geotechnical investigation to determine engineering properties of the sediments (see Section A1-4). Table A1-7 summarizes all core samples and the associated analyses.

### A1-2.3 Dive Team Sediment Samples

Under pier sediment samples collected from the Removal Action Area will be used to:

- evaluate the lateral extent of contamination, if contamination is present;
- evaluate the vertical extent of contamination, if contamination is present; and
- evaluate the thickness of recent sediment that is present on top of the rip rap.

Sediment samples collected under the pier structures will be collected using SCUBA dive teams. This is necessary because the structure of the piers does not facilitate use of a vibracore sampler. Dive teams will collect 15 surface (top 1 ft) sediment samples using hand cores: six samples from under the piers in Slip 1, five samples from under the Slip 3 pier, two samples from under the pier at Berth 401, and two samples from within the pilings of the former Pier 5. If recent sediment that is present on top of the rip rap is thicker than 1 ft, longer diver cores, up to 3 ft long, will be collected. The target sample locations are shown on Figure A1-3.

Clearance from the Port engineering division will be required prior to diving field activities. The engineering team will need to provide approval that the piers and pilings are structurally sound to allow diving underneath and within. No diving will be performed until this clearance is issued. Prior to field activities, sampling locations will be pre-plotted using visual recognition points and located using tape measures from known landmarks (i.e., pier pilings). Actual water depth will be measured using a lead line and recorded as MSL in accordance with Port water level records.

After locating the sampling point, dive teams will descend and collect a surface sediment sample using a hand-operated push core. The core devices will consist of a variety of lengths (1 ft, 2 ft, and 3 ft) of polycarbonate or acetate tube with a 4-inch diameter. Divers will push the core tube into the sediment approximately 3 ft or until the core tube hits hard substrate, which ever is shorter. Because it is possible that sediment conditions will be extremely soft, the core tubes may be fixed with a hand-operated valve on the top to help retain the sediment. After the divers push the cores into the sediment, they will place a plastic core cap on the bottom of the tube and withdraw the core from the sediment. The divers will then place a top cap on the tube and return to the surface, keeping the core upright. Upon surfacing, the divers will hand the core off to land-based personnel for processing.

If additional sediment is necessary to facilitate all analyses, additional cores may be collected. If multiple cores are necessary, the divers will not surface between cores and will place the completed cores into an upright core rack. All completed cores will be returned together.

To process the sediment, the land-based crew will remove the top core cap and carefully siphon off the surficial water. The bottom of the core will be opened and the core carefully extracted. The core will be logged and described for odor, color, texture, and visual grain size. The core will be cut at the 1.0 ft-below-mud-surface level, i.e., only the top 1.0 ft of the core will be analyzed. If the core is greater than 1 ft long, the core will be sectioned into 1 ft intervals and the 1 to 2 ft and 2 to 3 ft intervals will be frozen for possible future analysis.

The sediment samples will be homogenized until the sediment is of uniform color. This will be done in a stainless steel bowl with either a stainless steel mixing spoon or drill paddle. Proper decontamination procedures will be followed between the mixing of each subsample (see Section A1-7). Once homogenized, the subsamples will be placed in appropriate containers (Table A1-6) and properly labeled. The samples will be submitted for laboratory analysis following appropriate handling and chain-of-custody requirements (see Section A1-8). The samples will be analyzed for the following chemical constituents:

- metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc);
- SVOCs;
- tDDT;
- PCBs;
- TPH;
- TOC; and
- grain size.

A complete description of each analyte, analytical method, target detection limit, and holding requirements can be found in Table A2-1 of the QAPP. Table A1-8 summarizes all under-pier samples and associated analyses.

# A1-3. Composite Samples

Sample composites created from core samples will be used for leaching and elutriate tests as well as for physical properties tests such as grain size, moisture content, organic content, and Atterberg limits. Information derived from analysis of the composite samples will be used to:

- assess dredging technologies;
- assess onsite disposal in a CDF;
- assess offsite disposal in a Subtitle D landfill; and
- determine engineering characteristics of the sediments.

The following tests will be performed on the composite samples:

- thin-layer column leaching test (TCLT);
- column settling test (CST);
- dredging elutriate test (DRET);
- modified elutriate test (MET);
- toxicity characteristics leaching procedure (TCLP);
- ignitability, corrosivity, and reactivity;
- generation and loss of free liquid (i.e., paint filter test);
- grain size;
- moisture content;
- Atterberg limits (if applicable);
- specific gravity (if applicable);
- consolidation (selected samples); and
- organic content (selected samples).

For a summary of composite creation, see Figure A1-2.

### A1-3.1 Core Samples to Be Used for Composite Tests

Two composite sediment samples, one representing Slip 1 and the other representing Slip 3, will be created for DRET and TCLP analyses. For the CST, MET, and TCLT analyses, a Slip 3 sediment composite sample will be created for each test. For the determination of engineering properties, one composite sample will be created by subsampling vibracores at every sampling location. Figure A1-1 and Table A1-9 present the cores that will be included in each composite.

### A1-3.2 Composite Preparation

All composite samples will be homogenized from sediments collected from 0 to 11 ft below mudline. Composites will be developed by mixing core samples in a stainless steel metal bowl with a stainless steel spoon until consistent color and texture are achieved. Once mixed, composite samples will be placed in appropriate containers, properly labeled, and submitted for laboratory testing. Sample handling will be performed in accordance with BBL's Chain of Custody, Packing, Handling, and Shipping SOP (see Section A1-8).

Surface water will be collected onsite for preparation of elutriates at the laboratory. Surface water samples will be collected for:

- DRET from Slip 1 and Slip 3;
- MET from Slip 3; and
- CST from Slip 3.

During the collection of the water samples, the following field parameters will be determined:

- temperature;
- pH;
- conductivity; and
- turbidity.

Field parameters will be measured for informational purposes as part of standard water sampling methods. Calibration of the meter used to measure these parameters in the field is discussed in Section A1-8.7.

In addition, water samples collected for the DRET, MET, and CST analyses will be analyzed to determine background concentrations in elutriate samples. DRET surface water samples will be analyzed for metals, SVOCs, tDDT, PCBs, TPH, ammonia, and hydrogen sulfide. MET surface water samples will be analyzed for metals, SVOCs, tDDT, and PCBs.

The surface water samples will be collected by submerging tubing approximately 2 ft below the surface of the water. A peristaltic pump will be used to collect the water samples, and the water will be stored in 5-gallon plastic carboys. The carboys will be handled in accordance with BBL's Chain of Custody, Packing, Handling, and Shipping SOP (see Section A1-8).

### A1-3.3 Composite Tests

#### A1-3.3.1 Thin-layer Column Leaching Test

The TCLT will act as a laboratory-scale model of peak leachate contaminant concentrations from dredged material deposited in a CDF. The TCLT will be performed in accordance with *Leachate Testing and Evaluation for Estuarine Sediments* (Myers et al., 1996). One composite sediment sample will be submitted for the TCLT. The water for the TCLT will be deionized water. To perform the TCLT, a portion of the composite sample will be mixed and weighed. The material will then be placed into the thin-layer column. Leachant will be pumped through the composite sediment sample. The resulting leachate will be collected periodically and analyzed. Figure A1-4 illustrates the thin-layer column leaching test.

The TCLT will be performed for the collection of up to 30 pore volumes. A procedure blank will be developed by contacting leachant with the TCLT device and collecting the equivalent of one pore volume. The leachate, leachant, and procedure blanks will be placed in appropriate containers (Table A1-6), packaged, labeled, and sent to the laboratory for analysis. The TCLT leachates will be analyzed for the following constituents:

- metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc);
- SVOCs;

- tDDT; and
- PCBs.

See Table A2-2 of the QAPP for analytical methods and detection limits for the TLCT.

### A1-3.3.2 Column Settling Test

Onsite disposal in a CDF will be assessed with the column settling test. The CST provides information on the settling characteristics of dredged material in a containment area. The CST will be performed in accordance with *Confined Disposal of Dredged Material* (USACE, 1987). One composite sediment sample from Slip 3 will be used for the CST. The water for the CST will be surface water from Slip 3.

To begin the CST, a slurry will be produced using the composite sediment sample and surface water; the slurry will have a water-to-sediment ratio of 4:1 by volume. This ratio is based on the expected water-to-sediment ratio of dredged material at the Removal Action Area. The slurry will be thoroughly mixed in a polyethylene drum with an electrically operated stainless steel paddle. The slurry will then be pumped into the test column using a positive displacement pump. The test column is an 8-ft-tall plastic column with a diameter of approximately 8 inches. The test column has sample ports at 1-ft or closer intervals in the lower 3 ft of the column and at 0.5-ft intervals in the upper 3 ft of the column. The sampling ports sample from the center of the column. To produce a uniform concentration of suspended solids, compressed air will be injected at the base of the column during this step. After the fluid surface (zone settling interface) is below the highest port, the first sample will be taken. Samples will be collected from all sampling ports above the settling interface. Subsequent samples will be taken from any ports above the interface at 2, 4, 12, 24, 48, and 96 hours and then daily for up to 15 days. The time of extraction, sampling port height, and the height of the interface will be recorded for each sample. Samples will be analyzed for TSS. The average TSS value will be used as the initial condition of the test. See Figure A1-5 for an illustration of this test. See Table A2-2 of the QAPP for analytical method and detection limit for the CST.

### A1-3.3.3 Dredging Elutriate Test

The DRET results will be used to determine potential water quality impacts during dredging. The DRET simulates the release of sediment-bound and porewater constituents into the receiving water column at the point of dredging. The DRET will be performed in accordance with *Dredging Elutriate Test (DRET) Development* (DiGiano et al., 1995). Two composite sediment samples, one sample from Slip 1 and one sample from Slip 1, will be submitted for DRET analysis. The water for the DRET will consist of two surface water samples collected from Slips 1 and 3. Using the sediment and surface water, a slurry with a 1:250 solids-to-water volume ratio, or an approximate solids concentration of 10 grams per liter, will be produced. The slurry will be thoroughly mixed in a polyethylene drum with an electrically operated stainless steel paddle. Next, the slurry will be aerated for 1 hour using compressed air through a deionized water trap in a 5-gallon glass carboy. The slurry will then settle for 1 hour.

After settling, supernatant water samples will be extracted from the midpoint between the fluid surface and the settling interface. A peristaltic pump will be used to remove the samples. Samples tested for total constituents will not be filtered, but samples analyzed for dissolved constituents will be filtered through a 0.45 μm high-capacity in-line filter. Samples will be placed in appropriate containers (see Table A1-6), labeled, and shipped for laboratory analysis. Figure A1-6 illustrates this test. The DRET elutriate samples will be analyzed for the following constituents:

- metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc);
- SVOCs;
- tDDT;
- PCBs;
- TPH;
- ammonia; and
- hydrogen sulfide.

See Table A2-2 of the QAPP for analytical methods and detection limits for the DRET.

### A1-3.3.4 Modified Elutriate Test

The MET will provide information for assessing onsite disposal in a CDF. The MET simulates dissolved and particulate associated concentrations of contaminants in the effluent from the CDF. The MET will follow guidelines from *Environmental Effects of Dredging, Technical Notes, Interim Guidance for Predicting Quality of Effluent discharged from Confined Dredged Material Disposal Areas—Test Procedures* (Palermo, 1985). One composite sediment sample from Slip 3 will be submitted for the MET. The water for the MET will be surface water from Slip 3. For the MET slurry, the water-to-sediment ratio will be 4:1 based on volume. The slurry will be mixed for five minutes in a polyethylene drum with an electrically operated stainless steel paddle. The slurry will then be aerated for 1 hour using compressed air through a deionized water trap in a 5-gallon glass carboy. The slurry will settle for the anticipated field mean retention time of the dredge-material slurry in the CDF, up to a maximum of 24 hours.

After settling, supernatant water samples will be extracted from the midpoint between the fluid surface and the settling interface. A peristaltic pump will be used to remove the samples. Samples tested for total constituents will not be filtered, but samples analyzed for dissolved constituents will be filtered through a 0.45 µm high-capacity in-line filter. Samples will be placed in appropriate containers (see Table A1-6), labeled, and shipped for laboratory analysis. Figure A1-7 illustrates this test. The MET elutriate samples will be analyzed for the following constituents:

- metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc);
- SVOCs;
- tDDT; and
- PCBs.

See Table A2-2 of the QAPP for analytical methods and detection limits for the MET.

### A1-3.3.5 Toxicity Characteristics Leaching Procedure and Hazardous Waste Determination

The TCLP analysis will provide information for assessing offsite disposal at a Subtitle D landfill. Two composite sediment samples, one from Slip 1 and one from Slip 3, will be submitted for TLCP. The TLCP leachate will be analyzed for:

- metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver);
- pesticides (chlordane, endrin, heptachlor, heptachlor epoxide, lindane, and toxaphene);

- herbicides (2,4-D, methoxychlor, pyridine, 2,4,5-TP);
- volatile organic compounds (VOCs) (benzene, carbon tetrachloride, chlorobenzene, chloroform, 1,2-dichloroethane, 1,1-dichloroethylene, methyl ethyl ketone, nitrobenzene, tetrachloroethylene, trichloroethylene, 2,4,5-trichlorophenol, 2,4,6-trichlorophenol, and vinyl chloride); and
- SVOCs (2-methylphenol, 3-methylphenol, 4-methylphenol, methylphenol, 1,4-dichlorobenzene, 2,4-dinitrotoluene, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, and nitrobenzene, pentrachlorophenol).

These two composite sediment samples will also be used for hazardous waste determination (analysis of ignitability, corrosivity, and reactivity and generation and loss of free liquid, i.e., paint filter test) to provide information for assessing offsite disposal of dredged sediments in a Subtitle D landfill.

### A1-3.3.6 Engineering Properties

Composite samples composed of vibracore subsamples from every location will be used to determine engineering properties of the sediments in the Removal Action Area. The determination of these properties will provide information for assessing onsite disposal in a CDF (since sediments in a CDF would be from a variety of locations in the Removal Action Area). These composite samples will be analyzed for grain size, Atterberg limits, moisture content, organic content, consolidation, and specific gravity. Table A1-10 summarizes the composite samples and testing.

**Table A1-10**
**Summary of Composite Sample Tests**

| Composite Test Name | Removal Action Assessment | Composite Depth | Number of Composite Samples | Composite IDs | Analysis |
|---|---|---|---|---|---|
| DRET | Determine water quality impacts during dredging | 11 ft (0-11 ft below mudline) | 2 | T4-CM1<br>T4-CM2 | Metals (1), SVOCs, tDDT, PCBs, TPH, ammonia, hydrogen sulfide |
| CST | Onsite disposal in CDF | 11 ft (0-11 ft below mudline) | 1 | T4-CM2 | TSS |
| TCLT | Onsite disposal in CDF | 11 ft (0-11 ft below mudline) | 1 | T4-CM2 | Metals (1), SVOCs, tDDT, PCBs |
| MET | Onsite disposal in CDF | 11 ft (0-11 ft below mudline) | 1 | T4-CM2 | Metals (1), SVOCs, tDDT, PCBs |
| TCLP | Offsite disposal of dredged sediments in Subtitle D landfill | 11 ft (0-11 ft below mudline) | 2 | T4-CM1<br>T4-CM2 | Metals (2), pesticides, herbicides, VOCs, SVOCs |
| Hazardous Waste Determination | Offsite disposal of dredged sediments in Subtitle D landfill | 11 ft (0-11 ft below mudline) | 2 | T4-CM1<br>T4-CM2 | Ignitability, corrosivity, reactivity, paint filter test |
| Engineering Properties | Onsite disposal in CDF | 11 ft (0-11 ft below mudline) | 1 | T4-CM3 | Grain size, Atterberg limits, moisture content, organic content, consolidation, specific gravity |

(1) Metals include As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn
(2) Metals include As, Ba, Cd, Cr, Pb, Hg, Se, Ag

# A1-4. Geotechnical Sampling

Geotechnical investigations will be performed for the Removal Action Area to define geotechnical and engineering properties of the sediments, as well as to develop subsurface analysis cross sections for evaluation of Removal Action alternatives. Table A1-11 (in Section A1-4.3) summarizes the geotechnical investigations for the Removal Action. Station positioning for geotechnical sampling will follow the same procedure described in Section A1-2.1.

## A1-4.1 Vibracore Samples

Ten to 20% of sediment samples taken for chemical analysis by vibracore will concurrently be used to determine physical and engineering properties such as:

- soil density;
- grain size;
- moisture content;
- plasticity (i.e., Atterberg Limits);
- consolidation;
- organic content;
- specific gravity; and
- shear strength (note that laboratory testing of shear strength is reserved for samples from geotechnical explorations).

Auxiliary information, such as the coring refusal depth, will also be noted in the field notes during the vibracoring process to better explain the behavior of the sediments.

As shown in Table A1-11, a limited number of consolidation tests will be performed for composite samples from vibracores. These will be performed using the U.S. Army Corps of Engineers (USACE) Modification (i.e., USACE EM 1110-2-5027, Appendix D) to the standard American Society for Testing and Materials (ASTM) testing method for consolidation (i.e., ASTM D 2435).

## A1-4.2 Geotechnical Borings and Monitoring Wells

Six geotechnical borings and six clustered monitoring wells will be installed in the Removal Action Area. The information collected from these borings and well installations will be used to determine dredgeability, stability of dredged slopes, consolidation below potential onsite disposal facilities, stability of containment berms, liquefaction potential, and adjacent structure stability. Geotechnical borings and monitoring wells will be completed by hollow-stem auger methods unless the boring or well is to be completed in or below the Troutdale Formation. These borings and wells will be completed by Becker® drilling procedures or comparable procedure. Hydro-punch technology may be utilized for well installations as a substitute for the hollow-stem auger installation method for 4 to 6 of the shallow monitoring wells. Installation differences compared to that required by the hollow-stem auger method are described in subsequent sections. During installation of the wells by hollow-stem auger method, the Standard Penetration Testing (SPT) methodology will be performed in accordance with ASTM D 1586-99. This test is an approximate measure of soil density and consistency. The

test requires that a standard sampler (i.e., 2-inch outside diameter split-spoon) be driven into the sediment using standard energy (i.e., 18 inches using a 140-pound hammer with a 30-inch freefall). The Standard Penetration Resistance is measured by the number of blows required to drive the sampler the last 12 inches.

For geotechnical borings and monitoring wells that will be completed in or below the Troutdale Formation, Becker® drilling procedures will be used. The drilling method involves hammering a large-diameter dual pipe (7-inch OD and 4-1/4-inch ID) into the ground at a rate of around 90 blows per minute, while forcing air down the annulus between the tubes. Air returns upward through the inside pipe, carrying with it a continuous stream of drill cuttings which are extracted from the air stream by cyclone at the surface. Split-spoon samples will be collected as described as for the hollow-stem auger method.

The outside part of the dual tube acts as a drill casing, preventing collapse of the borehole wall. The inside diameter of 4-1/4 inches allows split-spoon drive samples to be taken without removing the drilling hardware from the borehole, as is necessary with wire-line drilling methods.

Hydro-punch technology utilizes a truck-mounted push-probe drilling method. Soil core is collected continuously as the boring is advanced. The wells are completed using a truck-mounted, push-probe drilling rig and pre-constructed monitoring wells (i.e., wells include a filter pack material around well screen held by a wire screen mesh or equivalent). The remaining annular space between pre-constructed well and push-probe hole is filled with sand filer pack around with well screen, along with other well construction materials for the remainder of the probe hole in accordance to applicable well construction requirements.

The estimated number of samples for geotechnical borings (Table A1-11) is based on the following assumptions:

- Upland geotechnical borings: Sampling will occur on a 5-ft sample interval to a depth of 100 ft, then on a 10-ft sample interval for the remaining depth.

- In-water geotechnical borings: The uppermost 20 ft of sediment will be continuously sampled, then on a 5-ft sample interval to a depth of 100 ft and finally to a 10-ft sample interval for the remaining depth.

Geotechnical boring T4-G03L will undergo a specialized completion methodology using a grout mixture that specifically facilitates down-hole shear wave velocity testing, which will be performed by the drilling subcontractor. A specialty consultant will provide the upland shear wave velocity profile testing following completion and an appropriate set time for the boring. This will be staged early in the drilling program, allowing sufficient time for the drilling contractor to return to the location and abandon the well in accordance with applicable standards.

The SPT methodology will also be used for monitoring well clusters (described in Section A1-5). These clusters will consist of two or more separate installations (i.e., each screened at a different depth). Figure A1-8 shows the location of these wells. MW01, MW02, MW05, and MW06 are clusters composed of three wells generally representing the shallow, intermediate, and deep hydrogeologic conditions. MW03 and MW04 are clusters likely composed of only two wells, each with specific objectives. The estimated number of samples (Table A1-11) to be collected from monitoring wells is based on the following assumptions.

- The deep wells of a given cluster will be drilled first. The monitoring well log and associated observations made in the field during drilling will be used to determine completion depths for the remaining wells of the cluster. Remaining wells of a cluster will not be sampled until approaching the targeted screened zone to verify conditions encountered in the deep well of the cluster for determining

the exact completion depth. For the latter, a sample representative of the screened zone will be collected and tested for grain size and moisture content. Note that this approach applies only to the wells identified as having three in the cluster.

- For wells at Gatton's Slough, sampling will be provided on a 5-ft sample interval and monitoring well installations are planned primarily below the previously identified fine-grained, organic silt/clay in-filled sediments into a water-bearing, transmissive zone. If conditions warrant another installation (e.g., a saturated sand layer within the in-filled sediments is encountered), a shallower screened interval will be provided.

The sampling activities for either exploration type may vary from what is stated here depending on conditions encountered in the field.

In addition to disturbed samples, relatively "undisturbed" thin-walled tube samples will be taken from the geotechnical boring and monitoring well installation. These samples, which are relatively few in number (Table A1-11), will be used for determining engineering characteristics that require relatively undisturbed samples to be representative of actual conditions (e.g., consolidation and shear strength).

Section A1-5 explains the hollow-stem auger boring procedure for installing the monitoring wells and the hydro-punch technology that may be substituted for hollow-stem auger methods for shallow wells.

### A1-4.3 Seismic Cone Penetrometer Testing (SCPT)

Ten SCPTs or other cone penetrometer testing will be performed using measures of tip resistance, sleeve friction, and pore pressure. The location of these tests is shown on Figure A1-8. This testing will be used to develop shear wave velocity profiles (at selected locations) as well as to supplement geotechnical borings. The cone collects continuous subsurface measurements during penetration. Field computers are used to record the collected data, which will be stored on disk for permanent record and post-processing. Profiles of stratigraphy, relative density, pore pressure, resistivity, and equivalent SPT blow counts will all be recorded in the final data report. The number of shear wave velocity profiles that are performed will be determined prior to the field program. One profile for Slip 1, Slip 3, and Wheeler Bay or a similar field test program will be performed to supplement the upland boring. These activities will be coordinated by BBL but performed by a subcontractor.

**Table A1-11**
**Summary of Geotechnical Investigations**

| Geotechnical Investigation | Number | Location ID | Analysis or Data | Removal Action Assessment |
|---|---|---|---|---|
| Engineering tests of sediment samples from cores | 10-20% of vibracore samples | T4-VC04, T4-VC09, T4-VC14, T4-VC21, T4-VC23, T4-VC26, and T4-VC29 | Engineering properties (1) | Capping/dredging, slope and structure stability, onsite disposal |
| Seismic Cone Penetrometer Testing | 10 | See Figure A1-8 T4-CP01—T4-CP10 | Relative strength of deposits, classification, etc. | Capping/dredging, onsite disposal |
| Clustered monitoring wells | 6 total | See Figure A1-9 MW01-MW06 | Utilize SPT method; samples for engineering properties (1) (2) | Capping/dredging, slope and structure stability |
| Deep geotechnical borings | 6 total: 4 in-water 2 upland | See Figure A1-8 GE01-GE06 | Utilize SPT method; specialized completion with specific grout mixture for down-hole shear wave velocity testing for one upland boring; samples for engineering properties; upland shear wave velocity profile: undisturbed thin-wall samples and disturbed SPT samples for engineering properties (1) | Slope and structure stability |

(1) Engineering properties include grain size, moisture content, organic content, specific gravity, Atterberg limits, soil density, consolidation, and shear strength.
(2) If hydro-punch technology is substituted for 4 of the shallow monitoring wells, the SPT would not be applicable and soil samples for geotechnical testing may be obtained from other wells or geotechnical borings, if necessary.

Drilling/SCPT, sampling, sample handling/transport, and laboratory testing will be performed in accordance with the applicable ASTM standards, as follows:

- ASTM D 422, 2002. Standard Test Method for Particle-Size Analysis of Soils.
- ASTM D 854, 2002. Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer.
- ASTM D 1452, 2000. Standard Practice for Soil Investigation and Sampling by Auger Borings.
- ASTM D 1586, 1999. Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.
- ASTM D 1587, 2000. Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes.
- ASTM D 2216, 1998. Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
- ASTM D 2435, 2002. Standard Test Method for One-Dimensional Consolidation Properties of Soils.
- ASTM D 2487, 2000. Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).

- ASTM D 2488, 2000. Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
- ASTM D 2850, 2003. Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils.
- ASTM D 2974, 2000. Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.
- ASTM D 3213, 2003. Standard Practices for Handling, Storing, and Preparing Soft Undisturbed Marine Soil.
- ASTM D 4220, 2000. Standard Practices for Preserving and Transporting Soil Samples.
- ASTM D 4318, 2000. Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
- ASTM D 4750, 2001. Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well).
- ASTM D 4767, 2002. Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils.
- ASTM D 5092, 2002. Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers.
- ASTM D 5434, 2003. Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock.
- ASTM D 5778, 2000. Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils.
- ASTM D 5784, 2000. Standard Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices.
- ASTM D 6066, 1996. Standard Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential.
- ASTM D 6067, 1996. Standard Guide for Using the Electronic Cone Penetrometer for Environmental Site Characterization.
- ASTM D 6151, 2003. Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling.

# A1-5. Hydrogeologic Sampling

To properly develop the hydrogeologic conceptual model and evaluate contaminant transport from capped sediments or from sediments placed in an onsite CDF, certain hydrogeologic properties of the Removal Action Area need to be investigated. This data will be collected with the monitoring well installations described here. Well locations are shown on Figure A1-9. Station positioning for hydrogeologic sampling will follow the same procedure presented in Section A1-2.1.

- Two monitoring well clusters will be installed near the Willamette River. These wells will be screened within each hydrostratigraphic unit (i.e. Upland Fill, Troutdale Gravel) influencing contaminant transport characteristics for sediments residing at the base of the slips.

- One intermediate/deep well cluster will be installed in Slip 1 in the Gatton's Slough organic silt/clay soils. It will be screened below the organic silt/clay (within the Recent Alluvial deposits) at or slightly below the elevation of Slip 3 (i.e., this cluster does not include a well screened within the Troutdale Gravel). If a saturated sand layer is encountered within the organic silt/clay and is interpreted to be a transmissive, water-bearing zone, it will also be screened within the Gatton's Slough in-filled sediment as a single additional well installation.

- Two monitoring well clusters upgradient of the slips will be installed and screened within each hydrostratigraphic unit.

- One shallow/intermediate monitoring well cluster will be installed between Slips 1 and 3, east of Wheeler Bay, with similar installation details as the wells described above. In addition to supporting the development of the hydrogeologic conceptual model, this monitoring well cluster is for determining whether groundwater mounding or other phenomenon may be occurring between the slips.

The monitoring well top-of-casing elevations and ground surface elevations will also be surveyed as a part of the hydrogeologic investigation. Pore pressure transducers will be placed in the wells for continuous water level monitoring for a minimum of one cluster of wells and period measurement of water levels would be provided for other wells.

## A1-5.1 Well Installation

The wells will be installed using a hollow-stem auger, hydro-punch, or Becker® drilling procedure and following BBL's Monitoring Well Installation SOP. No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools). No coated bentonite pellets will be allowed in the borehole. Prior to beginning work, all underground utilities will be delineated by the drilling contractor or an independent underground utility locator service. Material safety data sheets and specifications of materials to be installed in the wells will be obtained prior to mobilizing onsite, including:

- well casing;
- bentonite;
- sand; and
- grout.

Well materials will be inspected and, if needed, cleaned prior to installation.

### A1-5.1.1 Equipment

The following materials will be available during soil boring and monitoring well installation activities, as required:

- site plan with proposed soil boring/well locations;
- work plan, FSP, and HASP;
- PPE as required by the HASP;
- drilling equipment required by ASTM D 1586;
- appropriate sampling equipment (e.g., stainless steel spatulas, knife);
- equipment cleaning materials;
- appropriate sample containers and labels;
- chain-of-custody forms;
- insulated coolers with ice;
- photoionization detector;
- keys to wells;
- disposable plastic liners;
- well construction materials; and
- field notebook.

### A1-5.1.2 Procedures

The procedures for installing groundwater monitoring wells in soil using the hollow-stem auger drilling method are presented below.

1. Locate boring/well location, establish work zone, and set up sampling equipment cleaning area.
2. Advance soil boring to depth. Collect representative soil samples at intervals. The sampling method employed will be ASTM D 1586, Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.

3. Fully describe each soil sample including soil type, color, percent recovery, relative moisture content, soil texture, grain size and shape, consistency, and any other pertinent observations. Record descriptions in the field notebook. During soil boring advancement, document all drilling events, including blow counts (number of blows required to advance split-spoon sampler in 6-inch increments) and work stoppages, in field notebook. Blow counts may not be available if direct-push methods are used.

4. Upon completing the borehole to the desired depth, install the monitoring well by lowering the screen and casing assembly with sump through the hollow axis of the auger column. Monitoring wells typically will be constructed of 2-inch-diameter, flush-threaded polyvinyl chloride (PVC) slotted well screen and blank riser casing. The screen length will be 10 ft and the slot size will be 0.010 inches. A blank riser will extend from the top of the screen to approximately just below grade with a flush-mounted monitoring well.

5. When the monitoring well assembly has been set in place, place a washed silica sand pack in the annular space from the bottom of the boring to a height of 1 to 2 ft above the top of the well screen. The sand pack

will be consistent with the screen slot size and the soil particle size in the screened interval. A hydrated bentonite seal (a minimum of 2 ft thick) will then be placed in the annular space above the sand pack. If non-hydrated bentonite is used, the bentonite should be permitted to hydrate in place for a minimum of 30 minutes before proceeding. No bentonite pellets will be used in monitoring wells. Potable water may be added to hydrate the bentonite if the seal is above the water table. Monitor the placement of the sand pack and bentonite with a weighted tape measure. During the extraction of the augers, a cement/bentonite grout will be pumped through a tremie pipe to fill the annular space from the bentonite seal to a depth approximately 2 ft below ground surface.

6. Place a 10-inch curb box over the riser casing and secure with a neat Portland Cement seal. The cement seal will extend approximately 1.5 to 2.0 ft below grade and laterally at least 1 ft in all directions from the protective casing and will slope gently away to promote drainage away from the well. The PVC riser will be sealed using an unvented expandable locking plug. Monitoring wells will be labeled with the appropriate designation on both the inner and outer well casings.

7. At those locations where a flush-mounted installation is desired, the steel protective casing will be replaced with a 10-inch curb box or equivalent. When a flush-mounted installation is used, the PVC riser will be sealed using an unvented expandable locking plug.

8. During well installation, record exact construction details and actual measurements relayed by the drilling contractor and tabulate all materials used (e.g., screen and riser footages; bags of bentonite, cement, and sand) in the field notebook.

9. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section A1-10.

The following procedure describes the steps taken to install monitoring wells using hydro-punch technology:

1. At each monitoring well location, drill a boring using a truck-mounted push-probe drilling method to permit observation of subsurface geologic conditions prior to installation of the monitoring well.
2. Prior to drilling, pre-core the asphalt or concrete ground surface. The direct push drilling method uses a 2-inch-diameter (OD), by 4-foot-long Macro Core sampler, which is driven into the ground to the desired depth to retrieve a 4-foot-long soil core sample. During each sample interval, place a new, clean polyethylene liner inside the sample barrel to prevent cross-contamination and to facilitate removal of the soil sample from the sampling device.
3. Collect soil core continuously as the boring is advanced. Upon retrieval of each core, remove the polyethylene liner from the core barrel and cut in half lengthwise to expose the soil core for observation and sample collection. Fully describe the soil in accordance with ASTM D2488-84 and record observations on a boring log.
4. Upon completion of the 2-inch boring, complete well using a truck-mounted, push-probe drilling rig. The direct push well installation method drives a 3.5-inch (O.D.) diameter temporary steel casing with an expendable point to the desired monitoring well depth, which will be selected based on observations during drilling of the 2-inch boring. The pre-constructed monitoring well is then installed into the temporary casing. The monitoring well construction consists of a 2-inch inner diameter, Schedule 40 PVC well casing and screen. The well screen is 10 feet in length with a 10-slot prepacked screen consisting of a stainless steel wire mesh over 20-40 silica sand.

5. Place additional 20-40 sand in the annulus between the prepacked screen and the temporary steel casing to complete the filter pack, upon installation of the monitoring well into the temporary casing. Fill the annulus with sand to an elevation two feet above the top of the screen.
6. Fill the remainder of the annulus with bentonite to the ground surface to construct the seal. Remove the temporary casing from the ground incrementally as the filter pack and bentonite is placed into the annulus. The well completion consists of a flush-mounted, steel monument.

# A1-6. Hydrologic/Hydraulic Monitoring

Hydrologic and hydraulic investigations will include water level gauging (both in the river and in the monitoring wells), groundwater sampling from monitoring wells, stormwater outfall analysis, and Acoustic Doppler Profiling for currents. Station positioning for hydrologic and hydraulic investigation will follow the same procedure presented in Section A1-2.1.

## A1-6.1 Trackline Positioning

Acoustic Doppler current profiler (ADCP) tracklines will be conducted along 1 transect in the Willamette River, 6 transects in Slip 1, 2 transects in Wheeler Bay, and 5 transects in Slip 3. ADCP velocity surveys along these tracklines will be conducted by a qualified contractor with the requisite equipment and experience. Trackline positions are summarized in the following table.

**Table A1-12**
**ADCP Profiler Tracklines**

| Transect | Area | Start Point | End Point | Orientation |
|---|---|---|---|---|
| T-1 | Willamette R. | South end of Slip 3 | West bank | East-west |
| T-2 | Slip 3 | Midpoint of Slip 3 | Mid river | East-west |
| T-3 | Slip 3 | North end of Slip 3 | Mid river | East-west |
| T-4 | Slip 3 | Head of Slip 3 | | North-south |
| T-5 | Slip 3 | Mouth of Slip 3 | | North-south |
| T-6 | Slip 3 | Midpoint of Slip 3 | | North-south |
| T-7 | Wheeler Bay | Midpoint of Wheeler Bay | Mid river | East-west |
| T-8 | Wheeler Bay | North end of Wheeler Bay | Mid river | East-west |
| T-9 | Slip 1 | South end of Slip 1 | Mid river | East-west |
| T-10 | Slip 1 | Midpoint of Slip 1 | Mid river | East-west |
| T-11 | Slip 1 | North end of Slip 1 | Mid river | East-west |
| T-12 | Slip 1 | Head of Slip 1 | | North-south |
| T-13 | Slip 1 | Midpoint of Slip 1 | | North-south |
| T-14 | Slip 1 | Mouth of Slip 1 | | North-south |

GPS coordinates for intended trackline paths will be pre-established by the survey contractor and the actual trackline, as recorded by the DGPS equipment on the sampling vessel will be plotted with the intended tracklines.

ADCP trackline positions will also be identified based on stationary landmarks for the starting points on shore. These landmarks will be photographed and recorded by the field crew on registered base maps.

## A1-6.2 Moored Array Station Positioning

A description of the four moored array station locations is provided below.

**Table A1-13**
**Moored Array Station Locations**

| Station | Slip | East/West Position | North/South Position | Approximate Water Depth |
|---|---|---|---|---|
| M-1 | 1 | 1/3 of distance from mouth to east end of Slip 1 | Midpoint of Slip 1 | 30 ft |
| M-2 | | Near Berth 414 | Upstream end of Removal Action Area | 40 ft |
| M-3 | 3* | 2/3 of distance from mouth to the head of Slip 3 | Midpoint of Slip 3 | 40 ft |
| M-4 | 3* | 1/3 of distance from mouth to the head of Slip 3 | Midpoint of Slip 3 | 40 ft |

* Locations will be highly dependent on anticipated vessel movement during time of deployment.

The exact locations of these stations will be established in the field and recorded by a DGPS unit onboard the sampling vessel. Locations will be marked with a subsurface buoy. Following bouy placement, two stakes will be placed on shore in alignment with the buoy locations to provide a backup means to DGPS to aid in equipment recovery. Stake locations will be photographed and marked by the field crew on registered base maps.

Visual horizontal triangulation methods will be used as a backup method to the DGPS to establish locations of the moored arrays. This system will use pre-surveyed markers and established landmarks on shore. This method determines sampling locations based on horizontal distances to survey control points and/or landmarks identifiable on base maps.

## A1-6.3 ADCP Survey Mobilization

Sedimentation in Slips 1 and 3 occurs continually. Higher sediment transport rates occur in the Willamette River during high flow conditions. Sedimentation in Slip 1 appears to occur during low flow and sedimentation in Slip 3 exhibits variable patterns. Field work for the EE/CA will occur during the spring, which may limit the range of flow conditions that can be monitored during the spring. An effort will be made to capture a high and low flow event during field work. An objective of the ADCP survey will be to capture the highest flows during the sampling period that may be coincident with snow melt runoff or rainfall events. Velocity measurements will be made over the course of 2 months during the period of field work.

## A1-6.4 ADCP Survey Procedures and Data Collection

The ADCP surveys to obtain velocity measurements will be conducted following the selected surveying contractor's procedures for equipment testing, calibration, and operation. Documentation of the contractor's safety procedures and standard operating procedures for the vessel and equipment will be utilized. Copies of these procedures will be obtained from the contractor and filed with the Port of Portland. Data reduction and

processing will also be conducted by the subcontractor according to established procedures which will be documented and provided in the subcontracting process. Data products required of the contractor will include:

- Tabular ASCII data containing vessel position, current speed, and current direction at ½-meter vertical intervals and at a horizontal spacing of 10 meters. Data will be presented as formatted ASCII listings of current speed and direction verses position and depth.
- Current vector plots of the vertically averaged flow in hard copy and electronic format.

## A1-6.5 Moored Array Deployment and Data Collection

The assembly and deployment of the moored oceanographic arrays will be conducted following the selected surveying contractor's procedures for equipment testing, calibration, and operation. Documentation of the oceanographic monitoring contractor's safety procedures and standard operating procedures for the vessel and equipment will be utilized. Copies of these procedures will be obtained from the contractor and filed with the Port of Portland. Data reduction and processing will also be conducted by the subcontractor according to established procedures which will be documented and provided in the subcontracting process.

Four moored arrays will be assembled consisting of an Acoustic Doppler Current Meter (ADCM), and oceanographic sensors to record temperature and turbidity. One array will be placed near the mouth of Slip 1, two arrays will be placed within Slip 3, and one array will be place just upstream of the Removal Action Area. The arrays will be deployed as in-line vertical moorings comprised of a heavy anchor, a sufficient length of jacketed wire cable, and a subsurface floatation buoy. A surface buoy will be linked to the top of the subsurface sphere with a tether. The two moorings in Slip 3 will include a single sediment trap mounted 2 to 3 ft above the sediments and a Nortek Aquadopp® (or comparable) sensor mounted 3 ft above the sediment trap. The Aquadopp® sensors will record turbidity and current velocity. The ramining two arrays will just have Aquadopp® sensors. Sediment traps of typical design will be constructed or purchased. Sediment traps will generally consist of a series of 3 tubes capped on one end and positioned around the vertical mooring cable. A hexcel baffle composed of numerous individual cells will placed in the opening of each tube or cone to reduce turbulence around the mouth of the trap.

Prior to array deployment, ship activities will be reviewed with the Port and if necessary, locations will be adjusted and/or diver installation and retrieval of the arrays will be used to avoid placing buoys in ship traffic. The sensors may also record influences of vessel movement and ship propellers. The tenants of Slip 3, Kind Morgan, will be contacted in order to prepare a schedule of vessel movement in and out of Slip 3 during the sampling timeframe. Our current understanding is that approximately 100 ships per year are served at Slip 3, typically of the 50,000 ton class and never more than one ship at a time. During the sensor readings the time of vessel movement, type and size of the vessel and other pertinent information will also be recorded and their relation with the sensor readings will be evaluated.

Following installation, the arrays will be retrieved at 30-day intervals throughout the 60-day data collection period (two data retrievals are anticipated). Array retrieval will be conducted at a very slow rate taking care not to disturb the sediment trap samples. Data will be downloaded from the sensors each time and samples retrieved from the sediment traps for sediment mass measurement, grain size analysis, and chemical analysis. Data products required of the contractor will include a) basic processing of the current data – calculation of a magnitude and direction for each sample, b) mean speed and direction for each deployment, c) statistics providing the percentage of current values in given direction ranges for each deployment.

Water in the sediment traps will be carefully decanted and the remaining material collected in wide-mouth jars. The samples from each of the three tubes for a particular array will be composited for sediment chemical analysis. Sample handling and analysis procedures will follow those provided in Section A1-8 and A1-9.

### A1-6.6 River Stage Monitoring

River stage (water surface elevation) monitoring will be conducted using automated stage recorders as well as manual reading of stage from a staff gage. Water surface elevations will be recorded with two automated tide gages installed at the following locations.

**Table A1-14**
**Tide Gage Locations**

| Station | Location | Type |
|---|---|---|
| L-1 | Downstream end of Slip 3 | Automated tide gage |
| L-2 | Approximately 1.25 miles downstream of Removal Action Area | Automated tide gage |

Exact installation locations will be determined based on field reconnaissance. The objective will be to locate an installation point that is easily accessed by foot, is relatively free from localized effects such as obstructions, jetties, and stormwater outfalls. Prior to installation, a survey crew will stake or otherwise mark a reference elevation at the location of the tide gage (to within at least 0.1 ft) so that the gage can accurately record elevations relative to the project elevation datum. The marked reference elevation will be used to measure the exact position of the tide gage sensor and the sensor will be programmed to provide a record of the actual water surface elevationin the Columbia River Datum.

The gage locations will be established to the Columbia River datum programmed into the gages so that water depth measurements recorded by gage are automatically converted and stored as elevation. Water level recording will be initiated after the gage elevations have been established through field survey.

The gages will be installed for a 60-day period and data downloads will be conducted at 20 days, 30 days, and 60 days following installation.

### A1-6.7 Groundwater Level Monitoring

A series of water level elevations will be collected in wells adjacent to Slip 1 and Slip 3 to evaluate groundwater gradients, the spatial variation in these gradients, and the temporal variation in the gradients with fluctuation in river stage. This will be accomplished by pairing water level measurements with corresponding river stage measurements obtained at water level station L-1. Water level measurements will be conducted at wells T4-MW01 through T4-MW06 at approximately 7-day intervals throughout the data collection period. Timing will be adjusted as necessary to capture high stage fluctuations (a notable rise or drop in river elevation) that may occur during the study period.

The following procedure will be followed for water level measurements:

- Before sampling, the integrity of the well is checked including locks, well caps and the surface concrete seal. Well condition is recorded in the field notes. All wells must be locked and marked with the well

identification unless the client has requested otherwise. Any questions regarding well integrity, including missing locks or broken casing, should be brought to the attention of the project manager or project coordinator before beginning sampling.

- After the well check, the water level and a depth to bottom reading is collected from the well. A full round of water level and depth to bottom readings from each well at the project site should be done before any associated groundwater quality sampling begins. Water level readings are taken from the top of the well casing at the survey mark point. If no survey mark point is evident, the reading will be taken from the highest point on the well casing.

# A1-7. Decontamination

To ensure accurate sampling and to minimize cross-contamination from one sample location to the next, proper decontamination techniques must be followed in the field. These techniques apply to small sampling equipment, heavy-drilling and field-dedicated equipment, disposable equipment, and personal protective clothing and PPE. Different techniques apply to different types of equipment.

Reusable equipment, such as personal protective clothing, must be washed with non-phosphate detergent and rinsed with tap water. When appropriate, disposable equipment should be disposed of in accordance with the waste management plan in Section A1-10 of this appendix.

Decontamination of small sampling equipment such as spoons, bowls, and mixing devices will be performed in accordance with BBL's Field Equipment Cleaning SOP. For small sampling equipment, the following decontamination procedure will be followed:

- wash with non-phosphate detergent;
- rinse with tap water;
- rinse with deionized water; and
- allow to air dry.

Field sampling equipment will not be decontaminated with solvents (e.g., methanol) unless free-phase petroleum product comes in contact with the equipment. If this occurs, a methanol rinse step will be added after the tap water rinse.

Decontamination for drilling equipment such as drill rigs, well casings, and auger flights will follow BBL's Heavy Equipment Cleaning SOP. These pieces of equipment could contain potential sources of interference to environmental samples. The sampling equipment may have come in contact with the materials adjacent to the matrix being sampled or media may be attached to the actual sampling equipment. Heavy equipment may also retain contaminants from other sources such as roadways and storage areas or material from previous job sites that was not adequately removed. For these reasons, it is important that the sampling equipment be cleaned prior to use.

Two methods are used for cleaning heavy equipment: steam-cleaning and manual scrubbing. Steam-cleaning can remove visible debris. Since steam-cleaners provide a high-pressure medium, they are very effective for solids removal. They are also easy to handle and generate low volumes of wash solutions. A second method involves manual scrubbing of equipment using brushes. This procedure can be as effective as steam-cleaning and is preferred in situations where steam-cleaning fails to remove visible materials. Disadvantages to manual scrubbing are that it is labor-intensive and generates large volumes of wash and rinse solutions.

Heavy equipment will be thoroughly steam-cleaned or manually scrubbed upon arrival and when moved between sampling locations. Drill rig items (e.g., auger flights, drill rods, and drill bits) will be cleaned before changing sample locations.

### A1-7.1 Heavy Field Equipment Cleaning Equipment

The following equipment will be required for cleaning heavy equipment:

- shop vacuum;
- lint-free absorbent towels;
- 6-mil polyethylene sheeting;
- assorted scrub brushes;
- waste disposal drums;
- cleaning fluids, such as Knights Super Kleen®, Simple Green®, Aquanex MC®, Zep Formula 50®, Zep Big Orange®, or equivalent;
- aluminum duct tape; and
- oil/water absorbent Speedi-Dry® compounds.

Before a piece of equipment can be cleaned, it must be disconnected and disabled in accordance with standard Energy Control and Power Lock-Out Procedures. All energy sources, including stored energy, must be removed prior to cleaning. Do not attempt to clean equipment that is in service or still connected to power.

Protective clothing is required during cleaning. The subcontractor shall have a written HASP appropriate for the expected operations, including measurements for determining the need for more stringent levels of protection. The minimum allowable protective clothing shall include:

- plastic face shields;
- disposable Tyvek™ coveralls (Dupont/Saranex 23-P or equivalent);
- impervious rubber boots (neoprene, viton, or equivalent); and
- impervious gloves (neoprene, Viton, or equivalent).

### A1-7.2 Heavy Field Equipment Cleaning Procedure

The following procedure will be followed when cleaning heavy equipment.

1. Don protective clothing.

2. Provide proper signs and barricades for the cleaning area to control access.

3. Place the item to be cleaned on a cart inside one of the equipment decontamination area (EDA) washing areas.

4. Pre-clean the entire piece of equipment to remove all loose dust, dirt, and scale using a shop vacuum designed for solid material, supplemented by scraping, chipping, and spot cleaning with solvent or detergent to remove encrusted materials.

5. Apply the cleaning solution to each surface of the item via a mist, aerosol spray, or cloth soaked in the cleaning solution. Control the application so that little or none of the cleaning solution puddles in the EDA. Make sure that all surfaces are wetted. Use scrubbing brushes, if necessary, to loosen any visible dirt, stains, or grease and then wipe down all surfaces with clean absorbent towels to clean and dry. For larger items, it may be appropriate to clean the equipment in sections.

6. Rinse the equipment with water in the EDA high-pressure (1,500 pounds per square inch) washing area.

7. Repeat Steps 2 and 3. The item should be clean and dry. The equipment is ready to be reused onsite.

8. Completely cover the equipment with polyethylene sheeting and secure the sheeting.

9. Use the shop vacuum to remove all loose material from the plastic sheeting on the floor.

10. Update the equipment tag and log.

11. Before leaving the area in which a piece of equipment has been cleaned, conduct a final check to make sure all discarded materials, including paper towels, plastic sheeting, and disposable gloves, have been picked up and placed in a properly labeled drum.

12. As employees leave the cleaning area, boots and gloves must be left behind. At the end of the day, all PPE must be cleaned and stored onsite. No contaminated clothing or equipment will be permitted to leave the site.

13. All liquid and solid materials, including spent detergents, rinse waters, disposable clothing, residues from scraping and vacuuming, paper towels, plastic, and any other wastes generated during cleaning procedures, are to be collected and stored in Department of Transportation (DOT)-approved steel drums with open tops. All drums shall be properly marked, labeled, stored, and disposed of in accordance with the procedures identified in the HASP.

# A1-8. Sampling Documentation, Sample Handling, and Chain of Custody

## A1-8.1 Documentation

Field activities and samples must be properly documented during the sampling process. Field activity documentation will be performed in accordance with BBL's Quality Assurance Procedure 3.05, *Documentation of Field Activities*. Additionally, each sample must be logged on the appropriate field sampling log sheet.

Documentation of field activities provides an accurate and comprehensive record of the work performed sufficient for a technical peer to reconstruct the day's activities and provide certification that all or necessary client, regulatory, contract, and work plan requirements were met. General requirements include:

- Use of bound field books as the primary source for information collection and recording. Field books should be dedicated to the project and appropriately labeled.

- Use of a Field Activity Log to formally document activities and events as a supplement to bound field books. The Field Activity Log can be a standard or project-specific form or a bound field book. Preprinted standard forms are available for many activities and should be used whenever possible. These forms will provide prompts and request additional information that may be useful and/or needed and that the author is not aware of at the time. Project-specific field forms may be generated or existing forms may be modified to meet specific project needs. As required, client-supplied forms may be substituted.

- Appropriate header information documented on each page, including project title, project number, date, weather conditions, changes in weather conditions, other persons (if any) in the field party, and author. The specific information requested depends on the nature of work being performed and on the form being used. Information fields that are not applicable should be noted "N/A" or with other appropriate notations.

- Field documentation entries using indelible ink.

- Legible data entries. A single line should be drawn through incorrect entries and the corrected entry should be written next to the original strikeout. Strikeouts are to be initialed and dated by the originator.

- Applicable units of measurement with entry values.

- Field records maintained in project files unless otherwise specified by a client or stipulated by a contract.

## A1-8.2 Documentation Entries

A chronology of field events will be recorded. General entry requirements include:

- visitors to the site, including owner and regulatory representatives;
- summary of pertinent project communications with the client, regulators, or other site visitors;
- other contractors working onsite;
- a description of the day's field activities, in chronological sequence using military time notation (e.g., 9:00 am: 0900, and 5:00 pm:1700);
- if applicable, calibration of measuring and test equipment and identification of the calibration standard(s) and use of a Calibration Log, if available, with cross-reference entered into the field book;
- field equipment identification, including type, manufacturer, model number, or other specific information;
- general weather conditions including temperature, wind speed, and direction readings, including time of measurement and units;
- safety and/or monitoring equipment readings, including time of measurements and units;
- if applicable, reference in the field notebook to specific forms used for collection of data;
- subcontractor progress and/or problems encountered;
- changes in the scope of work; and
- other unusual events.

## A1-8.3 Specific Requirements

### A1-8.3.1 Sample Collection

Sample collection data are documented in a bound field book and/or on a Field Activity Log. Where both are being used, information contained in one is cross-referenced to the other. Entries include:

- sample identification number, location taken, depth interval, sample media, sample preservative, collection time, and date;
- sample collection method and protocol;
- physical description of the sample (standard classification system for soil);
- if a composite sample, the sample's make-up, including number and location of grab samples incorporated;
- quality control-related samples collected (e.g., duplicates, blinds, trip blanks, field blanks);
- container description and sample volume;
- pertinent technical data, such as pH, conductivity, temperature, and headspace reading;
- pertinent technical comments; and
- identification of personnel collecting the sample.

### A1-8.3.2 Sample Labeling

Sample labels must be prepared and attached to sample containers. Labels will either be provided by the laboratory performing the analyses or be generated internally. The information to be provided includes:

- sample identification number;
- sample date and collection time;
- physical description of the sample (e.g., water, solid, gas);

- analytical parameters;
- preservatives, if present;
- sample location; and
- client.

### A1-8.3.3 Subsurface Logs

Test pits, soil borings, monitoring wells, and piezometer installations are to be recorded in bound field books and may be supplemented with prepared forms. Personnel completing the log are to supply the following information:

- names(s) of personnel logging boring;
- administrative and technical information included in the header;
- types of equipment used (e.g., drill rig type, drilling tools used, backhoe model);
- subcontractor/driller used;
- descriptions of subsurface materials encountered and the number and type of samples collected, if any;
- subsurface exploration depth and units of measure;
- for drilling, length of recovery;
- sample type and sample number for geotechnical or analytical samples collected. These data are also to be entered on the sample collection log (if used) and the sample label;
- classification standard protocol used, if any (e.g., ASTM SPT);
- narrative description of the soil (using standard classification system) and other pertinent information;
- description of consistency of cohesive soils; and
- additional data such as (but not limited to) background and sample vapor/gas readings, observation of sheens, presence of non-aqueous phase liquid, depth to water (if encountered), odors, and changes in drilling conditions.

### A1-8.3.4 Monitoring Well/Piezometer Installation

The field notebook is to be used to identify the chronology and major events of the installation activity, and the computer-based boring log is to be used to correlate the geologic strata to the major elements of the monitoring well construction. Information to be collected and recorded includes:

- location identity;
- screen type, length, and location;
- diameter;
- total length;
- sump location and depth;
- materials of construction;
- riser length;
- seal type and location;
- sand type; and
- depth to water before and after installation.

For vibracoring, sediment logging information will be recorded on a Vibracore Log (Figure A1-10). For drilling, information is to be recorded on the Geotechnical Boring Log Form (FigureA1-11). For monitoring well installation, the Monitoring Well Installation Form should be completed (Figure A1-12).

### A1-8.4 Sample Identification

All samples must be properly identified on their labels as well as in any forms or other documentation.
All samples will have the prefix "T4" to identify them as Port of Portland Terminal 4 samples. Following T4, the notations listed below will be used to identify each sample type:

- vibracores—VC##
- under-pier sample—UP##
- geotechnical boring—GE##
- monitoring well—MW##
- seismic cone penetrometer—CP##
- surface water sample—SW##
- composite sample—CM##
- DRET elutriate sample—DT##
- MET elutriate sample—MT##
- CST sample—CS##
- TCLT leachate sample—TC##

For samples that have depths associated with them (such as vibracores, borings, and monitoring wells), the depth range (in ft) will follow the sample name. For example, T4-VC10-1-3 would indicate a sample from 1 to 3 ft below the mudline. Upland and in-water geotechnical borings will be distinguished with an "L" and a "W," respectively. For example, T4-GE01W-3-5 would be a sample from GE01 for the interval of 3 to 5 ft below mudline and T4-GE02L-3-5 would be a sample from GE02 for the interval of 3 to 5 ft below upland ground surface. Monitoring well clusters will have the same name, but be distinguished by screen internal depth in general terms of shallow ("S"), intermediate ("I"), or deep ("D"). For example, T4-MW04S-3-5; T4-MW04I-3-5; and T4-MW04D-3-5 would be three different samples at 3- to 5-ft intervals from three separate wells of the same cluster.

### A1-8.5 Sample Labeling and Packing

All samples must be labeled and packed correctly before transport for laboratory testing. Sample containers will be obtained from the analytical laboratory. Each container will be labeled appropriately with all relevant information, including at a minimum:

- sample type;
- project number and site name;
- sample number;
- date;
- time; and
- sampler's initials.

Samples will be stored and shipped in a properly packed container at 4°C. All samples will be delivered to the laboratory within 48 hours of the time of collection, with the possible exception of some samples collected on Friday or Saturday. In those cases, the samples will be stored at 4°C and shipped at the earliest allowable time.

### A1-8.6 Chain of Custody

A paramount component of data collection is the ability to demonstrate that the samples were obtained from the locations stated and that they reached the laboratory or archive without alteration. Evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal or archive must be properly documented. Documentation will be accomplished through an Analysis Request and Chain-of-Custody Record (AR/COC) that documents each sample and identifies the individuals responsible for sample collection, shipment, and receipt. A sample is considered in custody if at least one of the following criteria is met:

- The sample is in a person's actual possession;
- The sample is in unobstructed view, after being in the person's actual possession;
- The sample is locked and only accessible by the custodian after having been in the person's actual possession; and
- The sample is in a secured area, restricted to authorized personnel (e.g., laboratory).

Figure A1-13 provides an example AR/COC form to be used by BBL personnel in collecting and shipping samples. A laboratory typically will not accept samples for analysis without a correctly prepared AR/COC form. The AR/COC must be signed by each individual who has the sample in his/her custody. An AR/COC is to be prepared for each sample shipped to a laboratory for analysis. Information on this form correlates with other supporting documentation, including sample labels and sample collection logs.

The AR/COC accounts for the elapsed time and custodians of the sample from the time of its collection. The individuals who have physically handled the sample or witnessed initial sample collection and packaging (e.g., a sample team member) must be identified on the form. A sample team member relinquishes the sample by signing the AR/COC. Individuals who either relinquish or receive samples must include their complete names, company affiliation, and the date and time the samples were relinquished. The times that the samples are relinquished and received by the next custodian should coincide, with the exception of transfer by commercial carriers. Commercial carriers will not be required to sign the AR/COC.

If a sample is to be stored for a period of time (e.g., overnight), measures are to be taken to secure the sample container in a manner that provides only the custodian of record with access. If samples are relinquished to a commercial carrier (i.e., UPS, Federal Express), the carrier waybill number is recorded, and a copy of the waybill is attached to the AR/COC. These documents are maintained with other field documentation. The original AR/COC is sealed inside the shipping container with the samples.

If a correction is made to the AR/COC, the correction should be made by the originator of the change, who will draw a single line through the error, initial and date the correction, and, if necessary, provide an explanation of the change. The documentation should have sufficient detail to clearly document the change to a third-party reviewer.

All chain-of-custody activities will be performed in accordance with BBL's Chain-of-Custody, Packing, Handling, and Shipping SOP.

## A1-8.7 Calibration

Calibration will be performed on field parameter probes at the beginning of each day of intended use. Subsequent calibration during the day will be performed if needed (e.g., if an instrument malfunctions). Instruments will be calibrated for pH, conductivity, and turbidity. Temperature is calibrated by the manufacturer when the probe is serviced by the manufacturer. Calibration standards will be in accordance with BBL's Quality Assurance Procedure 2.04, *Calibration and Control of Measuring and Test Equipment.*

Records must be maintained for each piece of calibrated measuring and test equipment and each piece of reference equipment. The records must indicate that established calibration procedures have been followed and that the accuracy of reference chemical and radioactive standards has been verified.

Records for periodically calibrated equipment must include the following minimum information:

- type and identification number of equipment;
- calibration frequency and acceptance tolerances;
- calibration dates;
- the individual and organization performing the calibration;
- reference equipment and/or standards used for calibration;
- calibration data;
- certificates or statements of calibration provided by manufacturers and external organizations; and
- documentation of calibration acceptance or failure and of repair of failed equipment.

An individual file folder should be established to maintain records for each piece of measuring and test equipment. Equipment periodic calibration files should contain an equipment calibration and maintenance record, calibration data forms and/or certification of calibration provided by manufacturers or external organizations, and notice of equipment calibration failure.

Measuring and test equipment used for field investigations will typically be calibrated as part of operational use. For this equipment, records of the calibrations or checks will be documented as part of the test data (e.g., in the field notebook or on a Field Activity Log). Equipment-specific forms may also be developed. These records should include information similar to that required for periodically calibrated equipment. Documentation related to malfunctioning equipment or equipment that fails calibration should also be included in the individual equipment file.

Calibration files for equipment requiring periodic calibration should be sent with equipment that is transferred to allow a continuously updated record to be maintained. Recalibration of sensitive equipment should be performed following the transfer. When measuring and test equipment is rented or leased, procurement documents must specify that a current certificate of calibration must accompany the equipment. This certificate must be maintained with the project documentation calibration records.

# A1-9. Quality Assurance and Quality Control Requirements

All analyses described in this FSP will be conducted in accordance with the standard quality assurance/quality control (QA/QC) procedures described in the QAPP. Analytical instruments will be maintained and calibrated regularly. Logbooks will be maintained for major field and laboratory instrumentation to document servicing, maintenance and instrument modification.

## A1-9.1 Analytical Chemistry

Quality procedures are described for each analytical method in the QAPP. The type and frequency of QA/QC samples analyzed by the laboratory will be according to the specified analytical method. Necessary corrective actions will be taken to address problems, according to the guidelines for a particular method. All corrective actions will be reported, along with any deviations from the standard protocols.

Results of all laboratory QA/QC analyses and anything that might affect the integrity of the results will be reported. Any deviations from the standard testing guidelines, QA/QC limits, and acceptability criteria will be reported, including a discussion of their effect on data validity. All data sheets will be checked to ensure that test conditions are within the protocol specifications, and project data will be reviewed to determine their usability for making suitability determinations. All QA/QC records and raw data will be kept on file for review for 10 years.

# A1-10. Waste Management Plan

This waste management plan presents the procedures that will be used to track and properly dispose of field-generated waste from the Removal Action Area field work. Waste disposal will fall into four categories:

- Sediment that is spilled on the vessel deck during vibracoring and sediment from rejected cores will be washed into the surface water at the collection site.

- Waste in the category of excess sediment from processing the vibracores and the under-pier surface sediment samples will be temporarily placed in containers (such as 55-gallon drums) pending receipt of sample analysis results.

- Waste in the category of excess sediment and soil from geotechnical borings and monitoring wells, groundwater from well development and sampling, and decontamination water will be temporarily placed in containers (such as 55-gallon drums), and a sample from the container will be collected for characterization.

- Waste in the category of disposable sampling materials and PPE will be placed in heavy-weight garbage bags or other appropriate containers.

Containers that are used to temporarily store waste will be clearly labeled on the container and on the lid with an indelible marker. The labels will include the following identifying information:

- BBL;
- T4 EE/CA waste;
- container identification (T4-DR#);
- media (sediment, soil, groundwater, or decontamination water);
- sample location identifications (e.g., vibracore locations, monitoring well locations) for waste in the container;
- date that container was filled; and
- sampler's initials.

The container information will also be recorded on the Waste Tracking Form (Figure A1-14), as will the location of the container.

Different media or waste disposal categories will not be mixed in one container. For example, excess sediment from the processing of vibracores and under-pier surface sediment samples will not be placed in the same container as excess sediment and soil from geotechnical borings and monitoring wells. Waste water will not be placed in the same container as waste sediment or soil.

Disposal of the containerized waste will be based on analytical results. For excess sediment and soil from geotechnical borings and monitoring wells, a composite sample from each container, consisting of four samples, will be collected and submitted for chemical analysis of metals, SVOCs, pesticides, PCBs, and TPH. If chemical constituents of potential concern are detected below Subtitle D landfill levels of concern, then the waste sediment or soil will be disposed of at a Subtitle D landfill. If concentrations of constituents of potential concern are above Subtitle D landfill acceptance criteria, the waste will be disposed of by a contractor certified to dispose of the waste.

For groundwater and decontamination water wastes, a sample from each container will be collected and submitted for chemical analysis of metals, SVOCs, pesticides, PCBs, and TPH. If chemical constituents of potential concern are detected below sanitary sewer discharge criteria, then the water will be discharged to a sanitary sewer drain onsite. If concentrations of constituents of potential concern are above sanitary sewer criteria, the waste will be disposed of by a contractor certified to dispose of the waste.

All disposable sampling materials and PPE, such as disposable coveralls, gloves, and tubing, used in sample processing will be placed in heavy-weight garbage bags or other appropriate containers. Disposable materials will be placed in an onsite refuse container for disposal at a solid waste landfill.

# A1-11. References


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U.S. Environmental Protection Agency (USEPA), 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA.

U.S. Environmental Protection Agency (USEPA), 2001. Methods for Collection, Storage, and Maintenance of Sediments for Chemical and Toxicological Analyses.

# A1-12. Acronyms and Abbreviations

| | |
|---|---|
| AR/COC | Analysis Request and Chain-of-Custody Record |
| ASTM | American Society for Testing and Materials |
| BBL | Blasland, Bouck and Lee |
| CDF | confined disposal facility |
| CST | column settling test |
| DEQ | Oregon Department of Environmental Quality |
| DGPS | differential global positioning system |
| DRET | dredging elutriate test |
| EDA | equipment decontamination area |
| EE/CA | engineering evaluation/cost analysis |
| FSP | field sampling plan |
| ft | foot/feet |
| HASP | health and safety plan |
| MET | modified elutriate test |
| MSL | mean sea level |
| PCB | polychlorinated biphenyls |
| Port | Port of Portland |
| PPE | personal protective equipment |
| PVC | polyvinyl chloride |
| QAPP | quality assurance project plan |
| QA/QC | quality assurance/quality control |
| SCPT | Seismic Cone Penetrometer Testing |
| SOP | Standard Operating Procedure |
| SPT | Standard Penetration Testing |
| SVOC | semivolatile organic compounds |
| TCLP | toxicity characteristics leaching procedure |
| TCLT | thin-layer column leaching test |
| tDDT | total DDT |
| TPH | total petroleum hydrocarbons |
| TOC | total organic carbon |
| TSS | total suspended solids |
| USACE | U.S. Army Corps of Engineers |
| USEPA | U.S. Environmental Protection Agency |
| VOC | volatile organic compound |

## Table A1-1
## Vibracore Locations

| Core ID | Coordinates (a) | |
|---|---|---|
| | Easting | Northing |
| T4-VC01 | 7,618,577 | 715,410 |
| T4-VC02 | 7,618,703 | 714,960 |
| T4-VC03 | 7,618,825 | 714,692 |
| T4-VC04 | 7,619,005 | 714,688 |
| T4-VC05 | 7,619,277 | 714,675 |
| T4-VC06 | 7,619,567 | 714,674 |
| T4-VC07 | 7,619,757 | 714,638 |
| T4-VC08 | 7,619,918 | 714,548 |
| T4-VC09 | 7,620,089 | 714,612 |
| T4-VC10 | 7,620,348 | 714,624 |
| T4-VC11 | 7,619,037 | 714,503 |
| T4-VC12 | 7,619,191 | 714,406 |
| T4-VC13 | 7,619,440 | 714,385 |
| T4-VC14 | 7,619,721 | 714,450 |
| T4-VC15 | 7,620,140 | 714,452 |
| T4-VC16 | 7,620,382 | 714,450 |
| T4-VC17 | 7,619,030 | 714,187 |
| T4-VC18 | 7,619,324 | 713,955 |
| T4-VC19 | 7,619,679 | 713,720 |
| T4-VC20 | 7,619,234 | 713,725 |
| T4-VC21 | 7,619,500 | 713,807 |
| T4-VC22 | 7,619,607 | 713,460 |
| T4-VC23 | 7,620,016 | 713,416 |
| T4-VC24 | 7,620,323 | 713,385 |
| T4-VC25 | 7,619,427 | 713,308 |
| T4-VC26 | 7,619,590 | 713,228 |
| T4-VC27 | 7,619,751 | 713,087 |
| T4-VC28 | 7,620,103 | 713,091 |
| T4-VC29 | 7,620,342 | 713,137 |
| T4-VC30 | 7,619,573 | 712,974 |
| T4-VC31 | 7,619,768 | 712,585 |
| T4-VC32 | 7,619,950 | 713,236 |

(a) Coordinates are NAD83, state plane Oregon north

## Table A1-2
## Under-Pier Sample Locations

| Sample ID | Coordinates (a) | |
|---|---|---|
| | Easting | Northing |
| T4-UP01 | 7,618,620 | 715,202 |
| T4-UP02 | 7,618,721 | 714,982 |
| T4-UP03 | 7,619,819 | 714,707 |
| T4-UP04 | 7,620,058 | 714,699 |
| T4-UP05 | 7,620,317 | 714,695 |
| T4-UP06 | 7,619,882 | 714,355 |
| T4-UP07 | 7,620,125 | 714,346 |
| T4-UP08 | 7,620,414 | 714,343 |
| T4-UP09 | 7,619,497 | 713,607 |
| T4-UP10 | 7,619,680 | 713,580 |
| T4-UP11 | 7,619,838 | 713,561 |
| T4-UP12 | 7,620,114 | 713,524 |
| T4-UP13 | 7,620,431 | 713,486 |
| T4-UP14 | 7,620,258 | 713,047 |
| T4-UP15 | 7,619,953 | 713,062 |

(a) Coordinates are NAD83, state plane Oregon north

## Table A1-3
## Geotechnical Boring Locations

| Boring ID | Coordinates (a) | |
|---|---|---|
| | Easting | Northing |
| T4-GE01W | 7,619,056 | 714,559 |
| T4-GE02W | 7,619,653 | 714,547 |
| T4-GE03L | 7,619,340 | 714,085 |
| T4-GE04L | 7,620,072 | 713,586 |
| T4-GE05W | 7,619,557 | 713,362 |
| T4-GE06W | 7,620,038 | 713,280 |

(a) Coordinates are NAD83, state plane Oregon north

## Table A1-4
## Cone Penetrometer Locations

| Cone Penetrometer ID | Coordinates (a) | |
|---|---|---|
| | Easting | Northing |
| T4-CP01 | 7,618,834 | 714,466 |
| T4-CP02 | 7,619,167 | 714,551 |
| T4-CP03 | 7,620,077 | 714,515 |
| T4-CP04 | 7,620,331 | 714,509 |
| T4-CP05 | 7,619,196 | 713,712 |
| T4-CP06 | 7,619,407 | 713,761 |
| T4-CP07 | 7,619,608 | 713,852 |
| T4-CP08 | 7,619,349 | 713,343 |
| T4-CP09 | 7,619,799 | 713,307 |
| T4-CP10 | 7,620,367 | 713,233 |

(a) Coordinates are NAD83, state plane Oregon north

## Table A1-5
## Monitoring Well Locations

| Monitoring Well ID | Coordinates (a) | |
|---|---|---|
| | Easting | Northing |
| T4-MW01 | 7,618,929 | 715,313 |
| T4-MW02 | 7,621,084 | 714,953 |
| T4-MW03 | 7,620,436 | 714,783 |
| T4-MW04 | 7,619,943 | 713,967 |
| T4-MW05 | 7,621,127 | 713,447 |
| T4-MW06 | 7,619,772 | 712,971 |

(a) Coordinates are NAD83, state plane Oregon north

## Table A1-6
## Sediment Sample Container, Preservation, and Holding Times

| Chemical Analysis | Sample Container | Preservative | Holding Time |
|---|---|---|---|
| Metals (1) | 1 8 oz. G | R | 6 months |
| Mercury | 1 8 oz. G | R | 28 days |
| SVOC, pesticides, PCB | 1 16 oz. G | R | 14 days/40 days (2) |
| TPH-Dx | 1 8 oz. G | R | 14 days/40 days (2) |
| TPH-G | 1 2 oz. G | R | 14 days |
| TOC | 1 4 oz. G | — | 28 days |
| Grain size | 1 16 oz. P | — | 6 months |

Notes:
G=Glass, P=Plastic, R=Refrigerate at 4°C

(1) Metals include As, Cd, Cr, Cu, Pb, Ni, Se, Ag, Zn

(2) Holding times are days until analytical extraction/days until extraction analysis

## Table A1-7
## Vibracore Sample Identification and Analytical Parameters

| | | | | Laboratory Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core Identification | Sample Identification (a) | Analyze | Archive (b) | Metals (c) | SVOCs | Total DDT (d) | PCBs | TPH-G and TPH-Dx (e) | TOC | Grain Size | Engineering Properties (f) |
| T4-VC01 | T4-VC01-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC01-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC01-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC01-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC01-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC01-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC01-11-13 | | x | | | | | | | | |
| | T4-VC01-13-15 | | x | | | | | | | | |
| T4-VC02 | T4-VC02-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC02-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC02-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC02-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC02-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC02-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC02-11-13 | | x | | | | | | | | |
| | T4-VC02-13-15 | | x | | | | | | | | |
| T4-VC03 | T4-VC03-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC03-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC03-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC03-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC03-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC03-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC03-11-13 | | x | | | | | | | | |
| | T4-VC03-13-15 | | x | | | | | | | | |
| T4-VC04 | T4-VC04-0-1 | x | | x | x | x | x | x | x | x | x |
| | T4-VC04-1-3 | x | | x | x | x | x | x | x | x | x |
| | T4-VC04-3-5 | x | | x | x | x | x | x | x | x | x |
| | T4-VC04-5-7 | x | | x | x | x | x | x | x | x | x |
| | T4-VC04-7-9 | x | | x | x | x | x | x | x | x | x |
| | T4-VC04-9-11 | x | | x | x | x | x | x | x | x | x |
| | T4-VC04-11-13 | | x | | | | | | | | |
| | T4-VC04-13-15 | | x | | | | | | | | |

## Table A1-7
## Vibracore Sample Identification and Analytical Parameters

| | | | | Laboratory Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core Identification | Sample Identification (a) | Analyze | Archive (b) | Metals (c) | SVOCs | Total DDT (d) | PCBs | TPH-G and TPH-Dx (e) | TOC | Grain Size | Engineering Properties (f) |
| T4-VC05 | T4-VC05-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC05-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC05-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC05-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC05-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC05-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC05-11-13 | | x | | | | | | | | |
| | T4-VC05-13-15 | | x | | | | | | | | |
| T4-VC06 | T4-VC06-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC06-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC06-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC06-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC06-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC06-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC06-11-13 | | x | | | | | | | | |
| | T4-VC06-13-15 | | x | | | | | | | | |
| T4-VC07 | T4-VC07-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC07-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC07-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC07-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC07-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC07-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC07-11-13 | | x | | | | | | | | |
| | T4-VC07-13-15 | | x | | | | | | | | |
| T4-VC08 | T4-VC08-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC08-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC08-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC08-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC08-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC08-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC08-11-13 | | x | | | | | | | | |
| | T4-VC08-13-15 | | x | | | | | | | | |

## Table A1-7
## Vibracore Sample Identification and Analytical Parameters

| | | | | Laboratory Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core Identification | Sample Identification (a) | Analyze | Archive (b) | Metals (c) | SVOCs | Total DDT (d) | PCBs | TPH-G and TPH-Dx (e) | TOC | Grain Size | Engineering Properties (f) |
| T4-VC09 | T4-VC09-0-1 | x | | x | x | x | x | x | x | x | x |
| | T4-VC09-1-3 | x | | x | x | x | x | x | x | x | x |
| | T4-VC09-3-5 | x | | x | x | x | x | x | x | x | x |
| | T4-VC06-5-7 | x | | x | x | x | x | x | x | x | x |
| | T4-VC09-7-9 | x | | x | x | x | x | x | x | x | x |
| | T4-VC09-9-11 | x | | x | x | x | x | x | x | x | x |
| | T4-VC09-11-13 | | x | | | | | | | | |
| | T4-VC09-13-15 | | x | | | | | | | | |
| T4-VC10 | T4-VC10-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC10-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC10-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC10-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC10-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC10-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC10-11-13 | | x | | | | | | | | |
| | T4-VC10-13-15 | | x | | | | | | | | |
| T4-VC11 | T4-VC11-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC11-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC11-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC11-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC11-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC11-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC11-11-13 | | x | | | | | | | | |
| | T4-VC11-13-15 | | x | | | | | | | | |
| T4-VC12 | T4-VC12-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC12-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC12-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC12-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC12-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC12-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC12-11-13 | | x | | | | | | | | |
| | T4-VC12-13-15 | | x | | | | | | | | |

## Table A1-7
## Vibracore Sample Identification and Analytical Parameters

| | | | | Laboratory Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core Identification | Sample Identification (a) | Analyze | Archive (b) | Metals (c) | SVOCs | Total DDT (d) | PCBs | TPH-G and TPH-Dx (e) | TOC | Grain Size | Engineering Properties (f) |
| T4-VC13 | T4-VC13-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC13-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC13-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC13-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC13-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC13-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC13-11-13 | | x | | | | | | | | |
| | T4-VC13-13-15 | | x | | | | | | | | |
| T4-VC14 | T4-VC14-0-1 | x | | x | x | x | x | x | x | x | x |
| | T4-VC14-1-3 | x | | x | x | x | x | x | x | x | x |
| | T4-VC14-3-5 | x | | x | x | x | x | x | x | x | x |
| | T4-VC14-5-7 | x | | x | x | x | x | x | x | x | x |
| | T4-VC14-7-9 | x | | x | x | x | x | x | x | x | x |
| | T4-VC14-9-11 | x | | x | x | x | x | x | x | x | x |
| | T4-VC14-11-13 | | x | | | | | | | | |
| | T4-VC14-13-15 | | x | | | | | | | | |
| T4-VC15 | T4-VC15-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC15-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC15-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC15-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC15-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC15-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC15-11-13 | | x | | | | | | | | |
| | T4-VC15-13-15 | | x | | | | | | | | |
| T4-VC16 | T4-VC16-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC16-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC16-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC16-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC16-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC16-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC16-11-13 | | x | | | | | | | | |
| | T4-VC16-13-15 | | x | | | | | | | | |

## Table A1-7
## Vibracore Sample Identification and Analytical Parameters

| | | | | Laboratory Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core Identification | Sample Identification (a) | Analyze | Archive (b) | Metals (c) | SVOCs | Total DDT (d) | PCBs | TPH-G and TPH-Dx (e) | TOC | Grain Size | Engineering Properties (f) |
| T4-VC17 | T4-VC17-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC17-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC17-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC17-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC17-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC17-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC17-11-13 | | x | | | | | | | | |
| | T4-VC17-13-15 | | x | | | | | | | | |
| T4-VC18 | T4-VC18-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC18-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC18-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC18-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC18-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC18-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC18-11-13 | | x | | | | | | | | |
| | T4-VC18-13-15 | | x | | | | | | | | |
| T4-VC19 | T4-VC19-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC19-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC19-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC19-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC19-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC19-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC19-11-13 | | x | | | | | | | | |
| | T4-VC19-13-15 | | x | | | | | | | | |
| T4-VC20 | T4-VC20-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC20-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC20-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC20-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC20-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC20-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC20-11-13 | | x | | | | | | | | |
| | T4-VC20-13-15 | | x | | | | | | | | |

## Table A1-7
## Vibracore Sample Identification and Analytical Parameters

| | | | | Laboratory Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core Identification | Sample Identification (a) | Analyze | Archive (b) | Metals (c) | SVOCs | Total DDT (d) | PCBs | TPH-G and TPH-Dx (e) | TOC | Grain Size | Engineering Properties (f) |
| T4-VC21 | T4-VC21-0-1 | x | | x | x | x | x | x | x | x | x |
| | T4-VC21-1-3 | x | | x | x | x | x | x | x | x | x |
| | T4-VC21-3-5 | x | | x | x | x | x | x | x | x | x |
| | T4-VC21-5-7 | x | | x | x | x | x | x | x | x | x |
| | T4-VC21-7-9 | x | | x | x | x | x | x | x | x | x |
| | T4-VC21-9-11 | x | | x | x | x | x | x | x | x | x |
| | T4-VC21-11-13 | | x | | | | | | | | |
| | T4-VC21-13-15 | | x | | | | | | | | |
| T4-VC22 | T4-VC22-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC22-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC22-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC22-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC22-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC22-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC22-11-13 | | x | | | | | | | | |
| | T4-VC22-13-15 | | x | | | | | | | | |
| T4-VC23 | T4-VC23-0-1 | x | | x | x | x | x | x | x | x | x |
| | T4-VC23-1-3 | x | | x | x | x | x | x | x | x | x |
| | T4-VC23-3-5 | x | | x | x | x | x | x | x | x | x |
| | T4-VC23-5-7 | x | | x | x | x | x | x | x | x | x |
| | T4-VC23-7-9 | x | | x | x | x | x | x | x | x | x |
| | T4-VC23-9-11 | x | | x | x | x | x | x | x | x | x |
| | T4-VC23-11-13 | | x | | | | | | | | |
| | T4-VC23-13-15 | | x | | | | | | | | |
| T4-VC24 | T4-VC24-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC24-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC24-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC24-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC24-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC24-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC24-11-13 | | x | | | | | | | | |
| | T4-VC24-13-15 | | x | | | | | | | | |

## Table A1-7
## Vibracore Sample Identification and Analytical Parameters

| | | | | Laboratory Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core Identification | Sample Identification (a) | Analyze | Archive (b) | Metals (c) | SVOCs | Total DDT (d) | PCBs | TPH-G and TPH-Dx (e) | TOC | Grain Size | Engineering Properties (f) |
| T4-VC25 | T4-VC25-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC25-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC25-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC25-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC25-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC25-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC25-11-13 | | x | | | | | | | | |
| | T4-VC25-13-15 | | x | | | | | | | | |
| T4-VC26 | T4-VC26-0-1 | x | | x | x | x | x | x | x | x | x |
| | T4-VC26-1-3 | x | | x | x | x | x | x | x | x | x |
| | T4-VC26-3-5 | x | | x | x | x | x | x | x | x | x |
| | T4-VC26-5-7 | x | | x | x | x | x | x | x | x | x |
| | T4-VC26-7-9 | x | | x | x | x | x | x | x | x | x |
| | T4-VC26-9-11 | x | | x | x | x | x | x | x | x | x |
| | T4-VC26-11-13 | | x | | | | | | | | |
| | T4-VC26-13-15 | | x | | | | | | | | |
| T4-VC27 | T4-VC27-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC27-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC27-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC27-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC27-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC27-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC27-11-13 | | x | | | | | | | | |
| | T4-VC27-13-15 | | x | | | | | | | | |
| T4-VC28 | T4-VC28-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC28-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC28-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC28-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC28-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC28-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC28-11-13 | | x | | | | | | | | |
| | T4-VC28-13-15 | | x | | | | | | | | |

## Table A1-7
## Vibracore Sample Identification and Analytical Parameters

| | | | | Laboratory Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core Identification | Sample Identification (a) | Analyze | Archive (b) | Metals (c) | SVOCs | Total DDT (d) | PCBs | TPH-G and TPH-Dx (e) | TOC | Grain Size | Engineering Properties (f) |
| T4-VC29 | T4-VC29-0-1 | x | | x | x | x | x | x | x | x | x |
| | T4-VC29-1-3 | x | | x | x | x | x | x | x | x | x |
| | T4-VC29-3-5 | x | | x | x | x | x | x | x | x | x |
| | T4-VC29-5-7 | x | | x | x | x | x | x | x | x | x |
| | T4-VC29-7-9 | x | | x | x | x | x | x | x | x | x |
| | T4-VC29-9-11 | x | | x | x | x | x | x | x | x | x |
| | T4-VC29-11-13 | | x | | | | | | | | |
| | T4-VC29-13-15 | | x | | | | | | | | |
| T4-VC30 | T4-VC30-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC30-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC30-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC30-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC30-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC30-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC30-11-13 | | x | | | | | | | | |
| | T4-VC30-13-15 | | x | | | | | | | | |
| T4-VC31 | T4-VC31-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC31-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC31-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC31-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC31-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC31-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC31-11-13 | | x | | | | | | | | |
| | T4-VC31-13-15 | | x | | | | | | | | |
| T4-VC32 | T4-VC32-0-1 | x | | x | x | x | x | x | x | x | |
| | T4-VC32-1-3 | x | | x | x | x | x | x | x | x | |
| | T4-VC32-3-5 | x | | x | x | x | x | x | x | x | |
| | T4-VC32-5-7 | x | | x | x | x | x | x | x | x | |
| | T4-VC32-7-9 | x | | x | x | x | x | x | x | x | |
| | T4-VC32-9-11 | x | | x | x | x | x | x | x | x | |
| | T4-VC32-11-13 | | x | | | | | | | | |
| | T4-VC32-13-15 | | x | | | | | | | | |

## Table A1-7
## Vibracore Sample Identification and Analytical Parameters

| | | | | Laboratory Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core Identification | Sample Identification (a) | Analyze | Archive (b) | Metals (c) | SVOCs | Total DDT (d) | PCBs | TPH-G and TPH-Dx (e) | TOC | Grain Size | Engineering Properties (f) |

Notes:
a. The last two numbers in the sample identification indicate the sample depth in ft. below mudline.
b. Archived samples will be frozen and maintained at -20°C.
c. Includes arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc.
d. Samples will be analyzed for total DDT. The total DDT extract will be saved for possible analysis of pesticides.
e. Samples will be analyzed for TPH gasoline and TPH diesel and heavy oil.
f. Engineering properties include grain size, moisture content, organic content, specific gravity, and Atterberg limit for samples T4-VC04, T4-VC09, T4-VC14, T4-VC21, T4-VC23, T4-VC26, T4-VC29

## Table A1-8
## Under-Pier Surface Sediment Sample Identification and Analytical Parameters

| Sample Identification (a) | Metals (b) | SVOCs | Total DDT | PCBs | TPH-G and TPH-Dx (c) | TOC | Grain Size |
|---|---|---|---|---|---|---|---|
| T4-UP01 | x | x | x | x | x | x | x |
| T4-UP02 | x | x | x | x | x | x | x |
| T4-UP03 | x | x | x | x | x | x | x |
| T4-UP04 | x | x | x | x | x | x | x |
| T4-UP05 | x | x | x | x | x | x | x |
| T4-UP06 | x | x | x | x | x | x | x |
| T4-UP07 | x | x | x | x | x | x | x |
| T4-UP08 | x | x | x | x | x | x | x |
| T4-UP09 | x | x | x | x | x | x | x |
| T4-UP10 | x | x | x | x | x | x | x |
| T4-UP11 | x | x | x | x | x | x | x |
| T4-UP12 | x | x | x | x | x | x | x |
| T4-UP13 | x | x | x | x | x | x | x |
| T4-UP14 | x | x | x | x | x | x | x |

Notes:
a. All samples will be submitted to the laboratory for analysis.
b. Includes arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc.
c. Samples will be analyzed for TPH gasoline and TPH diesel and heavy oil.

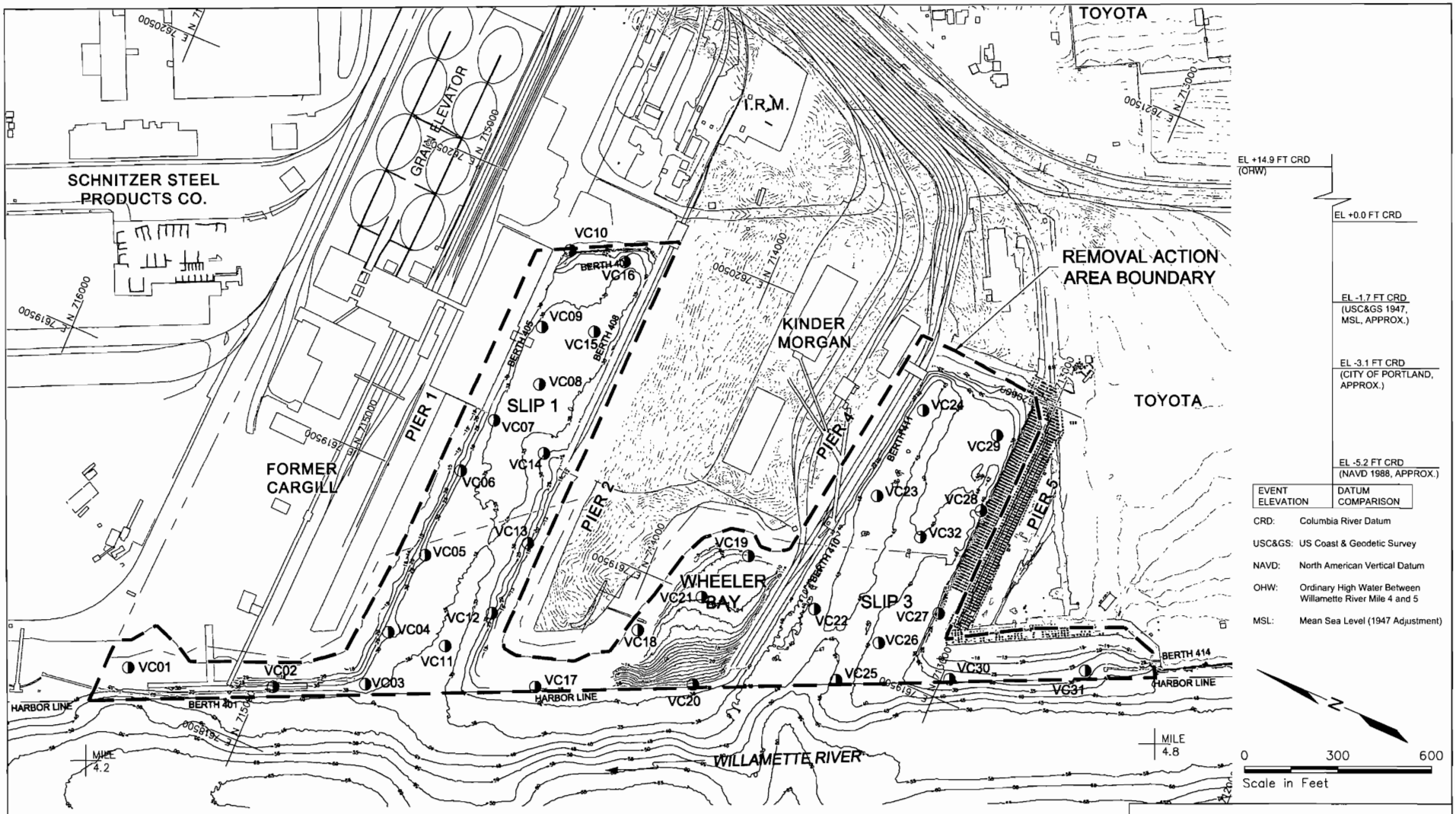
**Table A1-9**
**Composite Makeup**

| Composite ID | Subsamples in Composite (a) |
|---|---|
| T4-CM1 | T4-VC01 |
| | T4-VC02 |
| | T4-VC03 |
| | T4-VC04 |
| | T4-VC05 |
| | T4-VC06 |
| | T4-VC07 |
| | T4-VC08 |
| | T4-VC09 |
| | T4-VC10 |
| | T4-VC11 |
| | T4-VC12 |
| | T4-VC13 |
| | T4-VC14 |
| | T4-VC15 |
| | T4-VC16 |
| | T4-VC17 |
| T4-CM2 | T4-VC18 |
| | T4-VC19 |
| | T4-VC20 |
| | T4-VC21 |
| | T4-VC22 |
| | T4-VC23 |
| | T4-VC24 |
| | T4-VC25 |
| | T4-VC26 |
| | T4-VC27 |
| | T4-VC28 |
| | T4-VC29 |
| | T4-VC30 |
| | T4-VC31 |
| | T4-VC32 |
| T4-CM3 | T4-VC01 |
| | T4-VC02 |
| | T4-VC03 |
| | T4-VC04 |
| | T4-VC05 |
| | T4-VC06 |
| | T4-VC07 |
| | T4-VC08 |
| | T4-VC09 |
| | T4-VC10 |
| | T4-VC11 |
| | T4-VC12 |
| | T4-VC13 |
| | T4-VC14 |
| | T4-VC15 |

## Table A1-9
## Composite Makeup

| | |
|---|---|
| T4-CM-3 | T4-VC16 |
| | T4-VC17 |
| | T4-VC18 |
| | T4-VC19 |
| | T4-VC20 |
| | T4-VC21 |
| | T4-VC22 |
| | T4-VC23 |
| | T4-VC24 |
| | T4-VC25 |
| | T4-VC26 |
| | T4-VC27 |
| | T4-VC28 |
| | T4-VC29 |
| | T4-VC30 |
| | T4-VC31 |
| | T4-VC32 |

(a) See figure A1-1 for core locations




| EVENT ELEVATION | DATUM COMPARISON |
|---|---|
| CRD: | Columbia River Datum |
| USC&GS: | US Coast & Geodetic Survey |
| NAVD: | North American Vertical Datum |
| OHW: | Ordinary High Water Between Willamette River Mile 4 and 5 |
| MSL: | Mean Sea Level (1947 Adjustment) |

Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.

◑ Proposed Sediment Core Sample Location

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PROPOSED SEDIMENT CORE SAMPLE LOCATIONS

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FIGURE A1-1

DWG NAME: G:\project\Clients\BBL\Terminal 4\t4_002APPENDIX.dwg
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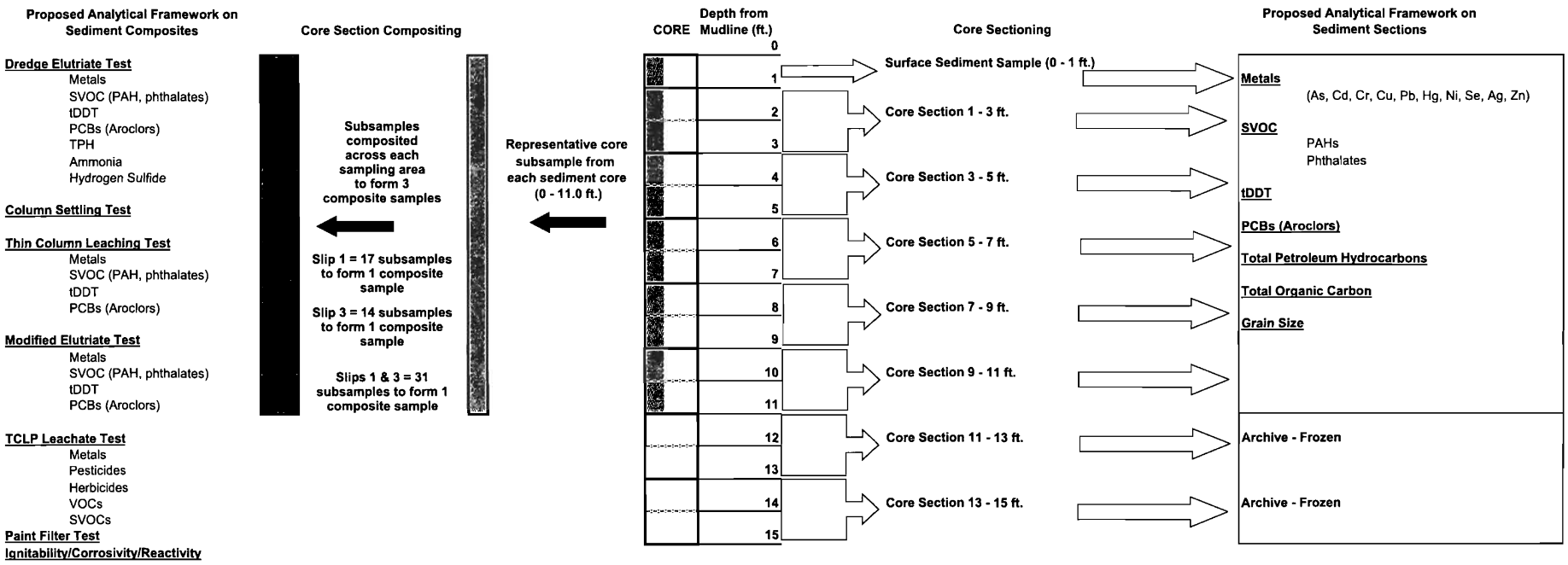


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SUMMARY OF PROPOSED SEDIMENT SAMPLES AND ANALYSES

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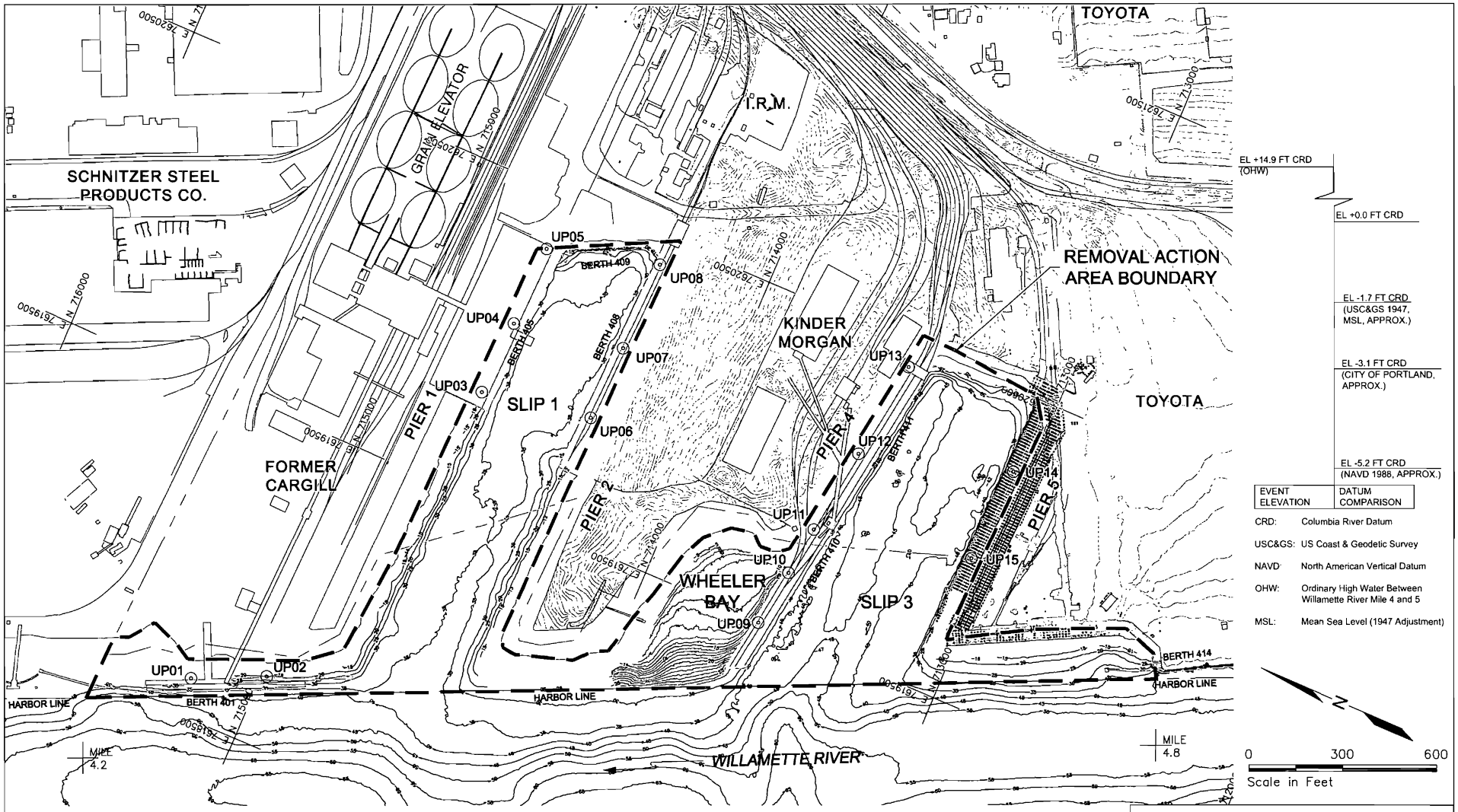
FIGURE
A1-2




| EVENT ELEVATION | DATUM COMPARISON |
|---|---|
| CRD: | Columbia River Datum |
| USC&GS: | US Coast & Geodetic Survey |
| NAVD: | North American Vertical Datum |
| OHW: | Ordinary High Water Between Willamette River Mile 4 and 5 |
| MSL: | Mean Sea Level (1947 Adjustment) |

⊙ Proposed Under-Pier Surface Sediment Sample Location

Existing Piers

Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.

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PROPOSED UNDER-PIER SAMPLE LOCATIONS

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FIGURE A1-3

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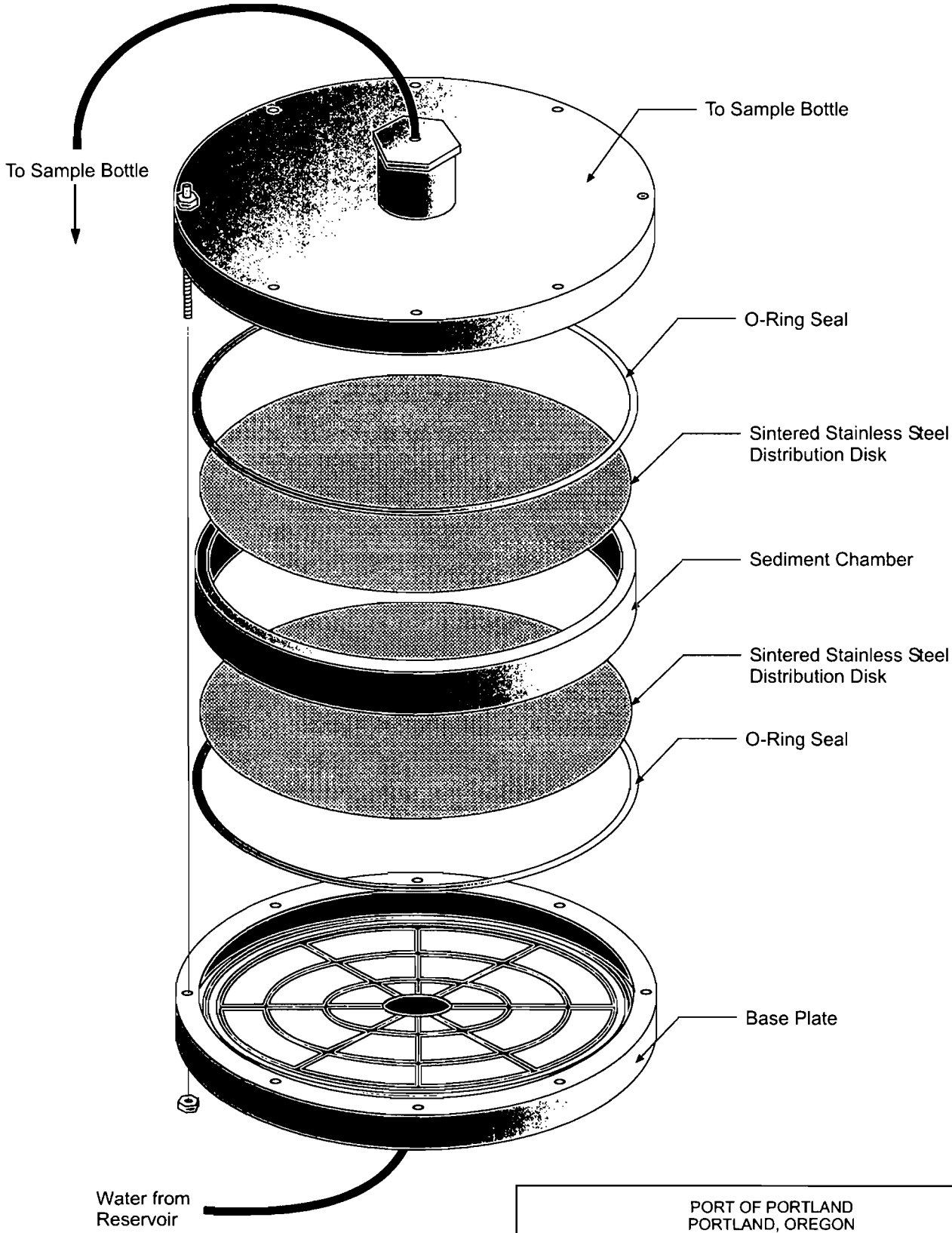


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SCHEMATIC OF THIN-LAYER
COLUMN LEACHING TEST

BBL
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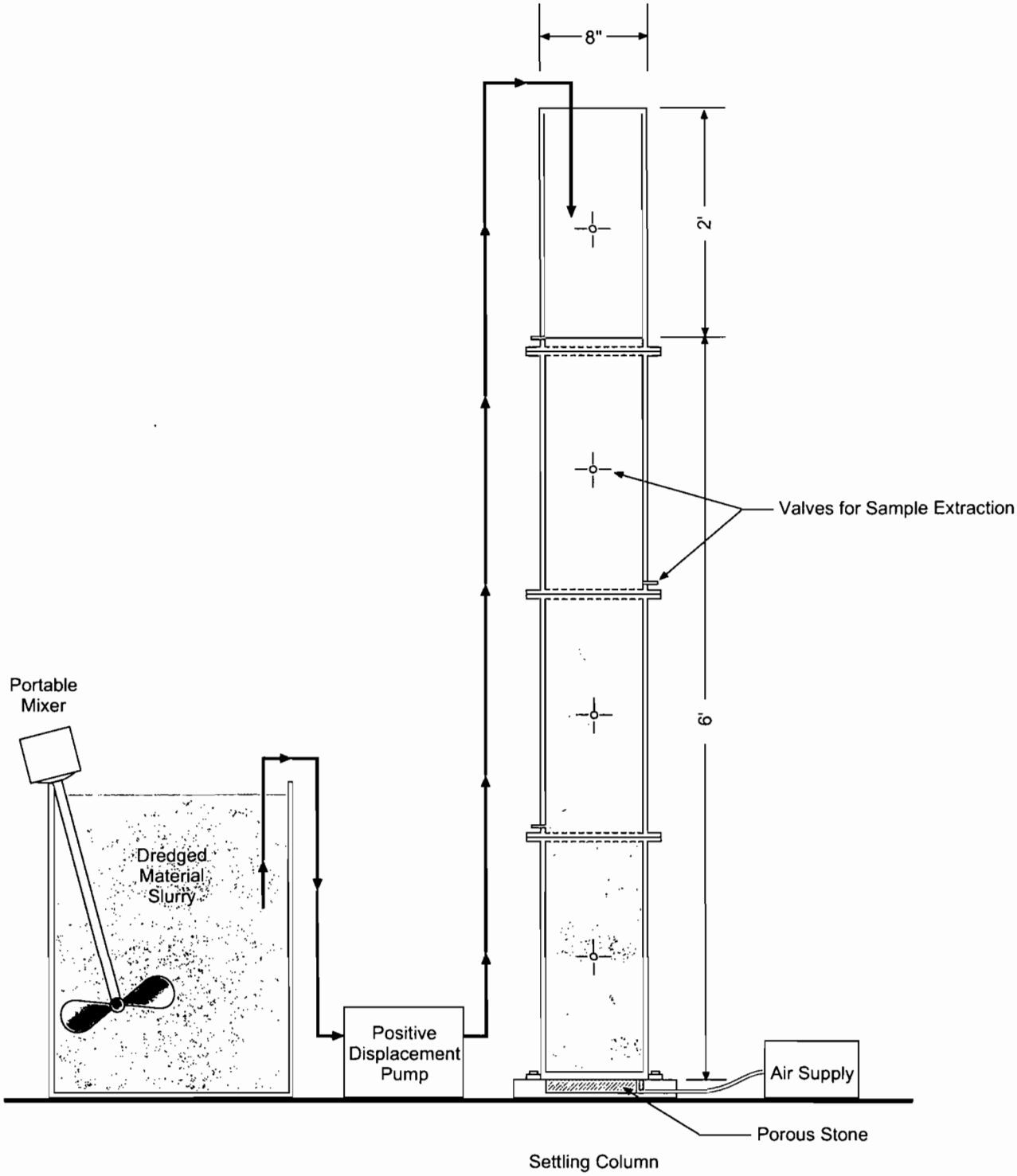
FIGURE
A1-4

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SCHEMATIC OF COLUMN SETTLING TEST

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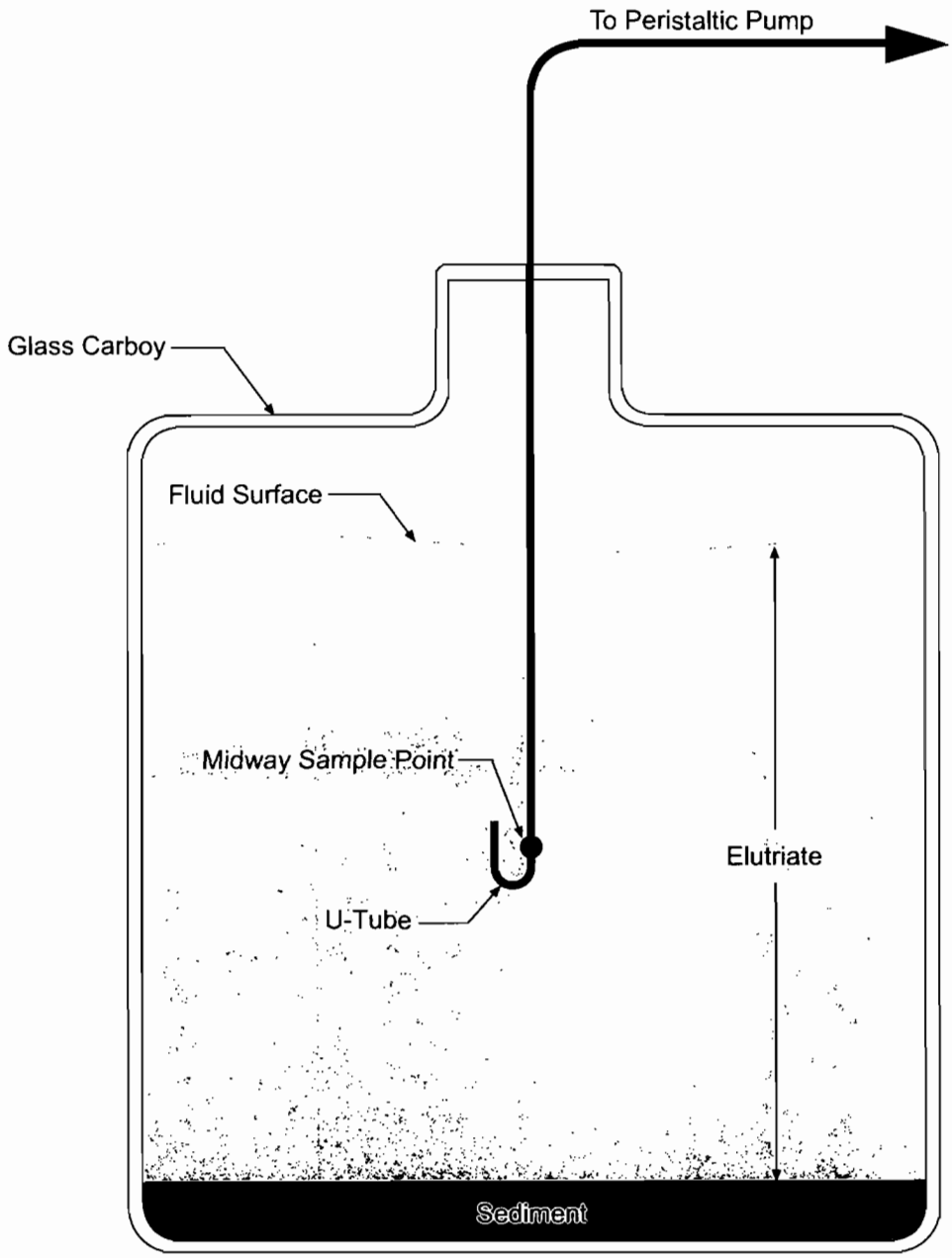
FIGURE
A1-5

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SCHEMATIC OF DREDGING
ELUTRIATE TEST

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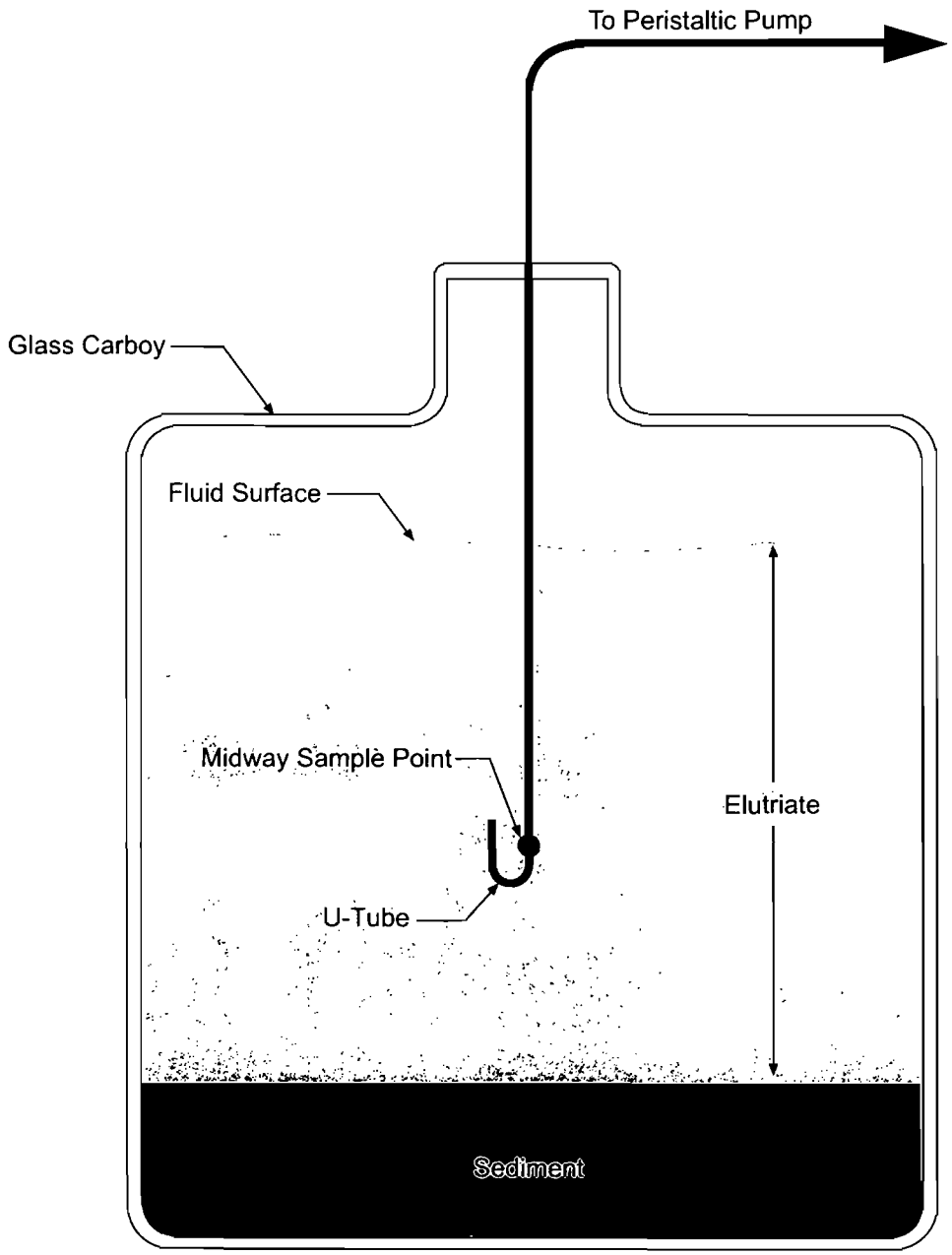
FIGURE
A1-6

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TERMINAL 4 EARLY ACTION WORK PLAN

SCHEMATIC OF MODIFIED ELUTRIATE TEST

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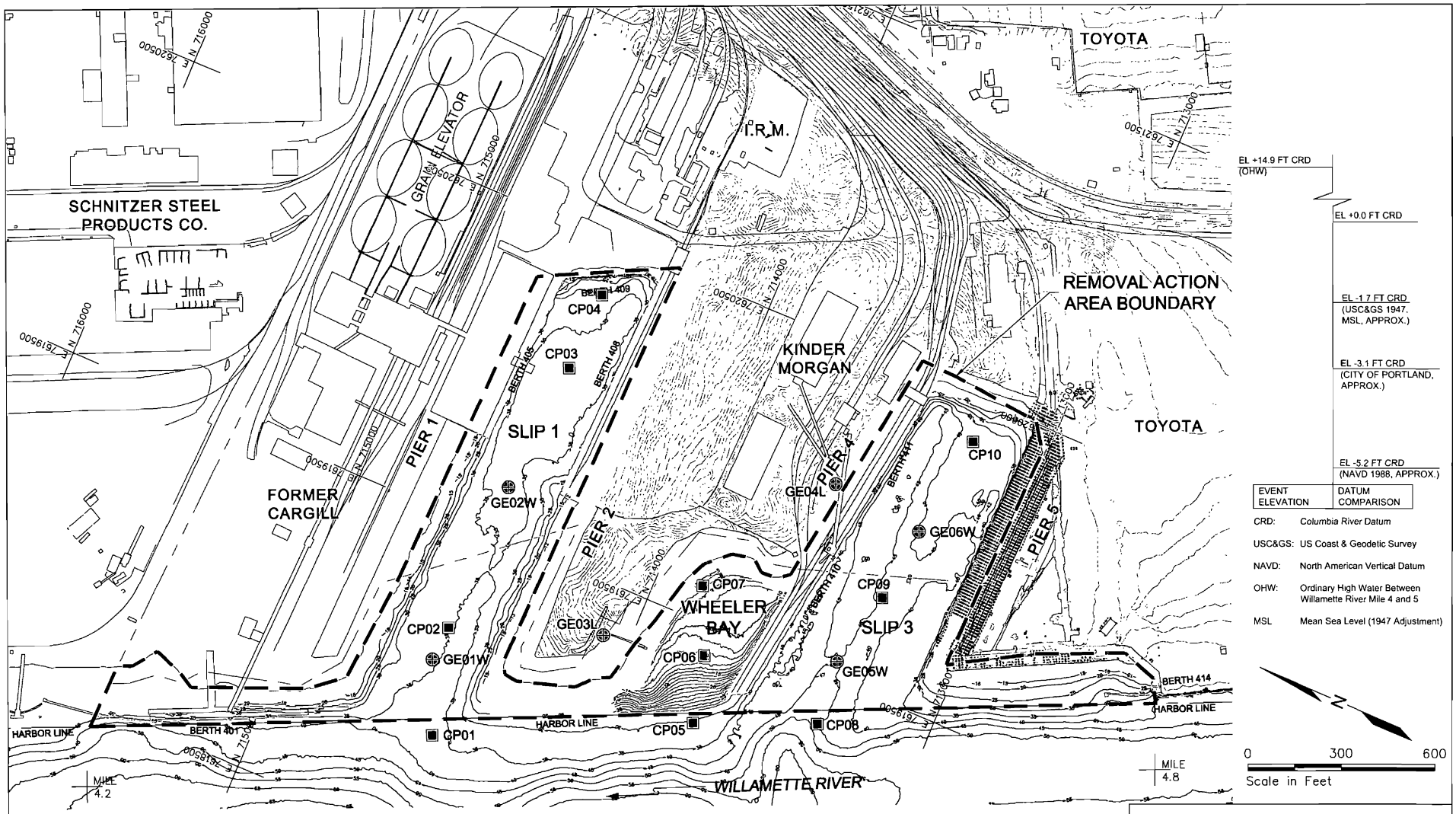
FIGURE
A1-7




Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.

Existing Piers

Proposed Geotechnical Exploration Location

Proposed Seismic Properties Boring Location

Proposed Seismic Cone Penetrometer Exploration

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PROPOSED GEOTECHNICAL EXPLORATION LOCATIONS

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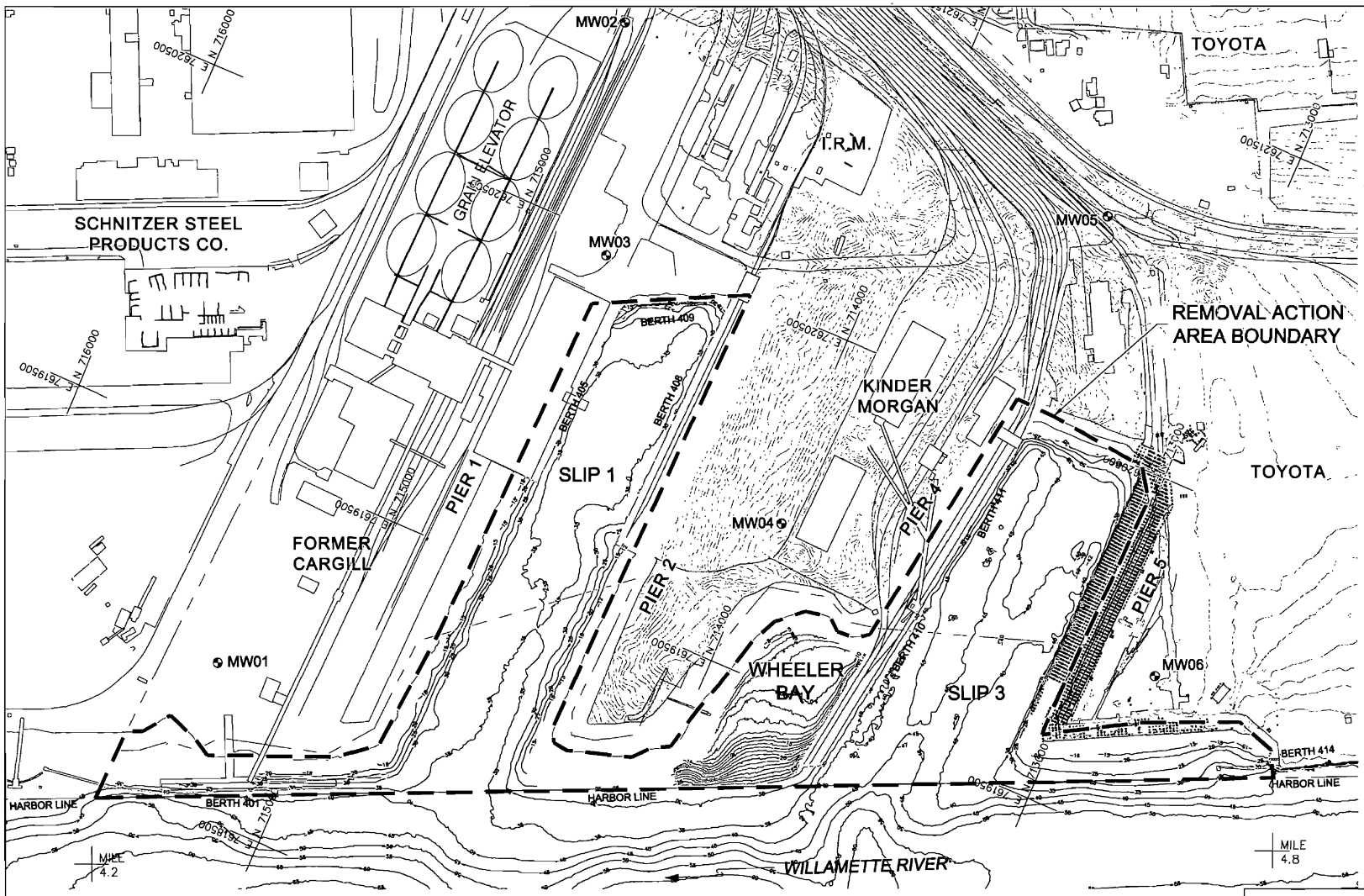
FIGURE
A1-8

DWG NAME: G:\project\Clients\BBL\Terminal 4\t4_005APPENDIX.dwg
DATE: 02/18/04 12:33pm




EL +14.9 FT CRD (OHW)

EL +0.0 FT CRD

EL -1.7 FT CRD (USC&GS 1947, MSL, APPROX.)

EL -3.1 FT CRD (CITY OF PORTLAND, APPROX.)

EL -5.2 FT CRD (NAVD 1988, APPROX.)

| EVENT ELEVATION | DATUM COMPARISON |
|---|---|

CRD: Columbia River Datum

USC&GS: US Coast & Geodetic Survey

NAVD: North American Vertical Datum

OHW: Ordinary High Water Between Willamette River Mile 4 and 5

MSL: Mean Sea Level (1947 Adjustment)

Notes:

1. Upland topographic vertical datum is MSL; Bathymetric vertical datum is CRD
2. Site Plan is based on drawings provided by the Port of Portland.
3. Shoreline boundary for Ordinary High Water is approximate.
4. Willamette River Mile Reference Marks are approximate.
5. Diurnal tide range during low river stages is 2.2 feet at St. Johns and 2.4 feet at Portland.
6. Datum conversion tables to CRD provided by Port of Portland.

Proposed Monitoring Well Cluster Location

Existing Piers

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PROPOSED MONITORING WELL CLUSTER LOCATIONS

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FIGURE A1-9

DWG NAME: G:\project\Clients\BBL\Terminal 4\t4_006APPENDIX.dwg
DATE: 02/18/04 12:35pm

| Sample Collecting Information | | |
|---|---|---|
| Sample Date: | Sample Time: | Sampler(s): |
| Sample ID: | Attempt _____ of _____ | |
| Latitude: | Longitude: | |
| Water Depth (ft): | Tide Height (ft): | |
| Permit Dredge Depth MSL (ft): | Current Depth MSL (ft): | |
| Target Core Length (ft): | Vibracore Penetration Depth (ft): | |
| Total Core Length Recovered (ft): | Final Core Length (ft): | |

| Sample Processing Information | | |
|---|---|---|
| Process Date: | Process Time: | Processor(s): |

| Penetration Depth (ft) | Color | Odor | Texture | Sample ID and Depth | Misc. |
|---|---|---|---|---|---|
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| Notes: | | | | | |

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VIBRACORE LOG

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FIGURE
A1-10

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## FIELD BOREHOLE LOG

| | | |
|---|---|---|
| Project Name: | Date: | Drilling Location: |
| Project No: | Sheet: of: | |
| Borehole Number: | Borehole Diameter: | |
| Elev. & Datum: | Total Depth (Feet): | |
| Drilling Co: | Depth to Water: | |
| Drilling Equip: | Logged By: | |
| Sampler Type: | Checked By: | |
| Drilling Method: | Completion Information: | |
| Driller: | Casing: ____ to ____ft/ (2 4 5 6) diameter / schedule (40 80) | |
| | Screen: ____ to ____ft/ (0.01 0.02) slot / schedule (40 80) pp | |
| Helper: | Filter Pack: ____ Seal: ____ to ____ft ____ buckets | |

| Depth (Feet) | FIELD NOTES | Samples: Interval | Blow Count | Sample Number | Headspace (ppm) | Time |
|---|---|---|---|---|---|---|
| | | | | | | |
| 5 | | | | | | |
| 10 | | | | | | |
| 15 | | | | | | |
| 20 | | | | | | |

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GEOTECHNICAL BORING LOG FORM

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FIGURE
A1-11

| | | |
|---|---|---|
| **Date Start/Finish:**<br>**Drilling Company:**<br>**Driller's Name:**<br>**Drilling Method:**<br>**Bit Size:**<br>**Auger Size:**<br>**Rig Type:**<br>**Sampling Method:** | **Northing:**<br>**Easting:**<br>**Casing Elevation:**<br><br>**Borehole Depth:**<br>**Surface Elevation:**<br><br>**Geologist:** | **Well ID:**<br><br>**Client:**<br><br>**Location:** |

| Sample Run Number | Sample/Int/Type | Recovery (feet) | Blows / 6 Inches | N - Value | PID Headspace (ppm) | Stratigraphic Description | Well Construction |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |

| | |
|---|---|
| BBL<br>BLASLAND, BOUCK & LEE, INC.<br>engineers & scientists | **Remarks:** |

Project: Template: *Page: __ of __*
Data File: Date:

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MONITORING WELL INSTALLATION FORM

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FIGURE
A1-12

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ID#: 00001

# CHAIN OF CUSTODY & LABORATORY ANALYSIS REQUEST FORM

Page ___ of ___

Lab Work Order #:

Send Results to:

| | |
|---|---|
| Contact & Company Name | Telephone: |
| Address: | Fax: |
| | e-mail address: |
| Proj. Name/Location (City/State): | |
| Sampler's Printed Name: | Sampler's Signature |

# of Containers

Bottle Information

PARAMETER ANALYSIS

Matrix Key:
So - Soil, Se - Sediment, NL - NAPL/Oil
W - Water, Sl - Sludge, SW - Sample Wipe
T - Tissue, A - Air, Other: _____

REMARKS

Special Instructions/Comments:

☹ Special QA/QC Instructions (x):

| Laboratory Information and Receipt | | Relinquished By | Received By | Relinquished By | Laboratory Received By |
|---|---|---|---|---|---|
| Lab Name: | Cooler Custody Seal (x): | Printed Name: | Printed Name: | Printed Name: | Printed Name: |
| ☹ Cooler packed with ice (x) | ☹ Intact ☹ Not Intact | | Signature: | Signature: | Signature: |
| Specify Turnaround Requirements: | Sample Receipt: | Firm: | Firm/Courier: | Firm/Courier: | Firm: |
| Shipping Tracking #: | Condition/Cooler Temp._____ | | Date/Time | Date/Time: | Date/Time: |

Distribution: WHITE – Lab returns with results YELLOW – Lab Copy PINK – Retained by BBL (for project files)

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CHAIN OF CUSTODY

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FIGURE
A1-13

| Container Identification (a) | Media (b) | Sample Locations in Container (c) | Date Container Was Filled | Sampler's Initials | Approximate Volume of Material in Container (d) | Location of Container | Date Container was Shipped Offsite | Final Waste Designation |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
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a. Identify containers as T4-GR#.
b. Media are sediment, soil, groundwater, or decontamination water.
c. Examples of sample locations are vibracore T4-VC04 and Monitoring Well T4-MW01S.
d. Give volume in gallons.

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

WASTE TRACKING FORM

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FIGURE
A1-14

# Appendix A2
# QAPP

# *Appendix A2*

# Quality Assurance Project Plan

**Approved by:**

, February 23, 2004

**Project Manager (date)**

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# A2-1. Introduction

This quality assurance project plan (QAPP) describes the quality assurance and quality control (QA/QC) procedures that will be implemented as part of the engineering evaluation/cost analysis (EE/CA) work plan for the Port of Portland's (Port's) Terminal 4 Removal Action. The purpose of the QAPP is to ensure that the data generated are of sufficient quality to meet the EE/CA objectives. This QAPP was prepared in accordance with the U.S. Environmental Protection Agency's (USEPA's) *EPA Requirements for Quality Assurance Project Plans* (USEPA, 2001a), *EPA Guidance for Quality Assurance Project Plans* (USEPA, 1998), and *EPA Requirements for Quality Management Plans* (USEPA, 2001b). Chemistry analytical laboratory work will be performed in accordance with the specified analytical methods, the data quality objectives, and this QAPP. This QAPP was also prepared in accordance with Blasland, Bouck & Lee's (BBL's) Quality Assurance Procedure 3.12, *Determination of Data Quality Objectives and Development of Quality Assurance Project Plans*. The QAPP should be reviewed with the field sampling plan (FSP), which the QAPP references in a number of places, and should remain attached to the FSP.

# A2-2. Project Organization and Responsibilities

## A2-2.1 Project Manager

Mr. Philip Spadaro is the Project Manager. Mr. Spadaro will be responsible for overall project coordination, including review of procedures and documents relative to contractual commitments. Mr. Spadaro will also be responsible for coordinating these tasks with the Project QA Manager, Project Chemist, Field Manager, and Health and Safety Officer. Mr. Spadaro can be reached at:

Blasland, Bouck, & Lee, Inc.
1100 Dexter Avenue North
Seattle, WA 98109
Telephone: (206) 273-7555
Mobile: (206) 390-2842
Fax: (206) 273-7805
E-mail: pspadaro@bbl-inc.com

## A2-2.2 Project QA Manager

Dr. Paul Krause is the Project QA Manager. Dr. Krause will be responsible for ensuring data quality for all sample collection efforts and supervising project quality assurance coordination. Dr. Krause's responsibilities and duties include:

- ensuring data of known and acceptable quality are generated;
- supervising the group that reviews and inspects all project-related laboratory activities; and
- conducting audits of all laboratory activities.

Dr. Krause can be reached at:

Blasland, Bouck, & Lee, Inc.
6080 Center Drive, 6th Floor
Suite 636
Los Angeles, CA 90045
Telephone: (310) 242-6712
Mobile: (562) 400-4570
Fax: (310) 242-6601
E-mail: pkrause@bbl-inc.com

## A2-2.3 Project Chemist

Shannon Dunn is the Project Chemist. Ms. Dunn will be responsible for ensuring that all chemistry-related goals are attained and that sample collection and analytical activities are implemented in accordance with the field sampling plan (FSP) and QAPP Ms. Dunn can be reached at:

Blasland, Bouck & Lee, Inc.
1100 Dexter Avenue North
Seattle, WA 98109
Telephone: (206) 273-7555
Mobile: (206) 399-5307
Fax: (206) 273-7805
E-mail: sdunn@bbl-inc.com

### A2-2.4 Chemistry Laboratory Project Manager

The contract chemistry laboratory for this project will be Columbia Analytical Services (CAS) of Kelso, Washington or a similarly qualified analytical laboratory with demonstrated expert capability in sediment chemistry analysis. Final selection of the laboratory and laboratory personnel is subject to the approval of the Project QA Manager and the Port of Portland.

The contract laboratory is expected to meet the following minimum requirements:

- adhere to the methods outlined in the QAPP, including methods referenced for each analytical procedure;
- deliver fax, hard copy, and electronic data as specified;
- meet reporting requirements for deliverables;
- meet turnaround times for deliverables;
- implement QA/QC procedures, including the QAPP data quality requirements, laboratory analysis plan requirements, and performance evaluation testing requirements;
- allow laboratory and data audits to be performed, if deemed necessary; and
- follow documentation, chain of custody, and sample logbook procedures.

Mr. Harvey Jackey of CAS will be the Chemistry Laboratory Project Manager. Mr. Jackey will provide analytical support to this project and will be responsible for ensuring that all laboratory analyses meet the project data quality objectives (DQOs) and other specifications detailed in the FSP/QAPP. Mr. Jackey's responsibilities and duties include:

- serving as primary communication link between BBL and laboratory technical staff;
- monitoring workloads and ensuring availability of resources;
- overseeing preparation of analytical reports; and
- supervising in-house chain-of-custody.

Mr. Jackey can be reached at:

Columbia Analytical Services, Inc.
1317 South 13th Ave.
P.O. Box 479
Kelso, Washington 98626
Telephone: (360) 577-7222
Mobile: (360) 431-8761
Fax: (360) 636-1068
E-mail: hjackey@kelso.caslab.com

### A2-2.5 Distribution List

The FSP and QAPP will be distributed to the USEPA and its team members as required in the AOC. The FSP and QAPP will also be distributed to the Port, the Project Manager, Project QA Manager, Project Chemist, Chemistry Laboratory Project Manager, all BBL field team members, and subcontractors.

### A2-2.6 Special Training Requirements/Certification

Training requirements are presented in Section B-8 of the Health and Safety Plan.

# A2-3. Data Quality Objectives

Data quality objectives (USEPA, 2000) provide a qualitative and quantitative framework and series of planning steps based on the scientific method around which data collection programs can be designed. The use of DQOs ensures that:

- The objectives of the investigation are clearly defined.
- The type, quantity, and quality of environmental data used in decision making are appropriate for their intended application.
- Acceptable levels of decision error and performance goals are specified such that the quantity and quality of data needed to support management decisions are provided.

The DQO process is described in detail in Section 6 of the EE/CA work plan. Sampling will be performed in accordance with the methods presented in the Field Sampling Plan.

## A2-3.1 Data Use and Type

### A2-3.1.1 Data Use

Data collected for the EE/CA will be used to develop Removal Action alternatives to a level of detail sufficient to facilitate (1) an assessment of how the alternatives address the Removal Action objectives and (2) a comparative evaluation of the alternatives using the criteria of effectiveness, implementability, and cost. The most important data needs for evaluating potential technologies associated with various Removal Action alternatives are listed below.

For dredging:

- lateral extent of contamination;
- vertical extent of contamination;
- sediment volume to be addressed by the Removal Action;
- engineering properties of sediment;
- stability of neighboring structures;
- impacts to water quality during dredging;
- resuspension potential of sediment;
- remobilization of chemicals;
- disposal methodology;
- impacts to cultural resources; and
- impacts to environment.

For capping:

- strength and compressibility of sediment;

- sediment leaching potential;
- hydraulic gradient across cap;
- periodic loads on cap, including seismic load, erosion (current, tides, floods), and propeller wash;
- impacts to cultural resources; and
- impacts to environment.

For transport:

- Dredging methodology (mechanical or hydraulic);
- Sediment volume to be transported;
- Water content of sediment;
- Sediment particle size affecting its ability for gravity dewatering;
- The need and type of flocculating additives to enhance gravity dewaterting; and
- Distance of transport

For treatment:

- volume of sediment to be treated;
- sediment water content;
- sediment chemical composition;
- sediment leaching potential;
- availability of site for treatment; and
- landfill waste acceptance criteria.

For onsite disposal in a confined disposal facility (CDF):

- strength and compressibility of subsurface sediment/soil;
- strength of containment berm aggregate;
- settling characteristics of dredged sediment;
- leaching potential of sediment;
- hydrogeological parameters;
- hydrogeological parameters of containment berm and enclosed sediment;
- impacts to cultural resources; and
- impacts to environment.

For offsite disposal:

- water acceptance criteria at disposal facility;
- Sediment chemical composition;
- Leaching potential of contaminants;
- Sediment volume and mass;
- Water content of sediment;
- Type of transport (truck, rail, or barge);
- Impact of transport on Port operations;
- Impact of transport on community; and
- Noise and air emissions during transport

## A2-3.2 Measurement Quality Objectives for Chemical Data

Reporting limit goals for sediment and water are presented in Tables A2-1 and A2-2, respectively.

The measurement quality objectives for the chemistry data will assess precision, accuracy, representativeness, comparability, and completeness of the data (as detailed in Section A2-6). Laboratory-generated control limits will be used to assess analytical performance with regard to precision and accuracy. Data representativeness will be addressed by the sample quantities and locations identified in the work plan. Data comparability will be achieved through the use of standard USEPA-approved methods. Data completeness will be assessed at the conclusion of analytical activities.

# A2-4. Analytical Methods

Sampling will be performed in accordance with the methods presented in the Field Sampling Plan. Surface, under-pier surface, and subsurface sediment samples will be submitted for chemical analysis of:

- total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc) by USEPA Method 6000/7000;
- semivolatile organic compounds (SVOCs), including polycyclic aromatic hydrocarbons (PAHs) and phthalates, by USEPA Method 8270C–selected ion monitoring (SIM);
- total DDT (tDDT) by USEPA Method 8081A;
- polychlorinated biphenyls (PCBs) by USEPA Method 8082;
- total petroleum hydrocarbons (TPH) by NWTPH-G and NWTPH-Dx;
- total organic carbon (TOC) by USEPA Method 9060; and
- grain size by American Society for Testing and Materials (ASTM) Method D 422.

Sediment samples for tDDT will be extracted and analyzed for the list of pesticides presented in Table A2-1 but only DDT will be reported. DDT and PCB results will be evaluated in Slip 1 for possible reporting of the full suite of pesticides. If elevated tDDT is observed in sediment samples from Slip 1, a select number of samples from Slip 1 will have the full pesticide listed reported. Surface water samples, elutriate samples derived from the dredging elutriate test (DRET) (DiGiano et al., 1995) and modified elutriate test (MET) (Palermo, 1985), and leachate samples derived from the thin-column leaching test (TCLT) (Myers et al., 1996) will be submitted for chemical analysis of:

- dissolved metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc) by USEPA Method 200.8;
- SVOCs, including PAHs and phthalates, by USEPA Method 8270C–SIM;
- tDDT by USEPA Method 8081A;
- PCBs by USEPA Method 8082; and
- TPH (NWTPH-G and NWTPH-Dx).

In addition, the DRET elutriate sample will be analyzed for ammonia (USEPA Method 350.1) and hydrogen sulfide (USEPA Method 376.2). Surface water samples will be analyzed to provide data on the initial conditions of water used in the elutriate tests. The DRET and MET methods recommend analyzing dissolved metals. To be consistent, surface water samples will also be analyzed for dissolved metals.

Water samples derived from the column settling test (CST) (USACE, 1987) will be submitted for chemical analysis of total suspended solids (TSS) by USEPA Method 160.2.

Composite sediment samples will be submitted for the toxicity characteristics leaching procedure (TCLP) by USEPA Method 1311. The TCLP leachate samples will be submitted for chemical analysis of the standard TCLP hazardous waste compounds:

- Metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) by USEPA Method 200.8;
- Pesticides (chlordane, endrin, heptachlor, heptachlor epoxide, lindane, and toxaphene) by USEPA Method 8081A;
- Herbicides (2,4-D, methoxychlor, pyridine, and 2,4,5-TP) by USEPA Method 8151;

- SVOCs (2-methylphenol, 3-methylphenol, 4-methylphenol, methylphenol, 1,4-dichlorobenzene, 2,4-dinitrotoluene, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, nitrobenzene, and pentachlorophenol) by USEPA Method 8270C–SIM; and
- volatile organic compounds (VOCs) (benzene, carbon tetrachloroide, chlorobenzene, chloroform, 1,2-dichloroethane, 1,1-dichloroethylene, methyl ethyl ketone, nitrobenzene, tetrachloroethylene, trichloroethylene, 2,4,5-trichlorophenol, 2,4,6-trichlorophenol, and vinyl chloride) by USEPA Method 8260.

Table A2-1 presents the methods of analysis and reporting limit goals for sediment samples. Table A2-2 presents the methods of analysis and reporting limit goals for water samples, including elutriate, leachate, and CST samples. The laboratory standard operating procedure (SOP) provided by the contracted analytical laboratory will describe the chemical analytical procedures in detail. These SOPs will be maintained in the analytical laboratory's file.

Based on the project DQOs, the level of support requested of the laboratory will be Level V, as described by USEPA (1987). Level V consists of using standard and modified standard methods with sufficient documentation to enable full validation of the data. Specifically, standard USEPA Contract Laboratory Program (CLP) methods will be used for all analyses, with modification of contract laboratory SOPs where applicable and appropriate to achieve required reporting limits. The contract analytical laboratory will follow the QC requirements of the CLP Statement of Work for inorganic and organic analyses (ILM05.2 and OLMO4.1).

### A2-4.1 Pesticide and PCB Analysis

The contract analytical laboratory will have the option of performing one extraction for pesticides and PCBs; however, the extract must be split into two portions to allow for cleanup of the PCB extract using the acid cleanup method. To minimize interferences and misidentification, PCBs will be analyzed separately from the pesticides. The initial calibration for the PCB analysis will consist of a minimum of a five-point initial calibration using Aroclors 1016 and 1260 and a single-point calibration for the remaining Aroclors.

All samples analyzed for pesticides and PCBs will be spiked with the surrogates tetrachloro-m-xylene and decachlorobiphenyl. Surrogate retention time shifts will be monitored from the beginning to the end of each analytical sequence for both columns.

Chromatograms for the standards and the samples shall be displayed on a full page with the same scale and range. For PCB analysis, the areas and/or heights of the peaks detected at greater than 2.5 times the signal-to-noise ratio will be integrated and reported on the quantitation list. If PCBs are detected in the sample, the type of Aroclor detected must be analyzed in the continuing calibration within 72 hours of detection in the sample. PCB and/or pesticide detections at concentrations greater than 0.5 mg/kg will be confirmed using a gas chromatograph/mass spectrometer. In addition, raw and background-subtracted spectra of the sample as compared to the spectra of the standard will be submitted as part of the contract analytical laboratory's deliverable.

### A2-4.2 Reporting Limits

In general, reporting limit goals for sediment are based on dry weight and assume 50% total solids content in the sediment samples. If the total solids content is less than 50%, sample reporting limits will increase. Interferences in individual samples may also result in increased reporting limits. To achieve the required low

reporting limits, some modifications to the methods may be necessary. These modifications from standard CLP protocol will be provided by the laboratory at the time of sample submittal.

# A2-5. Sample Handling, Chain of Custody, and Receipt

Sample documentation is a critical aspect of environmental investigations. Sample possession and handling must be traceable from the time of sample collection, through laboratory and data analysis, to the time sample results are potentially introduced as evidence. A sample log form and field logbook entries will be completed for each location occupied and each sample collected. Documentation procedures for sampling are provided in greater detail in the FSP.

## A2-5.1 Sample Containers, Preservation, and Holding Time Requirements

Pre-cleaned certified sample containers, which will be provided by the contract analytical laboratory, must be used for all sediment samples that will be analyzed for sediment conventional parameters and organic compounds. Specific types and sizes of containers for each parameter, as well as holding time and preservation requirements, are listed in Table A1-6 of the FSP.

Sample containers for conventional parameters, metals, and organics will be cleaned to USEPA protocols. Certifications attesting to the cleanliness of pre-cleaned containers are required for containers used for organic analyses and will be maintained in the project file.

Sample custody seals and packing materials for filled sample containers will be provided by the analytical laboratory. The filled, labeled, and sealed containers will be placed in a cooler on ice (see below) and carefully packed to eliminate the possibility of container breakage.

## A2-5.2 Sample Packing, Handling, and Shipping

Sample packaging and shipment procedures are designed to ensure that the samples will arrive at the laboratory with the chain of custody (COC) intact.

Samples will be packaged for shipment as outlined below.

1. Ensure that sample labels are securely affixed to sample containers with clear packing tape.

2. Check the caps on the sample containers to ensure that they are properly sealed.

3. Wrap sample container caps with clear packing tape to prevent them from loosening.

4. Complete the COC form with the required sampling information and ensure that the recorded information matches the sample labels. NOTE: If the designated sampler relinquishes the samples to other sampling or field personnel for packing or other purposes, the sampler will complete the COC prior to this transfer. The appropriate personnel will sign and date the COC form to document the sample custody transfer. If multiple coolers are shipped at one time, a separate COC should be prepared for each cooler.

5. Using duct tape, secure the outside drain plug at the bottom of the cooler.

6. Wrap sample containers in bubble wrap or other cushioning material.

7. Place 1 to 2 inches of cushioning material at the bottom of the cooler.

8. Place the sealed sample containers and a temperature blank in the cooler.

9. Place ice in plastic bags and seal. Place the ice-filled bags loosely in the cooler.

10. Fill the remaining space in the cooler with cushioning material.

11. Place COC forms in plastic bags and seal. Tape the forms to the inside of the appropriate cooler lid.

12. Close the cooler lid, lock, and secure with duct tape.

13. Wrap strapping tape around both ends of the cooler at least twice.

14. Mark the cooler on the outside with the following information: shipping address, return address, "Fragile" labels, and arrows indicating "this side up." Cover the labels with clear plastic tape. Place a signed custody seal over the cooler lid.

Samples will be packaged by the field personnel and transported as low-concentration environmental samples. The samples will be delivered by an express carrier within 48 hours of the time of collection with the possible exception of some Friday samples and the exception of Saturday samples. For all samples taken on Fridays, the field crew will verify with CAS by telephone whether laboratory personnel are available to receive samples on Saturday. If laboratory personnel are not available, samples will be held within the required temperature range and shipped on the following Monday. Samples collected on Saturday will be held within the required temperature range and shipped on the following Monday. Shipments will be accompanied by the COC form identifying the contents. The original form will accompany the shipment; copies will be retained by the sampler for the sampling office records. If the samples are sent by common carrier, a bill of lading will be used. Receipts or bills of lading will be retained as part of the permanent project documentation. Commercial carriers are not required to sign off on the COC form as long as the forms are sealed inside the sample coolers and the custody seals remain intact.

### A2-5.3 Sample Receipt

All samples received at the laboratory will be carefully checked for label identification and complete, accurate COC documentation. The condition of the samples will be checked, and the temperature blank will be measured and recorded (with a calibrated digital thermometer) immediately after the cooler is opened. These results, along with any questions or comments regarding sample integrity, will be recorded on the COC form (or appropriate laboratory cooler receipt form). The laboratory will contact BBL immediately if discrepancies between the samples and COC records are found upon receipt. If it is necessary for the receiving laboratory to ship samples to other laboratories, the COC form will be completed and will accompany the samples. A copy of the COC form (and cooler receipt form) will be faxed to BBL and included in the final analytical data report.

Once received at the laboratory, the samples will be maintained at 4 ± 2 °C, unless it is required that the samples be held at a lower temperature (not less than -20 ± 10 °C) to extend their holding time.

If a sample container is received broken, if a sample is received in an inappropriate container, or if a sample has not been preserved by appropriate means, the laboratory will notify BBL. The laboratory sample custodian will be responsible for logging the samples in, assigning a unique laboratory identification number to each sample, labeling each sample bottle with its laboratory identification number, and moving the samples to appropriate storage locations to await analysis. The project name, field sample code, date sampled, date received, analysis required, storage location and date, and action for final disposition will be recorded in the laboratory tracking system. Relevant custody documentation will be placed in the project file.

# A2-6. Quality Assurance Procedures

## A2-6.1 Preventive Maintenance

Preventive maintenance of laboratory equipment generally will follow the guidelines recommended by the manufacturer. A malfunctioning instrument will be repaired immediately by in-house staff or through a service call to the manufacturer.

Maintenance schedules for laboratory equipment will adhere to the manufacturers' recommendations. Records will reflect the complete history of each instrument and specify the time frame for future maintenance. Major repairs or maintenance procedures will be performed through service contracts with manufacturers or qualified contractors. Paperwork associated with service calls and preventive maintenance calls will be kept on file by the laboratory.

Laboratory Systems Managers are responsible for the routine maintenance of instruments used in a particular laboratory. Any routine preventive maintenance carried out is logged into the appropriate logbooks. Routine and non-routine maintenance schedules and procedures will be performed in accordance with the laboratory's quality assurance manual.

All major instruments will be backed up by comparable (if not equivalent) instrument systems in the event of unscheduled downtime. An inventory of spare parts will also be available to minimize equipment/instrument downtime.

## A2-6.2 Calibration Procedures and Frequency

When analyses are conducted according to USEPA methods, the calibration procedures and frequencies specified in the applicable method will be followed. For analyses governed by SOPs, see the appropriate laboratory SOP for the required calibration procedures and frequencies. Records of calibrations will be filed and maintained by the laboratory. These records will be subject to QA audit. For all instruments, the laboratory will maintain trained repair staff and in-house spare parts or will maintain service contracts with vendors.

All standards used in the calibration of equipment will be traceable, directly or indirectly, to the National Institute of Standards and Technology, Environmental Resource Associates, National Research Council of Canada, or other documented, reliable, commercial sources. All standards received shall be logged into standard receipt logs maintained by the individual analytical groups. Each group shall maintain a standards log that tracks the preparation of standards used for calibration and QC purposes.

## A2-6.3 Laboratory QC Requirements

### A2-6.3.1 Quality Assurance Indicators

The overall quality assurance objective of this QAPP is to develop and implement procedures for sampling, COC, laboratory analysis, instrument calibration, data reduction and reporting, internal quality control, audits, preventive maintenance, and corrective action such that valid data will be generated. These procedures are presented or referenced in the following sections of the QAPP. Specific QC checks are discussed in Section A2-6.5

Quality assurance indicators are generally defined in terms of five parameters:

- precision;
- accuracy;
- representativeness;
- comparability; and
- completeness.

Each parameter is defined below. Specific objectives for the Removal Action are set forth in other sections of this QAPP as referenced below.

### A2-6.3.2 Precision

Precision is a measure of the reproducibility of sample results. The goal is to maintain a level of analytical precision consistent with the objectives of the action. To maximize precision, sampling and analytical procedures will be followed. All work for the will adhere to established protocols presented in the QAPP. Analytical precision will be measured through matrix spike/matrix spike duplicates (MS/MSDs) and laboratory control sample/laboratory control sample duplicates (LCS/LCSDs) for organic analyses and through laboratory duplicate samples for inorganic analyses. Analytical precision measurements will be carried out on project-specific samples at a minimum frequency of one per laboratory analysis group or one in 20 samples, whichever is more frequent, per matrix analyzed. Laboratory precision will be evaluated against laboratory control limits established under the USEPA method for that analysis.

Field precision will be evaluated by the collection of blind field duplicates at a frequency of 10%. Field duplicate precision will be screened against a relative percent difference (RPD) of 50% for water samples and 75% for sediment samples.

The equation used to express precision is:

$$RPD = \frac{(A-B)}{(A+B)/2} \times 100$$

Where:

A = Analytical result from one of two duplicate measurements
B = Analytical result from the second measurement

Precision will generally be evaluated against laboratory control limits. Precision measurements can be affected by how close a chemical concentration is to the reporting limit, which can increase the percent error (expressed as RPD). When a sample or duplicate concentration is within five times the reporting limit, alternative control limits recommended by the USEPA (1999, 2002) of +/- the reporting limit for water samples and two times +/- the reporting limit for sediment samples will be used.

### A2-6.3.3 Accuracy

Accuracy is a measure of how close a measured result is to the true value. Both field and analytical accuracy will be monitored through initial and continuing calibration of instruments. In addition, reference standards, matrix spikes, blank spikes, laboratory control samples, and surrogate standards will be used to assess the accuracy of the analytical data. Accuracy measurements on MS samples will be carried out at a minimum frequency of one in 20 samples per matrix analyzed. Because MS/MSDs measure the effects of potential matrix interferences for a specific matrix, the laboratory will perform MS/MSDs only on project-specific samples. Surrogate recoveries will be determined for every sample analyzed for organics.

Laboratory accuracy will be evaluated against laboratory control limits established under the USEPA method for that analysis. Accuracy can be expressed as a percentage of the true or reference value or as a percent recovery in those analyses where reference materials are not available and spiked samples are analyzed. The equation used to express accuracy is:

$$\% \text{ Recovery} = \frac{A-X}{B} \times 100$$

Where:

A = Value measured in spiked sample or standard
X = Value measured in original sample
B = True value of amount added to sample or true value of standard

### A2-6.3.4 Representativeness

Representativeness is the degree to which sampling data accurately and precisely represent conditions in, for this project, the Removal Action Area. Representativeness is dependent on sampling and analytical variability and the variability of environmental media. The FSP has been designed to assess the presence of the chemical constituents at the time of sampling and presents the rationale for sample quantities and sampling locations. In addition, the use of the prescribed field and laboratory analytical methods, with their associated holding times and preservation requirements, is intended to provide representative data.

### A2-6.3.5 Comparability

Comparability is the degree of confidence with which one data set can be compared to another. Comparability will be maintained through consistent use of the sampling and analytical methodologies set forth in this QAPP and through the use of established QA/QC procedures and appropriately trained personnel.

### A2-6.3.6 Completeness

Completeness is defined as a measure of the amount of valid data obtained from an event and/or investigation compared to the total amount that was obtained. Completeness will be calculated as follows:

C = [(number of acceptable data points) x 100]/(total number of data points collected)

The data quality objective for completeness for all components of this project is 90%. Data qualified as estimated because the quality control criteria were not met will be considered valid for the purpose of assessing completeness. Data that have been qualified as rejected will not be considered valid for the purpose of assessing completeness.

## A2-6.4 Field Quality Control Checks

Field QC samples will be analyzed to identify possible problems resulting from sample collection or sample processing in the field. All field QC samples will be documented in the field logbook and verified by the Project QA Manager or designee.

### A2-6.4.1 Field Equipment Blanks

Field equipment blanks are used to determine whether cross contamination has occurred during sampling. A minimum of one rinseate blank of the vibracore will be submitted for each 10 vibracores collected. A minimum of one rinseate blank of the under-pier surface sediment sampling device will be submitted for each 10 under-pier surface sediment samples collected. No rinseate blank will be required for surface water samples because dedicated equipment will be used.

### A2-6.4.2 Trip Blanks

Trip blanks will be collected one per sampling event per matrix sampled when the samples are to be analyzed for TPH-gasoline and will also be analyzed for TPH-gasoline.

### A2-6.4.3 Field Duplicates

For surface, under-pier, and subsurface sediment samples, a minimum of one field duplicate will be collected per 10 samples submitted for analysis. Field duplicates for surface water samples will be collected at the same frequency.

## A2-6.5 Analytical Laboratory Quality Control Checks

Internal laboratory quality control checks will be used to monitor data integrity. These checks will include method blanks, MSs (and MSDs), LCSs (and LCSDs), spike blanks, internal standards, surrogate samples, calibration standards, and reference standards. Laboratory control limits will be used to evaluate MS/MSD, LCS/LCSD, and surrogate recoveries. Laboratory control charts will be used to determine long-term instrument trends.

Results of QC samples from each sample group will be reviewed by the analyst immediately after a sample group has been analyzed. The QC sample results will then be evaluated to determine whether control limits have been exceeded. If control limits are exceeded in the sample group, the Project QA Manager will be contacted immediately, and corrective action (e.g., method modifications followed by reprocessing of the affected samples) will be initiated prior to processing a subsequent group of samples.

All primary chemical standards and standard solutions used in this project will be traceable to the National Institute of Standards and Technology, Environmental Resource Associates, National Research Council of Canada, or other documented, reliable, commercial sources. Standards will be validated to determine their accuracy by comparison with an independent standard. Any impurities found in a standard will be documented.

### A2-6.5.1 Method Blanks

Sources of contamination in the analytical process, whether specific analyses or interferences, need to be identified, isolated, and corrected. The method blank is useful in identifying possible sources of contamination within the analytical process. For this reason, it is necessary that the method blank be initiated at the beginning of the analytical process and encompass all aspects of the analytical work so that the method blank can assist in accounting for any potential contamination attributable to glassware, reagents, instrumentation, or other sources. One method blank will be analyzed with each analytical series associated with no more than 20 samples.

### A2-6.5.2 Laboratory Control Samples

Laboratory control samples will be used; they will either be developed and spiked by the laboratory or laboratory standards will be used.

### A2-6.5.3 Matrix Spike/Matrix Spike Duplicate

Site-specific MS/MSDs will be used to measure the accuracy of analyte recovery from the sample matrices. Matrix spike duplicate pairs will be analyzed at a frequency of 5% (every 20 samples or once every week, whichever comes first).

When MS recoveries are outside QC limits, associated control sample and surrogate spike recoveries will be evaluated, as applicable, to attempt to verify the reason for the deviation and determine the effect on the reported sample results.

### A2-6.5.4 Surrogate Spikes

Surrogates are compounds that are unlikely to occur under natural conditions and that have properties similar to the analytes of interest. Surrogates are added to the samples prior to purging or extraction and are primarily used for organic samples analyzed by gas chromatography/mass spectrometry and gas chromatography methods. The surrogate spike provides broader insight into the proficiency and efficiency of an analytical method on a sample-specific basis. This control reflects analytical conditions that may not be attributable to sample matrix. All project samples analyzed for organic compounds will be spiked with appropriate surrogate compounds as defined in the analytical methods.

If surrogate spike recoveries exceed specified QC limits, then the analytical results will be evaluated thoroughly in conjunction with other control measures. In the absence of other control measures, the integrity of the data may not be verifiable and reanalysis of the samples with additional control may be necessary.

Surrogate spike compounds will be selected on the basis of guidance provided in the analytical methods.

### A2-6.5.5 Laboratory Duplicates

For inorganic analyses, laboratory duplicates will be analyzed to assess laboratory precision. A laboratory duplicate is defined as a separate aliquot of an individual sample that is analyzed as a separate sample.

### A2-6.5.6 Calibration Standards

Calibration check standards analyzed within a particular analytical series provide insight regarding instrument stability. A calibration check standard will be analyzed at the beginning and end of an analytical series or periodically throughout a series that contains a large number of samples.

In general, calibration check standards will be analyzed after every 12 hours or more frequently, as specified in the applicable analytical method. If results of the calibration check standard exceed specified tolerances, then samples analyzed since the last acceptable calibration check standard will be reanalyzed.

### A2-6.5.7 Reference Standards/Control Samples

Reference standards are standards of known concentration and are independent in origin from the calibration standards. Reference standard analysis provides insight into analytical proficiency within an analytical series, including the preparation of calibration standards, the validity of calibration, sample preparation, instrument setup, and the premises inherent in quantitation. Reference standards will be analyzed at the frequencies specified within the analytical methods.

For samples that are analyzed for metals by graphite furnace, an analytical spike will be analyzed after each sample analysis.

# A2-7. Data Management

All data will undergo two levels of QA/QC evaluation: one at the laboratory and one by a qualified independent data validator. Initial data reduction, evaluation, and reporting at the laboratory will be carried out as described in the appropriate analytical protocols and the laboratory's QA manual. Quality control data resulting from methods and procedures described in this document will also be reported.

## A2-7.1 Sample Management

All laboratory analytical batches will be assigned a unique number and tracking identifier at the laboratory. All data reports will include this tracking number. The laboratory will use a Laboratory Information Manager system to track all samples throughout the analytical stream.

## A2-7.2 Data Reporting

Analytical chemistry results will be provided by the laboratory in both digital and hard-copy formats. Upon receipt of each analytical package, the original COC form will be placed in the project files. The data packages will be examined to ensure that the correct analyses were performed for each sample submitted and that all of the analyses requested on the COC form were performed. If discrepancies are noted, the Project QA Manager will be notified and will promptly follow up with the laboratory to resolve any issues.

Any data that do not meet the specified standards will be flagged pending resolution of the issue. The flag will not be removed from the data until the issue associated with the sample results is resolved. Although flags may remain for certain data, the use of that data may not necessarily be restricted.

Following completion of data validation, the digital files will be used to generate the appropriate report tables. The format for the electronic data deliverable (EDD) specifies one data record for each constituent for each sample analyzed. Specific fields include:

- sample identification number;
- date sampled;
- date analyzed;
- parameter name;
- analytical result;
- units;
- detection limit; and
- qualifier(s).

The individual EDDs, which will be supplied by the laboratory in either an ASCII comma-separated value format or in a Microsoft Excel worksheet, will be loaded into the appropriate database table via a custom-designed user interface Visual Basic program. Any analytical data that cannot be provided by the laboratory in electronic format will be entered manually. After entry into the database, the EDD data will be compared to the field information previously entered into the database to confirm that all requested analytical data have been received.

### A2-7.3 Data Management Procedures

A record of all field documentation, as well as analytical and QA/QC results, will be maintained to ensure the validity of the data. To effectively execute such documentation, carefully constructed sample tracking and data management procedures will be used throughout the sampling program.

Sample tracking will begin with the completion of COC forms, as described in the FSP and summarized in Section A2-5 of this QAPP. Copies of all completed COC forms will be maintained in the field office. The laboratory shall verify receipt of the samples electronically (via fax) on the following day.

When analytical data are received from the laboratory, the Project Chemist will review the incoming analytical data packages against the information on the COCs to confirm that the correct analyses were performed for each sample and that results were received for all samples submitted for analysis. Any discrepancies noted will be promptly followed up by the Project Chemist.

After the USEPA approves the Removal Action characterization report, the Port will release the data to the Lower Willamette Group.

#### A2-7.3.1 Laboratory Turnaround Time

All chemical analytical work will be completed within 15 business days of sample receipt.

#### A2-7.3.2 Archival/Retention Requirements

Archival sediment samples will be stored in the dark at -20 ± 10 °C. After analysis is performed and within 14 days from the time of collection, samples will be frozen for possible reanalysis. Samples will be frozen at -20 ± 10 °C. Samples will be retained for one year after collection date. The laboratory will notify the Project QA Manager prior to disposing of any samples.

# A2-8. Data Assessment Procedures

Once the data are received from the laboratory, a number of QC procedures will be followed to accurately evaluate data quality and assess data precision, accuracy, and completeness.

## A2-8.1 Data QC Review

Chemistry data will be subject to multilevel review by CAS. The group leader will review all data reports prior to their release for final data report generation. The Quality Assurance Manager will review the final data reports, and the Laboratory Project Manager will review a cross section of the final data reports prior to shipment to BBL.

If discrepancies or deficiencies exist in the analytical results, then corrective action will be taken, as discussed in Section A2-9. The deficiencies and the corrective actions will be documented on a Corrective Action Form. This form will be submitted to the BBL Project QA Manager.

## A2-8.2 Data Evaluation and Verification

The first sediment data package that includes PCB and pesticide data will be submitted to the USEPA for review. All data validation will be performed by a third-party, independent data validator. Ten percent to 20% of the data will undergo Level IV data validation, and the remainder will undergo Level III data validation, in accordance with the USEPA's Functional Guidelines (USEPA, 1999, 2002). The data validation classifications of Level III and Level IV are derived from the USEPA CLP (USEPA, 1987). Level III data validation consists of reviewing chains of custody; holding times; field, trip, and method blanks; surrogate, matrix spike/matrix spike duplicate, and laboratory control sample/laboratory control sample duplicate recoveries; field duplicate, laboratory duplicate, matrix spike/matrix spike duplicate, and laboratory control sample/laboratory control sample duplicate relative percent differences; and reporting limits. Level IV data validation consists of a full data validation, including a review of raw data.

Level III data validation is comparable to the Puget Sound Dredge Disposal Analysis quality assurance 1 (QA1) data review, and Level IV data validation is comparable to the Puget Sound Dredge Disposal Analysis quality assurance 2 (QA2) data review (Washington State Department of Ecology, 1989). For consistency with the chemistry analytical work that will be performed in accordance with CLP protocols, data collected as part of the EE/CA work plan will also be validated in accordance with CLP, i.e., Level III and Level IV data validation will be performed.

Initially, 10% of the data will undergo a Level IV data validation. If the USEPA recommends that more than 10% of the data undergo a Level IV data validation following its review of the first sediment data package, the Port will discuss additional Level IV data validation with the USEPA at that time.

The contract analytical laboratory will deliver complete data packages for all chemical analyses. The data will be evaluated in accordance with the QAPP.

The third-party, independent data validator will perform data validation on all chemistry data generated using the USEPA's Functional Guidelines (USEPA, 1999, 2002). These procedures and criteria may be modified as necessary to address project-specific and method-specific criteria, control limits, and procedures. Data

evaluation will consist of data screening, checking, reviewing, editing, and interpretation to document analytical data quality and to determine whether the quality is sufficient to meet the DQOs. Data evaluation will include a review of completeness and compliance.

Any deviations from analytical methods or any special reporting requirements apart from those specified in this QAPP will be detailed on COC forms. The data validator will verify that reduction of laboratory measurements and laboratory reporting of analytical parameters are in accordance with the procedures specified for each analytical method and/or as specified in this QAPP.

The results of the data validation, including text assigning qualifiers in accordance with the USEPA's Functional Guidelines (USEPA, 1999, 2002) and a tabular summary of qualifiers, will be generated by the data validator.

Deficiencies discovered as a result of the data validation, as well as the corrective actions implemented in response, will be documented and submitted in the form of a written report addressing the following topics, as applicable to each method:

- assessment of the data package;
- description of any protocol deviations;
- failures to reconcile reported and/or raw data;
- assessment of any compromised data;
- overall appraisal of the analytical data; and
- table of site name, sample quantities, matrix, and fractions analyzed.

It should be noted that qualified data are not necessarily invalid if they are of sufficient quality to meet the intended use. The goal of producing the best possible data does not necessarily mean producing data without QC qualifiers. Qualified data can provide useful information.

Resolution of any issues regarding laboratory performance or deliverables will be handled between the laboratory and the Project Chemist. During that process, the Project QA Manager may make suggestions for reanalysis.

Data validation reports will be kept in the project file at the BBL office in Seattle, Washington.

# A2-9. Laboratory Audits and Corrective Actions

Laboratory and field performance audits and corrective action procedures are described in this section.

## A2-9.1 Laboratory and Field Performance Audits

Laboratory and field performance audits consist of onsite reviews of QA systems and equipment for sampling, calibration, and measurement. Laboratory audits will not be conducted for the EE/CA; however, all laboratory audit reports will be made available to the Project QA Manager upon request. All laboratories are required to have written procedures addressing internal QA/QC; these procedures have been submitted and will be reviewed by the Project QA Manager to ensure compliance with this QAPP. All laboratories must ensure that personnel engaged in sampling and analysis tasks have appropriate training.

The laboratory will, as part of the audit process, provide written details of any and all planned modifications for BBL's review.

## A2-9.2 Corrective Action Procedures

### A2-9.2.1 Corrective Action for Field Sampling

The Field Manager will be responsible for correcting equipment malfunctions during the field sampling effort. The Project QA Manager will be responsible for resolving situations in the field that may result in noncompliance with the QAPP. All corrective measures will be immediately documented in the field logbook.

### A2-9.2.2 Corrective Action for Laboratory Analyses

The laboratory is required to submit and comply with its SOPs. The Laboratory Project Manager will be responsible for ensuring that appropriate corrective actions are initiated as required for conformance with the QAPP. All laboratory personnel will be responsible for reporting problems that may compromise the quality of the data.

The Project QA Manager will be notified immediately if any QC sample exceeds the laboratory control limits. The analyst will identify and correct the anomaly before continuing with the sample analysis. The Laboratory Project Manager will document the corrective action taken in a memorandum submitted to the Project QA Manager within five days of the initial notification. A narrative describing the anomaly, the steps taken to identify and correct the anomaly, and the treatment of the relevant sample batch (i.e., recalculation, reanalysis, reextraction) will be submitted with the data package in the form of a cover letter.

# A2-10. References


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Palermo, M. R., 1985. Environmental Effects of Dredging, Technical Notes, Interim Guidance for Predicting Quality of Effluent discharged from Confined Dredged Material Disposal Areas—Test Procedures. Prepared for the U.S. Army Corps of Engineers, Waterways Experiment Station. EEDP-04-2. June.

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# A2-11. Abbreviations and Acronyms

| | |
|---|---|
| ASTM | American Society for Testing and Materials |
| BBL | Blasland, Bouck and Lee, Inc. |
| CAS | Columbia Analytical Services |
| CLP | Contract Laboratory Program |
| COC | chain of custody |
| CST | column settling test |
| DQO | data quality objective |
| DRET | dredging elutriate test |
| EDD | electronic data deliverable |
| EE/CA | engineering evaluation/cost analysis |
| FSP | field sampling plan |
| LCS/LCSD | laboratory control sample/laboratory control sample duplicate |
| MET | modified elutriate test |
| MS/MSD | matrix spike/matrix spike duplicate |
| PAH | polycyclic aromatic hydrocarbons |
| PCB | polychlorinated biphenyl |
| Port | Port of Portland |
| QAPP | quality assurance project plan |
| QA/QC | quality assurance/quality control |
| RPD | relative percent difference |
| SIM | selected ion monitoring |
| SOP | standard operating procedure |
| SVOC | semivolatile organic compound |
| TCLP | toxicity characteristics leaching procedure |
| TCLT | thin-column leaching test |
| tDDT | total DDT |
| TOC | total organic carbon |
| TPH | total petroleum hydrocarbons |
| TSS | total suspended solids |
| USEPA | U.S. Environmental Protection Agency |
| VOC | volatile organic compound |

## TABLE A2-1
## ANALYTICAL EXTRACTION/CLEANUP METHODS, TEST METHODS, AND REPORTING LIMIT GOALS FOR SEDIMENT

| Chemical Parameter | Extraction/Cleanup Method | Analytical Method | Reporting Limit Goal |
|---|---|---|---|
| **Metals (ug/kg)** | | | |
| Arsenic | USEPA Method 3050 | USEPA Method 6000/7000 | 100 |
| Cadmium | USEPA Method 3050 | USEPA Method 6000/7000 | 20 |
| Chromium | USEPA Method 3050 | USEPA Method 6000/7000 | 500 |
| Copper | USEPA Method 3050 | USEPA Method 6000/7000 | 200 |
| Lead | USEPA Method 3050 | USEPA Method 6000/7000 | 100 |
| Mercury | USEPA Method 3050 | USEPA Method 6000/7000 | 50 |
| Nickel | USEPA Method 3050 | USEPA Method 6000/7000 | 1,000 |
| Selenium | USEPA Method 3050 | USEPA Method 6000/7000 | 200 |
| Silver | USEPA Method 3050 | USEPA Method 6000/7000 | 20 |
| Zinc | USEPA Method 3050 | USEPA Method 6000/7000 | 600 |
| **Semivolatile Organic Compounds (ug/kg)** | | | |
| **PAHs (ug/kg)** | | | |
| Naphthalene | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Acenaphthylene | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Acenaphthene | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Fluorene | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Phenanthrene | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Anthracene | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| 2-Methylnaphthalene | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| 1-Methylnaphthalene | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Biphenyl | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| 2,6-Dimethylnaphthalene | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| 2,3,5-Trimethylnaphthalene | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Fluoranthene | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Pyrene | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Benzo(a)anthracene | USEPA Method 3541 | USEPA Method 8270C-SIM | 6.7 |
| Chrysene | USEPA Method 3541 | USEPA Method 8270C-SIM | 6.7 |
| Benzo(b)fluoranthene | USEPA Method 3541 | USEPA Method 8270C-SIM | 6.7 |
| Benzo(k)fluoranthene | USEPA Method 3541 | USEPA Method 8270C-SIM | 6.7 |
| Benzo(a)pyrene | USEPA Method 3541 | USEPA Method 8270C-SIM | 6.7 |
| Ideno(1,2,3-cd)pyrene | USEPA Method 3541 | USEPA Method 8270C-SIM | 6.7 |
| Dibenz(a,h)anthracene | USEPA Method 3541 | USEPA Method 8270C-SIM | 6.7 |
| Benzo(g,h,i)perylene | USEPA Method 3541 | USEPA Method 8270C-SIM | 6.7 |
| Benzo(e)pyrene | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Perylene | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| **Phthalates (ug/kg)** | | | |
| Dimethyl phthalate | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Diethyl phthalate | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Di-n-butyl phthalate | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Butyl benzyl phthalate | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Bis(2-ethylhexyl)phthalate | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |
| Di-n-octyl phthalate | USEPA Method 3541 | USEPA Method 8270C-SIM | 20 |

**TABLE A2-1**
**ANALYTICAL EXTRACTION/CLEANUP METHODS, TEST METHODS, AND REPORTING LIMIT GOALS FOR SEDIMENT**

| Chemical Parameter | Extraction/Cleanup Method | Analytical Method | Reporting Limit Goal |
|---|---|---|---|
| **Total DDT (ug/kg)** | | | |
| 2,4'-DDD | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| 4,4'-DDD | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| 2,4'-DDE | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| 4,4'-DDE | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| 2,4'-DDT | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| 4,4'-DDT | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| **Pesticides (ug/kg)** | | | |
| alpha-BHC | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.2 |
| beta-BHC | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.2 |
| gamma-BHC | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.2 |
| delta-BHC | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.2 |
| Heptachlor | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.2 |
| Aldrin | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.2 |
| Heptachlor Epoxide | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.2 |
| gamma-Chlordane | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.2 |
| Endosulfan I | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.2 |
| alpha-Chlordane | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.2 |
| Dieldrin | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| Endrin | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| Endrin aldehyde | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| Endrin ketone | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| Endosulfan II | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| Endosulfan Sulfate | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| cis-nonachlor | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |

**TABLE A2-1**
**ANALYTICAL EXTRACTION/CLEANUP METHODS, TEST METHODS, AND REPORTING LIMIT GOALS FOR SEDIMENT**

| Chemical Parameter | Extraction/Cleanup Method | Analytical Method | Reporting Limit Goal |
|---|---|---|---|
| oxy-chlordane | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| trans-nonachlor | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| Methyoxychlor | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 2 |
| Mirex | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 0.4 |
| Toxaphene | USEPA Method 3540C/3640A/3660B | USEPA Method 8081A | 100 |
| **PCBs (ug/kg)** | | | |
| Aroclor 1016 | USEPA Method 3540C/3640A/3660B/3665A | USEPA Method 8082 | 5 |
| Aroclor 1221 | USEPA Method 3540C/3640A/3660B/3665A | USEPA Method 8082 | 10 |
| Aroclor 1232 | USEPA Method 3540C/3640A/3660B/3665A | USEPA Method 8082 | 5 |
| Aroclor 1242 | USEPA Method 3540C/3640A/3660B/3665A | USEPA Method 8082 | 5 |
| Aroclor 1248 | USEPA Method 3540C/3640A/3660B/3665A | USEPA Method 8082 | 5 |
| Aroclor 1254 | USEPA Method 3540C/3640A/3660B/3665A | USEPA Method 8082 | 5 |
| Aroclor 1260 | USEPA Method 3540C/3640A/3660B/3665A | USEPA Method 8082 | 5 |
| **TPH (mg/kg)** | | | |
| Gasoline-range petroleum hydrocarbons | -- | NWTPH-G | 5 |
| Diesel-range petroleum hydrocarbons | Acid/silica gel | NWTPH-D | 0.25 |
| Heavy oil-range petroleum hydrocarbons | Acid/silica gel | NWTPH-D | 0.5 |
| **Conventionals (%)** | | | |
| TOC | -- | USEPA Method 9060 | 0.005 |
| Total Solids | -- | USEPA Method 160.3 | 0.01 |

Notes:
All units are in dry weight.
Actual reporting limits may vary depending on sample moisture content and possible matrix interference.

## TABLE A2-2
## ANALYTICAL TEST METHODS AND REPORTING LIMIT GOALS FOR WATER

| Chemical Parameter | Analytical Method | Reporting Limit Goal |
|---|---|---|
| **Metals (mg/L)** | | |
| Arsenic | USEPA Method 200.8 | 90 |
| Barium | USEPA Method 200.8 | 20 |
| Cadmium | USEPA Method 200.8 | 20 |
| Chromium | USEPA Method 200.8 | 20 |
| Copper | USEPA Method 200.8 | 30 |
| Lead | USEPA Method 200.8 | 20 |
| Mercury | USEPA Method 200.8 | 0.2 |
| Nickel | USEPA Method 200.8 | 50 |
| Selenium | USEPA Method 200.8 | 20 |
| Silver | USEPA Method 200.8 | 6 |
| Zinc | USEPA Method 200.8 | 10 |
| **Semivolatile Organic Compounds (ug/L)** | | |
| **PAHs (ug/L)** | | |
| Naphthalene | USEPA Method 8270C-SIM | 10 |
| Acenaphthylene | USEPA Method 8270C-SIM | 10 |
| Acenaphthene | USEPA Method 8270C-SIM | 10 |
| Fluorene | USEPA Method 8270C-SIM | 10 |
| Phenanthrene | USEPA Method 8270C-SIM | 10 |
| Anthracene | USEPA Method 8270C-SIM | 10 |
| 2-Methylnaphthalene | USEPA Method 8270C-SIM | 10 |
| 1-Methylnaphthalene | USEPA Method 8270C-SIM | 10 |
| Biphenyl | USEPA Method 8270C-SIM | 10 |
| 2,6-Dimethylnaphthalene | USEPA Method 8270C-SIM | 10 |
| 2,3,5-Trimethylnaphthalene | USEPA Method 8270C-SIM | 10 |
| 1-Methylnaphthalene | USEPA Method 8270C-SIM | 10 |
| Fluoranthene | USEPA Method 8270C-SIM | 10 |
| Pyrene | USEPA Method 8270C-SIM | 10 |
| Benzo(a)anthracene | USEPA Method 8270C-SIM | 10 |
| Chrysene | USEPA Method 8270C-SIM | 10 |
| Total benzofluoranthenes | USEPA Method 8270C-SIM | 10 |
| Benzo(a)pyrene | USEPA Method 8270C-SIM | 10 |
| Ideno(1,2,3-cd)pyrene | USEPA Method 8270C-SIM | 10 |
| Dibenz(a,h)anthracene | USEPA Method 8270C-SIM | 10 |
| Benzo(g,h,i)perylene | USEPA Method 8270C-SIM | 10 |
| Benzo(e)pyrene | USEPA Method 8270C-SIM | 10 |
| Perylene | USEPA Method 8270C-SIM | 10 |
| **Phthalates (ug/L)** | | |
| Dimethyl phthalate | USEPA Method 8270C-SIM | 10 |
| Diethyl phthalate | USEPA Method 8270C-SIM | 10 |
| Di-n-butyl phthalate | USEPA Method 8270C-SIM | 10 |
| Butyl benzyl phthalate | USEPA Method 8270C-SIM | 10 |
| Bis(2-ethylhexyl)phthalate | USEPA Method 8270C-SIM | 10 |
| Di-n-octyl phthalate | USEPA Method 8270C-SIM | 10 |
| **Miscellaneous SVOCs (ug/L)** | | |
| 4-Methylphenol | USEPA Method 8270C-SIM | 10 |
| 3-Methylphenol | USEPA Method 8270C-SIM | 10 |
| 2-Methylphenol | USEPA Method 8270C-SIM | 10 |
| Methylphenol | USEPA Method 8270C-SIM | 10 |

## TABLE A2-2
## ANALYTICAL TEST METHODS AND REPORTING LIMIT GOALS FOR WATER

| Chemical Parameter | Analytical Method | Reporting Limit Goal |
|---|---|---|
| 1,4-Dichlorobenzene | USEPA Method 8270C-SIM | 0.5 |
| 2,4-Dinitrotoluene | USEPA Method 8270C-SIM | 10 |
| Hexachlorobenzene | USEPA Method 8270C-SIM | 10 |
| Hexachlorobutadiene | USEPA Method 8270C-SIM | 10 |
| Hexachloroethane | USEPA Method 8270C-SIM | 10 |
| Pentachlorophenol | USEPA Method 8270C-SIM | 25 |
| **Pesticides (ug/L)** | | |
| 2,4'-DDD | USEPA Method 8081A | 0.1 |
| 4,4'-DDD | USEPA Method 8081A | 0.1 |
| 2,4'-DDE | USEPA Method 8081A | 0.1 |
| 4,4'-DDE | USEPA Method 8081A | 0.1 |
| 2,4'-DDT | USEPA Method 8081A | 0.1 |
| 4,4'-DDT | USEPA Method 8081A | 0.1 |
| Chlordane | USEPA Method 8081A | 0.1 |
| Endrin | USEPA Method 8081A | 0.1 |
| Heptachlor | USEPA Method 8081A | 0.1 |
| Heptachlor epoxide | USEPA Method 8081A | 0.1 |
| Lindane | USEPA Method 8081A | 0.1 |
| Toxaphene | USEPA Method 8081A | 5 |
| **Herbicides (ug/L)** | | |
| 2,4-D | USEPA Method 8151 | 0.2 |
| Methoxylchlor | USEPA Method 8151 | 0.2 |
| Pyridine | USEPA Method 8151 | 0.2 |
| 2,4,5-TP | USEPA Method 8151 | 0.2 |
| **PCBs (ug/L)** | | |
| Aroclor 1016 | USEPA Method 8082 | 0.1 |
| Aroclor 1221 | USEPA Method 8082 | 0.1 |
| Aroclor 1232 | USEPA Method 8082 | 0.1 |
| Aroclor 1242 | USEPA Method 8082 | 0.1 |
| Aroclor 1248 | USEPA Method 8082 | 0.1 |
| Aroclor 1254 | USEPA Method 8082 | 0.1 |
| Aroclor 1260 | USEPA Method 8082 | 0.1 |
| **Volatile Organic Compounds (ug/L)** | | |
| Benzene | USEPA Method 8260 | 0.5 |
| Carbon tetrachloride | USEPA Method 8260 | 0.5 |
| Chlorobenzene | USEPA Method 8260 | 0.5 |
| Chloroform | USEPA Method 8260 | 0.5 |
| 1,2-Dichloroethane | USEPA Method 8260 | 0.5 |
| 1,1-Dichloroethylene | USEPA Method 8260 | 0.5 |
| Methyl ethyl ketone | USEPA Method 8260 | 0.5 |
| Nitrobenzene | USEPA Method 8260 | 0.5 |
| Tetrachloroethylene | USEPA Method 8260 | 0.5 |
| Trichloroethylene | USEPA Method 8260 | 0.5 |
| 2,4,5-Trichlorophenol | USEPA Method 8260 | 0.5 |
| 2,4,6-Trichlorophenol | USEPA Method 8260 | 0.5 |
| Vinyl chloride | USEPA Method 8260 | 0.5 |
| **TPH (mg/L)** | | |
| Gasoline-range petroleum hydrocarbons | NWTPH-G | 100 |
| Diesel-range petroleum hydrocarbons | NWTPH-D | 250 |

## TABLE A2-2
## ANALYTICAL TEST METHODS AND REPORTING LIMIT GOALS FOR WATER

| Chemical Parameter | Analytical Method | Reporting Limit Goal |
|---|---|---|
| Heavy oil-range petroleum hydrocarbons | NWTPH-D | 500 |
| **Conventionals (mg/L)** | | |
| TSS | USEPA Method 160.2 | 1 |
| Ammonia | USEPA Method 350.1 | 0.05 |
| Sulfide | USEPA Method 376.2 | 0.005 |

# Appendix B
# HASP

# *Appendix B*

# Health and Safety Plan

BBL®
BLASLAND, BOUCK & LEE, INC.
*engineers & scientists*

# Approvals and Acknowledgments

## Approvals

I have read and approved this *Health and Safety Plan* (HASP) with respect to project hazards, regulatory requirements, and Waste Management procedures.

Project Name: Port of Portland Terminal 4
Project Number:

Project Manager/Date

Health and Safety Officer/Date

Health and Safety Supervisor/Date

## Acknowledgments

The final approved version of this HASP has been provided to the site supervisor. I acknowledge my responsibility to provide the site supervisor with the equipment, materials and qualified personnel to implement fully all safety requirements in this HASP. I will formally review this plan with the Health and Safety Staff every 6 months until project completion.

Project Manager/Date

I acknowledge receipt of this HASP from the project manager, and that it is my responsibility to explain its contents to all site personnel and cause these requirements to be fully implemented. Any change in conditions, scope of work, or other change that might affect worker safety requires me to notify the project manager and/or the health and safety officer.

Site Supervisor/Date

Site Supervisor/Date

Site Supervisor/Date

# Health and Safety Plan Acknowledgment

I have read this Site-Specific Health and Safety Plan, or its contents have been presented to me, and I understand the contents and I agree to abide by its requirements.

| Name (Print) | Signature | Representing | Date |
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A Sediment Sampling Checklist
B Underground/Overhead Utility Checklist
C Material Safety Data Sheets
D Chemical Hazard Information
E Incident/Near-Miss Investigation Report
F Safe Work Observation Form
G Air Monitoring Log
H Health and Safety Inspection Form
I Safety Meeting Log

# B-1. Introduction

## B-1.1 General

This health and safety plan (HASP) has been prepared as an appendix to the Port of Portland (Port) Terminal 4 engineering evaluation/cost analysis (EE/CA) work plan. The objective of the project is to conduct environmental investigation activities at the Terminal 4 Removal Action Area. The purpose of the investigation activities is to collect additional chemical and geotechnical data to be used in preparing the EE/CA as required by an Administrative Order on Consent between the U.S. Environmental Protection Agency (USEPA) and the Port. Field activities will include the following tasks:

- mobilization/site survey;
- sediment and surface water sampling;
- installation of groundwater monitoring wells and soil borings;
- groundwater sampling and monitoring;
- surface and subsurface soil sampling;
- decontamination; and
- demobilization.

The objective of this HASP is to provide a mechanism for establishing safe working conditions during field activities at the Removal Action Area. The safety organization, procedures, and protective equipment have been established based on an analysis of potential physical, chemical, and biological hazards. Specific hazard control methodologies have been evaluated and selected to minimize the potential of injury, illness, or other hazardous incident.

## B-1.2 Removal Action Area Description

The Terminal 4 Removal Action Area encompasses sediments within Terminal 4 at 11040 North Lombard, Portland, Oregon. The Removal Action Area extends west from the ordinary high water line on the northeast bank of the lower Willamette River to the edge of the navigation channel and south from the downstream end of Berth 414 to the downstream end of Berth 401, including Slip 1, Slip 3 and Wheeler Bay.

Tenants associated with these areas of Terminal 4 include Kinder Morgan, Cereal Food Processors, International Raw Materials, and Rogers Terminal. Kinder Morgan operates a bulk loading facility at Slip 3 for export of soda ash and/or unloading of bulk cargo from rail. Cereal Food Processor conducts specialty milling at the Terminal 4 flour mill associated with Slip 1. International Raw Materials and Rogers Terminal lease facilities near the slips. International Raw Materials off-loads approximately one barge per month at Slip 1.

## B-1.3 Policy Statement

Blasland, Bouck & Lee, Inc.'s (BBL's) policy is to provide a safe and healthful work environment. No aspect of operations is of greater importance than prevention of injury and illness. A fundamental principle of safety management is that all injuries, illnesses, and incidents are preventable. BBL will take every reasonable step to eliminate or control hazards to minimize the possibility of injury, illness, or incident.

This HASP prescribes the procedures that must be followed during activities at the site. Operational changes that could affect the health and safety of personnel, the community, or the environment will not be made without prior approval of the project manager (PM) and the health and safety officer (HSO). This document will be reviewed periodically to confirm that it is current and technically correct. Any changes in conditions at the Removal Action Area and/or the scope of work will require a review of and modification to this HASP. Such changes will be completed in the form of an addendum or a revision to the HASP.

The provisions of this HASP are mandatory for all BBL personnel and BBL subcontractors assigned to the project. Subcontractors may prepare their own site-specific HASPs that must meet the basic requirements of this HASP. All visitors to BBL work areas must abide by the requirements of this HASP.

This HASP complies with applicable state and federal Occupational Safety and Health Administration (OSHA) regulations, USEPA regulations, and BBL health and safety policies and procedures. This plan follows the guidelines established in the references listed in Section B-11.

## B-1.4 Definitions

The following definitions (listed alphabetically) are applicable to this HASP:

- *Contamination-Reduction Zone (CRZ)* - Area between the exclusion zone and support zone that provides a transition between contaminated and clean areas. Decontamination stations are located in this zone.

- *Exclusion Zone (EZ)* - Any portions of the site where hazardous substances are present, or are reasonably suspected to be present, and pose an exposure hazard to onsite personnel.

- *Incident* - All losses, including first-aid cases, injuries, illnesses, near misses, spills/leaks, equipment and property damage, motor vehicle accidents, regulatory violations, fires, and business interruptions.

- *Near Miss* - An incident in which no injury, illness, motor vehicle accident, equipment or property damage, etc., occurred, but in which, under slightly different circumstances, such injury, etc. could have occurred.

- *Onsite Personnel* - All BBL and subcontractor personnel involved with the project.

- *Project* - All onsite work performed under the scope of work.

- *Site* - The area described in Section B-1.2, Removal Action Area Description, where the work is to be performed by BBL personnel and subcontractors.

- *Support Zone (SZ)* - All areas of the site, except the EZ and CRZ. The SZ surrounds the CRZ and EZ. Support equipment and break areas are located in this zone.

- *Subcontractor* - Includes contractor personnel hired by BBL.

- *Visitor* - All other personnel, except the onsite personnel.

- *Work Area* - The portion of the site where work activities are actively being performed. This area may change daily as work progresses and includes the SZ, CRZ, and EZ. If the work area is located in an area onsite that is not contaminated or suspected of being contaminated, the entire work area may be an SZ.

# B-2. Roles and Responsibilities

## B-2.1 All Personnel

All BBL and subcontractor personnel must adhere to the procedures outlined in this HASP during the performance of their work. Each person is responsible for completing tasks safely and for reporting any unsafe acts or conditions to his/her supervisor. No person may work in a manner that conflicts with these procedures. After due warnings, the PM will dismiss from the site any person or subcontractor who violates safety procedures.

All BBL and subcontractor personnel will receive training in accordance with applicable regulations and be familiar with the requirements and procedures contained in this HASP prior to initiating site activities. In addition, all personnel will attend an initial hazard briefing prior to beginning work at the site.

The roles of BBL personnel and subcontractors are outlined in the following subsections. Table B-1 summarizes key project personnel and their contact information.

## B-2.2 BBL Personnel

### B-2.2.1 Project Manager (PM)

The PM is responsible for providing resources so that project activities are completed in accordance with this HASP and for meeting all regulatory and contractual requirements. The PM is also responsible for confirming that the site supervisor (SS) has the equipment, materials, and qualified personnel to fully implement the safety requirements of this HASP and/or that those subcontractors assigned to this project meet the requirements established by BBL. It is also the responsibility of the PM to perform the following duties:

- Consult with the HSO on site health and safety issues.
- Verify that subcontractors meet health and safety requirements prior to commencing work.
- Review Safe Work Observation (SWO) Forms.
- Verify that all incidents are thoroughly investigated.
- Approve, in writing, addenda or modifications to this HASP.
- Suspend work or modify work practices, as necessary, for personal safety, protection of property, and regulatory compliance.

### B-2.2.2 Health and Safety Officer (HSO)

The HSO or his/her designee has overall responsibility for the technical health and safety aspects of the project, including review and approval of this HASP. Inquiries regarding BBL health and safety procedures, project procedures, and other technical or regulatory issues should be addressed to this individual. The HSO or his/her designee must approve changes or addenda to this HASP.

### B-2.2.3 Health and Safety Supervisor (HSS)

The HSS is responsible for field health and safety issues, including the execution of this HASP. Questions in the field regarding health and safety procedures, project procedures, and other technical or regulatory issues should be addressed to this individual. The HSS will advise the PM on health and safety issues and will establish and coordinate the project air monitoring program if one is deemed necessary (see Section B-6.1, Air Monitoring). The HSS is the primary site contact on health and safety matters. It is the responsibility of the HSS to perform the following duties:

- Provide onsite technical assistance, if necessary.
- Participate in all Incident Investigations (IIs) and confirm that they are reported to the HSO and PM within 24 hours.
- Coordinate site and personal air monitoring, as required, including equipment maintenance and calibration.
- Conduct site safety orientation training and safety meetings.
- Verify that BBL personnel and subcontractors have received the required physical examinations and medical certifications.
- Review site activities with respect to compliance with this HASP.
- Maintain required health and safety documents and records.
- Assist the SS in instructing field personnel on project hazards and protective procedures.
- Review SWO Forms.

### B-2.2.4 Site Supervisor

The SS is responsible for implementing this HASP, including communicating requirements to onsite personnel and subcontractors. The SS will be responsible for informing the PM of changes in the work plan, procedures, or site conditions so that those changes may be addressed in this HASP. Other responsibilities are to:

- Consult with the HSS on site health and safety issues.
- Conduct SWOs at the site and complete the SWO Forms.

- Stop work, as necessary, for personal safety, protection of property, and regulatory compliance.
- Obtain a site map and determine and post routes to medical facilities and emergency telephone numbers.
- Notify local public emergency representatives (as appropriate) of the nature of the site operations, and post their telephone numbers (e.g., local fire department personnel who would respond for a confined-space rescue).
- Observe onsite project personnel for signs of ill-health effects.
- Investigate and report any incidents to the HSS.
- Verify that all onsite personnel have completed applicable training.
- Verify that onsite personnel are informed of the physical, chemical, and biological hazards associated with the site activities and of the procedures and protective equipment necessary to control the hazards.
- Issue/obtain any required work permits (hot work, confined space, etc.).

### B-2.3 Subcontractors

Subcontractors and their personnel must understand and comply with applicable regulations and site requirements established in this HASP. Subcontractors may prepare their own site-specific HASP that must be consistent with the requirements of this HASP.

All subcontractor personnel will receive training in accordance with applicable regulations and be familiar with the requirements and procedures contained in this HASP prior to initiating site activities. All subcontractor personnel will attend an initial hazard briefing prior to beginning work at the site. Additionally, onsite subcontractor personnel must attend and participate in the daily site safety meetings.

Subcontractors must designate individuals to function as the PM, HSO, HSS, and SS. In some firms, it is not uncommon for the duties of the HSO to be carried out by the PM. This is acceptable, provided that the PM has the required knowledge, training, and experience to properly address all hazards associated with the work and to prepare, approve, and oversee the execution of the site-specific HASP. A subcontractor may designate one person to perform the duties of both the HSS and the SS. However, depending on the level of complexity of a contractor's scope of work, it may not be feasible for one person to perform both functions satisfactorily.

## B-2.4 All Onsite Personnel

All onsite personnel (including subcontractors) must read and acknowledge their understanding of this HASP before commencing work and abide by the requirements of the HASP. All onsite personnel must sign the HASP Acknowledgement Form after reviewing this HASP.

All BBL and subcontractor personnel will receive training in accordance with applicable regulations and be familiar with the requirements and procedures contained in this HASP prior to initiating site activities. In addition, all onsite personnel will attend an initial hazard briefing prior to beginning work at the site and the daily safety meetings.

All onsite personnel must perform a risk self-assessment (RSA) prior to beginning each work activity. The RSA process involves determining worst-case scenarios for the tasks at hand and then ensuring that adequate steps are taken to eliminate or mitigate the risks. This process must be performed prior to beginning each activity and after any near-miss or other incident to determine whether it is safe to proceed. Onsite personnel will immediately report the following to the SS or HSS:

- personal injuries and illnesses, no matter how minor;
- unexpected or uncontrolled release of chemical substances;
- symptoms of chemical exposure;
- unsafe or hazardous situations;
- unsafe or malfunctioning equipment;
- changes in site conditions that may affect the health and safety of project personnel;
- damage to equipment or property;
- situations or activities for which they are not properly trained; and
- near misses.

## B-2.5 Visitors

All visitors to BBL work areas must check in with the SS. Visitors will be cautioned to avoid skin contact with surfaces, soils, groundwater, or other materials that may be, or are suspected to be, impacted by constituents of potential concern (COPCs).

Visitors requesting to observe work at the site must don appropriate personal protective equipment (PPE) prior to entry to the work area and must have the appropriate training and medical clearances to do so. If respiratory protective devices are necessary, visitors who wish to enter the work area must have been respirator-trained and fit-tested for a respirator within the past 12 months.

## Table B-1
## Key Personnel

| Port of Portland Key Personnel | | |
|---|---|---|
| **Role** | **Name** | **Address/Telephone No.** |
| Project Manager | Anne Summers | 121 NW Everett<br>Portland, Oregon 97209<br>(503) 944-7508 |
| Primary Field Contact | Frank Schmidt | 121 NW Everett<br>Portland, Oregon 97209<br>(503) 460-4857 (Office)<br>(503) 799-3524 (Mobile)<br>(503) 548-1519 (Pager) |
| **BBL Key Personnel** | | |
| **Role** | **Name** | **Address/Telephone No.** |
| Project Manager | Philip Spadaro. | 1100 Dexter Avenue North<br>Seattle, WA 98109<br>(206) 273-7555 (Office)<br>(206) 390-2842 (Mobile) |
| Health and Safety Supervisor | Randi Wexler | 1001 SW Fifth Avenue, Suite 1100<br>Portland, Oregon 97204<br>(503) 535-0696 (Office)<br>(503) 913-8249 (Mobile) |
| Site Supervisors | Shannon Dunn | 1100 Dexter Avenue North<br>Seattle, WA 98109<br>(206) 273-7555 (Office)<br>(206) 399-5307 (Mobile) |
| | Jamie Beaver/Brooke Miller | 1001 SW Fifth Avenue, Suite 1100<br>Portland, Oregon 97204<br>(503) 866-5764 (Mobile/Miller)<br>(971) 409-2478 (Mobile/Beaver)<br>(503) 535-0696 (Office) |
| Health and Safety Officer | Jay D. Keough, CIH | 8 S. River Rd.<br>Cranbury, NJ 08512-9502<br>(609) 860-0590 (Office)<br>(908) 492 -5674 (Mobile) |

| Subcontractor Personnel | | |
|---|---|---|
| **Company/Role** | **Name** | **Address/Telephone No.** |
| Geo-Tech Explorations/<br>Well Installation | Pete Larsen | 19700 SW Teton<br>Tualatin, OR 97062<br>(503) 692-6400 (Office) |
| Layne Drilling/<br>Well Installation | Steve Story | 9001 Pacific Avenue, Building B<br>Tacoma, WA 98444<br>(253) 536-1161 |
| Columbia Analytical Services, Inc./<br>Laboratory Analytical Services | Mr. Harvey Jackey | 1317 South 13th Ave.<br>P.O. Box 479<br>Kelso, WA 98626<br>(360) 577-7222 |
| Soil Technologies/Geotechnical Testing | Richard Sheets | 7865 NE Day Road W.<br>Bainbridge Island, WA 98110<br>(206) 842-8977 (Office) |
| Marine Sampling Systems/<br>Sediment Sampling | Bill Jaworski | PO Box 290<br>Burley, WA 98322<br>(253) 857-3336 (Office) |
| Blue Water Engineering/<br>Hydrodynamics/Sedimentation/Data Collection | Tony Petrillo | 4019 Phinney Avenue North<br>Seattle, WA 98103<br>(206) 633-5567 (Office) |
| AINW/Archeological Oversight | David Ellis | 2632 SE 162nd Avenue<br>Portland, OR 97236<br>(503) 761-6605 (Office) |
| MFG/Ecological Oversight | Mark Lewis | 4900 Pearl East Circle, Suite 300W<br>Boulder, CO 80301-6118<br>(303) 447-1823 |

# B-3. Project Hazards and Control Measures

## B-3.1 Introduction

Field activities will include the following tasks:

- mobilization/site survey;
- sediment and surface water sampling;
- installation of groundwater monitoring wells and soil borings;
- groundwater sampling and monitoring;
- surface and subsurface soil sampling;
- decontamination; and
- demobilization.

The following job safety analyses (JSAs) identify potential health, safety, and environmental hazards associated with each type of field activity listed above. Because of the complex and changing nature of field projects, supervisors must continually inspect the site to identify hazards that may affect onsite personnel, the community, or the environment. The SS must be aware of these changing conditions and discuss them with the PM whenever these changes impact employee health, safety, the environment, or performance of the project. The SS will keep onsite personnel informed of the changing conditions and the PM will write and/or approve addenda or revisions to this HASP as necessary.

Each field activity is described below, along with a discussion of potential hazards and control measures for each activity.

## B-3.2 Mobilization

Site mobilization will include the following activities:

- establishing sampling locations;
- determining the location of utilities and other installations; and
- establishing work areas.

Sediment and surface water sampling activities will take place on a vessel in the Willamette River. Break areas will be on vessel as well as mobilization and demobilization areas. Site mobilization will also include establishing drilling locations, determining the location of utilities and other installations, and establishing upland work areas. Mobilization may also include setting up equipment and establishing a temporary site office. A break area will be set up outside of regulated work areas. Mobilization may involve clearing areas for the SZ and CRZ. During the initial phase, project personnel will inspect the vessel and the sampling areas, confirm the existence of anticipated hazards, and identify safety and health issues that may have arisen since this HASP was written.

### B-3.2.1 Hazards

The hazards of this phase of activity are:

- work aboard a boat;
- heavy equipment operation;
- manual materials handling;
- installation of temporary onsite facilities; and
- manual site preparation.

Manual materials handling and manual site preparation may cause blisters, sore muscles, and joint and skeletal injuries; manual materials handling may also present eye, contusion, and laceration hazards. Installation of temporary field office and support facilities may expose personnel to electrical hazards, underground and overhead utilities, and physical injury due to the manual lifting and moving of materials. The work areas may present slip, trip, and fall hazards from scattered debris and irregular walking surfaces. Rainy weather may cause wet, muddy, or slick walking surfaces and unstable soil. Freezing weather hazards include frozen, slick, and irregular walking surfaces.

Environmental hazards include:

- weather, such as sunburn, lightning, rain, and heat- and cold-related illnesses;
- plants, such as poison ivy and poison oak;
- aggressive fauna, such as ticks, fleas, wasps, spiders, and snakes;
- waterborne biological hazards such as coliform; and
- pathogens, such as rabies and blood-borne pathogens.

### B-3.2.2 Control of Hazards

Control procedures for these hazards are presented in Section B-4, General Safety Practices.

## B-3.3 Field Activities

Field activities to be undertaken during the project include:

- sediment and surface water sampling;
- installation of groundwater monitoring wells and soil borings;
- groundwater sampling and monitoring; and
- surface and subsurface soil sampling;

Hazards and control measures and procedures for each sampling activity are discussed in the following subsections.

### B-3.3.1 Sediment and Surface Water Sampling

Sediment sampling involves collecting samples for subsequent field and laboratory analysis. The physical hazards of sediment sampling are primarily associated with the sample collection methods, procedures used, and the environment itself. Working on or near water also presents the risk of drowning, if proper procedures are not instituted.

The collection of seismic data using a seismic cone penetrometer involves the use of direct push-type boring equipment. This equipment poses a hazard if it is not properly operated. The equipment is hydraulically powered and uses static force and dynamic percussion force to advance a small-diameter probe. Because the hazards are similar to those encountered when using a conventional drill rig, the required procedures are also the same as for a conventional rig and are discussed in the drilling hazards section (B-3.3.3.1).

#### B-3.3.1.1 Hazards

The most significant hazard is that of working in or over water. Inhalation and absorption of COPCs are also potential hazards due to the manipulation of sample media and equipment, manual transfer of media into sample containers, and proximity of operations to the breathing zone. During this project, several different sampling methodologies may be used depending on equipment accessibility and the types of materials to be sampled. These sampling methods may include sampling probes, sediment traps, or sampling poles. The primary hazards associated with these specific sampling procedures are not potentially serious; however, other operations in the area or the conditions under which samples must be collected may present chemical and physical hazards. The hazards directly associated with sediment sampling procedures are generally limited to strains or sprains and potential eye hazards. Potential chemical hazards may include contact with media containing site COPCs and potential contact with chemicals used for equipment decontamination. In addition to the safety hazards specific to sample collection, hazards associated with working over the water or from a boat or barge will be a concern.

Biological hazards include bacteria and viruses potentially present due to waste materials and waste residue. The work area presents slip, trip, and fall hazards from irregular walking surfaces. Rainy weather may cause wet, muddy, and slick walking surfaces. Freezing weather hazards include frozen, slick, and irregular walking surfaces.

#### B-3.3.1.2 Controls

Control procedures for environmental and general hazards are discussed in Section B-4. Levels of protection are defined in Section B-5.1. Section B-6.1 describes air monitoring requirements and action levels. To control dermal exposure during sediment sampling activities, a minimum of Modified Level D protection will be worn. If necessary, based on field observations and site conditions, air monitoring may be conducted during sediment sampling activities. If the results of air monitoring indicate the presence of airborne contaminants in a concentration causing concern, personnel will upgrade to Level C protection.

The following sections provide general safety procedures for boat-based sampling, wader use, and working near water. In addition, the items on the Sediment Sampling Checklist (see Attachment A) must be addressed and the checklist must be in the possession of the SS prior to initiating sediment or water-column sampling activities.

#### B-3.3.1.3 Hazards of Working from a Boat or Barge

Boats or barges may be utilized for sediment sampling activities. This section outlines the precautions that will be taken by BBL personnel and subcontractors.

Working from a boat or barge presents the obvious hazard of drowning, but several other hazards exist. Powered craft carry a fuel supply, with the potential for fire or explosion if vapors accumulate and reach an ignition source. Weather, currents, and other watercraft may also pose significant hazards to the crew. **In the event**

**that a small craft advisory is issued by the National Weather Service, all work from a vessel will be halted and the vessel will return to shore. If a small craft advisory is issued before work commences, work will be rescheduled following lifting of the advisory. At all other times, on-water work is at the discretion of the vessel captain.**

At a minimum, each employee working from a boat or barge is required to participate in a boating safety training session conducted prior to beginning field operations. The training session shall provide instruction on the following topics: proper boat and safety equipment inspections; content and frequency of equipment safety inspections; proper use of onboard safety equipment, including fire extinguisher, radio or cellular phone, flares, horn, etc.; proper procedures on the completion and filing of a float plan; appropriate boating "rules-of-the-road"; emergency procedures in the event of capsizing or being thrown overboard; and different types of personal flotation devices (PFD) and their proper inspection and use.

BBL personnel working over, adjacent, or near water, where the danger of drowning exists, must wear U.S. Coast Guard (USCG)-approved life jackets or buoyant work vests. Prior to and after each use, the buoyant work vests or life preservers must be inspected for defects, which would alter their strength and buoyancy. Defective units must be removed from service. Ring buoys with at least 90 feet of line must be provided and readily available for emergency rescue operations. Distance from ring buoys shall not exceed 200 feet. At least one boat must be immediately available at locations where employees are working over or adjacent to water.

Prior to each day or shift of operations, a vessel inspection must be conducted by the vessel operator. This inspection shall be conducted in accordance with accepted USCG inspection procedures and any applicable state boating safety inspection procedures. The inspection must verify that necessary safety equipment is aboard and functioning properly and that all members of the crew are aware of proper procedures that are to be followed upon the water. In addition, this information shall be reviewed during the daily tailgate safety meeting to ensure the procedures have been followed and all crew members are satisfied as to their completion.

It will be the responsibility of the SS to verify that the daily boat/equipment inspections are completed and documented and that daily tailgate safety meetings are conducted. The following safety procedures shall be observed at all times:

- Vessels shall not be overloaded with equipment or personnel.
- Two personnel shall be on board at all times.
- Loads shall be distributed evenly throughout the vessel.
- PFD Types I, II, or III shall be worn at all times when working on or adjacent to the water.
- All PFDs shall be properly inspected to verify that appropriate USCG approvals and ratings information is available.
- At least one Type IV PFD (seat cushion, ring buoy) shall be available on board.
- An audible signal/alarm (capable of being heard up to ½ mile away) shall be maintained in each vessel.
- Each vessel shall be equipped with a ship-to-shore radio, cellular phone, and/or "walkie-talkie" capable of contacting the USCG, marine police, or other onshore station for help in an emergency.

- Each vessel shall be equipped with some type of visual display signal/device (e.g., flares or appropriate distress flag).

- All powerboats shall have a valid state registration. This registration shall be maintained on the boat, and as necessary be made available for USCG or marine police inspection.

- At a minimum, each powerboat shall be equipped with a Type 4-A, 10-B, C-rated fire extinguisher.

- Boats shall not be operated at night without proper lighting and the capability for making visual distress signals.

In addition to PFDs, personnel who are working from a boat or barge when water temperatures are below 50 degrees Fahrenheit must be equipped with thermal protective clothing/equipment (wet suits, dry suits, etc.). The thermal protective clothing must be adequate to protect personnel from hypothermic effects of immersion in water at the temperatures encountered.

#### B-3.3.1.4 Waders

Sampling activities may be performed using hip waders and the required level of PPE. Prior to donning them, waders shall be inspected for holes, punctures, tears, or any other defects (e.g., missing straps) that would allow water to enter. Personnel must wear a USCG-approved PFD or buoyant work vest during all activities conducted in water. Prior to each use, the PFD or work vest shall be inspected for defects that may alter its strength or buoyancy. Defective units shall be tagged "DO NOT USE" and removed from service. The "buddy system" will be strictly adhered to during any water-related activities. At no time will anyone enter the water without another individual readily available who can contact emergency services.

In addition to the drowning hazards associated with working on or near the water, there exists the possibility for slips, trips, or falls caused by slippery, unstable, and irregular walking surfaces. Waders used for sampling activities shall be properly sized and provide the wearer with adequate traction.

### B-3.3.2 Underwater Operations

Subcontracted divers will carry out a number of sampling and data collection tasks. The purpose of these sections is to provide general requirements for all diving operations on the project. The specific dive procedures will be defined and implemented by the subcontractor.

In 1982, OSHA exempted scientific diving from commercial diving regulations (29 Code of Federal Regulations [CFR] Part 1910, Subpart T) under certain conditions, which are met by the work planned for this project. All diving performed on this project is considered scientific diving, as opposed to commercial diving. The tasks of a scientific diver are those of an observer and data gatherer. Construction and troubleshooting tasks traditionally associated with commercial diving are not included within scientific diving and are not included in the scope of work for this project. Scientific divers, based on the nature of their activities, must use scientific expertise in studying the underwater environment and, therefore, are scientists or scientists in training.

**Diving activities at Slip 1 may not be undertaken until the Port Engineering Department provides special clearance regarding the structural integrity of the piers at Slip 1. Under no circumstances are diving activities in this area to commence without this special clearance from the Port.**

### B-3.3.2.1 Diving Safety Manual

A diving safety manual must be prepared by the subcontractor. The manual must present procedures covering all diving operations specific to the project, including criteria for diver training and authorization, safe diving procedures, equipment specifications, and procedures for emergency care, recompression, and evacuation. The manual must include:

- training and medical surveillance requirements for scientific divers;
- safety procedures and checklists for diving operations;
- assignments and responsibilities of the dive team members;
- equipment procedures and checklists; and
- emergency procedures.

### B-3.3.2.2 Diving Safety Officer

A diving safety officer (DSO) must be appointed to oversee all diving operations, including the conduct of training and authorization, approval of dive plans, maintenance of diving records, and verification of compliance with the diving safety manual and all relevant regulations. The DSO must be trained as a scientific diver as defined by the American Academy of Underwater Sciences (AAUS), must have technical and scientific expertise in activities related to scientific diving, and must be a member in good standing of the AAUS.

The DSO serves as a member of the Diving Control Board and supervises all diving operations. The DSO must suspend diving operations that he/she considers to be unsafe.

### B-3.3.2.3 General Diving Safety Requirements

General diving safety requirements are summarized in the following section. Complete safety requirements and procedures should be presented in the subcontractor's diving safety manual.

- All diving activities must be conducted with two comparably equipped divers (SCUBA or surface-supplied air) in the water in constant communication.

- All diving will be conducted with similar equipment. No diving will be conducted at depths greater than 35 feet.

- No diving will be conducted in enclosed or physically confining spaces.

- No diving will be conducted against currents exceeding 1 knot unless line-tended.

- No diving will take place if visibility is less than 200 feet at that given location.

- The diver must terminate a dive while there is still sufficient cylinder pressure remaining to permit the diver to safely reach the surface, including required in-water decompression time, if applicable.

The following subsections summarize requirements for dive site preparation, training and medical surveillance, dive planning, pre-dive briefing, equipment inspections, water entry and exit, and emergency procedures.

### B-3.3.2.4 Training and Medical Surveillance

Each diver must possess a nationally recognized diving certificate. Tasks must be assigned in accordance with the experience and training of the diver. Each diver must be trained, qualified, and authorized for the diving mode and specialized equipment being used, the diving activity to be performed, and the depths at which the dive is to be conducted.

Tasks may be assigned to an employee who has not previously performed the specific task provided that these tasks are performed under the direct supervision of an experienced dive team member.

All dive team members must be trained in cardiopulmonary resuscitation (CPR) and first aid (American Red Cross standard course or equivalent) and have current certification in these areas.

### B-3.3.2.5 Dive Planning

Planning of each diving operation will include an assessment of the safety and health aspects of each task. Planning elements include:

- diving mode;
- vessel use of waterway (use of ship's safe procedure checklist if dive operations are conducted while a ship is in port);
- surface and underwater conditions and hazards;
- breathing gas supply (including reserves);
- thermal protection;
- decontamination procedure;
- diving equipment and systems; and
- dive team assignments and physical fitness of dive team members.

To minimize hazards to the dive team, diving operations must be coordinated with other activities in the vicinity that could potentially interfere with the diving operation. To the extent possible, diving activities will be scheduled when vessels are not in port.

### B-3.3.2.6 Dive Site Preparation

For field efforts that require using divers for river bottom observations, appropriate protocols such as notifying the USCG Marine Safety Office of the upcoming activity and dive flagging will be used to alert boaters where diving operations are under way.

When diving from surfaces other than vessels in areas capable of supporting marine traffic, a rigid replica of the international code flag "A" at least 1 meter in height must be displayed at the dive location in a manner that allows all-round visibility and must be illuminated during night-diving operations.

### B-3.3.2.7 Pre-Dive Briefing

All dive team members must be briefed by the DSO on the following topics:

- tasks to be undertaken;
- safety procedures for the diving mode;
- any unusual hazards or environmental conditions likely to affect the safety of the diving operation; and
- any modifications to operating procedures necessitated by the specific diving operation.

Prior to making individual dive team member assignments, the DSO must inquire into each dive team member's current state of physical fitness and indicate to the dive team member the procedure for reporting physical problems or adverse physiological effects during and after the dive.

### B-3.3.2.8 Equipment Inspection

The procedures listed below must be followed when conducting equipment inspection.

- Each diver must conduct a functional check of his/her diving equipment in the presence of the DSO. Each diver must ensure that his/her equipment is in proper working order and that the equipment is suitable and sufficient for the type of diving operation planned. The DSO must verify that the equipment check has been performed.

- Each diver must have a submersible pressure gauge for monitoring SCUBA cylinder pressure that is capable of being monitored by the diver during the dive or a surface monitor air regulator.

- Each diver must have the capability of achieving and maintaining positive buoyancy on the surface.

- Each diver must have the capability to execute a controlled neutrally buoyant ascent, through the use of an approved buoyancy control device.

- The entire dive apparatus for each diver must be inspected by the diver and by the DSO prior to the dive.

- Critical inspection points include the breathing gas supply system, masks, thermal protection, and weights.

- The proper function of the cylinder pressure gauge must be inspected by each SCUBA diver and verified by the DSO.

### B-3.3.2.9 Water Entry and Exit

The procedures listed below must be followed when entering and exiting the water.

- A means capable of supporting the diver will be provided for entering and exiting the water, unless the entry is in water of wading depth. The means provided for exiting the water must extend below the water surface.

- A means will be provided to assist an injured diver from the water.

### B-3.3.2.10 Emergency Procedures

The procedures listed below must be followed in the event of an emergency during underwater operations.

- A standby diver must be available any time a diver is in the water.

- Divers must be line-tended from the surface or accompanied by another diver in the water in continuous visual contact during the diving operations.

- A diver must be stationed at the underwater point of entry when diving is conducted in enclosed or physically confining spaces.

- A diver-carried reserve breathing gas supply must be provided for each diver. The reserve must be either a manual reserve (J valve) or an independent reserve cylinder with a separate regulator or connected to the underwater breathing apparatus.

- The valve of the reserve breathing gas supply must be in the closed position prior to the dive.

### B-3.3.3 Installation of Groundwater Monitoring Wells and Soil Borings

This task includes the installation of groundwater monitoring wells and soil borings at specified locations. After the wells are completed, the wells will be developed using the standard operating procedures.

#### B-3.3.3.1 Drilling Hazards

The primary physical hazards for this activity are associated with the use of drilling equipment, since tools and equipment (such as elevators, cat lines, and wire rope) have the potential for striking, pinning, or cutting personnel. The following definitions (listed alphabetically) are applicable to this section:

- *Cat Lines* — Cat lines are used on drilling rigs to hoist material. Accidents that occur during cat-line operations may injure the employee doing the rigging, as well as the operator. Minimal hoisting control causes sudden and erratic load movements, which may result in hand and foot injuries.

- *Materials Handling* — The most common type of accident that occurs in material handling operations is the "caught between" situation when a load is being handled and a finger or toe gets caught between two objects. Rolling stock can shift and/or fall from a pipe rack or truck bed.

- *Rig Accidents* — Rig accidents can occur as a result of improperly placing the rig on uneven or unstable terrain or failing to adequately secure the rig prior to starting operations.

- *Utility Lines* — Underground and overhead utility lines can create hazardous conditions if contacted by drilling equipment.

- *Wire Rope* — Worn or frayed wire rope presents a laceration hazard if loose wires protrude from the main bundle.

- *Working Surfaces* — Slippery work surfaces can increase the likelihood of back injuries, overexertion injuries, and slips and falls.

### B-3.3.3.2 Drilling Safety Controls

The following control procedures are required for this activity:

- *Drill Crews* — All drillers must possess required state or local licenses to perform drilling work. All members of the drill crew must receive site-specific training prior to beginning work. The driller is responsible for the safe operation of the drill rig, as well as the crew's adherence to the requirements of this HASP. The driller must confirm that all safety equipment is in proper condition and is properly used. The members of the crew must follow all instructions of the driller, wear appropriate PPE, and be aware of all hazards and control procedures. The drill crews must participate in the daily safety meetings and be aware of all emergency procedures.

- *Rig Inspection* — Each day, prior to starting work, the drill rig and associated equipment must be inspected by the driller and/or drill crew. The following items must be inspected:

  - vehicle condition;
  - proper storage of equipment;
  - condition of all wire rope and hydraulic lines;
  - fire extinguisher; and
  - first-aid kit.

- *Drill Rig Setup* — The drill rig must be properly blocked and leveled prior to raising the derrick. The wheels that remain on the ground must be chocked even if the rig's parking brake has been applied. The leveling jacks must not be raised until the derrick is lowered. The rig should be moved only after the derrick has been lowered.

- *Site Drilling Rules* — Before drilling activities commence, the existence and location of underground pipe, electrical equipment, and gas lines must be determined. The Underground Facility Protection Organization must be contacted at least 1 week, but no more than 2 weeks, prior to subsurface activities. BBL's SS will meet with electrical and natural gas locators onsite prior to marking out the underground utilities. During this meeting, BBL's SS will provide the electrical and natural gas locators with a site figure showing the locations where excavation and drilling activities will be completed. BBL's SS will conduct a site walkover with the electrical and natural gas locators to visually identify each location where excavation and drilling activities are to be completed during site operations. The Underground/Overhead Utility Checklist (see Attachment B) will be used to document that nearby utilities have been marked on the ground and that the excavation and drilling areas have been cleared. The completed Underground/Overhead Utility Checklist will be in the possession of the SS prior to commencing any intrusive investigation.

  The following additional site drilling rules apply to project sites:

  - Combustible gas readings of the general work area will be made regularly (see Section B-6).

  - Operations must be suspended and corrective action taken if the airborne flammable concentration reaches 10% of the lower explosive limit (LEL) in the immediate area (a 1-foot radius) of the point of drilling or near any other ignition sources.

  - Under no circumstances will personnel be permitted to ride the traveling block or elevators, nor will the cat line be used as a personnel carrier.

- *Overhead Electrical Clearances* — If drilling activities are conducted in the vicinity of overhead power lines, the power to the lines must be de-energized, tested to confirm that it is de-energized, marked up, and guaranteed, or the equipment must be positioned such that no part (including the excavation boom) can come within the minimum clearances shown in Table B-2.

**Table B-2**
**Minimum Overhead Electrical Clearances (All Equipment)**

| Nominal System Voltage | Minimum Required Clearance |
|---|---|
| 0-50kV | 10 feet |
| 51-100kV | 12 feet |
| 101-200kV | 15 feet |
| 201-300kV | 20 feet |
| 301-500kV | 25 feet |
| 501-750kV | 35 feet |
| 751-1,000kV | 45 feet |

When the drill rig is in transit, with the boom lowered and no load, the equipment clearance must be at least 4 feet for voltages less than 50kV, 10 feet for voltages of 50kV to 345kV, and 16 feet for voltages above 345kV.

- *Rig Setup* — Three control procedures apply to rig setup:

  - All well sites will be inspected by the driller prior to establishing the location of the rig to verify that a stable surface exists. This is especially important in areas where soft, unstable terrain is common.

  - All rigs will be properly blocked and leveled prior to raising the derrick. Blocking provides a more stable drilling structure by evenly distributing the weight of the rig. Proper blocking confirms that differential settling of the rig does not occur. Wheels remaining on the ground will be chocked and the parking brake will be applied.

  - When the ground surface is soft or otherwise unstable, wooden blocks at least 24 inches by 24 inches and 4 inches to 8 inches thick must be placed between the jack swivels and the ground. The emergency brake must be engaged and the wheels that are on the ground must be chocked.

- *Hoisting Operations* — The following control procedures apply to hoisting operations:

  - Drillers should never engage the rotary clutch without watching the rotary table so that it is clear of personnel and equipment.

  - Unless the drawworks is equipped with an automatic-feed control, the brake should not be left unattended without first being tied down.

  - Auger strings or casing should be picked up slowly.

  - During instances of unusual loading of the derrick or mast, such as when making an unusually hard pull, only the driller should be on the rig floor; no one else should be on the rig or derrick.

- The brakes on the drawworks of the drill rig should be tested by the driller each day. The brakes should be thoroughly inspected by a competent individual each week.

- A hoisting line with a load imposed should not be permitted to be in direct contact with any derrick member or stationary equipment unless it has been specifically designed for line contact.

- Workers should never stand near the borehole whenever any wire-line device is being run.

- Hoisting control stations should be kept clean and controls labeled as to their functions.

- *Cat-Line Operations* — The following control procedures apply to cat-line operations:

  - Only experienced workers will be allowed to operate the cathead controls. The kill switch must be clearly labeled and operational prior to operating the cat line. The cathead area must be kept free of obstructions and entanglements.

  - The operator should not use more wraps than necessary to pick up the load. More than one layer of wrapping is not permitted.

  - Personnel should not stand near, step over, or go under a cable or cat line that is under tension.

  - Employees rigging loads on cat lines must:

    ✓ Keep out from under the load;
    ✓ Keep fingers and feet where they will not be crushed;
    ✓ Be sure to signal clearly when the load is being picked up;
    ✓ Use standard visual signals only and not depend on shouting to co-workers for communication; and
    ✓ Make sure the load is properly rigged, since a sudden jerk in the cat line will shift or drop the load.

- *Wire Rope* — The following control procedures apply to the use of wire rope:

  - When two wires are broken or rust or corrosion is found adjacent to a socket or end fitting, the wire rope must be removed from service or resocketed. Special attention must be given to the inspection of end fittings on boom support, pendants, and guy ropes.

  - Wire rope removed from service due to defects must be cut up or plainly marked as being unfit for further use as rigging.

  - Wire rope clips attached with U-bolts must have the U-bolts on the dead or short end of the rope; the clip nuts must be retightened immediately after initial load carrying use and at frequent intervals thereafter.

  - When a wedge socket fastening is used, the dead or short end of the wire rope must have a clip attached to it or looped back and secured to itself by a clip; the clip must not be attached directly to the live end.

  - Protruding ends of strands in splices on slings and bridles must be covered or blunted.

- Except for eye splices in the ends of wires and for endless wire rope slings, wire rope used in hoisting, lowering, or pulling loads must consist of one continuous piece without knot or splice.

- An eye splice made in any wire rope must have not less than five full tucks.

- Wire rope must not be secured by knots. Wire rope clips must not be used to splice rope.

- Eyes in wire rope bridles, slings, or bull wires must not be formed by wire clips or knots.

- *Auger Handling* — The following control procedures apply to auger handling:

  - Auger sections must be transported by cart or carried by two persons. Individuals should not carry auger sections without assistance.

  - Workers should not be permitted on top of the load while loading, unloading, or transferring rolling stock.

  - When equipment is being hoisted, personnel should not stand where the bottom end of the equipment could whip and strike them.

  - Augers stored in racks, catwalks, or on flatbed trucks should be secured to prevent rolling.

### B-3.3.4 Groundwater Sampling and Monitoring

Groundwater sampling will involve uncapping, purging (pumping water out of the well), sampling, and monitoring new or existing monitoring wells. A mechanical pump may be used to purge the wells and can be hand-, gas-, or electric-operated. Water samples taken from the wells are then placed in containers and shipped to the analytical laboratory for analysis. The physical hazards of these operations are primarily associated with the sample collection methods and procedures used.

#### B-3.3.4.1 Hazards

Inhalation and absorption of COPCs are the primary routes of entry associated with groundwater sampling, due to the manipulation of sample media and equipment, manual transfer of media into sample containers, and proximity of operations to the breathing zone. During this project, several different groundwater sampling methodologies may be used depending on equipment accessibility and the types of materials to be sampled. These sampling methods may include hand or mechanical bailing. The primary hazards associated with these specific sampling procedures are not potentially serious; however, other operations in the area or the conditions under which samples must be collected may present chemical and physical hazards. The hazards directly associated with groundwater sampling procedures are generally limited to strains or sprains from hand bailing, and potential eye hazards. Exposure to water containing COPCs is also possible.

The flora and fauna of the site may present hazards of poison ivy, poison oak, ticks, fleas, mosquitoes, wasps, spiders, and snakes. The work area presents slip, trip, and fall hazards from scattered debris and irregular walking surfaces. Rainy weather may cause wet, muddy, and slick walking surfaces and unstable soil. Freezing weather hazards include frozen, slick, and irregular walking surfaces.

### B-3.3.4.2 Control

To control dermal exposure during groundwater sampling activities, a minimum of Modified Level D protection will be worn. If necessary, based on field observations and site conditions, air monitoring may be conducted during groundwater sampling to assess the potential for exposure to airborne COPCs. If the results of air monitoring indicate the presence of organic vapors in a concentration causing concern, personnel will upgrade to Level C protection. Section B-5 describes PPE and levels of protection. Section B-6.1 describes air monitoring requirements and action levels. Control procedures for environmental and general hazards are discussed in Section B-4.

### B-3.3.5 Surface and Subsurface Soil Sampling

This task involves collecting soil samples for subsequent analysis and evaluation of potential impact by COPCs. The physical hazards of these operations are primarily associated with the sample collection methods and procedures used. In addition, personnel may be exposed to hazards associated with working in or near excavations and heavy equipment.

### B-3.3.5.1 Hazards

Inhalation and absorption of COPCs are the primary routes of entry associated with soil sampling due to the manipulation of sample media and equipment, manual transfer of media into sample containers, and proximity of operations to the breathing zone. During this project, several different soil sampling methodologies may be used depending on equipment accessibility and the types of materials to be sampled. These sampling methods may include the use of hand-auger/sampling probes, sampling spoons, or trowels. The primary hazards associated with these specific sampling procedures are not potentially serious; however, other operations in the area or the conditions under which samples must be collected may present chemical and physical hazards. The hazards directly associated with soil sampling procedures are generally limited to strains or sprains and potential eye hazards. Exposure to soil containing COPCs is also possible. In addition to the safety hazards specific to sampling operations, hazards associated with the operation of vehicles (especially large vehicles with limited operator visibility) are a concern. Of particular concern will be the backing up of trucks, rigs, and other support vehicles.

The flora and fauna of the site may present hazards of poison ivy, poison oak, ticks, ants, fleas, mosquitoes, wasps, spiders, and snakes. The work area presents slip, trip, and fall hazards from scattered debris and irregular walking surfaces. Rainy weather may cause wet, muddy, and slick walking surfaces and unstable soil. Freezing weather hazards include frozen, slick, and irregular walking surfaces.

### B-3.3.5.2 Control

To control dermal exposure during soil sampling activities, a minimum of Modified Level D protection will be worn. Avoid laying tools and equipment on the ground to avoid contact with native poisonous or irritating flora and fauna. If necessary, based on field observations and site conditions, air monitoring may be conducted during soil sampling activities to assess the potential for exposure to airborne COPCs. If the results of air monitoring indicate the presence of organic vapors in a concentration causing concern, personnel will upgrade to Level C protection. Section B-5 describes PPE and levels of protection. Section B-6.1 describes air monitoring

requirements and action levels. Control procedures for environmental and general hazards are discussed in Section B-4.

### B-3.3.6 Equipment Decontamination

All equipment is to be decontaminated before leaving the site. In addition, all operations that have the potential to generate or release hazardous material will be conducted in a controlled area using the appropriate engineering controls. Specific decontamination techniques will be established based on site conditions. Decontamination procedures will be reviewed with all personnel onsite. A decontamination pad on a suitable surface (concrete or paved area) with polyethylene sheeting or other appropriate containment system will be established. Pressure washing with manual scrub brushing as needed will be used to decontaminate equipment. COPC-impacted equipment will be determined "clean" through visual inspection of all equipment.

The decontamination facility will be inspected on a daily basis for evidence of leaks or loss of integrity to the containment system. If any deficiencies are noted, they will be corrected immediately. All waste water and waste materials generated onsite will be contained in the decontamination system for characterization and proper disposal.

Personnel involved in decontamination activities may be exposed to skin contact with contaminated materials and chemicals brought to the site as part of the project work. All personnel will review the operating procedures and PPE prior to decontamination. Personnel involved in decontamination activities must wear PPE that is appropriate for the task and no more than one level below the level worn by personnel working in the EZ.

#### B-3.3.6.1 Pressure Washing

Equipment will be decontaminated before leaving the site. Personnel involved in decontamination activities may be exposed to skin contact with residuals containing site constituents, volatile emissions from heavily soiled equipment, high-pressure water spray, and noise.

Hydro blasting is the process of using a stream of water at high pressure to clean or prepare surfaces by removing foreign matter and contaminants. The hazards of high-pressure water cleaning are related to the high pressure of the water, which may exceed 10,000 pounds per square inch (psi) at the nozzle. Contact with the water spray may cause severe lacerations, which may then be contaminated with hazardous material. Because of the high pressure involved, the opportunity for slicing or injecting the water stream through soft tissues of the body exists. Hydro blasters will also cut through bone at high enough pressures. A second hazard is repetitive motion, or cumulative trauma disorder. These serious disorders are related to repeatedly squeezing the trigger or constantly fighting the pressure of the spray gun with the forearm or wrist. When pressure washing, steaming, or hydro blasting, the health and safety precautions for hydro blasting outlined below must be observed.

Pressure washing presents a splash hazard. Protection against splash to face and skin is mandatory. The pressure washer is not to be pointed at a person at any time. Steam cleaning presents a thermal burn hazard in addition to the hazards presented by pressure washing. Adequate protection from the hot surfaces must be provided.

Only persons trained in use and maintenance of a hydro blaster may use such equipment. Hydro blasting operations will conducted only by qualified subcontractor personnel.

The following general requirements are provided for high-pressure water cleaning activities:

- The gun, pressure piping, pressure hose ends, and couplings will have a burst pressure of at least four times the operating pressure.
- No equipment or component of such equipment will be operated beyond the manufacturer's specifications or beyond the rated working pressure.
- The maximum operating pressure will be permanently displayed on the pumping unit.
- Wear safety glasses, face shield, hearing protection, and safety shoes.
- Alternate hands frequently during long periods of use.
- Rotate personnel periodically.
- Use a washer with a gun which supplies water to the wand in a straight line as opposed to supplying water through the grip. This eliminates the gun's twisting motion.
- Keep the equipment in good condition.
- Check to see that releasing the trigger stops the flow of water. Do not wire back the trigger.
- A hose safety shroud will be placed on hoses whenever operating pressure exceeds 2,000 psi.
- The pressure control will be a "deadman" type to safely reduce the nozzle discharge pressure when control is released.
- The pressure discharge gauge indicating pump pressure will be clearly visible for monitoring pump pressure.
- A pressure relief device set to relieve at 110% of the maximum working pressure of the unit or its components, whichever is lower, will be installed on the pump. The relief will be clearly marked and displayed on the device.
- A strainer or filter should be installed on the water supply system to prevent debris from entering the water blasting units and clogging the gun, control, or other device.
- Pay close attention to the water line. It is under pressure, and may whip about if broken. If a water line breaks, relieve the pressure before trying to grab the line.

### B-3.3.7 Demobilization

Demobilization involves removing all tools, equipment, supplies, and vehicles brought to the site. The hazards of this phase of activity are associated with heavy equipment operation and manual materials handling.

#### B-3.3.7.1 Hazards

Manual materials handling may cause blisters, sore muscles, and joint and skeletal injuries and may present eye, contusion, and laceration hazards. Heavy equipment operation presents noise and vibration hazards and hot surfaces to operators. Personnel in the vicinity of heavy equipment operation may be exposed to physical hazards resulting in fractures, contusions, and lacerations and may be exposed to high noise levels. The work area presents slip, trip, and fall hazards from scattered debris and irregular walking surfaces. Rainy weather may cause wet, muddy, and slick walking surfaces and unstable soil. Freezing weather hazards include frozen, slick, and irregular walking surfaces.

Environmental hazards include plants, such as poison ivy and poison oak; aggressive fauna, such as ticks, fleas, mosquitoes, wasps, spiders, and snakes; weather, such as sunburn, lightning, rain, and heat- or cold-related illnesses; and pathogens, such as rabies and blood-borne pathogens.

#### B-3.3.7.2 Control

Control procedures for these hazards are discussed in Section B-4.

### B-3.4 Chemical and Biological Hazards

#### B-3.4.1 Chemical Hazards

The chemical hazards associated with site operations are related to inhalation, ingestion, and skin exposure to site COPCs. Concentrations of airborne COPCs during site tasks may be measurable and may require air monitoring during certain operations. Air monitoring requirements for site tasks are outlined in Section B-6.1.

Site COPCs may include metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc), DDT, polychlorinated biphenyls (PCBs), bis (2-ethylhexyl)phthalate (BEP), and polycyclic aromatic hydrocarbons (PAHs). Exposure to these materials is possible by inhaling vapors or contacting soils or other dusts containing COPCs. Soil or other media contaminated with COPCs may be ingested or may come in contact with exposed skin. Excessive dermal exposure to these materials may cause dermatitis, hyperpigmentation of the skin, and skin irritation. Excessive inhalation exposure to these metals may cause respiratory tract irritation, headache, dizziness, and nausea. Ingestion may cause abdominal pain, nausea, vomiting, and diarrhea.

The potential for ingesting COPCs, soil, or other impacted media is low. The potential for inhaling impacted media is also low. The potential for dermal exposure is moderate.

Material Safety Data Sheets (MSDSs) for the COPCs are included in Attachment C. Chemical hazard information for site COPCs is included in Attachment D.

### B-3.4.2 Biological Hazards

Diving poses risks of exposure to biological contaminants such as coliform bacteria. Numerous forms of pollution are present in almost every body of water in the United States. Non-point source pollution includes any biological waste that flows with the runoff from rain into lakes, streams, rivers, and oceans. One of the major problems with diving in polluted water is that the contaminants are frequently suspended in the water and so are all around the diver. Some chemicals may float on the surface and others may sink to the bottom, but biological hazards are in suspension and can enter through any weak point in the diver's gear.

Protection against these contaminants involves isolation of the diver during the dive and careful decontamination upon leaving the water. Ingestion of and dermal contact with water must be avoided. The best protection is to totally encapsulate the diver with either a full face mask or a full coverage diving helmet, a vulcanized rubber dry suit, and dry gloves. This type of gear affords excellent protection from virtually all biohazards, as well as from many chemicals.

# B-4. General Safety Practices

## B-4.1 General Safety Rules

General safety rules for site activities include, but are not limited to, the following:

- At least one copy of this HASP must be in a location at the site that is readily available to personnel, and all project personnel must review the plan prior to starting work.
- Consume or use food, beverages, chewing gum, and tobacco products only in the SZ or other designated area outside the EZ and CRZ. Cosmetics must not be applied in the EZ or CRZ.
- Wash hands before eating, drinking, smoking, or using toilet facilities.
- Wear all PPE as required and stop work and replace damaged PPE immediately.
- Secure disposable coveralls, boots, and gloves at the wrists and legs and confirm closure of the suit around the neck.
- Upon skin contact with materials that may be impacted by COPCs, remove contaminated clothing and wash the affected area immediately. Contaminated clothing must be changed. Any skin contact with materials potentially impacted by COPCs must be reported to the SS or HSS immediately. If needed, medical attention should be sought.
- Practice contamination avoidance. Avoid contact with surfaces either suspected or known to be impacted by COPCs, such as standing water, mud, or discolored soil. Equipment must be stored on elevated or protected surfaces to reduce the potential for incidental contamination.
- Remove PPE as required in the CRZ to limit the spread of COPC-containing materials.
- At the end of each shift, or as required, dispose of all single-use coveralls, soiled gloves, and respirator cartridges in receptacles designated for this purpose.
- Do **not** remove soil containing site COPCs from protective clothing or equipment with compressed air, shaking, or any other means that disperses contaminants into the air.
- Inspect all non-disposable PPE for contamination in the CRZ. Any PPE found to be contaminated must be decontaminated or disposed of appropriately.
- Recognize emergency signals used for evacuation, injury, fire, etc.
- Report all injuries, illnesses, near misses, and unsafe conditions or work practices to the SS or HSS.
- Use the "buddy system" during all operations requiring Level C PPE and, when appropriate, during Modified Level D operations.
- Obey all warning signs, tags, and barriers. Do not remove any warnings unless authorized to do so.

- Use, adjust, alter, and repair equipment only if trained and authorized to do so and in accordance with the manufacturer's directions.

- Personnel are to perform only tasks for which they have been properly trained and will advise their supervisor if they have been assigned a task for which they are not trained.

- The presence or consumption of alcoholic beverages or illicit drugs during the workday, including breaks, is strictly prohibited. Do not take prescription or over-the-counter drugs when assigned to tasks with the potential for absorption, inhalation, or ingestion of hazardous substances, unless given written approval by an appropriate health care professional.

- Remain upwind during site activities whenever possible.

### B-4.1.1 Incident Investigation

An incident includes any of the following events:

- first-aid cases;
- injuries;
- illnesses;
- near misses;
- spills/leaks;
- equipment and property damage;
- motor vehicle accidents;
- regulatory violations;
- fires; and
- business interruptions.

All incidents must be investigated within 24 hours and reported to the PM and the HSO.

The purpose of an II is to prevent the recurrence of a similar hazardous event. An II reviews all incidents in the same manner. Using the information gathered during an II, appropriate measures will be taken to protect personnel from the hazard in question. The Incident/Near-Miss Investigation Report is included in Attachment E.

### B-4.1.2 Safe Work Observation

The SS or the HSS will perform the SWO (see Attachment F for the SWO Form). The purpose of the SWO is to identify and correct potential hazards and to positively reinforce behaviors and practices that are correct. The SS or HSS must identify potential deviations from safe work practices that could possibly result in an incident and take prompt corrective action. The SWO process includes the following steps:

- Identify tasks that have the greatest potential for hazardous incidents.

- Review the standard procedure for completing the task.

- Discuss with the observed employee the task and the SS/HSS role in observing the task.
- Observe the employee completing the task.
- Reference the SWO Form for criteria. Complete the form, documenting positive actions as well as areas in need of improvement.
- Discuss the results of the SWO with the employee. Discuss any corrective action that is necessary.
- Implement corrective action.
- Communicate the results of the SWO and corrective action to the PM and the HSO.

### B-4.1.3 Job Safety Analysis

A JSA is a tool used to identify potential hazards and to develop corrective or protective systems to eliminate the hazard. A JSA lists all the potential hazards associated with an activity. Hazards may be physical, such as lifting hazards or eye hazards, or environmental, such as weather or biological (stinging insects, snakes, etc.). After identifying the hazards associated with an activity, control measures are evaluated and protective measures or procedures are then instituted. JSAs are reviewed periodically to confirm that the procedures and protective equipment specified for each activity are current and technically correct. Any changes in site conditions and/or the scope of work may require a review and modification to the JSA in question. During this review process, comments on the JSA and its procedures should be obtained from personnel associated with the activity being analyzed.

## B-4.2 Buddy System

Onsite personnel must use the "buddy system" as required by operations. Use of the buddy system is required during all operations requiring Level C to Level A PPE and, when appropriate, during Level D operations. Crewmembers must observe each other for signs of chemical exposure and heat or cold stress. Indications of adverse effects include, but are not limited to:

- changes in complexion and skin coloration;
- changes in coordination;
- changes in demeanor;
- excessive salivation and pupillary response; and
- changes in speech pattern.

Crewmembers must also be aware of the potential exposure to possible safety hazards, unsafe acts, or non-compliance with safety procedures.

Field personnel must inform their partners or fellow crewmembers of non-visible effects of exposure to toxic materials that they may be experiencing. The symptoms of such exposure may include, but are not limited to:

- headaches;
- dizziness;
- nausea;

- blurred vision;
- cramps; and
- irritation of eyes, skin, or respiratory tract.

If protective equipment or noise levels impair communications, pre-arranged hand signals must be used for communication. Personnel must stay within line of sight of another team member.

### B-4.3 Heat Stress

Heat stress is caused by several interacting factors, including environmental conditions, clothing, and workload, as well as the physical and conditioning characteristics of the individual. Since heat stress is one of the most common illnesses associated with heavy outdoor work conducted with direct solar load and, in particular, because wearing PPE can increase the risk of developing heat stress, workers must be capable of recognizing the signs and symptoms of heat-related illnesses. Personnel must be aware of the types and causes of heat-related illnesses and be able to recognize the signs and symptoms of these illnesses in both themselves and their co-workers.

#### B-4.3.1 Heat Rashes

Heat rash is one of the most common problems in hot work environments. Commonly known as prickly heat, a heat rash is manifested as red papules and usually appears in areas where the clothing is restrictive. As sweating increases, these papules give rise to a prickling sensation. Prickly heat occurs in skin that is persistently wetted by unevaporated sweat, and heat rash papules may become infected if they are not treated. In most cases, heat rashes will disappear when the affected individual returns to a cool environment.

#### B-4.3.2 Heat Cramps

Heat cramps are usually caused by performing hard physical labor in a hot environment. These cramps have been attributed to an electrolyte imbalance caused by sweating. It is important to understand that cramps can be caused both by too much and too little salt.

Cramps appear to be related to a lack of water replenishment. Because sweat is a hypotonic solution (plus or minus 0.3% NaCl), excess salt can build up in the body if the water lost through sweating is not replaced. Thirst cannot be relied on as a guide to the need for water; instead, water must be taken every 15 to 20 minutes in hot environments.

Under extreme conditions, such as working for 6 to 8 hours in heavy protective gear, a loss of sodium may occur. Drinking commercially available carbohydrate electrolyte replacement liquids is effective in minimizing physiological disturbances during recovery.

#### B-4.3.3 Heat Exhaustion

Heat exhaustion occurs from increased stress on various body organs due to inadequate blood circulation, cardiovascular insufficiency, or dehydration. Signs and symptoms include:

- pale, cool, moist skin;
- heavy sweating;
- dizziness;
- nausea;
- headache;
- vertigo;
- weakness;
- thirst; and
- giddiness.

Fortunately, this condition responds readily to prompt treatment.

Heat exhaustion should not be dismissed lightly, however, for several reasons. One is that the fainting associated with heat exhaustion can be dangerous because the victim may be operating machinery or controlling an operation that should not be left unattended; moreover, the victim may be injured when he or she faints. Also, the signs and symptoms seen in heat exhaustion are similar to those of heat stroke, which is a medical emergency.

Workers suffering from heat exhaustion should be removed from the hot environment, given fluid replacement, and be encouraged to get adequate rest.

### B-4.3.4 Heat Stroke

Heat stroke is the most serious form of heat stress. Heat stroke occurs when the body's system of temperature regulation fails, and the body's temperature rises to critical levels. This condition is caused by a combination of highly variable factors and its occurrence is difficult to predict.

Heat stroke is a medical emergency. The primary signs and symptoms of heat stroke are:

- confusion;
- irrational behavior;
- loss of consciousness;
- convulsions;
- a lack of sweating (usually);
- hot, dry skin; and
- an abnormally high body temperature, e.g., a rectal temperature of 41°C (105.8°F).

If body temperature is too high, it causes death. The elevated metabolic temperatures caused by a combination of workload and environmental heat load, both of which contribute to heat stroke, are also highly variable and difficult to predict.

If a worker shows signs of possible heat stroke, professional medical treatment should be obtained immediately. The worker should be placed in a shady area and the outer clothing should be removed. The worker's skin should be wetted and air movement around the worker should be increased to improve evaporative cooling until professional methods of cooling are initiated and the seriousness of the condition can be assessed. Fluids should be replaced as soon as possible. The medical outcome of an episode of heat stroke depends on the victim's physical fitness and the timing and effectiveness of first-aid treatment.

Regardless of the worker's protestations, no employee suspected of being ill from heat stroke should be sent home or left unattended unless a physician has specifically approved such an order.

Proper training and preventive measures will help avert serious illness and loss of work productivity. Preventing heat stress is particularly important because once someone suffers from heat stroke or exhaustion, that person may be predisposed to additional heat injuries.

### B-4.3.5 Heat Stress Safety Precautions

Heat-stress monitoring and work-rest cycle implementation should commence when the ambient adjusted temperature exceeds 72°F. A minimum work-rest regimen and procedures for calculating ambient adjusted temperature are described in Table B-3.

**Table B-3**
**Work/Rest Schedule[1]**

| Adjusted Temperature[2] | Work/Rest Regimen Normal Work Ensemble[3] | Work/Rest Regimen Impermeable Ensemble |
|---|---|---|
| 90°F (32.2°C) or above | After each 45 minutes of work | After each 15 minutes of work |
| 87.5°-90°F (30.8°-32.2°C) | After each 60 minutes of work | After each 30 minutes of work |
| 82.5°-87.5°F (28.1°-30.8°C) | After each 90 minutes of work | After each 60 minutes of work |
| 77.5°-82.5°F (25.3°-28.1°C) | After each 120 minutes of work | After each 90 minutes of work |
| 72.5°-77.5°F (30.8°-32.2°C) | After each 150 minutes of work | After each 120 minutes of work |

[1] For work levels of 250 kilocalories/hour (light to moderate type of work)
[2] Calculate the adjusted air temperature (ta adj) by using this equation: ta adj °F = ta °F + (13 x % sunshine). Measure air temperature (ta) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate percent sunshine by judging what percent time the sun is not covered by clouds that are thick enough to produce a shadow. (100% sunshine = no cloud cover and a sharp, distinct shadow; 0% sunshine = no shadows.)
[3] A normal work ensemble consists of cotton coveralls or other cotton clothing with long sleeves and pants.
Source: The information presented above was generated using the information provided in the American Conference of Governmental Industrial Hygienists (ACGIH) *Threshold Limit Values [TLV] Handbook.*

To determine whether the work-rest cycles are adequate for the personnel and specific site conditions, additional monitoring of individual heart rates will be conducted during the rest cycle. To check the heart rate, count the radial pulse for 30 seconds at the beginning of the rest period. If the heart rate exceeds 110 beats per minute, shorten the next work period by one-third and maintain the same rest period.

Additionally, one or more of the following control measures can be used to help control heat stress and is mandatory if any site worker has a heart rate (measure immediately prior to rest period) exceeding 115 beats per minute:

- Site workers will be encouraged to drink plenty of water and electrolyte replacement fluids throughout the day.
- Onsite drinking water will be kept cool (50 to 60°F).
- A work regimen provides adequate rest periods for cooling down will be established, as required.
- All personnel will be advised of the dangers and symptoms of heat stroke, heat exhaustion, and heat cramps.

- Cooling devices, such as vortex tubes or cooling vests, should be used when personnel must wear impermeable clothing in conditions of extreme heat.

- Employees should be instructed to monitor themselves and co-workers for signs of heat stress and to take additional breaks as necessary.

- A shaded rest area must be provided. All breaks should take place in the shaded rest area.

- Employees must not be assigned to other tasks during breaks.

- Employees must remove impermeable garments during rest periods. This includes white Tyvek®-type garments.

- All employees must be informed of the importance of adequate rest, acclimation, and proper diet in the prevention of heat-stress disorders.

## B-4.4 Cold Stress

Cold stress normally occurs in temperatures at or below freezing or under certain circumstances in temperatures of 40°F. Extreme cold for a short time may cause severe injury to exposed body surfaces or result in profound generalized cooling, causing death. Areas of the body that have high surface area-to-volume ratio, such as fingers, toes, and ears, are the most susceptible. Two factors influence the development of a cold-weather injury: ambient temperature and the velocity of the wind. For instance, 10°F with a wind of 15 miles per hour (mph) is equivalent in chilling effect to still air at 18°F. An equivalent chill temperature chart relating the actual dry-bulb temperature and wind velocity is presented in Table B-4.

**Table B-4**
**Chill Temperature Chart**

| Estimated Wind Speed (in mph) | Actual Temperature Reading (°F) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50 | 40 | 30 | 20 | 10 | 0 | -10 | -20 | -30 | -40 | -50 | -60 |
| | Equivalent Chill Temperature (°F) | | | | | | | | | | | |
| Calm | 50 | 40 | 30 | 20 | 10 | 0 | -10 | -20 | -30 | -40 | -50 | -60 |
| 5 | 48 | 37 | 27 | 16 | 6 | -5 | -15 | -26 | -36 | -47 | -57 | -68 |
| 10 | 40 | 28 | 16 | 4 | -9 | -24 | -33 | -46 | -58 | -70 | -83 | -95 |
| 15 | 36 | 22 | 9 | -5 | -18 | -32 | -45 | -58 | -72 | -85 | -99 | -112 |
| 20 | 32 | 18 | 4 | -10 | -25 | -39 | -53 | -67 | -82 | -96 | -110 | -121 |
| 25 | 30 | 16 | 0 | -15 | -29 | -44 | -59 | -74 | -88 | -104 | -118 | -133 |
| 30 | 28 | 13 | -2 | -18 | -33 | -48 | -63 | -79 | -94 | -109 | -125 | -140 |
| 35 | 27 | 11 | -4 | -20 | -35 | -51 | -67 | -82 | -98 | -113 | -129 | -145 |
| 40 | 26 | 10 | -6 | -21 | -37 | -53 | -69 | -85 | -100 | -116 | -132 | -148 |
| **(Wind speeds greater than 40 mph have little additional effect.)** | **Little Danger Maximum danger of false sense of security.** | | | | **Increasing Danger Danger from freezing of exposed flesh within 1 minute.** | | | **Great Danger Flesh may freeze within 30 seconds.** | | | | |
| | **Trench foot and immersion foot may occur at any point on this chart.** | | | | | | | | | | | |

This chart was developed by the U.S. Army Research Institute of Environmental Medicine, Natick, MA.
[Source: ACGIH *TLV Handbook*]

Local injury resulting from cold is included in the generic term "frostbite." There are several degrees of tissue damage associated with frostbite. Frostbite of the extremities can be categorized into:

- *Frost Nip or Incipient Frostbite* — Characterized by sudden blanching or whitening of skin.
- *Superficial Frostbite* — Skin has a waxy or white appearance and is firm to the touch, but tissue beneath is resilient.
- *Deep Frostbite* — Tissues are cold, pale, and solid; extremely serious injury.

Systemic hypothermia is caused by exposure to freezing or rapidly dropping temperature. It can be fatal. Its symptoms are usually exhibited in five stages:

1) shivering;
2) apathy, listlessness, sleepiness, and (sometimes) rapid cooling of the body to less than 95°F;
3) unconsciousness, glassy stare, slow pulse, and slow respiratory rate;
4) freezing of the extremities; and
5) death.

Trauma sustained in freezing or sub-zero conditions requires special attention because an injured worker is predisposed to secondary cold injury. Special provisions must be made to prevent hypothermia and secondary freezing of damaged tissues in addition to providing for first-aid treatment. To avoid cold stress, site personnel must wear protective clothing appropriate for the level of cold and physical activity. In addition to protective clothing, preventive safe work practices, additional training, and warming regimens may be used to prevent cold stress.

### B-4.4.1 Cold Stress Safety Precautions

The following safety precautions should be followed to prevent cold stress:

- For air temperature of 0°F or less, mittens should be used to protect the hands. For exposed skin, continuous exposure should not be permitted when air speed and temperature results in a wind chill temperature of –25°F.
- At air temperatures of 36°F or less, field personnel who become immersed in water or whose clothing becomes wet must be immediately provided with a change of clothing and be treated for hypothermia.
- If work is done at normal temperature or in a hot environment before entering the cold, the field personnel must confirm that their clothing is not wet as a consequence of sweating. If clothing is wet, field personnel must change into dry clothes prior to entering the cold area.
- If the available clothing does not give adequate protection to prevent hypothermia or frostbite, work must be modified or suspended until adequate clothing is made available or until weather conditions improve.
- Field personnel handling evaporative liquid (e.g., gasoline, alcohol, or cleaning fluids) at air temperatures below 40°F must take special precaution to avoid soaking of clothing or gloves with the liquids because of the added danger of cold injury due to evaporative cooling.

### B-4.4.2 Safe Work Practices

The following safe work practices must be employed to prevent cold stress:

- Direct contact between bare skin and cold surfaces (< 20°F) should be avoided. Metal tool handles and/or equipment controls should be covered by thermal insulating material.
- For work performed in a wind chill temperature at or below 10°F, workers should be under constant protective observation (buddy system). The work rate should be established to prevent heavy sweating that will result in wet clothing. For heavy work, rest periods must be taken in heated shelters and workers should be provided with an opportunity to change into dry clothing if needed.
- Field personnel should be provided the opportunity to become accustomed to cold-weather working conditions and required protective clothing.
- Work should be arranged in such a way that sitting or standing still for long periods is minimized.
- During the warming regimen (rest period), field personnel should be encouraged to remove outer clothing to permit sweat evaporation or to change into dry work clothing. Dehydration, or loss of body fluids, occurs insidiously in the cold environment and may increase susceptibility to cold injury due to a significant change in blood flow to the extremities. Fluid replacement with warm, sweet drinks and soups is recommended. The intake of coffee should be limited because of diuretic and circulatory effects.

## B-4.5 Flora/Fauna Hazards

Hazards may include poisonous plants, snakes, ticks, spiders, and mosquitoes.

### B-4.5.1 Poisonous Plants

#### B-4.5.1.1 Hazards

Poisonous plants may be present in the work area. Personnel should be alerted to their presence and instructed on methods to prevent exposure.

#### B-4.5.1.2 Control

The main control is to avoid contact with the plant, cover arms and hands, and frequently wash potentially exposed skin. Particular attention must be given to avoiding skin contact with objects or protective clothing that have touched the plants. Treat every surface that may have touched the plant as contaminated and practice contamination avoidance. If skin contact is made, the area should be washed immediately with soap and water and observed for signs of reddening.

### B-4.5.2 Snakes

#### B-4.5.2.1 Hazards

The possibility of encountering snakes exists, specifically for personnel working in wooded or vegetated areas. Snake venoms are complex and include proteins, some of which have enzymatic activity. The effects produced by venoms include:

- neurotoxic effects with sensory, motor, cardiac, and respiratory difficulties;
- cytotoxic effects on red blood cells, blood vessels, heart muscle, kidneys, and lungs;
- defects in coagulation; and
- effects from local release of substances by enzymatic actions.

Other noticeable effects of venomous snakebites include swelling, edema, and pain around the bite and the development of ecchymosis (the escape of blood into tissues from ruptured blood vessels).

#### B-4.5.2.2 Control

To minimize the threat of snakebites, all personnel walking through vegetated areas must be aware of the potential for encountering snakes and the need to avoid actions that may result in encounters, such as turning over logs. If a snake bite occurs, an attempt should be made to identify the snake via markings and size. The victim must be transported to the nearest hospital within 30 minutes; first aid consists of applying a constriction band and washing the area around the wound to remove any unabsorbed venom.

### B-4.5.3 Ticks

#### B-4.5.3.1 Hazards

Rocky Mountain Spotted Fever (RMSF) is a disease that is transmitted via the bite of an infected tick. The tick must be attached 4 to 6 hours before the disease-causing organism (*Rickettsia rickettsii*) becomes reactivated and can infect humans. The primary symptom of RMSF is the sudden appearance of a moderate-to-high fever. The fever may persist for 2 to 3 weeks. The victim may also have a headache, deep muscle pain, and chills. A rash appears on the hands and feet on about the third day and eventually spreads to all parts of the body. For this reason, RMSF may be confused with measles or meningitis. The disease may cause death, if untreated, but if identified and treated promptly, death is uncommon.

#### B-4.5.3.2 Control

Tick repellant containing diethyltoluamide (DEET) should be used when working in tick-infested areas, and pant legs should be tucked into boots. In addition, workers should search the entire body every 3 or 4 hours for attached ticks. Ticks should be removed promptly and carefully without crushing, since crushing can squeeze the disease-causing organism into the skin. A gentle and steady pulling action should be used to avoid leaving the head or mouth parts in the skin. Hands should be protected with surgical gloves when removing ticks.

### B-4.5.4 Spiders

#### B-4.5.4.1 Hazards

Personnel may encounter spiders during work activities. Two spiders of concern are the black widow and the brown recluse. Both prefer dark sheltered areas such as basements, equipment sheds and enclosures, and woodpiles or other scattered debris. The black widow is shiny black, approximately 1 inch long, and found throughout the United States. There is a distinctive red hourglass marking on the underside of the black widow's body. The bite of a black widow is seldom fatal to healthy adults, but effects include respiratory distress, nausea, vomiting, and muscle spasms. The brown recluse is smaller than the black widow and gets its name from its brown coloring and behavior. The brown recluse is more prevalent in the southern United States. The brown recluse has a distinctive violin shape on the top of its body. The bite of the brown recluse is painful, and the bite site ulcerates and takes many weeks to heal completely.

#### B-4.5.4.2 Control

To minimize the threat of spider bites, all personnel walking through vegetated areas must be aware of the potential for encountering these arachnids. Personnel need to avoid actions that may result in encounters, such as turning over logs and placing hands in dark places such as behind equipment or in corners of equipment sheds or enclosures. If a spider bite occurs, the victim must be transported to the nearest hospital as soon as possible; first aid consists of applying ice packs and washing the area around the wound to remove any unabsorbed venom.

### B-4.5.5 Mosquitoes

#### B-4.5.5.1 Hazards

Personnel may be exposed to mosquitoes during work activities. Typical exposure to mosquitoes does not present a significant hazard. However, if West Nile virus is prevalent in the area, exposure to this virus is increased. West Nile virus results in flu-like symptoms and can be serious if not treated or in immune compromised individuals.

#### B-4.5.5.2 Control

To minimize the threat of mosquito bites, all personnel working outside must be aware of the potential for encountering mosquitoes and implement the basic precautions listed below:

- Avoid working at dawn or dusk when mosquitoes are most active.
- Prevent accumulation of standing water at the work site.
- Apply an insect repellent that contains DEET to exposed skin and to clothing.

- Wear light-colored clothes, preferably with long sleeves and full-length pants.
- Do not touch any dead birds or animals that are encountered.

If dead birds are detected near the site, report them to the local County Health Department. If flu-like symptoms are present, contact your doctor or the HSO for more information.

## B-4.6 Noise

### B-4.6.1 Hazards

Exposure to noise over the appropriate action level can cause temporary impairment of hearing; prolonged and repeated exposure can cause permanent damage to hearing. The risk and severity of hearing loss increase with the intensity and duration of exposure to noise. In addition to damaging hearing, noise can impair voice communication, thereby increasing the risk of accidents onsite.

### B-4.6.2 Control

All personnel must wear hearing protection, with a noise reduction rating (NRR) of at least 20 dBA, when noise levels exceed 85 dBA. When it is difficult to hear a co-worker at normal conversation distance, the noise level is approaching or exceeding 85 dBA and hearing protection is necessary. All site personnel who may be exposed to noise must also receive baseline and annual audiograms and training as to the causes and prevention of hearing loss. Noise monitoring is discussed in Section B-6.2.

Whenever possible, equipment that does not generate excessive noise levels will be selected. If the use of noisy equipment is unavoidable, barriers or increased distances will be used to minimize worker exposure to noise, if feasible.

## B-4.7 Spill Control

All personnel must take every precaution to minimize the potential for spills during site operations. All onsite personnel must immediately report any discharge, no matter how small, to the SS.

Spill control equipment and materials will be located onsite in the areas that present the potential for discharge. All sorbent materials used to clean up spills will be containerized and labeled appropriately. In the event of a spill, the SS will follow the emergency provisions in Section B-9 to contain and control released materials and to prevent their spread to offsite areas.

## B-4.8 Sanitation

Site sanitation will be maintained according to appropriate federal, state, and local requirements as described in the following sections.

### B-4.8.1 Break Area

Breaks must be taken in the SZ or on the vessel, away from the active work area, after site personnel go through decontamination procedures. There will be no smoking, eating, drinking, or chewing gum or tobacco in any area other than the SZ.

### B-4.8.2 Potable Water

The following rules regarding potable water apply to all field operations:

- An adequate supply of potable water will be provided at each project site. Potable water must be kept away from hazardous materials or media and contaminated clothing or equipment.
- Portable containers used to dispense drinking water must be capable of being tightly closed and must be equipped with a tap dispenser. Water must not be consumed directly from the container (drinking from the tap is prohibited) or removed from the container by dipping.
- Containers used for drinking water must be clearly marked and must not be used for any other purpose.

Disposable drinking cups must be provided. A sanitary container for dispensing cups and a receptacle for disposing of used cups is required.

### B-4.8.3 Sanitary Facilities

Access to facilities for washing before eating, drinking, or smoking, or alternative methods such as waterless hand cleaner and paper towels, will be provided.

### B-4.8.4 Lavatory

If permanent toilet facilities are not available, an appropriate number of portable chemical toilets will be provided.

This requirement does not apply to mobile crews or to normally unattended site locations so long as employees at these locations have transportation immediately available to nearby toilet facilities.

## B-4.9 Emergency Equipment

Adequate emergency equipment for the activities being conducted onsite and as required by applicable sections of 29 CFR 1910 and 29 CFR 1926 will be onsite prior to commencing project activities. Personnel will be provided with access to emergency equipment including, but not limited to, the following:

- fire extinguishers of adequate size, class, number, and location as required by applicable sections of 29 CFR 1910 and 1926;

- industrial first-aid kits of adequate size for the number of personnel onsite; and
- emergency eyewash and/or shower if required by operations being conducted onsite.

## B-4.10 Electrical Safety

Electricity may pose a particular hazard to site workers due to the use of portable electrical equipment. If wiring or other electrical work is needed, a qualified electrician must perform it.

General electrical safety requirements include:

- All electrical wiring and equipment must be of a type listed by Underwriters Laboratory (UL), Factory Mutual Engineering Corporation (FM), or other recognized testing or listing agency.
- All installations must comply with the National Electrical Safety Code (NESC), the National Electrical Code (NEC), or USCG regulations.
- Portable and semi-portable tools and equipment must be grounded by a multi-conductor cord having an identified grounding conductor and a multi-contact polarized plug-in receptacle.
- Tools protected by an approved system of double insulation, or its equivalent, need not be grounded. Double-insulated tools must be distinctly marked and listed by UL or FM.
- Live parts of wiring or equipment must be guarded to prevent persons or objects from touching them.
- Electric wire or flexible cord passing through work areas must be covered or elevated to protect it from damage by foot traffic, vehicles, sharp corners, projections, or pinching.
- All circuits must be protected from overload.
- Temporary power lines, switchboxes, receptacle boxes, metal cabinets, and enclosures around equipment must be marked to indicate the maximum operating voltage.
- Plugs and receptacles must be kept out of water unless of an approved submersible construction.
- All extension cord outlets must be equipped with ground-fault-circuit interrupters (GFCIs).
- Attachment plugs or other connectors must be equipped with a cord grip and be constructed to endure rough treatment.
- Extension cords or cables must be inspected prior to each use and replaced if worn or damaged. Cords and cables must not be fastened with staples, hung from nails, or suspended by bare wire.
- Flexible cords must be used only in continuous lengths without splice, with the exception of molded or vulcanized splices made by a qualified electrician.

## B-4.11 Lifting Safety

Using proper lifting techniques may prevent back strain or injury. The fundamentals of proper lifting include:

- Consider the size, shape, and weight of the object to be lifted. A mechanical lifting device or additional persons must be used to lift an object if it cannot be lifted safely alone.
- The hands and the object should be free of dirt or grease that could prevent a firm grip.
- Gloves must be used and the object inspected for metal slivers, jagged edges, burrs, or rough or slippery surfaces.
- Fingers must be kept away from points that could crush or pinch them, especially when putting an object down.
- Feet must be placed far enough apart for balance. The footing should be solid and the intended pathway should be clear.
- The load should be kept as low as possible, close to the body with the knees bent.
- To lift the load, grip firmly and lift with the legs, keeping the back as straight as possible.
- A worker should not carry a load that he or she cannot see around or over.
- When putting an object down, the stance and position are identical to that for lifting; the legs are bent at the knees, and the back is straight as the object is lowered.

# B-5. Personal Protective Equipment

## B-5.1 Levels of Protection

PPE is required to safeguard site personnel from various hazards. Varying levels of protection may be required depending on the levels of COPCs and the degree of physical hazard. This section presents the various levels of protection and defines the conditions of use for each level. Table B-5 summarizes the available levels of personal protection.

### B-5.1.1 Level D Protection

The minimum level of protection that is required of BBL personnel and subcontractors at the site is Level D, which is worn when site conditions present minimal dermal exposure hazard and no inhalation hazard. Level D protection includes the following equipment:

- work clothing as prescribed by weather;
- high-visibility safety apparel when working in active areas at Terminal 4, around vehicle traffic and during times of low visibility (darkness and inclement weather) (ANSI/ISEA 107-1999);
- steel-toe work boots, meeting American National Standards Institute (ANSI) Z41;
- safety glasses with side shields or goggles, meeting ANSI Z87;
- hard hat, meeting ANSI Z89, when falling object hazards are present;
- hearing protection (if noise levels exceed 85 dBA, then hearing protection with a USEPA NRR of at least 20 dBA must be used); and
- PFD if working over or near water.

### B-5.1.2 Modified Level D Protection

Modified Level D will be used when airborne contaminants are not present at levels of concern, but site activities present an increased potential for skin contact with contaminated materials. Modified Level D consists of:

- nitrile gloves worn over nitrile surgical gloves;
- latex/polyvinyl chloride (PVC) overboots when contact with COPC-impacted media is anticipated;
- steel-toe work boots, meeting ANSI Z41;
- high-visibility safety apparel when working in active areas at Terminal 4, around vehicle traffic and during times of low visibility (darkness and inclement weather) (ANSI/ISEA 107-1999);
- safety glasses or goggles, meeting ANSI Z87;
- face shield in addition to safety glasses or goggles when projectiles or splash hazards exist;
- hard hat, meeting ANSI Z89 when falling object hazards are present;
- hearing protection (if noise levels exceed 85 dBA, then hearing protection with a USEPA NRR of at least 20 dBA must be used);
- Tyvek® suit (polyethylene coated Tyvek® suits for handling liquids) when body contact with COPC-impacted media is anticipated; and
- PFD if working on or near the water.

### B-5.1.3 Level C Protection

Level C protection will be required when the airborne concentration of COPCs reaches one-half of the OSHA Permissible Exposure Limit (PEL) or American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value. The following equipment will be used for Level C protection:

- full-face, NIOSH approved air-purifying respirator with appropriate cartridges for site COPCs;
- Tyvek® suit with ankles and cuffs taped to boots and gloves;
- nitrile outer gloves worn over nitrile surgical gloves;
- steel-toe work boots, meeting ANSI Z41;
- high-visibility safety apparel when working in active areas at Terminal 4, around vehicle traffic and during times of low visibility (darkness and inclement weather) (ANSI/ISEA 107-1999);
- chemical-resistant boots with steel toes or latex/PVC overboots over steel-toe boots;
- hard hat, meeting ANSI Z89;
- hearing protection (if noise levels exceed 85 dBA, then hearing protection with a USEPA NRR of at least 20 dBA must be used); and
- PFD if working on or near the water.

## B-5.2 PPE Selection

PPE will be selected based on the potential for contact, site conditions, ambient air quality, and the judgment of supervising site personnel and health and safety professionals. The PPE used will be chosen to be effective against the COPCs present on site.

Specifically, the level of PPE selected will be based on air monitoring of the work environment and an assessment by the SS and HSS of the potential for skin contact with COPCs. The PPE selection matrix is presented in Table B-5. This matrix is based on information available at the time this plan was written. The Airborne Contaminant Action Levels in Table B-6 (in Section B-6) should be used to verify that the PPE prescribed in Table B-5 is appropriate.

**Table B-5**
**PPE Selection Matrix**

| Task | Anticipated Level of Protection |
|---|---|
| Mobilization | Level D |
| Field Sampling | Modified Level D |
| Installation of Wells | Modified Level D |
| Decontamination | Modified Level D |
| Demobilization | Level D/Modified Level D |

## B-5.3 Site Respiratory Protection Program

Respiratory protection is an integral part of employee health and safety at the site due to potentially hazardous concentrations of airborne COPCs. The site respiratory protection program will consist of the following elements (at a minimum):

- All onsite personnel who may use respiratory protection will have an assigned respirator.
- All onsite personnel who may use respiratory protection will have been fit-tested and trained in the use of a full-face air-purifying respirator within the past 12 months.
- All onsite personnel who may use respiratory protection must, within the past year, have been medically certified as being capable of wearing a respirator. Documentation of the medical certification must be provided to the HSS prior to commencing site work.
- Only cleaned, maintained, National Institute for Occupational Safety and Health (NIOSH)-approved respirators will be used.
- If respirators are used, the respirator cartridge is to be properly disposed of at the end of each work shift or when load-up or breakthrough occurs.
- Contact lenses are not to be worn when a respirator is worn.
- All onsite personnel who may use respiratory protection must be clean-shaven. Mustaches and sideburns are permitted, but they must not touch the sealing surface of the respirator.
- Respirators will be inspected and a negative-pressure test performed prior to each use.
- After each use, the respirator will be wiped with a disinfectant, cleansing wipe. When used, the respirator will be thoroughly cleaned at the end of the work shift. The respirator will be stored in a clean plastic bag, away from direct sunlight in a clean, dry location in a manner that will not distort the face piece.

## B-5.4 Using PPE

Depending on the level of protection selected, specific donning and doffing procedures may be required. The procedures presented in this section are mandatory if Modified Level D or Level C PPE is used. All personnel entering the EZ must don the required PPE in accordance with the requirements of this HASP. When leaving the EZ, personnel will remove the PPE in accordance with the doffing procedures to minimize the spread of COPCs.

### B-5.4.1 Donning Procedures

These procedures are mandatory only if Modified Level D or Level C PPE is used onsite:

- Remove bulky outerwear. Remove street clothes and store in clean location.

- Put on work clothes or coveralls.
- Put on the required chemical-protective coveralls.
- Put on the required chemical-protective boots or boot covers.
- Tape the legs of the coveralls to the boots with duct tape.
- Put on the required chemical-protective gloves.
- Tape the wrists of the protective coveralls to the gloves.
- Don the required respirator and perform appropriate fit check (Level C).
- Put hood or head covering over head and respirator straps and tape hood to face piece (Level C).
- Don remaining PPE, such as safety glasses or goggles and hard hat.

When these procedures are instituted, one person must remain outside the work area to confirm that each person entering has the proper protective equipment.

### B-5.4.2 Doffing Procedures

The following procedures are only mandatory if Modified Level D or Level C PPE is required for the site. Whenever a person leaves the work area, the following decontamination sequence will be followed:

- Upon entering the CRZ, rinse contaminated materials from the boots or remove contaminated boot covers.
- Clean reusable protective equipment.
- Remove protective garments, equipment, and respirator (Level C). All disposable clothing should be placed in plastic bags that are labeled with contaminated-waste labels.
- Wash hands, face, and neck (or shower if necessary).
- Proceed to clean area and dress in clean clothing.
- Clean and disinfect respirator for next use.

All disposable equipment, garments, and PPE must be bagged in plastic bags labeled for disposal. See Section B-7 for detailed information on decontamination stations.

# B-6. Air and Noise Monitoring

## B-6.1 Air Monitoring

Air monitoring will be conducted based on site-specific conditions to determine employee exposure to airborne constituents. If there is no odor, discoloration, or obvious contamination, air monitoring may not be required. The SS will determine whether air monitoring will be required at each location. The monitoring results will dictate work procedures and the selection of PPE. The monitoring device to be used is a Multi Rae detector photoionization detector (PID) (10.6 eV lamp) with oxygen, LEL, carbon monoxide, and hydrogen sulfide sensors. The HSS will be responsible for using the air monitoring results to determine appropriate health and safety precautions for BBL personnel and subcontractors. A copy of the Air Monitoring Log is provided in Attachment G.

Air monitoring will be conducted continuously with the LEL/oxygen meter during drilling and core sampling in areas where flammable vapors or gases are suspect. Work activity must stop where tests indicate that the concentration of flammable vapors exceeds 10% of the LEL at a location with a potential ignition source. Such an area must be ventilated to reduce the concentration to an acceptable level.

Colorimetric detector tubes will be used to measure benzene concentrations in areas where total hydrocarbons are detected in excess of 5 parts per million (ppm).

## B-6.2 Noise Monitoring

Noise monitoring may be conducted as required. Hearing protection is mandatory for all employees in noise hazardous areas, such as around heavy equipment. As a general rule, sound levels that cause speech interference at normal conversation distance should require the use of hearing protection.

## B-6.3 Monitoring Equipment Maintenance and Calibration

All direct-reading instrumentation calibrations should be conducted under the approximate environmental conditions under which the instrument will be used. Instruments must be calibrated before and after use, and the readings and any necessary adjustments noted. All air monitoring equipment calibrations, including the standard used for calibration, must be documented on a calibration log or in the field notebook. All completed documentation/forms must be reviewed by the HSS and maintained by the SS.

All air-monitoring equipment will be maintained and calibrated in accordance with the specific manufacturer's procedures. Preventive maintenance and repairs will be conducted in accordance with the respective manufacturer's procedures. When applicable, only manufacturer-trained and/or authorized personnel will be allowed to perform instrument repairs or preventive maintenance.

If an instrument is found to be inoperative or suspected of giving erroneous readings, the HSS must be responsible for immediately removing the instrument from service and obtaining a replacement unit. If the instrument is essential for safe operation during a specific activity, that activity must cease until an appropriate replacement unit is obtained. The HSS will be responsible for confirming that a replacement unit is obtained and/or repairs are initiated on the defective equipment.

## B-6.4 Action Levels

Table B-6 presents airborne contaminant action levels that will be used to determine the procedures and protective equipment necessary based on conditions as measured at the site.

**Table B-6**
**Airborne Contaminant Action Levels**

| Parameter | Reading | Action |
|---|---|---|
| Total Hydrocarbons | 0 to ≤ 5 ppm | Normal operations; continue hourly breathing-zone monitoring. |
| | > 5 to 25 ppm | Upgrade to Level C PPE if conditions persist, monitor for benzene with colorimetric detector tubes. |
| | > 25 ppm | Stop work; investigate cause of reading. |
| Oxygen | ≤ 19.5% | Stop work, evacuate work area, investigate cause of reading, and ventilate area. |
| | > 19.5 to < 23.5% | Normal operations. |
| | ≥ 23.5% | Stop work, evacuate work area, investigate cause of reading, and ventilate area. |
| Carbon Monoxide | 0 to ≤ 20 ppm | Normal operations. |
| | > 20 ppm | Stop work, evacuate confined spaces/work area, investigate cause of reading, and ventilate area. |
| Hydrogen Sulfide | 0 to ≤ 5 ppm | Normal operations. |
| | > 5 ppm | Stop work, evacuate confined spaces/work area, investigate cause of reading, and ventilate area. |
| Flammable Vapors (LEL) | < 10% LEL | Normal operations. |
| | ≥ 10% LEL | Stop work, ventilate area, investigate source of vapors. |

# B-7. Work Zones and Decontamination

## B-7.1 Work Zones

### B-7.1.1 Authorization to Enter

Only personnel with the appropriate training and medical certifications (if respirators are required) will be allowed to work at the project site. The SS will maintain a list of authorized persons; only personnel on the authorized-persons list will be allowed to enter the site work areas.

### B-7.1.2 Site Orientation and Hazard Briefing

No person will be allowed in the work area during site operations without first being given a site orientation and hazard briefing. This orientation will be presented by the SS or HSS and will consist of a review of this HASP. This review must cover the chemical, physical, and biological hazards; protective equipment; safe work procedures; and emergency procedures for the project. Following this initial meeting, safety meetings will be held each day before work begins.

All people entering the site work areas, including visitors, must document their attendance at the orientation and hazard briefing, as well as at the daily safety meetings, on the forms included with this plan.

### B-7.1.3 Certification Documents

A training and medical file may be established for the project and kept onsite during all site operations. Specialty training, such as first aid/ CPR, as well as current medical clearances for all project field personnel required to wear respirators, will be maintained in that file. All BBL and subcontractor personnel must provide their training and medical documentation to the HSS prior to starting work.

### B-7.1.4 Entry Log

A log-in/log-out sheet will be maintained onsite by the SS. Personnel must sign in and out on a log sheet as they enter and leave the work area, and the SS may document entry and exit in the field notebook.

### B-7.1.5 Entry Requirements

In addition to the authorization, hazard briefing, and certification requirements listed above, no person will be allowed in any BBL work area unless they are wearing the minimum PPE as described in Section B-5.

### B-7.1.6 Emergency Entry and Exit

People who must enter the work area on an emergency basis will be briefed of the hazards by the SS. All activities will cease in the event of an emergency. People exiting the work area because of an emergency will gather in a safe area for a head count. The SS is responsible for confirming that all people who entered the work area have exited in the event of an emergency.

### B-7.1.7 Contamination-Control Zones

Contamination-control zones are maintained to prevent the spread of contamination and to prevent unauthorized people from entering hazardous areas.

#### B-7.1.7.1 Exclusion Zone

An EZ may consist of a specific work area or may be the entire area of potential contamination. All employees entering an EZ must use the required PPE and must have the appropriate training and medical clearance for hazardous waste work. The EZ is the defined area where there is a possible respiratory and/or contact health hazard. Cones, caution tape, or a site diagram will identify the location of each EZ.

#### B-7.1.7.2 Contamination-Reduction Zone

The CRZ or transition area will be established, if necessary, to perform decontamination of personnel and equipment. All personnel entering or leaving the EZ will pass through this area to prevent any cross-contamination. Tools, equipment, and machinery will be decontaminated in a specific location. All personnel will be decontaminated onsite adjacent to the EZ. Personal protective outer garments and respiratory protection will be removed in the CRZ and prepared for cleaning or disposal. This zone is the only appropriate corridor between the EZ and the SZ.

#### B-7.1.7.3 Support Zone

The SZ is a clean area outside the CRZ located to prevent employee exposure to hazardous substances. Eating and drinking will be permitted in the support area only after proper decontamination. Smoking may be permitted in the SZ, subject to site requirements.

### B-7.1.8 Posting

Work areas will be prominently marked and delineated using cones, caution tape, or a site diagram.

### B-7.1.9 Site Inspections

The SS will conduct a daily inspection of site activities, equipment, and procedures to verify that the required elements are in place. The Health and Safety Inspection Form in Attachment H may be used as a guide for daily inspections. A monthly SWO must also be completed and forwarded to the PM for review.

## B-7.2 Decontamination

### B-7.2.1 Personnel Decontamination

All personnel wearing Modified Level D or Level C protective equipment in the EZ must undergo personal decontamination prior to entering the SZ. The personnel decontamination area will consist of the following stations, at a minimum:

- *Station 1* — Personnel leaving the contaminated zone will remove the gross contamination from their outer clothing and boots.
- *Station 2* — Personnel will remove their outer garment and gloves and dispose of them in properly labeled containers. Personnel will then decontaminate their hard hats and boots with an aqueous solution of detergent or other appropriate cleaning solution. These items are then hand-carried to the next station.
- *Station 3* — Personnel will thoroughly wash their hands and face before leaving the CRZ. Respirators will be sanitized and then placed in a clean plastic bag.

### B-7.2.2 Equipment Decontamination

All vehicles that have entered the EZ will be decontaminated at the decontamination pad prior to leaving the zone. If the level of vehicle contamination is low, decontamination may be limited to rinsing tires and wheel wells with water. If the vehicle is significantly contaminated, steam cleaning or pressure washing of the vehicle and equipment may be required.

### B-7.2.3 PPE Decontamination

Where and whenever possible, single-use, external protective clothing must be used for work within the EZ or CRZ. This protective clothing must be disposed of in properly labeled containers. Reusable protective clothing will be rinsed onsite with detergent and water. The rinsate will be collected for disposal.

When removed from the CRZ, the respirator will be thoroughly cleaned with soap and water. The respirator face piece, straps, valves, and covers must be thoroughly cleaned at the end of each work shift and ready for use prior to the next shift. Respirator parts may be disinfected with a solution of bleach and water or by using a spray disinfectant.

# B-8. Training and Medical Surveillance

## B-8.1 Training

### B-8.1.1 General

All onsite project personnel who work in areas where they may be exposed to site contaminants must be trained as required by OSHA Regulation 29 CFR 1910.120 (HAZWOPER). Field employees also must receive a minimum of 3 days of actual field experience under the direct supervision of a trained, experienced supervisor. Personnel who completed their initial training more than 12 months prior to the start of the project must have completed an 8-hour refresher course within the past 12 months. The SS must have completed an additional 8 hours of supervisory training and must have current first-aid and CPR certificates.

### B-8.1.2 Basic 40-Hour Course

The following is a list of the topics typically covered in a 40-hour HAZWOPER training course:

- general safety procedures;
- physical hazards (fall protection, noise, heat stress, cold stress);
- names and job descriptions of key personnel responsible for site health and safety;
- safety, health, and other hazards typically present at hazardous waste sites;
- use, application, and limitations of PPE;
- work practices by which employees can minimize risks from hazards;
- safe use of engineering controls and equipment onsite;
- medical surveillance requirements;
- recognition of symptoms and signs that might indicate overexposure to hazards;
- worker right-to-know (Hazard Communication OSHA 1910.1200);
- routes of exposure to contaminants;
- engineering controls and safe work practices;
- components of a health and safety program and a site-specific HASP;
- decontamination practices for personnel and equipment;
- confined-space entry procedures; and
- general emergency response procedures.

### B-8.1.3 Supervisor Course

Managers and supervisors must receive an additional 8 hours of training, which typically includes:

- general site safety and health procedures;
- PPE programs; and
- air monitoring techniques.

### B-8.1.4 Site-Specific Training

Site-specific training will be accomplished by having onsite personnel read this HASP or through a thorough site briefing by the PM, SS, or HSS on the contents of this HASP before work begins. The review must include a discussion of the chemical, physical, and biological hazards; protective equipment and safety procedures; and emergency procedures.

### B-8.1.5 Daily Safety Meetings

Daily safety meetings will be held to cover the work to be accomplished, hazards anticipated, PPE and procedures required to minimize site hazards, and emergency procedures. The SS or HSS should present these meetings prior to beginning the day's fieldwork. No work will be performed in an EZ before the daily safety meeting has been held. The daily safety meeting must also be held prior to new tasks and repeated if new hazards are encountered. The Safety Meeting Log is included in Attachment I.

### B-8.1.6 First Aid and CPR

At least one employee current in first aid and CPR will be assigned to the work crew and will be onsite during operations. Refresher training in first aid (triennially) and CPR (annually) is required to keep the certificate current. These individuals must also receive training regarding the precautions and protective equipment necessary to protect against exposure to blood-borne pathogens.

## B-8.2 Medical Surveillance

### B-8.2.1 Medical Examination

All personnel who are potentially exposed to site contaminants must participate in a medical surveillance program as defined by OSHA at 29 CFR 1910.120(f).

### B-8.2.2 Pre-Placement Medical Examination

All potentially exposed personnel must have completed a comprehensive medical examination prior to assignment and periodically thereafter as defined by applicable regulations. The pre-placement and periodic medical examinations typically include the following elements:

- medical and occupational history questionnaire;
- physical examination;
- complete blood count, with differential;
- liver enzyme profile;
- chest X-ray, at a frequency determined by the physician;
- pulmonary function test;
- audiogram;
- electrocardiogram for persons older than 45 years of age or if indicated during the physical examination;

- drug and alcohol screening, as required by job assignment;
- visual acuity; and
- follow-up examinations, at the discretion of the examining physician or the corporate medical director.

The examining physician provides the employee with a letter summarizing his/her findings and recommendations, confirming the worker's fitness for work and ability to wear a respirator. Documentation of medical clearance will be available for each employee during all project site work.

Subcontractors will certify that all their employees have successfully completed a physical examination by a qualified physician. The physical examinations must meet the requirements of 29 CFR 1910.120 and 29 CFR 1910.134. Subcontractors will supply copies of the medical examination certificate for each onsite employee.

### B-8.2.3 Other Medical Examinations

In addition to pre-employment, annual, and exit physicals, personnel may be examined:

- at employee request after known or suspected exposure to toxic or hazardous materials; and
- at the discretion of the HSS, HSO, or occupational physician in anticipation of, or after known or suspected, exposure to toxic or hazardous materials.

### B-8.2.4 Periodic Exam

Following the pre-placement examination, all employees must undergo a periodic examination, similar in scope to the pre-placement examination. For employees potentially exposed more than 30 days per year, the frequency of periodic examinations will be annual. For employees potentially exposed less than 30 days per year, the frequency for periodic examinations will be 24 months.

### B-8.2.5 Medical Restriction

When the examining physician identifies a need to restrict work activity, the employee's supervisor must communicate the restriction to the employee and the HSS. The terms of the restriction will be discussed with the employee and the supervisor.

# B-9. Emergency Procedures

## B-9.1 General

Prior to the start of operations, the work area will be evaluated for the potential for fire, contaminant release, or other catastrophic event. Unusual conditions or events, activities, chemicals, and conditions will be reported to the SS/HSS immediately.

The SS/HSS will establish evacuation routes and assembly areas for the site. All personnel entering the site will be informed of these routes and assembly areas.

## B-9.2 Emergency Response

If an incident occurs, the SS or HSS should take the following steps:

- Evaluate the incident and assess the need for assistance and/or evacuation.
- Call for outside assistance as needed.
- Confirm that the PM is notified promptly of the incident.
- Take appropriate measures to stabilize the incident scene.

### B-9.2.1 Fire

In the case of a fire onsite, the SS/HSS will assess the situation and direct fire-fighting activities. The SS/HSS will confirm that the PM is immediately notified of any fires. Site personnel will attempt to extinguish the fire with available extinguishers, if safe to do so. In the event of a fire that site personnel are unable to safely extinguish with one fire extinguisher, the local fire department will be summoned.

### B-9.2.2 Contaminant Release

In the event of a contaminant release, the following steps will be taken:

- Notify SS/HSS immediately.
- Evacuate immediate area of release.
- Conduct air monitoring to determine needed level of PPE.
- Don required level of PPE and prepare to implement control procedures.

The SS/HSS has the authority to commit resources as needed to contain and control released material and to prevent its spread to offsite areas.

### B-9.3 Medical Emergency

All employee injuries must be promptly reported to the HSS/SS, who will:

- Confirm that the injured employee receives prompt first aid and medical attention.
- In emergency situations, see that the worker is transported by appropriate means to the nearest urgent care facility (normally a hospital emergency room).
- If the injured person is a BBL employee, notify ClinNet, BBL's medical surveillance consultant, as soon as possible after an injured worker has left the site. The caller should dial 1-800-229-3674 and follow the instructions for reaching the Injury Management Office. When the Case Manager answers, the caller should provide the information requested by the Case Manager.

#### B-9.3.1 Emergency Care Steps

Upon entering an accident area, site personnel must follow these emergency care steps:

- Survey the scene. Determine whether it is safe to proceed. Try to determine whether the conditions that caused the incident are still a threat. Protect yourself from exposure before attempting to rescue the victim.
- Do a primary survey of the victim. Check for airway obstruction, breathing, and pulse. Assess likely routes of chemical exposure by examining the eyes, mouth, nose, and skin of the victim for symptoms.
- Phone Emergency Medical Services (EMS). Give the location, telephone number used, caller's name, what happened, number of victims, victim's or victims' condition, and help being given.
- Maintain airway and perform rescue breathing as necessary.
- Perform CPR as necessary.
- Do a secondary survey of the victim. Check vital signs and do a head-to-toe exam.
- Treat other conditions as necessary. If the victim can be moved, take him/her to a location away from the work area where EMS can gain access.

### B-9.4 First Aid — General

All persons must report any injury or illness to their immediate supervisor or the SS. Trained personnel will provide first aid. Injuries and illnesses requiring medical treatment must be documented. The SS and HSS must conduct an II as soon as emergency conditions no longer exist and first aid and/or medical treatment has been confirmed. IIs must be completed and submitted to the PM within 24 hours after the incident.

If first-aid treatment is required, first-aid kits are kept at the CRZ. If treatment beyond first aid is required, the injured person(s) should be transported to the medical facility. If the injured person is not ambulatory, or shows any sign of not being in a comfortable and stable condition for transport, then an ambulance and/or paramedics should be summoned. If there is any doubt as to the injured worker's condition, it is best to let the local paramedic or ambulance service examine and transport the worker.

### B-9.4.1 First Aid — Inhalation

Any employee complaining of symptoms of chemical overexposure as described in Section B-4 will be removed from the work area and transported to the designated medical facility for examination and treatment.

### B-9.4.2 First Aid — Ingestion

Call EMS and consult a poison control center for advice. If available, refer to the MSDS for treatment information. If the victim is unconscious, keep him/her on his/her side and clear the airway if vomiting occurs.

### B-9.4.3 First Aid — Skin Contact

Project personnel who have had skin contact with contaminants will, unless the contact is severe, proceed through the CRZ to the wash area. Personnel will remove any contaminated clothing and then flush the affected area with water for at least 15 minutes. The worker should be transported to the medical facility if he/she shows any sign of skin reddening, irritation, or if he/she requests a medical examination.

### B-9.4.4 First Aid — Eye Contact

Project personnel who have had contaminants splashed in their eyes or who have experienced eye irritation while in the EZ must immediately proceed to the eyewash station in the CRZ. Do not decontaminate prior to using the eyewash. Remove whatever protective clothing is necessary to use the eyewash. Flush the eye with clean running water for at least 15 minutes. Arrange prompt transport to the designated medical facility.

## B-9.5 Reporting Injuries, Illnesses, and Near-Miss Incidents

Injuries and illnesses, however minor, will be reported to the SS immediately. The SS will complete an injury report and submit it to the HSO and the PM within 24 hours.

Near-miss incidents are situations in which no injury or property damage occurred, but under slightly different circumstances an injury or property damage could have occurred. Near misses are caused by the same factors as injuries; therefore, they must be reported and investigated in the same manner. A Safe Performance Self-Assessment (SPSA) must be done immediately after an injury, illness, near miss, or other incident to determine whether it is safe to proceed with the work.

## B-9.6 Emergency Information

The means to summon local public response agencies such as police, fire, and ambulance will be reviewed in the daily safety meeting These agencies are identified in Table B-7

**Table B-7**
**Emergency Contacts**

| EMERGENCY/CONTINGENCY CONTACT TELEPHONE LIST | | |
|---|---|---|
| LOCAL EMERGENCY CONTACTS | | PHONE NUMBER |
| COAST GUARD | | 911 or 206-220-7001 or Channel 16 on VHF-FM radio |
| FIRE DEPARTMENT | | 911 |
| LOCAL POLICE | | 911 |
| SHERIFF | | 911 |
| STATE POLICE | | 911 |
| HOSPITAL<br><br>Legacy Emanuel Children's Hospital<br>2801 N Gantenbein Avenue, Portland | | 503-413-2500 |
| PROJECT EMERGENCY CONTACTS | | |
| BBL Project Manager | Philip Spadaro | (206) 273-7555 (Office)<br>(206) 390-2842 (Mobile) |
| BBL Health and Safety Supervisor | Randi Wexler | (503) 535-0696 (Office)<br>(503) 913-8249 (Mobile) |
| BBL Site Supervisors | Brooke Miller/ | (503) 535-0696 (Office)<br>(503) 866-5764 (Mobile) |
| | Shannon Dunn | (206) 273-7555 (Office)<br>(206) 399-5307 (Mobile) |

| | |
|---|---|
| Jamie Beaver | (971) 409-2478 (Mobile)<br>(503) 535-0696 (Office) |
| OTHER EMERGENCY CONTACTS | |
| Port of Portland Primary Field Contact Frank Schmidt | (503) 460-4857 (Office)<br>(503) 799-3524 (Mobile)<br>(503) 548-1519 (Pager) |
| | |

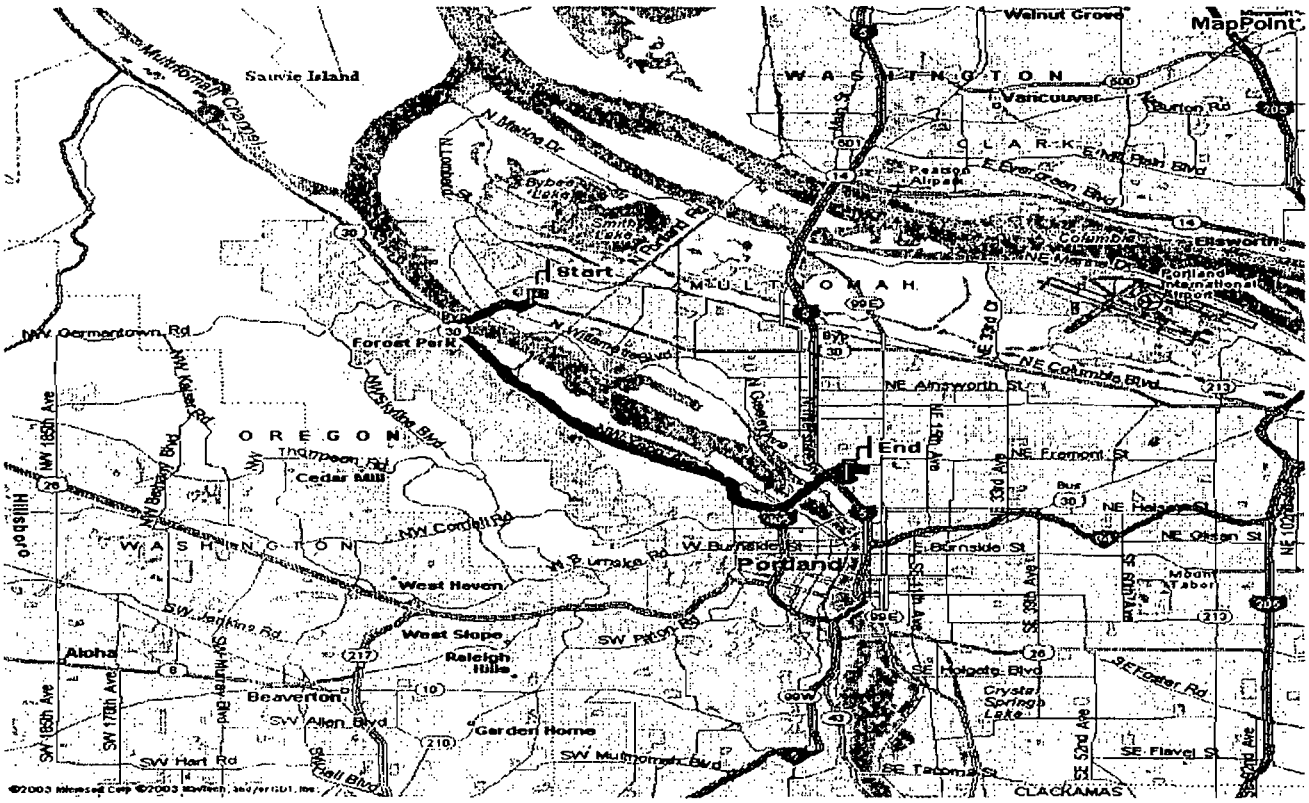
### B-9.6.1 Directions to Hospital

Direction to Legacy Emanuel Children's Hospital

Directions from Terminal 4 site

Turn right out of Terminal onto Lombard
Continue on Lombard until North Ivanhoe, bear right
Turn right on to St Helens and cross St Johns Bridge
At the end of the bridge, bear left and then bear right onto US 30
Take left ramp onto I-405 toward The Dalles/Seattle
Stay straight toward Kerby Avenue, turn right onto Kerby
Turn left onto North Graham, continue on until Gantenbein

**Figure B-1: Map to Legacy Emanuel Children's Hospital**



# B-10. Acronyms and Abbreviations

| | |
|---|---|
| AAUS | American Academy of Underwater Sciences |
| ACGIH | American Conference of Governmental Industrial Hygienists |
| ANSI | American National Standards Institute |
| BEP | bis(2-ethylhexyl)phthalate |
| BBL | Blasland, Bouck and Lee, Inc. |
| CFR | Code of Federal Regulations |
| COPC | constituents of potential concern |
| CPR | cardiopulmonary resuscitation |
| CRZ | contamination-reduction zone |
| DEET | diethyltoluamide |
| DSO | diving safety officer |
| EE/CA | engineering evaluation/cost analysis |
| EMS | Emergency Medical Services |
| EZ | exclusion zone |
| FM | Factory Mutual Engineering Corporation |
| GFCI | ground-fault-circuit interrupter |
| HASP | health and safety plan |
| HSO | health and safety officer |
| HSS | health and safety supervisor |
| II | Incident Investigations |
| JSA | job safety analyses |
| LEL | lower explosive limit |
| MSDS | Material Safety Data Sheet |
| NEC | National Electrical Code |
| NESC | National Electrical Safety Code |
| NIOSH | National Institute for Occupational Safety and Health |
| NRR | noise reduction rating |
| OSHA | Occupational Safety and Health Administration |
| PAH | polycyclic aromatic hydrocarbon |
| PCB | polychlorinated biphenyl |
| PEL | Permissible Exposure Limit |
| PFD | personal flotation device |
| PID | photoionization detector |
| PM | project manager |
| Port | Port of Portland |
| PPE | personal protective equipment |
| ppm | parts per million |
| psi | pounds per square inch |
| PVC | polyvinyl chloride |
| RMSF | Rocky Mountain Spotted Fever |
| RSA | risk self-assessment |
| SS | site supervisor |
| SWO | Safe Work Observation |
| SZ | support zone |
| Ta adj | adjusted air temperature |
| TLV | Threshold Limit Value |

| | |
|---|---|
| UL | Underwriters Laboratory |
| USCG | U S Coast Guard |
| USEPA | U S Environmental Protection Agency |

# B-11. References

American Conference of Governmental Industrial Hygienists (ACGIH), 2003. *Threshold Limit Values Handbook.*

American Conference of Governmental Industrial Hygienists (ACGIH), 2003. *Guide to Occupational Exposure Values.*

Blasland, Bouck and Lee (BBL), 2003. *Health and Safety Policies and Procedures Manual.*

Forsberg, K. and S.Z. Mansdorf, 1993. *Quick Selection Guide to Chemical Protective Clothing,* 2nd Edition.

National Institute for Occupational Safety and Health (NIOSH), 2003. Pocket Guide to Chemical Hazards.

National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA), U.S. Coast Guard (USCG), and U.S. Environmental Protection Agency (USEPA), 1985. *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities.* 86116.

*Title 29 of the Code of Federal Regulations* (CFR), Parts 1910 and 1926.

U.S. Environmental Protection Agency (USEPA), 1992. *Standard Operating Safety Guides.* Publication 9285.1-03.

# SEDIMENT/SURFACE WATER SAMPLING CHECKLIST

**Project Name/Number**_____ **Date**_____

**Location**_____

**Prepared By**_____ **Project Manager**_____

This checklist must be completed for any sediment or surface water sampling. It documents that the required, permits, notifications, procedures and equipment are in place prior to commencing sampling activities. The Project Manager shall identify the need for and arrange to obtain sampling permits, clearance or right-of-way access from the appropriate entity during project planning.

**Procedure**

Prior to any work on a navigable waterway or any activity that requires access the following items will be completed:

| Activity: | Required for project: | Completed: | Comments: |
|---|---|---|---|
| Access rights to property | YES NO | YES NO | |
| Activity planned that impedes traffic on navigable waterway | YES NO | YES NO | |
| Notification and approval obtained from United States Coast Guard and/or other regulating authority (County, US Parks Service, EPA) | YES NO | YES NO | |
| Buoys, signs markings or other forms of notification present | YES NO | YES NO | |
| Other (Specify) | | | |

**Boating/Water Safety Checklist:**

| Activity: | Required for project: | Requirement: | Comments: |
|---|---|---|---|
| Working on over or near water (within 6 feet) | YES NO | PFD Available for all personnel | |
| Boat has current registration, has been inspected and loaded safely | YES NO | Capacity, load distribution<br>PFDs and throwable floatation device available<br>Fire extinguisher on board | |
| Boat operator has appropriate training (USCG Boating Safety Course or equivalent) | YES NO | | |
| Sampling on or near water below 50 degrees Fahrenheit | YES NO | Cold water immersion suit for affected personnel | |
| Method of communication available | YES NO | Radio, cell phone or scheduled check-in | |

Client Representative_____ Date_____

BBL Project Manager_____ Date_____

BBL Site Supervisor_____ Date_____

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

# Underground / Overhead Utility Checklist

| | |
|---|---|
| **Project Name:** | **Date:** |
| **Project Number:** | **Location:** |
| **Prepared By:** | **Project Manager:** |

This checklist must be completed for any intrusive subsurface work such as excavation or drilling It documents that overhead and underground utilities in the work area are identified and located The Project Manager shall request utility markouts before the start of field operations to allow the client and utility companies sufficient time to provide them If complete information is not available, a magnetometer or other survey shall be performed to locate obstacles prior to intrusive subsurface activities

**Procedure:** A diagram of the work area depicting the proposed location of intrusive subsurface work sites (i e., boring locations, excavation locations) must be attached to this form The diagram must clearly indicate the areas checked for underground structures / utilities, and overhead power lines This form and the diagram must be signed by the BBL Project Manager (if present), the BBL Site Supervisor, and the client representative

| Type of Structure | Present | Not Present | Method of Markout |
|---|---|---|---|
| Electric Power Line | | | |
| Natural Gas Line | | | |
| Telephone Line | | | |
| Water Line | | | |
| Product Line | | | |
| Sewer Line | | | |
| Steam Line | | | |
| Drain Line | | | |
| Underground Tank | | | |
| Underground Cable | | | |
| Overhead Power Line | | | |
| Overhead Product Line | | | |
| Other (Specify) | | | |

**Reviewed By**

| Name | Job Title | Date |
|---|---|---|
| | Client Representative | |
| | BBL Project Manager | |
| | BBL Site Supervisor | |

*Material Safety Data Sheet Collection*
**Genium Publishing Corp.**
1171 RiverFront Center
Amsterdam, NY 12010
(518) 842-4111

Issue Date: 2002-02

**Arsenic**
**ARS2340**

## Section 1 - Chemical Product and Company Identification 54

**Material Name:** Arsenic **CAS Number:** 7440-38-2
**Chemical Formula:** As
**Structural Chemical Formula:** $As_4$
**Synonyms:** ARSEN; ARSENIA; ARSENIC; ARSENIC-75; ARSENIC BLACK; ARSENICALS; COLLOIDAL ARSENIC; GRAY ARSENIC; GREY ARSENIC; METALLIC ARSENIC
**General Use:** In metallurgy for hardening copper, lead alloys. In the manufacture of certain types of glass.

## Section 2 - Composition / Information on Ingredients

| Name | CAS | % |
|---|---|---|
| Arsenic | | >98 |

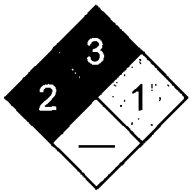
**OSHA PEL**
TWA: 0.01 mg/m$^3$.

**NIOSH REL**
Ceiling: 0.002 mg/m$^3$; 15 min.

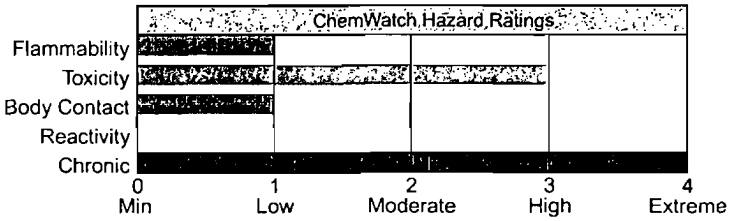
**ACGIH TLV**
TWA: 0.01 mg/m$^3$.

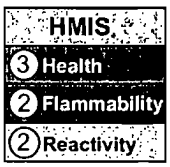
**IDLH Level**
5 mg/m$^3$; as As.

## Section 3 - Hazards Identification



Fire Diamond




**ANSI Signal Word**
**Warning!**

Flammable

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Brittle, crystalline, silvery-black metal. Irritating to eyes/skin/respiratory tract. Also causes: damage to blood-forming organs, nervous and cardiovascular systems. Cancer hazard. Generally found as a powder which is flammable.

### Potential Health Effects

**Target Organs:** liver, kidneys, skin, lungs, lymphatic system
**Primary Entry Routes:** inhalation, ingestion of dust and fumes, skin absorption
**Acute Effects**

**Inhalation:** The dust is toxic and discomforting to the upper respiratory tract and lungs.
Acute inhalation exposure can cause cough, chest pain, shortness of breath, dizziness, headache, pulmonary edema and extreme general weakness.
Prolonged or repeated exposure can cause perforation of the nasal septum.
High exposures can cause poor appetite, nausea, vomiting and muscle cramps. Heart effects with abnormal EKG can also occur with very high exposures.

**Eye:** The dust may produce eye discomfort causing smarting, pain and redness.

**Skin:** The material is moderately discomforting to the skin and may be harmful.
Exposure may result in abnormal redness (caused by capillary congestion), burning, itching, swelling, skin eruptions and dermatitis.
Toxic effects may result from skin absorption.
Repeated skin contact can cause thickened skin and/or patchy areas of darkening and loss of pigment. Some persons develop white lines on the nails.

**Ingestion:** The solid/dust is discomforting to the gastrointestinal tract and is toxic and may be fatal if swallowed.

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Symptoms of acute poisoning by ingestion, which develop within 4 hours include epigastric pain, vomiting and watery diarrhea. Blood may appear in vomitus and stools. If amount ingested is sufficiently high, shock may develop, followed by death within 24 hours.

Considered an unlikely route of entry in commercial/industrial environments.

**Carcinogenicity:** NTP - Class 1, Known to be a carcinogen; IARC - Group 1, Carcinogenic to humans; OSHA - Listed as a carcinogen; NIOSH - Listed as carcinogen; ACGIH - Class A1, Confirmed human carcinogen; EPA - Class A, Human carcinogen; MAK - Class A1, Capable of inducing malignant tumors as shown by experience with humans.

**Chronic Effects:** Symptoms of chronic poisoning by inhalation include weight loss, nausea and diarrhea alternating with constipation, pigmentation and eruption of the skin, loss of hair, peripheral neuritis, blood disorders (anemia), striations on fingernails and toenails.

Long-term exposure can cause an ulcer or hole in the `bone' dividing the inner nose. Hoarseness and sore eyes also occur.

High or repeated exposure can cause nerve damage with `pins and needles', burning, numbness, and later weakness of arms and legs. Repeated exposure can also damage the liver, causing narrowing of the blood vessels, or interfere with the bone marrow's ability to make red blood cells.

Many cases of skin cancer have been reported among people exposed to arsenic through medical treatment with inorganic trivalent arsenic compounds. In some instances skin cancers have occurred in combination with other cancers, such as liver angiosarcoma, intestinal and urinary bladder carcinomas and meningioma. Epidemiological studies of cancer after medical treatment have shown an excess of skin cancers but no clear association with other cancers has been shown. An association between environmental exposure to arsenic through drinking water and skin cancer has been observed and confirmed. Epidemiological studies in areas where drinking water contained 0.35-1.14 mg/l arsenic elevated risks for cancers of the bladder, kidney, skin, liver, lung and colon in both men and women. Occupational exposure to inorganic arsenic, especially in mining and copper smelting, has consistently been associated with an increased risk of cancer. An almost tenfold increase in the incidence of lung cancer was found in workers most heavily exposed to arsenic and relatively clear dose-response relationships have been obtained with regard to cumulative exposure. Other smelter worker populations have been shown to have consistent increases in lung cancer incidence, as well as increases of about 20% in the incidence of gastrointestinal cancer and of 30% for renal cancer and hematolymphatic malignancies.

## Section 4 - First Aid Measures

**Inhalation:** Remove to fresh air. Lay patient down. Keep warm and rested.

If breathing is shallow or has stopped, ensure clear airway and apply resuscitation. Transport to hospital or doctor.

**Eye Contact:** Immediately hold the eyes open and wash continuously for at least 15 minutes with fresh running water.

Ensure irrigation under eyelids by occasionally lifting the upper and lower lids.

Transport to hospital or doctor without delay. Removal of contact lenses after an eye injury should only be undertaken by skilled personnel.

**Skin Contact:** Quickly but gently, wipe material off skin with a dry, clean cloth.

Immediately remove all contaminated clothing, including footwear.

Wash affected areas with water (and soap if available) for at least 15 minutes. Transport to hospital or doctor.

**Ingestion:** Contact a Poison Control Center.

If swallowed, and if more than 15 minutes from a hospital, induce vomiting, preferably using Ipecac Syrup APF.

Note: DO NOT INDUCE VOMITING in an unconscious person

***After first aid, get appropriate in-plant, paramedic, or community medical support.***

**Note to Physicians:** For acute or short term repeated exposures to arsenic, soluble compounds:

Treat as per arsenic poisoning.

1. Acute skin lesions such as contact dermatitis usually do not require other treatment than removal from exposure.
2. If more severe symptoms of the respiratory system, the skin or the gastrointestinal tract occur, British Anti-Lewisite (BAL, dimercaprol) may be given. Prompt administration in such cases is vital; to obtain maximum benefit such treatment should be administered within 4 hours of poisoning.
3. In addition, general treatment such as prevention of further absorption from the gastrointestinal tract are mandatory.
4. General supportive therapy such as maintenance of respiration and circulation, maintenance of water and electrolyte balance and control of nervous system effects, as well as elimination of absorbed poison through dialysis and exchange transfusion, may be used if feasible.
5. Dimercaprol is given by deep intramuscular injection as a 5% solution in peanut oil (or a 10% solution with benzyl-benzoate in vegetable oil). It is usually given in a dose of 3 mg/kg, 4-hourly, for the first two days, or twice daily for up to seven days.
6. BAL Therapy is effective for hematological manifestations of chronic arsenic poisoning but not for neurological symptoms. Watch for side effects (e.g. urticaria, burning sensation in the lips, mouth and throat, fever, conjunctivitis etc).
7. Some relief results from administration of diphenhydramine (Benadryl) (1.5 mg/kg intramuscularly or by mouth every 6 hour).

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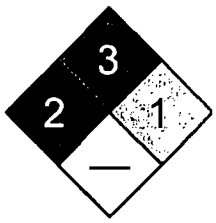
BIOLOGICAL EXPOSURE INDEX - BEI (Notice of Intent to Establish) BEIs represent the levels of determinants which are most likely to be observed in specimens collected from a healthy worker who has been exposed to chemicals to the same extent as a worker with inhalation exposure to the Exposure Standard (ES or TLV):

| Determinant | Index | Sampling Time | Comments |
|---|---|---|---|
| Inorganic arsenic metabolites in urine | 50 ug/g creatinine | End of workweek | B |

B: Background levels occur in specimens collected from subjects NOT exposed
Consult specific documentation.

## Section 5 - Fire-Fighting Measures

**Flash Point:** Noncombustible solid
**Extinguishing Media:** Use fire fighting procedures suitable for surrounding area.
**General Fire Hazards/Hazardous Combustion Products:** Solid which exhibits difficult combustion or is difficult to ignite.
Avoid generating dust, particularly clouds of dust in a confined or unventilated space. Dust may form an explosive mixture with air, and any source of ignition, i.e. flame or spark, will cause fire or explosion.



Fire Diamond

Dry dust can be charged electrostatically by turbulence, pneumatic transport, pouring, in exhaust ducts and during transport. Build-up of electrostatic charge may be prevented by bonding and grounding.
Powder handling equipment such as dust collectors, dryers and mills may require additional protection measures such as explosion venting.
Decomposes on heating and produces toxic fumes of arsenic oxides ($AsO_x$).
**Fire Incompatibility:** Avoid contact with acids, oxidizing agents, halogens.
**Fire-Fighting Instructions:** Contact fire department and tell them location and nature of hazard.
Wear breathing apparatus plus protective gloves for fire only. Prevent, by any means available, spillage from entering drains or waterways.
Use fire fighting procedures suitable for surrounding area.
Do not approach containers suspected to be hot.
Cool fire exposed containers with water spray from a protected location.
If safe to do so, remove containers from path of fire.
Equipment should be thoroughly decontaminated after use.

## Section 6 - Accidental Release Measures

**Small Spills:** Clean up all spills immediately. Wear protective clothing, impervious gloves and safety glasses. Increase ventilation.
Use a vacuum or a wet method to reduce dust during clean-up. DO NOT dry sweep.
Place in suitable containers for disposal.
Wash area down with large quantity of water and prevent runoff into drains.
**Large Spills:** POLLUTANT -contain spillage. Clear area of personnel and move upwind.
Wear breathing apparatus plus protective gloves. Prevent, by any means available, spillage from entering drains or waterways.
If contamination of drains or waterways occurs, advise emergency services.
Shut off all possible sources of ignition and increase ventilation.
Stop leak if safe to do so.
Contain spill with sand, earth or vermiculite.
Use dry clean up procedures and avoid generating dust.
Collect recoverable product into labeled containers for recycling. Collect residues and seal in labeled drums for disposal.
Wash area down with large quantity of water and prevent runoff into drains.
**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

## Section 7 - Handling and Storage

**Handling Precautions:** Atmosphere should be regularly checked against established exposure standards to ensure safe working conditions are maintained.
Use good occupational work practice.
Avoid contact with skin and eyes.
Avoid generating and breathing dust.
Use in a well-ventilated area.
Wear protective clothing when risk of exposure occurs.

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Avoid sources of heat. Avoid contact with incompatible materials. Avoid physical damage to containers.
Keep containers securely sealed when not in use.
When handling, DO NOT eat, drink or smoke.
Wash hands with soap and water after handling.
Work clothes should be laundered separately: NOT at home.

**Recommended Storage Methods:** Glass container. Plastic drum. Polyethylene or polypropylene container. Steel drum. Metal drum.
Check that containers are clearly labeled.

**Storage Requirements:** Observe manufacturer's storing and handling recommendations.
Store in a cool, dry place. Store in a well-ventilated area. Store away from sources of heat or ignition/bare lights. Avoid storage at temperatures higher than 60 °C. Store away from incompatible materials. Store away from foodstuff containers.
Protect containers against physical damage.
Keep containers securely sealed.
Check regularly for spills and leaks.

**Regulatory Requirements:** Follow applicable OSHA regulations.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** General exhaust is adequate under normal operating conditions.
Local exhaust ventilation may be required.
Use ventilated helmet or air-line hood to provide clean air at the breathing zone.
If risk of overexposure exists, wear NIOSH approved respirator. Correct fit is essential to obtain adequate protection.

**Personal Protective Clothing/Equipment**

**Eyes:** Safety glasses. Chemical goggles.
Full face shield.
Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them.

**Hands/Feet:** Impervious, gauntlet length gloves; Rubber gloves. Neoprene gloves.
Rubber boots.

**Respiratory Protection:**
Exposure Range >0.01 to 0.1 mg/m$^3$: Air Purifying, Negative Pressure, Half Mask
Exposure Range >0.1 to 1 mg/m$^3$: Air Purifying, Negative Pressure, Full Face
Exposure Range >1 to <5 mg/m$^3$: Supplied Air, Constant Flow/Pressure Demand, Full Face
Exposure Range 5 to unlimited mg/m$^3$: Self-contained Breathing Apparatus, Pressure Demand, Full Face
Cartridge Color: magenta (P100)

**Other:** Overalls. PVC apron. PVC protective suit may be required if exposure severe.
Eyewash unit. Ensure there is ready access to a safety shower.
* Preplacement and periodic medical examinations are essential for workers exposed to arsenic. Preplacement physical examinations should give particular attention to allergic and chronic skin lesions, eye disease, psoriasis, chronic eczematous dermatitis, hyperpigmentation of the skin, keratosis and warts, baseline weight, baseline blood and hemoglobin counts, baseline urinary arsenic determinations.
Annual physical examinations should give attention to general health, weight, skin condition, and any evidence of excessive exposure or absorption of arsenic.

## Section 9 - Physical and Chemical Properties

**Appearance/General Info:** Grey, shiny, brittle, metallic-looking rhombohedral crystals. Can be heated to burn in air with a bluish flame, giving off an odor of garlic and dense white fumes of arsenic trioxide. Loses its luster on exposure to air. Converted by nitric acid or hot sulfuric acid into arsenous or arsenic acid.
Brinell hardness: 147
Mohs' scale: 3.5

**Physical State:** Divided solid
**Vapor Pressure (kPa):** Not applicable
**Vapor Density (Air=1):** Not applicable
**Formula Weight:** 74.92
**Specific Gravity ($H_2O$=1, at 4 °C):** 5.73
**Water Solubility:** Insoluble
**Evaporation Rate:** Not applicable
**pH:** Not applicable

**pH (1% Solution):** Not applicable
**Boiling Point Range:** Sublimes
**Freezing/Melting Point Range:** 817 °C (1502.6 °F) at 28 atm
**Volatile Component (% Vol):** Not applicable

## Section 10 - Stability and Reactivity

**Stability/Polymerization/Conditions to Avoid:** Contact with acids liberates toxic gases. Presence of heat source and ignition source.
Product is considered stable under normal handling conditions. Hazardous polymerization will not occur.

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**Storage Incompatibilities:** Segregate from oxidizing agents, halogens.
Contact with acids produces toxic fumes.

## Section 11 - Toxicological Information

TOXICITY
Oral (man) $TD_{Lo}$: 7857 mg/kg/55 years
Oral (rat) $LD_{50}$: 763 mg/kg
Tumorigenic - Carcinogenic by RTECS criteria.

IRRITATION
Nil reported

See NIOSH, *RTECS* CG 0525000, for additional data.

## Section 12 - Ecological Information

**Environmental Fate:** No data found.
**Ecotoxicity:** Food chain concentration potential: Bioaccumulated by fresh water and marine aquatic organisms
**BCF:** bioaccumulated by aquatic organisms
**Biochemical Oxygen Demand (BOD):** none

## Section 13 - Disposal Considerations

**Disposal:** Follow all federal, state, and local regulations.

## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

**Shipping Name:** ARSENIC
**Hazard Class:** 6.1
**ID No.:** 1558
**Packing Group:** II
**Label:** Poison [6]

## Section 15 - Regulatory Information

**EPA Regulations:**
**RCRA 40 CFR:** Listed
**CERCLA 40 CFR 302.4:** Listed per CWA Section 307(a), per CAA Section 112 1 lb (0.454 kg)
**SARA 40 CFR 372.65:** Listed
**SARA EHS 40 CFR 355:** Not listed
**TSCA:** Listed

## Section 16 - Other Information

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## Section 1 - Chemical Product and Company Identification 53

**Product/Chemical Name:** Cadmium
**Chemical Formula:** Cd
**CAS Number:** 7440-43-9 **EINECS Number:** 231-152-8
**Synonyms:** colloidal cadmium
**Derivation:** Cadmium is collected as dust or fume from roasting zinc ores, mixed with coal or coke and sodium or zinc chloride, and sintered. The cadmium fume is collected in an electrostatic precipitator, leached, fractionally precipitated, and distilled; collected as sludge from zinc sulfate purification; prepared from direct distillation of cadmium-bearing zinc; obtained by recovery from electrolytic zinc process; may be prepared from cadmium sulfate in the laboratory.
**General Use:** Cadmium is used as a constituent of easily fusible alloys; soft solder and solder for aluminum; in electroplating; as a deoxidizer for nickel plating; for process engraving; electrodes for cadmium vapor lamps; photoelectric cells; photometry of ultraviolet sun-rays; in Ni-Cd storage batteries; to charge Jones reductors; as an amalgam in dentistry; power transmission wire; TV phosphors; basis of pigments used in ceramic glazing, machinery enamels, baking enamels; Weston-standard-cell control of atomic fission in nuclear reactors; reactor control rods; fungicide; photography and lithography; selenium rectifiers.
**Vendors:** Consult the latest *Chemical Week Buyers' Guide.* (73)

## Section 2 - Composition / Information on Ingredients

Cadmium, ca 99.5+% wt
**Trace Impurities:** < 10 ppm

**OSHA PELs**
8-hr TWA: 0.005 mg/m$^3$
Fume* TWA: 0.1 mg/m$^3$; Ceiling 0.3 mg/m$^3$
Dust* TWA: 0.2 mg/m$^3$; Ceiling 0.6 mg/m$^3$

**ACGIH TLVs**
TWA: 0.01 mg/m$^3$ (inhalable fraction); 0.002 mg/m$^3$ (respirable fraction)

**NIOSH REL**
Reduce to lowest feasible level (LOQ 0.1 mg/m$^3$)

**DFG (Germany) MAK**
None established

**IDLH Level**
9 mg/m$^3$

**AIHA WEEL**
8-hr Dust TWA: (0.002 mg/m$^3$)

*Applies to operations or sectors for which the cadmium standard, 1910.1027, is stayed or otherwise not in effect.

## Section 3 - Hazards Identification

**ANSI Signal Word:** Danger!

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Cadmium is a lustrous metal solid of silver-white to bluish color without odor. It is toxic by inhalation. Cadmium is irritating to the respiratory tract and mildly irritating to the skin. Chronic health effects include kidney damage and obstructive lung disease. Cadmium dust ignites spontaneously in air. It is an experimental carcinogen and teratogen.

| Wilson Risk Scale | |
|---|---|
| R | 1 |
| I | 4 |
| S | 1 |
| K | 1 |

| HMIS | |
|---|---|
| H | 3* |
| F | 4** |
| R | 0 |
| PPE† | |

*Chronic effects
** Fine dust
†Sec. 8

### Potential Health Effects

**Primary Entry Routes:** Inhalation and ingestion
**Target Organs:** Respiratory system, kidneys
**Acute Effects**
**Inhalation:** Initial signs/symptoms of cadmium poisoning resemble those of the flu. Inhalation of dust or fumes causes throat dryness, cough, headache, vomiting, chest pain, dyspnea (shortness of breath), central nervous system (CNS) effects, extreme restlessness and irritability, pneumonitis, possibly bronchopneumonia, pulmonary edema, and death due to respiratory failure in severe cases. Symptoms may be delayed up to 24 hours. Residual emphysema and fibrosis may result. Note: heating of cadmium may produce cadmium oxide, the inhalation of which can result in metal fume fever, characterized by fever, chills, malaise, headache, myalgias, fatigue, cough, thirst, and abdominal discomfort, with symptom onset about 3 to 10 hours after exposure. Symptoms do not usually last beyond 24 to 48 hours.
**Eye:** May cause irritation.
**Skin:** Contact may cause irritation, skin eruptions and pruritus. Significant dermal absorption rarely occurs.
**Ingestion:** Causes increased salivation, dry mouth, choking, nausea, vomiting, abdominal pain and cramping, blurred vision, anemia, kidney dysfunction, diarrhea, gastroenteritis, and substernal pain.
**Carcinogenicity:** IARC - Group 1, Carcinogenic to humans; NIOSH - listed as carcinogen; NTP - Class 2A, Reasonably anticipated to be a carcinogen; OSHA - listed as a carcinogen; EPA - Class B1, Probable human carcinogen based on epidemiologic studies; MAK - Class A2, Unmistakably carcinogenic in animal experimentation only; ACGIH - A2, Suspected human carcinogen.

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**Medical Conditions Aggravated by Long-Term Exposure:** Kidney disorders, respiratory disorders.
**Chronic Effects:** Include chronic obstructive lung disease such as emphysema, kidney damage (renal tubular disorder and proteinuria (low molecular weight)), bone demineralization, microfractures and osteomalacia, respiratory cancer, gastrointestinal symptoms, anosmia (loss of sense of smell), rhinitis and discoloration of the teeth. It is implicated as the causative agent in Itai-Itai disease in Japan.

## Section 4 - First Aid Measures

**Inhalation:** Remove exposed person to fresh air and support breathing as needed.
**Eye Contact:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water for at least 15 minutes. Consult a physician or ophthalmologist if pain or irritation persist.
**Skin Contact:** Quickly remove contaminated clothing. Rinse with flooding amounts of water. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.
**Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.
***After first aid, get appropriate in-plant, paramedic, or community medical support.***
**Note to Physicians:** Consider a chest X-ray after acute exposure.

## Section 5 - Fire-Fighting Measures

NFPA

**Flash Point:** Data not found.
**Autoignition Temperature:** 482 °F (250 °C) (layer cadmium metal dust)
**LEL:** Data not found.
**UEL:** Data not found.
**OSHA Flammability Classification:** Flammable
**Extinguishing Media:** Extinguish with carbon dioxide, dolomite, dry powder, graphite, soda ash, sodium chloride, dry chemical, or sand.
**Unusual Fire or Explosion Hazards:** The finely divided material is pyrophoric. The more finely divided the powder the greater the fire/explosion hazard.
**Hazardous Combustion Products:** When heated to decomposition, toxic fumes of cadmium are emitted.
**Fire-Fighting Instructions:** *Do not* release runoff from fire control methods to sewers or waterways. Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode.

## Section 6 - Accidental Release Measures

**Spill /Leak Procedures:** Notify safety personnel, evacuate all unnecessary personnel, remove heat and ignition sources. Isolate and ventilate area, deny entry, stay upwind. Cleanup personnel should protect against exposure (Sec. 8). Prevent entry into water, sewers, basements or confined areas.
**Small Spills:** If in solid form, *do not* sweep! Absorb or cover with dry earth, sand or other noncombustible material. Carefully scoop up or vacuum (with a HEPA filter).
**Large Spills:** *Do not* release into sewers or waterways.
**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120 and 1910.1027).

## Section 7 - Handling and Storage

**Handling Precautions:** Wear personal protective clothing and equipment to prevent dust inhalation and any contact with skin or eyes (Sec. 8). Wash thoroughly after handling cadmium.
**Storage Requirements:** Store in tightly closed containers in a cool, well-ventilated area away from heat, light, ignition sources, incompatibles, and air. Cadmium slowly oxidizes in air to form cadmium oxide.
**Regulatory Requirements:** Areas where cadmium is used or stored must be labeled according to 29 CFR 1910.1027.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** Where feasible, enclose operations to avoid dust dispersion into the work area.
**Ventilation:** Provide general or local exhaust ventilation systems to maintain airborne concentrations below exposure limits (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.
**Administrative Controls:** Educate workers about the health and safety hazards associated with this material. Train in work practices which minimize exposure. Consider preplacement and periodic medical exams with emphasis on kidney functions (including urine screening for micro-globulins), lungs and blood. Follow written procedures set forth by OSHA in 29 CFR 1910.1027.
**Respiratory Protection:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. Select respirator based on exposure range as follows. Exposure range >0.005 to 0.05 mg/m$^3$ use air purifying respirator, negative-pressure, half-mask; >0.05 to 0.5 mg/m$^3$ use air purifying respirator, negative-pressure, full-face; >0.5 to 5 mg/m$^3$/use supplied-air respirator, constant flow/pressure-demand, full-face; >5 mg/m$^3$/use a SCBA, pressure-demand, full-face. Use a magenta cartridge (P100). For emergency or nonroutine


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operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, cartridge change schedules, and convenient, sanitary storage areas.

**Protective Clothing/Equipment:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent any skin contact. Butyl rubber, chlorinated polyethylene, and polyvinyl chloride are recommended materials. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not protective eye devices. Appropriate eye protection must be worn instead of, or in conjunction with, contact lenses.

**Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

**Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment.

**Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

## Section 9 - Physical and Chemical Properties

**Physical State:** Solid; lustrous metal or granular powder
**Color:** Silver-white, blue-tinged
**Odor:** Odorless
**Vapor Pressure:** 1 mm Hg at 741 °F (394 °C)
**Formula Weight:** 112.41
**Density:** 8.642 at 77 °F (25 °C)
**Water Solubility:** Insoluble
**Other Solubilities:** Dissolved by acids; ammonium nitrate solution
**Boiling Point:** 1409 °F (765 °C)
**Melting Point:** 609.8 °F (321 °C)
**Refractive Index:** 1.8 at 578 nm and 20 °C/D
**Ionization Potential (eV):** 8.99367

## Section 10 - Stability and Reactivity

**Stability:** Cadmium is stable at room temperature in closed containers under normal storage and handling conditions. It slowly oxidizes in air to form cadmium oxide. Finely divided material is pyrophoric, i.e., it may ignite or explode spontaneously in air.

**Polymerization:** Hazardous polymerization cannot occur.

**Chemical Incompatibilities:** Include acids (reacts readily with dilute nitric acid, slowly with hydrochloric acid); explodes on contact with hydrazoic acid; violent or explosive reaction when heated with ammonium nitrate; tellurium; zinc; ammonia; sulfur; selenium; nitryl fluoride; oxidizing agents; metals.

**Conditions to Avoid:** Avoid creation of dust clouds, contact with chemical incompatibles, heat, and sources of ignition.

**Hazardous Decomposition Products:** Thermal oxidative decomposition of cadmium can produce toxic fumes of cadmium and cadmium oxide.

## Section 11 - Toxicological Information

### Toxicity Data:*

**Acute Dermal Effects:**
Rabbit, subcutaneous, $LD_{Lo}$: 6 mg/kg

**Acute Inhalation Effects:**
Human, inhalation, $LC_{Lo}$: 39 mg/m$^3$/20 minutes produced cardiac changes; respiratory depression.
Rat, inhalation, $LC_{50}$: 25 mg/m$^3$/30 minutes produced dyspnea.

**Acute Oral Effects:**
Rat, oral, $LD_{50}$: 2330 mg/kg
Mouse, oral, $LD_{50}$: 890 mg/kg

**Multiple Dose Toxicity Data:**
Human, inhalation, $TC_{Lo}$: 88 µg/m$^3$/8.6 years produced proteinuria.
Rat, oral, 546 mg/kg administered for 26 weeks continuously produced toxic effects: changes in serum composition; transminases; weight loss or decreased weight gain.
Rat, oral, 1512 mg/kg administered for 48 weeks continuously produced toxic effects: changes to liver, kidneys, ureter and bladder.

**Tumorigenic Effects:**
Woman, inhalation, 129 µg/m$^3$/20 years, continuous produced toxic effects: carcinogenic by RTECS criteria; Lung, thorax or respiration - tumors.
Rat, subcutaneous, 3372 µg/kg produced toxic effects: carcinogenic by RTECS criteria, tumors at site of application.

**Genetic Effects:**
Mouse, micronucleus test, cell type - embryo: 6 µmol/L induced mutation.
Hamster, cytogenic analysis, cell type - ovary: 1 µmol/L induced mutation.

**Reproductive Effects:**
Rat, female, oral, 23 mg/kg administered on gestational days 1 - 22 produced specific developmental abnormalities - blood and lymphatic system (including spleen and marrow).
Rat, female, oral, 21.5 mg/kg administered to multigenerations produced toxic effects: Effects on fertility - preimplantation mortality; Effects on newborn - germ cell effects in offspring.
Rat, male, oral, 155 mg/kg administered 13 weeks prior to mating produced toxic effects: Effects on newborn - reduced weight gain and behavioral.

* See NIOSH, *RTECS* (EU9800000), for additional toxicity data.

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## Section 12 - Ecological Information

**Ecotoxicity:** *Dreisena polymorpha,* zebra mussels, chronic $LC_{50}$: 130 mcg/L; *Rivulus marmoratus*, mangrove fish, $LC_{50}$ in fresh water: 2.96 mg/L; Steelhead trout, $LC_{50}$: 0.0009 ppm for 96 hours; *Daphnia magna*, 0.1 ppm lethal.
**Environmental Fate:** Data not found.

## Section 13 - Disposal Considerations

**Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable federal, state, and local regulations.
**Disposal Regulatory Requirements:** Dispose of according to EPA regulations.

## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

**Shipping Name:** Cadmium compounds
**Shipping Symbols:** -
**Hazard Class:** 6.1
**ID No.:** UN2570
**Packing Group:** III
**Label:** Keep away from food
**Special Provisions (172.102):** -

**Packaging Authorizations**
**a) Exceptions:** 173.153
**b) Non-bulk Packaging:** 173.213
**c) Bulk Packaging:** 173.240

**Quantity Limitations**
**a) Passenger Aircraft/Rail:** 100 kg
**b) Cargo Aircraft Only:** 200 kg

**Vessel Stowage Requirements**
**a) Vessel Stowage:** A
**b) Other:** -

## Section 15 - Regulatory Information

**EPA Regulations:**
Listed as a RCRA Hazardous Waste (40 CFR 261.33); RCRA Hazardous Waste Number: D006
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) specific per (2) CWA, Sec. 307(a)
CERCLA Final Reportable Quantity (RQ): 10 lb (4.54 kg)
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed
Toxic Substances Control Act (TSCA): Listed

**OSHA Regulations:**
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)
OSHA Specifically Regulated Substance (29 CFR 1910.1027 )

## Section 16 - Other Information

**References:** 1, 99, 124, 136, 149, 161, 176, 164, 198, 209, 216, 222, 225, 226, 227, 230, 233, 234

**Prepared By** ..... M. Adams, Ph.D/S Fleming, BS
**Research Date** ..... 1999-3
**Review Date** ..... 1999-7
**Industrial Hygiene Review** ..... R Everett Langford, Ph.D., CIH, CSP
**Medical Review** ..... T Thoburn, MD, MPH

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*Material Safety Data Sheet Collection*
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Issue Date 2000-07

**Chromium**
**MSDS 83**
**CHR4520**

## Section 1 - Chemical Product and Company Identification 54.1

**Material Name:** Chromium **CAS Number:** 7440-47-3
**Chemical Formula:** Cr
**Structural Chemical Formula:** Cr
**Synonyms:** CHROM, CHROME, CHROMIUM, CHROMIUM METAL
**General Use:** Used in the manufacture of chrome-steel or chrome-nickel-steel alloys (stainless steel), for greatly increasing resistance and durability of metals, for chrome-plating of other metals

## Section 2 - Composition / Information on Ingredients

| Name | CAS | % |
|---|---|---|
| chromium | 7440-47-3 | > 99 5 |

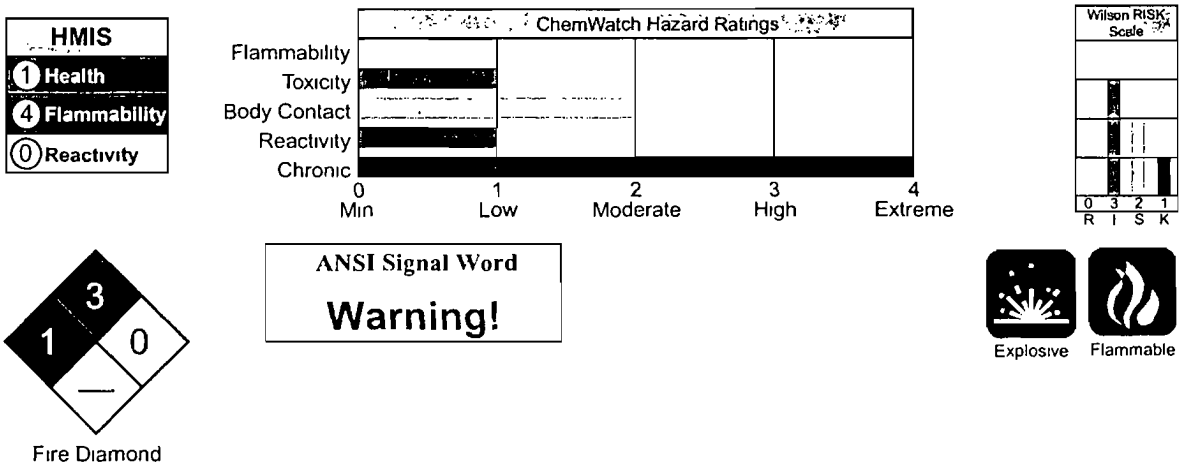
**OSHA PEL**
TWA 1 mg/m$^3$, as Cr Other Values 0 1 mg/m$^3$, Clg Cr-VI as $CrO_3$

**ACGIH TLV**
TWA 0 5 mg/m$^3$

**NIOSH REL**
TWA 0 5 mg/m$^3$, as Cr,Cr-II,Cr-III,Cr(VI)= 001

**IDLH Level**
250 mg/m$^3$, as Cr

## Section 3 - Hazards Identification




### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Steel-gray, lustrous metal powder, odorless Irritating to eyes/skin/respiratory tract Chronic exposure to chromium fumes can cause fibrosis of the lungs with decreased function Flammable Explosive in air

### Potential Health Effects

**Primary Entry Routes:** inhalation, skin absorption, ingestion
**Target Organs:** respiratory system
**Acute Effects**
**Inhalation:** The dust may be discomforting to the upper respiratory tract and may be harmful if inhaled
Chrome fume is irritating to the respiratory tract and lungs
Toxic effects result from over-exposure
Asthmatic conditions may result as a consequence of the sensitizing action of chrome VI compounds
**Eye:** The dust may produce eye discomfort and abrasive eye inflammation
**Skin:** The material may be mildly discomforting to the skin and is capable of causing skin reactions which may lead to dermatitis
Chrome fume, as the chrome VI oxide, is corrosive to the skin and may aggravate pre-existing skin conditions such as dermatitis and eczema
As a potential skin sensitizer, the fume may cause dermatoses to appear suddenly and without warning Absorption of chrome VI compounds through the skin can cause systemic poisoning effecting the kidneys and liver

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**Ingestion:** The material is moderately discomforting to the gastrointestinal tract and may be harmful if swallowed in large quantity.

**Carcinogenicity:** NTP - Listed; IARC - Group 3, Not classifiable as to carcinogenicity to humans; OSHA - Not listed; NIOSH - Not listed; ACGIH - Class A4, Not classifiable as a human carcinogen; EPA - Not listed; MAK - Not listed.

**Chronic Effects:** Metallic dusts generated by the industrial process give rise to a number of potential health problems. The larger particles, above 5 micron, are nose and throat irritants. Smaller particles however, may cause lung deterioration. Particles of less than 1.5 micron can be trapped in the lungs and, dependent on the nature of the particle, may give rise to further serious health consequences.

Chromium(III) is considered an essential trace nutrient serving as a component of the "glucose tolerance factor" and a cofactor for insulin action. High concentrations of chromium are also found in RNA. Trivalent chromium is the most common form found in nature.

Chronic inhalation of trivalent chromium compounds produces irritation of the bronchus and lungs, dystrophic changes to the liver and kidney, pulmonary edema, and adverse effects on macrophages. Intratracheal administration of chromium(III) oxide, in rats, increased the incidence of sarcomas, and tumors and reticulum cell sarcomas of the lung. There is inadequate evidence of carcinogenicity of chromium(III) compounds in experimental animals and humans (IARC).

Chronic exposure to hexavalent chromium compounds reportedly produces skin, eye and respiratory tract irritation, yellowing of the eyes and skin, allergic skin and respiratory reactions, diminished sense of smell and taste, blood disorders, liver and kidney damage, digestive disorders and lung damage. There is sufficient evidence of carcinogenicity of chromium(VI) compounds in experimental animals and humans to confirm these as Class 1 carcinogens (IARC).

Exposure to chromium during chrome production and in the chrome pigment industry is associated with cancer of the respiratory tract. A slight increase in gastrointestinal cancer following exposure to chromium compounds has also been reported. The greatest risk is attributed to exposure to acid- soluble, water-insoluble hexavalent chromium which occurs in roasting and refining processes. Animal studies support the idea that the most potent carcinogenic compounds are the slightly soluble hexavalent compounds.

The cells are more active in the uptake of the hexavalent forms compared to trivalent forms and this may explain the difference in occupational effect. It is the trivalent form, however, which is metabolically active and binds with nucleic acid within the cell suggesting that chromium mutagenesis first requires biotransformation of the hexavalent form by reduction.

Hexavalent chromes produce chronic ulceration of skin surfaces (quite independent of other hypersensitivity reactions exhibited by the skin).

Water-soluble chromium(VI) compounds come close to the top of any published "hit list" of contact allergens (eczematogens) producing positive results in 4 to 10% of tested individuals. On the other hand only chromium(III) compounds can bind to high molecular weight carriers such as proteins to form a complete allergen (such as a hapten). Chromium(VI) compounds cannot.

## Section 4 - First Aid Measures

**Inhalation:** Remove to fresh air.

Encourage patient to blow nose to ensure clear breathing passages. Rinse mouth with water. Consider drinking water to remove dust from throat.

Seek medical attention if irritation or discomfort persist.

**Eye Contact:** Immediately hold the eyes open and flush continuously for at least 15 minutes with fresh running water. Ensure irrigation under eyelids by occasionally lifting the upper and lower lids.

Transport to hospital or doctor without delay. Removal of contact lenses after an eye injury should only be undertaken by skilled personnel.

**Skin Contact:** Immediately remove all contaminated clothing, including footwear (after rinsing with water).

Wash affected areas thoroughly with water (and soap if available).

Seek medical attention in event of irritation.

**Ingestion:** Contact a Poison Control Center.

Do NOT induce vomiting. Give a glass of water.

***After first aid, get appropriate in-plant, paramedic, or community medical support.***

**Note to Physicians:** Long term exposure to high dust concentrations may cause changes in lung function i.e. pneumoconiosis; caused by particles less than 0.5 micron penetrating and remaining in the lung. Prime symptom is breathlessness; lung shadows show on X-ray.

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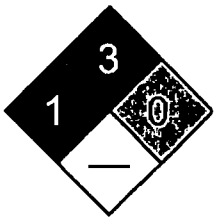
## Section 5 - Fire-Fighting Measures

**Flash Point:** Noncombustible Solid
**Autoignition Temperature:** 580 °C (cloud)
**LEL:** Not applicable
**UEL:** Not applicable
**Extinguishing Media:** Sand, dry powder extinguishers or other inerts should be used to smother dust fires.
These are the only suitable means for extinguishing metal dust fires.
Do NOT use water.



Fire Diamond

**General Fire Hazards/Hazardous Combustion Products:** Sand, dry powder extinguishers or other inerts should be used to smother dust fires.
These are the only suitable means for extinguishing metal dust fires.
Do NOT use water.
**Fire Incompatibility:** Avoid contamination with oxidizing agents i.e. nitrates, oxidizing acids, chlorine bleaches, pool chlorine etc. as ignition may result.
***Fire-Fighting Instructions:*** *Contact fire department and tell them location and nature of hazard.*
Wear breathing apparatus plus protective gloves. Prevent, by any means available, spillage from entering drains or waterways.
Cool fire-exposed containers with water spray from a protected location.
If safe to do so, remove containers from path of fire.

## Section 6 - Accidental Release Measures

**Small Spills:** Clean up all spills immediately. Avoid contact with skin and eyes.
Wear impervious gloves and safety glasses.
Remove all ignition sources.
Use dry clean-up procedures and avoid generating dust.
Vacuum up or sweep up.
Place spilled material in clean, dry, sealable, labeled container.
**Large Spills:** Clear area of personnel.
Contact fire department and tell them location and nature of hazard.
Control personal contact by using protective equipment.
Prevent, by any means available, spillage from entering drains or water ways.
Moderate hazard.
No smoking, bare lights or ignition sources. Increase ventilation.
Stop leak if safe to do so.
Avoid generating dust.
Collect recoverable product into labeled containers for recycling.
Collect residues and seal in labeled drums for disposal.
Wash area down with large quantity of water and prevent runoff into drains.
After clean-up operations, decontaminate and launder all protective clothing and equipment before storing and reusing.
If contamination of drains or waterways occurs, advise emergency services.
**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

## Section 7 - Handling and Storage

**Handling Precautions:** Limit all unnecessary personal contact.
Wear protective clothing when risk of exposure occurs.
Use in a well-ventilated area. When handling DO NOT eat, drink or smoke.
Always wash hands with soap and water after handling.
Avoid physical damage to containers. Use good occupational work practices.
Observe manufacturer's storing and handling recommendations.
**Recommended Storage Methods:** Packaging as recommended by manufacturer.
Check that containers are clearly labeled.
Store in metal drums or safety cans.
Plastic container.
Metal can.
Metal drum.
**Regulatory Requirements:** Follow applicable OSHA regulations.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** Metal dusts must be collected at the source of generation as they are potentially explosive.
1. Vacuum cleaners, of flame-proof design, should be used to minimize dust accumulation.

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2. Metal spraying and blasting should, where possible, be conducted in separate rooms. This minimizes the risk of supplying oxygen, in the form of metal oxides, to potentially reactive finely divided metals such as aluminum, zinc, magnesium or titanium.
3. Work-shops designed for metal spraying should possess smooth walls and a minimum of obstructions, such as ledges, on which dust accumulation is possible.
4. Wet scrubbers are preferable to dry dust collectors.
5. Bag or filter-type collectors should be sited outside the workrooms and be fitted with explosion relief doors.
6. Cyclones should be protected against entry of moisture as reactive metal dusts are capable of spontaneous combustion in humid or partially wetted state.
7. Local exhaust systems must be designed to provide a minimum capture velocity at the fume source, away from the worker, of 0.5 meter/sec.

Special ventilation requirements apply for processes which result in the generation of barium, chromium, lead, or nickel fume and in those processes which generate ozone.

The use of mechanical ventilation by local exhaust systems is required as a minimum in all circumstances (including outdoor work).

(In confined spaces always check that oxygen has not been depleted by excessive rusting of steel or snowflake corrosion of aluminum). Local exhaust systems must be designed to provide a minimum capture velocity at the fume source, away from the worker, of 0.5 meter/sec.

**Personal Protective Clothing/Equipment**

**Eyes:** Safety glasses with side shields; or as required, chemical goggles.
Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them.

**Hands/Feet:** PVC gloves; Safety footwear.
Rubber gloves.

**Respiratory Protection:**
Exposure Range >1 to 10 mg/m$^3$: Air Purifying, Negative Pressure, Half Mask
Exposure Range >10 to 100 mg/m$^3$: Air Purifying, Negative Pressure, Full Face
Exposure Range >100 to <250 mg/m$^3$: Supplied Air, Constant Flow/Pressure Demand, Half Mask
Exposure Range 250 to unlimited mg/m$^3$: Self-contained Breathing Apparatus, Pressure Demand, Full Face
Cartridge Color: dust/mist filter (use P100 or consult supervisor for appropriate dust/mist filter)

**Other:** Overalls. Eyewash unit.

## Section 9 - Physical and Chemical Properties

**Appearance/General Info:** A hard, brittle, lustrous, steel-grey metal which is very resistant to corrosion. Soluble in dilute sulphuric and hydrochloric acids. Welding flux grades typical sieve analysis (cumulative retention %):- 200 um 0, 150 um 10-40, 100 50-80, 75 um 80-95, 63 um 90-96, 43 um 97-100.

**Physical State:** Divided solid
**Vapor Pressure (kPa):** 0.13 at 1616 °C
**Vapor Density (Air=1):** 1.79
**Formula Weight:** 52.00
**Specific Gravity ($H_2O$=1, at 4 °C):** 7.2
**Water Solubility:** Insoluble in water
**Evaporation Rate:** Not applicable

**pH:** Not applicable
**pH (1% Solution):** Not applicable.
**Boiling Point Range:** 2642 °C (4788 °F)
**Freezing/Melting Point Range:** 1900 °C (3452 °F)
**Volatile Component (% Vol):** Nil
**Decomposition Temperature (°C):** Not applicable

## Section 10 - Stability and Reactivity

**Stability/Polymerization:** Product is considered stable. Hazardous polymerization will not occur.
**Storage Incompatibilities:** Segregate from strong oxidizers, nitric oxide, potassium chlorate, sulfur dioxide, acids and strong alkalis.

## Section 11 - Toxicological Information

No relevant toxicological data found at time of research.

See NIOSH, *RTECS* GB 4200000, for additional data.

## Section 12 - Ecological Information

**Environmental Fate:** No data found.
**Ecotoxicity:** No data found.
**BCF:** snails 1 x$10^6$
**Biochemical Oxygen Demand (BOD):** 62.5 lb/lb, 5 days

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## Section 13 - Disposal Considerations

**Disposal:** Recycle wherever possible. Consult manufacturer for recycling options. Follow applicable federal, state, and local regulations.
Bury residue in an authorized landfill.
Recycle containers if possible, or dispose of in an authorized landfill.

## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

**Shipping Name:** None
**Hazard Class:** None
**ID No.:** None
**Packing Group:** None
**Label:** No class label assigned

**Additional Shipping Information:**

## Section 15 - Regulatory Information

**EPA Regulations:**
**RCRA 40 CFR:** Not listed
**CERCLA 40 CFR 302.4:** Listed per CWA Section 307(a) 5000 lb (2268 kg)
**SARA 40 CFR 372.65:** Listed
**SARA EHS 40 CFR 355:** Not listed
**TSCA:** Listed

## Section 16 - Other Information

**Research Date:**.....*1999-11* **Review Date:** .....*2000-07*

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**Coal Tar Creosote**
**COA9000**

Issue Date: 2003-02

## Section 1 - Chemical Product and Company Identification 50/57

**Material Name:** Coal Tar Creosote **CAS Number:** 8001-58-9
**Chemical Formula:** No data found.
**EINECS Number:** 232-287-5
**Synonyms:** AWPA #1; BRICK OIL; COAL TAR CREOSOTE; COAL TAR CRESOTE; COAL TAR OIL; CREOSOTE; CREOSOTE OIL; CREOSOTE P1; CREOSOTE,FROM COAL TAR; CREOSOTUM; CRESYLIC CREOSOTE; DEAD OIL; EPA PESTICIDE CHEMICAL CODE 025004; HEAVY OIL; HODGSONS CREOSOTE; LIQUID PITCH OIL; NAPHTHALENE OIL; PRESERV-O-SOTE; SAKRESOTE 100; TAR OIL; WASH OIL
**Derivation:** By distillation of coal tar produced by high-temperature carbonization of bituminous coal; by mixing strained naphthalene oil, wash oil, and strained or light anthracene oil; as a by-product of conventional coal coking.
**General Use:** Used mainly as a wood preservative for railroad ties, poles, fence posts, marine pilings, and other lumber for outdoor use; as a water-proofing agent, fuel oil constituent, frothing agent for mineral separation, tap hole refractory cement, and lubricant for die molds. Used only in limited quantities as an animal and bird repellent, animal dip, and insecticide (ovicide).

## Section 2 - Composition / Information on Ingredients

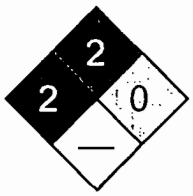
| Name | CAS | % |
|---|---|---|
| Coal tar creosote | 8001-58-9 | Consists of aromatic hydrocarbons, anthracene, naphthalene, and phenanthrene derivatives; some tar acids; and tar bases. Polycylic aromatic hydrocarbons make up at least 75%. * Creosote contains several carcinogenic polycyclic aromatic hydrocarbons including benz[a]anthracene, benzo[a]pyrene, and dibenz[a,h]anthracene. |

**OSHA PEL**
No data found.

**NIOSH REL**
No data found.

**ACGIH TLV**
No data found.

## Section 3 - Hazards Identification



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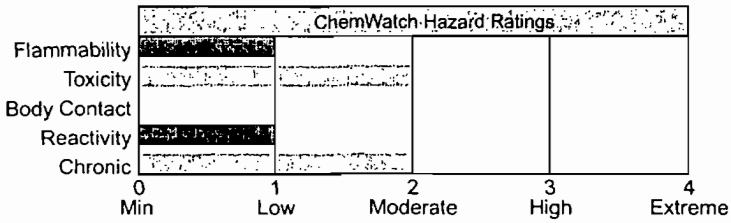

**ANSI Signal Word**

**Warning!**

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Coal tar creosote is a colorless (pure) or yellow to black (industrial) liquid with an aromatic smoky smell. It is irritating to the eyes, skin and respiratory tract and can be corrosive, causing severe burns. Coal tar creosote is a probable human carcinogen. It is a combustible liquid that is a moderate fire hazard when exposed to an ignition source.

### Potential Health Effects

**Target Organs:** Eyes, skin, bladder, kidneys, and respiratory system
**Primary Entry Routes:** Inhalation, skin absorption, and skin and/or eye contact
**Acute Effects** *Note! Phenol and phenolic derivatives of various aromatic hydrocarbons (tar acids), present in low concentrations, are the constituents most likely to be responsible for acute toxicity.*
**Inhalation:** Inhalation of vapors causes moderate irritation to the nose, throat, and upper respiratory tract.
**Eye:** Contact with liquid causes conjunctivitis (inflammation of the eye's lining), keratitis (corneal inflammation), or corneal burns with scarring. May cause loss of vision.

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**Skin:** Contact causes irritation, burning, itching, redness, pigment changes, dermatitis (a rash of redness and bumps), or burns. Photosensitization (worsening of rash with exposure to sunlight) may occur.

**Ingestion:** Causes salivation, nausea; vomiting; gastrointestinal tract irritation or bleeding; abdominal pain; rapid, thready pulse; vertigo; headaches; loss of pupillary reflexes; hypothermia; cyanosis; respiratory distress; shock and mild convulsions. Large doses may be fatal.

**Carcinogenicity:** NTP - Not listed; IARC - Group 2A, Probably carcinogenic to humans; OSHA - Not listed; NIOSH - Not listed; ACGIH - Not listed; EPA - Class B1, Probable human carcinogen based on epidemiologic studies; MAK - Not listed.

**Medical Conditions Aggravated by Long-Term Exposure:** Skin disorders.

**Chronic Effects:** Include dermatitis and, possibly, skin cancer or other forms of cancer. An increased risk of scrotal cancer for creosote-exposed brick makers was indicated in a worker mortality analysis. Epidemiological studies of coke oven workers reveal increased incidences of lung, bladder, prostate, pancreas, and intestinal cancer.

## Section 4 - First Aid Measures

**Inhalation:** Remove exposed person to fresh air, monitor for respiratory distress, and support breathing as needed.

**Eye Contact:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician or ophthalmologist immediately.

**Skin Contact:** *Quickly* remove contaminated clothing. Prior to washing and if readily available, use undiluted polyethylene glycol 300 to 400. Wash affected area with soap and flooding amounts of water for at least 15 min. *Do not* rub or apply pressure to the affected skin, apply any oily substance or use hot water to rinse. For reddened or blistered skin, consult a physician.

**Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Rinse the mouth several times with cold water. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water. *Do not induce vomiting!* Keep victim warm and at rest.

***After first aid, get appropriate in-plant, paramedic, or community medical support.***

**Note to Physicians:** Creosote may be detected in urine.

**Special Precautions/Procedures:** An exposed person should examine their skin periodically for growths, changes in warts or moles, and sores that do not heal.

## Section 5 - Fire-Fighting Measures

**Flash Point:** 165.2 °F (74 °C), Closed Cup

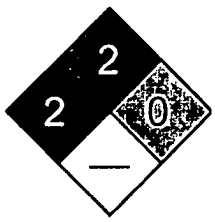
**Autoignition Temperature:** 637 °F (336 °C)

**LEL:** None reported.

**UEL:** None reported.

**Flammability Classification:** OSHA IIIA combustible liquid

**Extinguishing Media:** For small fires, use dry chemical, carbon dioxide, water spray or regular foam. For large fires, use water spray, fog or regular foam.



Fire Diamond

**General Fire Hazards/Hazardous Combustion Products:** Include carbon oxides. Coal tar creosote may present a vapor explosion hazard indoors, outdoors, and in sewers. Vapors may travel to an ignition source and flash back.

**Fire-Fighting Instructions:** If feasible and without undue risk, remove containers from fire hazard area. Otherwise use water spray to cool fire-exposed containers until well after they are extinguished. *Do not* release runoff from fire control methods to sewers or waterways. Because fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Also, wear full protective clothing. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from area and let fire burn. Immediately leave area if you hear a rising sound from venting safety device or notice any fire-caused tank discoloration as a BLEVE (boiling liquid expanding vapor explosion) may be imminent. Isolate area for 1/2 mile in all directions if fire involves tank, rail car or tank truck. Fully decontaminate or properly dispose of personal protective clothing.

## Section 6 - Accidental Release Measures

**Spill/Leak Procedures:** Notify safety personnel. Isolate hazard area, deny entry, and stay upwind of spills. Shut off all ignition sources. Cleanup personnel should protect against vapor inhalation and skin and eye contact.

**Small Spills:** Take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers for later disposal.

**Large Spills:** Consider initial downwind evacuation for at least 300 meters (1000 feet). For large spills, dike far ahead of liquid spill for later disposal. Water spray may reduce vapor. *Do not* release into sewers or waterways. Use nonsparking tools during clean-up.

**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

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## Section 7 - Handling and Storage

**Handling Precautions:** Avoid vapor inhalation and skin and eye contact. Use ventilation sufficient to reduce airborne exposures to nonhazardous levels (Sec. 2). Wear protective gloves, goggles, and clothing to avoid contact. Wear respiratory protection when necessary (Sec. 8). Consult your industrial hygienist. Practice good personal hygiene procedures to avoid inadvertently ingesting this material. Keep away from ignition sources.
Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

**Recommended Storage Methods:** Store in a cool, dry, well-ventilated area away from heat and ignition sources. Store coal tar creosote as close to area of use as possible to minimize transporting distance. Avoid physical damage to containers.

**Regulatory Requirements:** Follow applicable OSHA regulations.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** Enclose all operations and/or ventilate at the site of release to avoid vapor dispersion into the work area. To prevent static sparks, electrically ground and bond all containers and equipment. Provide general or local exhaust ventilation systems equipped with high-efficiency particulate filters to maintain airborne concentrations below OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.

**Administrative Controls:** Preplacement and periodic medical examinations of exposed workers emphasizing respiratory, skin, liver, and kidney disorders, including comprehensive work and medical history, physical examination, CXR, PFTs, urinalysis, LFT, and sputum cytology as the attending physician considers appropriate. Educate workers about the health and safety hazards associated with coal tar creosote.

**Personal Protective Clothing/Equipment:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent any skin contact. With breakthrough times of >8 hr, butyl rubber, Teflon, and Viton are recommended materials. Frequent change of protective garments is an additional protective measure. Wear protective eyeglasses or chemical safety goggles and face shield, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of contact lenses.

**Respiratory Protection:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. (The following respirator recommendations are for coal tar pitch volatiles.) For concentrations above the NIOSH REL or at any detectable concentrations, wear a SCBA that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; or 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 SCBA operated in pressure-demand or other positive-pressure mode. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air- purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

**Other:** Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment. Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

## Section 9 - Physical and Chemical Properties

**Appearance/General Info:** Colorless (pure) or yellow to black (industrial); aromatic smoky smell.

**Physical State:** Oily liquid

**Specific Gravity ($H_2O$=1, at 4 °C):** 1.07 to 1.08 at 68 °F (20 °C)

**Boiling Point:** 381 to 752 °F (194 to 400 °C)

**Water Solubility:** Slightly soluble

**Other Solubilities:** Soluble in alcohol; ether; glycerin; dimethyl sulfate; fixed or volatile oils; in solution of fixed alkali hydroxides.

## Section 10 - Stability and Reactivity

**Stability/Polymerization/Conditions to Avoid:** Coal tar creosote is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. Avoid excessive heat and contact with chlorosulfonic acid.

**Storage Incompatibilities:** Creosote oil mixed with chlorosulfonic acid in a closed container causes an increase in temperature and pressure.

**Hazardous Decomposition Products:** Thermal oxidative decomposition of coal tar creosote can produce carbon oxides and thick, black, acrid smoke.

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## Section 11 - Toxicological Information

**Acute Oral Effects:**
Rat, oral, $LD_{50}$: 725 mg/kg.
Mouse, oral, $LD_{50}$: 433 mg/kg.
**Other Effects:**
Tumorgenicity, mouse, oral: 2 g/kg administered on gestational days 5-9 produced maternal effects and fetotoxicity.
Reproductive Effects - Hamster, ovary cell: 10 mg/L induced sister chromatid exchange.
Tumorigenicity: Mouse, skin, 99 g/kg/33 weeks administered intermittently produced tumors on skin and appendages (carcinogenic by RTECS criteria).
*S. typhimurium*: 20 µg/plate (-S9) produced mutations.

See NIOSH, *RTECS* GF8615000, for additional data.

## Section 12 - Ecological Information

**Environmental Fate:** No data found.
**Ecotoxicity:** TL50, goldfish (*Carassius auratus*), 3.51 ppm/24 hr (60:40) mixture of creosote and coal tar; TL50, rainbow trout (*Salmo gairdneri*), 3.72 ppm/24 hr (60:40) mixture of creosote and coal tar; $LD_{50}$, bob white quail (*Colinus virginianus*), 1,260 ppm/8 days (60:40) mixture of creosote and coal tar.
**Octanol/Water Partition Coefficient:** log $K_{OW}$ = 1.0

## Section 13 - Disposal Considerations

**Disposal:** Coal tar creosote is a good candidate for rotary kiln and fluidized bed incineration. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations. Handle empty containers carefully as hazardous residues may still remain.

## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

**Shipping Name:** Corrosive liquids, n.o.s.
**Hazard Class:** 8
**ID No.:** UN1760
**Packing Group:** I, II, or III*
**Label:** CORROSIVE

**Additional Shipping Information:** * See 49 CFR 173.137 to assign Packing Group.

## Section 15 - Regulatory Information

**EPA Regulations:**
**RCRA 40 CFR:** Not listed
**CERCLA 40 CFR 302.4:** Not listed
**SARA 40 CFR 372.65:** Listed
**SARA EHS 40 CFR 355:** Not listed
**TSCA:** Listed

## Section 16 - Other Information

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Issue Date: 2000-07

**Copper**
**MSDS 162**
**COP1000**

## Section 1 - Chemical Product and Company Identification 54.1

**Material Name:** Copper **CAS Number:** 7440-50-8
**Chemical Formula:** Cu
**Structural Chemical Formula:** Cu
**Synonyms:** ALLBRI NATURAL COPPER; ANAC 110; ARWOOD COPPER; BRONZE POWDER; C.I. 77400; C.I. PIGMENT METAL 2; CDA 101; CDA 102; CDA 110; CDA 122; CE 1110; COPPER; COPPER BRONZE; COPPER M 1; COPPER METAL DUSTS; COPPER METAL FUMES; COPPER POWDER; COPPER SLAG-AIRBORNE; COPPER SLAG-MILLED; COPPER-AIRBORNE; COPPER,METALLIC POWDER; COPPER-MILLED; CU M3; CUPRUM; E 115 (METAL); EPA PESTICIDE CHEMICAL CODE 022501; 1721 GOLD; GOLD BRONZE; KAFAR COPPER; M 1; M 3; M 4; M1 (COPPER); M2 (COPPER); M3 (COPPER); M3R; M3S; M4 (COPPER); OFHC CU; RANEY COPPER
**General Use:** Manufacture of bronzes, brass, other copper alloys, electrical conductors, ammunition, copper salts, works of art, catalyst, oxygen scavenger.

## Section 2 - Composition / Information on Ingredients

| Name | CAS | % |
|---|---|---|
| copper | 7440-50-8 | >99 |

**OSHA PEL**
TWA: 0.1 mg/m$^3$; as Cu, fume.

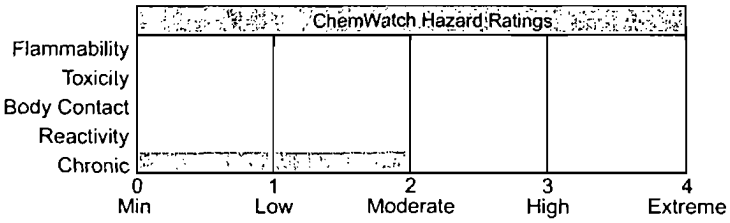
**NIOSH REL**
TWA: 1 mg/m$^3$.

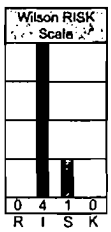
**DFG (Germany) MAK**
TWA: 0.1 mg/m$^3$.

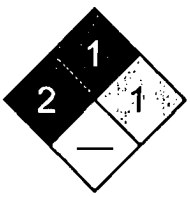
**ACGIH TLV**
TWA: 0.2 mg/m$^3$; as Cu; Inhalable.

**IDLH Level**
100 mg/m$^3$; as Cu.

## Section 3 - Hazards Identification



Fire Diamond

**ANSI Signal Word**
**Caution**

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Red/brown-colored powder; odorless. Irritating. Also causes: skin discoloration; ingestion: nausea, vomiting, abdominal pain, diarrhea. Inhalation of copper fume: metal fume fever. Chronic: respiratory disease, dermatitis.

### Potential Health Effects

**Primary Entry Routes:** inhalation, ingestion
**Target Organs:** respiratory system, skin, eyes, liver, kidneys
**Acute Effects**
**Inhalation:** The dust may be discomforting to the upper respiratory tract.
Persons with impaired respiratory function, airway diseases, and conditions such as emphysema or chronic bronchitis may incur further disability if excessive concentrations of particulate are inhaled.

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Copper poisoning following exposure to copper dusts and fume may result in headache, cold sweat and weak pulse. Capillary, kidney, liver and brain damage are the longer term manifestations of such poisoning. Inhalation of freshly formed metal oxide particles sized below 1.5 microns and generally between 0.02 to 0.05 microns may result in "metal fume fever". Symptoms may be delayed for up to 12 hours and begin with the sudden onset of thirst, and a sweet, metallic or foul taste in the mouth.

Other symptoms include upper respiratory tract irritation accompanied by coughing and a dryness of the mucous membranes, lassitude and a generalized feeling of malaise. Mild to severe headache, nausea, occasional vomiting, fever or chills, exaggerated mental activity, profuse sweating, diarrhea, excessive urination and prostration may also occur. Tolerance to the fumes develops rapidly, but is quickly lost. All symptoms usually subside within 24-36 hours following removal from exposure.

Nasal ulcerations with resultant nose-bleed may occur following inhalation of fine dusts.

**Eye:** Particulate/dust is regarded as discomforting and abrasive to the eyes.

**Skin:** The material may be slightly discomforting and abrasive to the skin.

**Ingestion:** The material may be mildly discomforting to the gastrointestinal tract if swallowed in large quantity. Large oral doses may cause nausea, vomiting, abdominal pain, metallic taste and diarrhea. If vomiting does not occur immediately, systematic copper poisoning may occur; capillary damage, headache, cold sweat, weak pulse, kidney and liver damage may be the result of poisoning.

**Carcinogenicity:** NTP - Not listed; IARC - Not listed; OSHA - Not listed; NIOSH - Not listed; ACGIH - Not listed; EPA - Class D, Not classifiable as to human carcinogenicity; MAK - Not listed.

**Chronic Effects:** *Chronic exposure to copper dusts may result in runny nose, irritation of mucous membranes and* atrophic changes with resultant dementia.

Pre-existing skin, kidney, liver and pulmonary disorders may be aggravated by exposure.

Chronic copper poisoning is rarely recognized in man although in one instance, at least, symptoms more commonly associated with exposures to mercury, namely infantile acrodynia (pink disease), have been described.

Tissue damage of mucous membranes may follow chronic dust exposure.

A hazardous situation is exposure of a worker with the rare hereditary condition (Wilson's disease or hereditary hepatolenticular degeneration) to copper exposure which may cause liver, kidney, CNS, bone and sight damage and is potentially lethal.

Hemolytic anemia (a result of red-blood cell damage) is common in cows and sheep poisoned by copper derivatives. *Overdosing of copper feed supplements has resulted in pigmentary cirrhosis of the liver.*

## Section 4 - First Aid Measures

**Inhalation:** Remove to fresh air.

Encourage patient to blow nose to ensure clear breathing passages. Rinse mouth with water. Consider drinking water to remove dust from throat.

Lay patient down. Keep warm and rested.

If available, administer medical oxygen by trained personnel.

If breathing is shallow or has stopped, ensure clear airway and apply resuscitation. Transport to hospital or doctor, without delay.

**Eye Contact:** Immediately hold the eyes open and flush with fresh running water.

Ensure irrigation under the eyelids by occasionally lifting upper and lower lids. If pain persists or recurs seek medical attention.

Removal of contact lenses after an eye injury should only be undertaken by skilled personnel.

**Skin Contact:** Immediately remove all contaminated clothing, including footwear (after rinsing with water).

Wash affected areas thoroughly with water (and soap if available).

Seek medical attention in event of irritation.

**Ingestion:** Contact a Poison Control Center.

Do NOT induce vomiting. Give a glass of water.

***After first aid, get appropriate in-plant, paramedic, or community medical support.***

**Note to Physicians:** Copper, magnesium, aluminum, antimony, iron, manganese, nickel (and their compounds) in welding, galvanizing or smelting operations all give rise to thermally produced particulates of smaller dimension than might be produced if the metals are divided mechanically. Where insufficient ventilation or respiratory protection is available these particulates may produce "metal fume fever" in the worker.

1.Onset occurs in 4-6 hours generally on the evening following exposure.

Tolerance develops in workers but may be lost over the weekend. (Monday Morning Fever).

2.Pulmonary function tests may indicate reduced lung volumes, small airway obstruction and decreased carbon monoxide diffusing capacity but these abnormalities resolve after several months.

3.Although mildly elevated urinary levels of heavy metal may occur they do not correlate with clinical effects.

4.The general approach to treatment is recognition of the disease, supportive care and prevention of exposure.

5.Seriously symptomatic patients should receive chest x-rays, have arterial blood gases determined and be observed for the development of tracheobronchitis and pulmonary edema.

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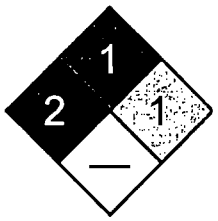
## Section 5 - Fire-Fighting Measures

**Flash Point:** Noncombustible, except as a powder
**Autoignition Temperature:** Not applicable
**Extinguishing Media:** Sand, dry powder extinguishers or other inerts should be used to smother dust fires.
These are the only suitable means for extinguishing metal dust fires.
Do NOT use water.
**General Fire Hazards/Hazardous Combustion Products:** Does not burn.



Fire Diamond

Metal powders, while generally regarded as noncombustible, may burn when metal is finely divided and energy input is high. Metal dust fires are slow moving but intense and difficult to extinguish. DO NOT disturb burning dust. Explosion may result if dust is stirred into a cloud, by providing oxygen to a large surface of hot metal. DO NOT use water or foam as generation of explosive hydrogen may result.
**Fire Incompatibility:** Avoid contact with acetylene, ammonium nitrate, barium bromate, chlorate and iodate, bromates, phosphorus, potassium chlorate, potassium iodate, potassium peroxide, sodium azide, sodium chlorate and iodate, sodium peroxide, sulfur and chlorates.
**Fire-Fighting Instructions:** Contact fire department and tell them location and nature of hazard.
Wear breathing apparatus plus protective gloves. Prevent, by any means available, spillage from entering drains or waterways.
Cool fire-exposed containers with water spray from a protected location.
Do not approach containers suspected to be hot.
If safe to do so, remove containers from path of fire.
Equipment should be thoroughly decontaminated after use.

## Section 6 - Accidental Release Measures

**Small Spills:** Clean up all spills immediately. Avoid contact with skin and eyes.
Wear impervious gloves and safety glasses.
Use dry clean-up procedures and avoid generating dust.
Vacuum up or sweep up.
Place spilled material in clean, dry, sealable, labeled container.
**Large Spills:** Clear area of personnel and move upwind.
Contact fire department and tell them location and nature of hazard.
Control personal contact by using protective equipment and dust respirator.
Prevent spillage from entering drains, sewers or waterways.
Avoid generating dust. Sweep, shovel up. Recover product wherever possible.
Put residues in labeled plastic bags or other containers for disposal.
If contamination of drains or waterways occurs, advise emergency services.
**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

## Section 7 - Handling and Storage

**Handling Precautions:** Limit all unnecessary personal contact.
Wear protective clothing when risk of exposure occurs.
Use in a well-ventilated area. When handling DO NOT eat, drink or smoke.
Always wash hands with soap and water after handling.
Avoid physical damage to containers. Use good occupational work practices.
Observe manufacturer's storing and handling recommendations.
**Recommended Storage Methods:** Packaging as recommended by manufacturer.
Check that containers are clearly labeled.
Glass container.
Plastic drum.
Polyethylene or polypropylene container.
Metal can.
Metal drum.
**Regulatory Requirements:** Follow applicable OSHA regulations.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** General exhaust is adequate under normal operating conditions.
If risk of overexposure exists, wear NIOSH-approved respirator.
Correct fit is essential to obtain adequate protection.
Provide adequate ventilation in warehouse or closed storage areas.

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**Personal Protective Clothing/Equipment**

**Eyes:** Safety glasses; safety glasses with side shields; chemical goggles.
Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them.

**Hands/Feet:** No special equipment needed when handling small quantities.
OTHERWISE: Wear chemical protective gloves, eg. PVC.

**Respiratory Protection:**
Exposure Range >0.1 to 1 mg/m$^3$: Air Purifying, Negative Pressure, Half Mask
Exposure Range >1 to 10 mg/m$^3$: Air Purifying, Negative Pressure, Full Face
Exposure Range >10 to 100 mg/m$^3$: Supplied Air, Constant Flow/Pressure Demand, Full Face
Exposure Range >100 to unlimited mg/m$^3$: Self-contained Breathing Apparatus, Pressure Demand, Full Face
Cartridge Color: magenta (P100)
**Note:** as a fume; if exposure is as a dust, respirator recommendations are different

**Other:** No special equipment needed when handling small quantities.
OTHERWISE: Overalls. Barrier cream. Eyewash unit.

## Section 9 - Physical and Chemical Properties

**Appearance/General Info:** Reddish metallic solid with high electrical conductivity. Odorless.

**Physical State:** Divided solid
**Vapor Pressure (kPa):** 0.13 at 1628 °C
**Formula Weight:** 63.5
**Specific Gravity ($H_2O$=1, at 4 °C):** 8.94
**Water Solubility:** Insoluble in water
**Evaporation Rate:** Not applicable

**pH:** Not applicable
**pH (1% Solution):** Not applicable.
**Boiling Point Range:** 2595 °C (4703 °F)
**Freezing/Melting Point Range:** 1083 °C (1981.4 °F)
**Volatile Component (% Vol):** Not applicable
**Decomposition Temperature (°C):** Not applicable

## Section 10 - Stability and Reactivity

**Stability/Polymerization:** Product is considered stable. Hazardous polymerization will not occur.
**Storage Incompatibilities:** Avoid storage with acetylene, ammonium nitrate, bromates, chlorates, chlorine, chlorine plus oxygen difluoride, chlorine trifluoride, ethylene oxide, fluorine, hydrazine, mononitrate, hydrozoic acid, hydrogen peroxide, hydrogen sulfide, iodates, lead azide, phosphorus, nitric acid, potassium peroxide, sodium azide, sodium peroxide, sulfur plus chlorates, and 1-bromo-2-propylene.

## Section 11 - Toxicological Information

Unless otherwise specified data extracted from RTECS - Registry of Toxic Effects of Chemical Substances

TOXICITY
Oral (human) $TD_{Lo}$: 0.12 mg/kg

IRRITATION
Nil Reported

See NIOSH, *RTECS* GL 5325000, for additional data.

## Section 12 - Ecological Information

**Environmental Fate:** No data found.
**Ecotoxicity:** No data found.

## Section 13 - Disposal Considerations

**Disposal:** Recycle wherever possible or consult manufacturer for recycling options. Follow applicable federal, state, and local regulations.
Bury residue in an authorized landfill.
Recycle containers where possible, or dispose of in an authorized landfill.

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## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

**Shipping Name:** NONE
**Hazard Class:** None
**ID No.:** None
**Packing Group:** None
**Label:** No class label assigned

**Additional Shipping Information:**

## Section 15 - Regulatory Information

**EPA Regulations:**
**RCRA 40 CFR:** Not listed
**CERCLA 40 CFR 302.4:** Listed per CWA Section 307(a) 5000 lb (2268 kg)
**SARA 40 CFR 372.65:** Listed
**SARA EHS 40 CFR 355:** Not listed
**TSCA:** Listed

## Section 16 - Other Information

**Research Date:**.....1999-11 **Review Date:** .....2000-07

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## Section 1 - Chemical Product and Company Identification 42/57

**Material Name:** DDT **CAS Number:** 50-29-3
**Chemical Formula:** $C_{14}H_9Cl_5$
**Structural Chemical Formula:** $(ClC_6H_4)_2CHCCl_3$
**EINECS Number:** 200-024-3
**Synonyms:** AAVERO-EXTRA; AGRITAN; ANOFEX; ARKOTINE; AZOTOX; AZOTOX M-33; BENZENE,1,1'-(2,2,2-TRICHLOROETHYLIDENE)BIS(4-CHLORO-; 2,2-BIS (P-CHLOROPHENYL)-1,1,1-TRICHLOROETHANE; ALPHA,ALPHA-BIS(P-CHLOROPHENYL)-BETA,BETA,BETA-TRICHLORETHANE; 1,1-BIS(P-CHLOROPHENYL)-2,2,2-TRICHLOROETHANE; 1,1-BIS-(P-CHLOROPHENYL)-2,2,2-TRICHLOROETHANE; 2,2-BIS(P-CHLOROPHENYL)-1,1,1-TRICHLOROETHANE; ALPHA,ALPHA-BIS(P-CHLOROPHENYL)-BETA,BETA,BETA-TRICHLOROETHANE; BOSAN SUPRA; BOVIDERMOL; CHLOFENOTAN; CHLOROPHENOTHAN; CHLOROPHENOTHANE; CHLOROPHENOTOXUM; CHLORPHENOTHAN; CHLORPHENOTOXUM; CITOX; CLOFENOTANE; 4,4'-DDT; DDT; P,P'-DDT; P,P-DDT; DEDELO; DEOVAL; DETOX; DETOXAN; DIBOVAN; DIBOVIN; 4,4'-DICHLORODIPHENYLTRICHLOROETHANE; DICHLORODIPHENYLTRICHLOROETHANE; P,P'-DICHLORODIPHENYLTRICHLOROETHANE; DICOPHANE; DIDIGAM; DIDIMAC; DIPHENYLTRICHLOROETHANE; DODAT; DYKOL; ENT 1,506; ENT-1506; EPA PESTICIDE CODE 029201; ESTONATE; ETHANE,1,1,1-TRICHLORO-2,2-BIS(4-CHLOROPHENYL)-; ETHANE,1,1,1-TRICHLORO-2,2-BIS(P-CHLOROPHENYL)-; GENITOX; GESAFID; GESAPON; GESAREX; GESAROL; GUESAPON; GUESAROL; GYRON; HAVERO-EXTRA; HILDIT; IVORAN; IXODEX; KLORFENOTON; KOPSOL; MICRO DDT 75; MUTOXAN; MUTOXIN; NEOCID; NEOCIDOL; NEOCIDOL (SOLID); OMS 0016; OMS 16; PARACHLOROCIDUM; PEB1; PENTACHLORIN; PENTECH; PENTICIDUM; PPZEIDAN; PP'-ZEIDANE; R50; RUKSEAM; SANTOBANE; TAFIDEX; TECH DDT; 1,1,1-TRICHLOOR-2,2-BIS(4-CHLOOR FENYL)-ETHAAN; 1,1,1-TRICHLOR-2,2-BIS(4-CHLOR-PHENYL)-AETHAN; 1,1,1-TRICHLORO-2,2-BIS(P-CHLOROPHENYL)ETHANE; TRICHLOROBIS(4-CHLOROPHENYL)ETHANE; 1,1,1-TRICHLORO-2,2-DI(4-CHLOROPHENYL)-ETHANE; 1,1,1-TRICHLORO-2,2-DI(4-CHLOROPHENYL)ETHANE; 1,1'-(2,2,2-TRICHLOROETHYLIDENE)BIS(4-CHLOROBENZENE); 1,1,1-TRICLORO-2,2-BIS(4-CLORO-FENIL)-ETANO; 1,1,1-TRICLORO-2,2-BIS(4-CLORO-FENYL)-ETANO; ZEIDANE; ZERDANE
**Derivation:** Prepared by condensing chloral or chloral hydrate with chlorobenzene in presence of sulfuric acid.
**General Use:** One of the most widely used contact insecticides from 1945 until its ban in 1972. Although banned in the U.S. (except for such uses as emergency health situations and for controlling body lice), it is still widely used in the tropics for control of vector-carrying diseases such as malaria, yellow fever, dengue, filariasis, louse-borne typhus, and louse-borne relapsing fever.

## Section 2 - Composition / Information on Ingredients

| Name | CAS | % |
|---|---|---|
| DDT | 50-29-3 | *p'p'*DDT 70% wt + *o'p'*DDT 30% wt (technical grade) |

**Trace Impurities:** DDD, DDE

**OSHA PEL**
TWA: 1 mg/m$^3$; skin.

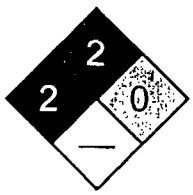
**ACGIH TLV**
TWA: 1 mg/m$^3$.

**NIOSH REL**
TWA: 0.5 mg/m$^3$.

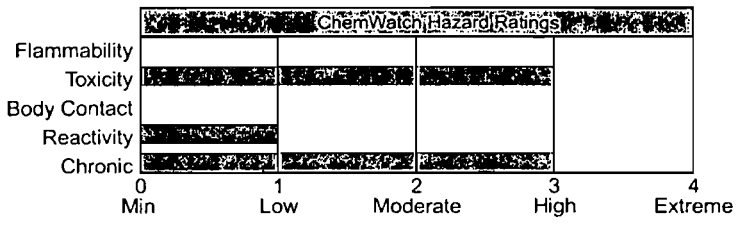
**IDLH Level**
500 mg/m$^3$.

**DFG (Germany) MAK**
TWA: 1 mg/m$^3$; skin, substances with systemic effects, onset of effect greater than 2 hours, half-life greater than shift length, strongly cumulative, measured as inhalable fraction of the aerosol.

## Section 3 - Hazards Identification



Fire Diamond



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**ANSI Signal Word**

**Caution**

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

DDT is a white to gray, crystalline solid. Although it has been banned in the U.S. because of its persistence in the environment and potential for bioaccumulation, DDT has not produced toxicity in workers who either manufactured or used it (even over many years). However, this lack of toxicity is based on inhalation and skin absorption. If DDT is ingested, especially in large amounts, central nervous system effects will occur with possible liver damage. DDT is considered a confirmed animal carcinogen and a suspected human carcinogen.

### Potential Health Effects

**Target Organs:** Central nervous system, liver, skin, peripheral nervous system.

**Primary Entry Routes:** Inhalation, ingestion, skin contact.

**Acute Effects**

**Inhalation:** Inhalation does not appear to cause toxicity beyond that of minor mechanical irritation.

**Eye:** Exposure to 423 mg/m$^3$/1 hr/day for 6 days caused eye irritation.

**Skin:** Skin absorption may occur from some DDT solutions, but degree of absorption will depend on the solvent involved. Aqueous solutions and the powder or crystals are not easily absorbed.

**Ingestion:** DDT can cause a variety of central nervous system effects if ingested. Large doses generally result in vomiting, while smaller doses cause symptoms within 2 to 3 hr post-ingestion. Symptoms include tingling of the lips, tongue, and face; malaise; headache; sore throat; fatigue; tremors of the head, neck, and eyelids; apprehension; ataxia; and confusion. Convulsions and paralysis of the hands is possible in severe exposures (if vomiting does not occur). Vital signs are usually normal, but in severe poisonings, the pulse may be irregular and abnormally slow. Based on animal studies, it is expected that ventricular fibrillation and sudden death can occur at any time during acute poisoning. Recovery from acute poisoning generally occurs within 24 hr except in the most serious cases.

**Carcinogenicity:** NTP - Class 2B, Reasonably anticipated to be a carcinogen, sufficient evidence of carcinogenicity from studies in experimental animals; IARC - Group 2B, Possibly carcinogenic to humans; OSHA - Not listed; NIOSH - Listed as carcinogen; ACGIH - Class A3, Animal carcinogen; EPA - Class B2, Probable human carcinogen based on animal studies; MAK - Not listed.

**Medical Conditions Aggravated by Long-Term Exposure:** Possibly, disorders of the central nervous system and liver.

**Chronic Effects:** There are conflicting reports on whether or not DDT produces chronic effects in humans. Although it is well established that chronic exposure in experimental animals produces effects including liver damage, CNS degeneration, dermatitis, weakness, convulsions, coma, and death, these effects are not confirmed in humans. Liver cancer is confirmed in animals, but has not been documented in humans. These conflicting reports appear due to the lack of documented chronic toxicity in workers and data showing that DDT and its metabolites are retained in the body fat for long time periods, thus providing a basis for the *possibility* of chronic toxicity.

## Section 4 - First Aid Measures

**Inhalation:** Remove exposed person to fresh air and support breathing as needed.

**Eye Contact:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.

**Skin Contact:** *Quickly* remove contaminated clothing. Rinse away any loose material and wash exposed area with soap and water. For reddened or blistered skin, consult a physician. Carefully dispose of contaminated clothing because it may pose a fire hazard.

**Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting. Gastric lavage should be performed promptly.

***After first aid, get appropriate in-plant, paramedic, or community medical support.***

**Note to Physicians:** Effects may be delayed; keep under observation. Solvents such as kerosine are added to DDT as a vehicle and, depending on the type involved, may be more toxic than DDT itself.

**Special Precautions/Procedures:** Amobarbital or pentobarbital is recommended for the relief of central neurological manifestations; tribromoethanol and paraldehyde are recommended for allaying prolonged convulsions.

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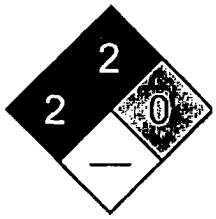
## Section 5 - Fire-Fighting Measures

**Flash Point:** DDT itself is noncombustible but is dissolved in a variety of solvents. The average quoted Flash Point is 162 °F (72.2 °C) (CC) although the specific vehicle is not identified.
**Autoignition Temperature:** None reported
**LEL:** None reported
**UEL:** None reported
**Flammability Classification:** Class IIIA Combustible Liquid (varies depending on vehicle)
**Extinguishing Media:** For small fires, use dry chemical, water spray, or regular foam. For large fires, use water spray, fog, or regular foam.
**General Fire Hazards/Hazardous Combustion Products:** Chloride fumes and carbon oxide gases. Container may explode in heat of fire.



Fire Diamond

**Fire-Fighting Instructions:** Do not release runoff from fire control methods to sewers or waterways. Fight fire from maximum distance. Stay away from ends of tanks. Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural fire fighters' protective clothing is *not* effective.

## Section 6 - Accidental Release Measures

**Spill/Leak Procedures:** Notify safety personnel, isolate area, deny entry, and stay upwind. Shut off all ignition sources. Cleanup personnel should protect against contamination.
**Small Spills:** For dry spills, carefully scoop up material or vacuum (with an approved filter). Damp mop any residue. For small solution spills, take up with earth, sand, vermiculite, or other absorbent material and place in suitable containers for disposal.
**Large Spills:** Dike far ahead of liquid spill for later reclamation or disposal. Do not release into sewers or waterways.
**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

## Section 7 - Handling and Storage

**Handling Precautions:** Use non-sparking tools to open containers. Keep dry chemical extinguishers on hand in case of fire.
Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.
**Recommended Storage Methods:** Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from heat, ignition sources, and incompatibles (Sec. 10). *Do not* store in aluminum or iron containers.
**Regulatory Requirements:** Follow applicable OSHA regulations.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** To prevent static sparks, electrically ground and bond all equipment used with and around DDT. Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.
**Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers with emphasis on the liver and central nervous system.
**Personal Protective Clothing/Equipment:** Wear chemically protective gloves, boots, aprons, and gauntlets made of butyl rubber to prevent prolonged or repeated skin contact. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face- protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.
**Respiratory Protection:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For any detectable concentration, use a SCBA with a full facepiece and operated in pressure demand or other positive-pressure mode, or any supplied-air respirator with a full facepiece and operated in pressure demand or other positive-pressure mode with an auxiliary SCBA. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
**Other:** Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment. Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

## Section 9 - Physical and Chemical Properties

**Appearance/General Info:** White to gray crystals or powder which is odorless or has a slight aromatic odor.

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**Physical State:** Solid
**Odor Threshold:** 5.0725 mg/m$^3$
**Vapor Pressure (kPa):** 5.5 x 10-6 mm Hg at 68 °F (20 °C)
**Formula Weight:** 354.48
**Specific Gravity ($H_2O$=1, at 4 °C):** 0.98 to 0.99
**Boiling Point:** 365 °F (185 °C)
**Freezing/Melting Point:** 227 °F (108.3 °C)
**Water Solubility:** 0.0012 ppm

**Other Solubilities:** (g DDT/100 mL): acetone 58, 95% alcohol 2, benzene 78, benzyl benzoate 42, carbon tetrachloride 45, chlorobenzene 74, cyclohexanone 116, dibutyl phthalate 33, o-dichlorobenzene 68, dichlorodifluoromethane 2, dioxane 100, ethyl ether 28, gasoline 10, isopropanol 3, kerosine 8 to 10, methylated naphthalenes 40 to 60, mineral oil 5, morpholine 75, peanut oil 11, pine oil 0 to 16, tetralin 61, tributyl phosphate 50, and xylene 60.

## Section 10 - Stability and Reactivity

**Stability/Polymerization/Conditions to Avoid:** DDT is stable at room temperature in closed containers under normal storage and handling conditions. It biodegrades very slowly. Hazardous polymerization does not occur. Exposure to heat, ignition sources, and incompatibles.
**Storage Incompatibilities:** Strong oxidizers, alkaline materials, iron and aluminum salts.
**Hazardous Decomposition Products:** Thermal oxidative decomposition of DDT can produce carbon dioxide.

## Section 11 - Toxicological Information

**Acute Oral Effects:**
Rat, oral, $LD_{50}$: 87 mg/kg; details not reported.
Human, oral, $LD_{Lo}$: 500 mg/kg caused convulsions, cardiac arrhythmias, and respiratory changes.
**Other Effects:**
Mutagenicity - *E. coli*: 15 µmol/L caused DNA damage.
Teratogenicity - Rat, oral, $TD_{Lo}$: 112 mg/kg given to a 56 day old male caused paternal effects (spermatogenesis, testes, epididymis, sperm duct).
Rat, oral, $TD_{Lo}$: 1225 mg/kg given for 7 continuous weeks caused liver tumors.
See NIOSH, *RTECS* KJ3325000, for additional data.

## Section 12 - Ecological Information

**Environmental Fate:** In water, DDT will adsorb strongly to sediments, significantly bioconcentrate in fish, and will be subject to considerable evaporation with an estimated half-life of several hr to almost 50 hr from certain waters. It may biodegrade when high concentrations of required microbes (*Escherichia*, *Hydrogenomonas*, and *Saccharomyces*) are present. On land, DDT will adsorb strongly and should not appreciably leach to groundwater. It may evaporate (half-life of 100 days) and is subject to photooxidation from soil. DDT may significantly biodegrade in flooded soils or under anaerobic conditions provided high populations of the required microbes are present. Half-life ranges from 2 to >15 yr. In the air, DDT is subject to direct photooxidation and reaction with photochemically produced hydroxyl radicals (est. half-life = 2 days). Wet and dry deposition are significant mechanisms for removal from air.
**Ecotoxicity:** Glass shrimp (*Palaemonestes kadiakensis*), $LC_{50}$ = 2.3 mcg/L/96 hr at 69.8 °F (21 °C); Japanese quail, 2 month old male, (*Coturnix japonica*), $LD_{50}$ = 841 mg/kg; bluegill (*Lepomis macrochirus*), $LC_{50}$ = 28.7 mcg/L/36 hr.

## Section 13 - Disposal Considerations

**Disposal:** DDT is a good candidate for rotary kiln or liquid injection incineration (furnace with afterburner and alkali scrubber). 60 to 80% removal of DDT from contaminated soils has been achieved in 10 min. by super critical-carbon dioxide extraction. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations. Triple rinse containers. Containers in good condition should be returned to the manufacturer and those that are not reusable should be punctured and transported to a scrap metal facility for recycling, disposal, or burial in a designated landfill.

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## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

**Shipping Name:** Organochlorine pesticides, solid toxic, n.o.s.
**Hazard Class:** 6.1
**ID No.:** UN2761
**Packing Group:** III
**Label:** Keep Away From Food

## Section 15 - Regulatory Information

**EPA Regulations:**
**RCRA 40 CFR:** Listed U061 Toxic Waste
**CERCLA 40 CFR 302.4:** Listed per CWA Section 311(b)(4), per RCRA Section 3001, per CWA Section 307(a) 1 lb (0.454 kg)
**SARA 40 CFR 372.65:** Listed as Compound
**SARA EHS 40 CFR 355:** Not listed
**TSCA:** Listed

## Section 16 - Other Information

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**di-sec-Octyl Phthalate**
**DIE8100**

Issue Date: 2002-02

## Section 1 - Chemical Product and Company Identification 54

**Material Name:** di-sec-Octyl Phthalate **CAS Number:** 117-81-7
**Chemical Formula:** $C_{24}H_{38}O_4$
**Structural Chemical Formula:** $C_6H_4[COOCH_2CH(C_2H_5)(CH_2)_3]_2$
**Synonyms:** BEHP; 1,2-BENZENEDICARBOXYLIC ACID,BIS(2-ETHYLHEXYL) ESTER; 1,2-BENZENEDICARBOXYLIC ACID,BIS(ETHYLHEXYL) ESTER; BIS(2-ETHYLHEXYL) 1,2-BENZENEDICARBOXYLATE; BIS(2-ETHYLHEXYL)-1,2-BENZENEDICARBOXYLATE; BIS-(2-ETHYLHEXYL)-1,2-BENZENEDICARBOXYLATE; BIS-(2-ETHYLHEXYL)ESTER KYSELINY FTALOVE; BIS(2-ETHYLHEXYL)ESTER PHTHALIC ACID; BIS(2-ETHYLHEXYL)PHTHALATE; BIS-(2-ETHYLHEXYL)PHTHALATE; BISOFLEX 81; BISOFLEX DOP; COMPOUND 889; DAF 68; DEHP; DI(2-ETHYLHEXYL) PHTHALATE; DI(ETHYLHEXYL) PHTHALATE; DIETHYLHEXYL PHTHALATE; DI(2-ETHYLHEXYL)ORTHOPHTHALATE; DI(2-ETHYLHEXYL)PHTHALATE; DI-2-ETHYLHEXYLPHTHALATE; DI-SEC-OCTYL PHTHALATE; DIOCTYL PHTHALATE; DOF; DOP; ERGOPLAST FDO; ERGOPLAST FDO-S; 2-ETHYLHEXYL PHTHALATE; ETHYLHEXYL PHTHALATE; EVIPLAST 80; EVIPLAST 81; FLEXIMEL; FLEXOL DOP; FLEXOL PLASTICIZER DOP; GOOD-RITE GP 264; HATCOL DOP; HERCOFLEX 260; JAYFLEX DOP; KODAFLEX DOP; MOLLAN O; NUOPLAZ DOP; OCTOIL; OCTYL PHTHALATE; PALATINOL AH; PHTHALIC ACID DIOCTYL ESTER; PHTHALIC ACID,BIS(2-ETHYLHEXYL) ESTER; PITTSBURGH PX-138; PLATINOL AH; PLATINOL DOP; RC PLASTICIZER DOP; REOMOL D 79P; REOMOL DOP; SICOL 150; STAFLEX DOP; TRUFLEX DOP; VESTINOL AH; VINICIZER 80; WITCIZER 312
**General Use:** Used as a plasticizer for resins, elastomers, vinyl products, films for packaging, containers and electrical cables.
High purity grades used as electrical insulating (dielectric) fluid.

## Section 2 - Composition / Information on Ingredients

| Name | CAS | % |
|---|---|---|
| di-sec-octyl phthalate | 117-81-7 | >99 |

**OSHA PEL**
TWA: 5 mg/m$^3$.

**OSHA PEL Vacated 1989 Limits**
TWA: 5 mg/m$^3$; STEL: 10 mg/m$^3$.

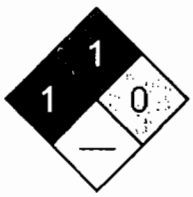
**ACGIH TLV**
TWA: 5 mg/m$^3$.

**NIOSH REL**
TWA: 5 mg/m$^3$; STEL: 10 mg/m$^3$.

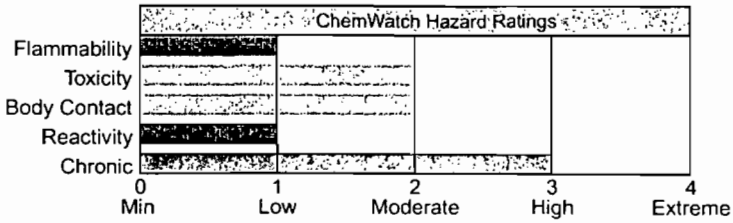
**IDLH Level**
5000 mg/m$^3$.

**DFG (Germany) MAK**
TWA: 10 mg/m$^3$; ceiling, substances with systemic effects, onset of effect greater than 2 hours, half-life greater than shift length, strongly cumulative.

## Section 3 - Hazards Identification



Fire Diamond



### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Light colored liquid; slight odor. Mildly irritating to eyes/skin/respiratory tract. Also causes: conjunctivitis, keratitis, bronchial irritation, eczema, staggering, abdominal cramps, nausea, diarrhea, CNS depression. Possible cancer hazard.

### Potential Health Effects

**Target Organs:** eyes, upper respiratory system, skin, central nervous system (CNS)
**Primary Entry Routes:** inhalation, ingestion

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**Acute Effects**

**Inhalation:** Not normally a hazard due to nonvolatile nature of product. Inhalation hazard is increased at higher temperatures.
The mist is discomforting to the upper respiratory tract.
Inhalation of concentrated mists can cause coughing, sneezing, severe irritation, dizziness, headache and nausea.

**Eye:** The liquid may produce eye discomfort and is capable of causing temporary impairment of vision and/or transient eye inflammation, ulceration. The mist is moderately discomforting to the eyes.
The material may be irritating to the eye, with prolonged contact causing inflammation. Repeated or prolonged exposure to irritants may produce conjunctivitis.

**Skin:** The liquid is mildly discomforting to the skin if exposure is prolonged and may cause drying of the skin, which may lead to dermatitis.
Irritation and skin reactions are possible with sensitive skin.
The material may accentuate any pre-existing dermatitis condition.
The material may cause skin irritation after prolonged or repeated exposure and may produce a contact dermatitis (nonallergic). This form of dermatitis is often characterized by skin redness (erythema) and swelling (edema) which may progress to vesiculation, scaling and thickening of the epidermis. Histologically there may be intercellular edema of the spongy layer (spongiosis) and intracellular edema of the epidermis.

**Ingestion:** Considered an unlikely route of entry in commercial/industrial environments.
The liquid is discomforting and is regarded as harmful if swallowed.
Ingestion may result in nausea, abdominal irritation, pain and vomiting.
Phthalates (aromatic dicarboxylic acid esters), in general, exhibit low toxicity, partly because of poor absorption but mainly as a result of rapid metabolism in which the esters are saponified to phthalic acid (which is rapidly excreted) and the parent alcohol (which is subsequently metabolized). The pathology of these compounds seems to be related to the released alcohol and its biological effects. Testicular atrophy produced in rats during feeding studies depends on the length and structure of the alcohol; in general the lower molecular weight esters produce the more severe effects.
The toxicity of phthalic acid isomers decreases in the order o-phthalic acid, isophthalic acid and terephthalic acid.
Phthalic acid is not metabolized but is excreted, unchanged, in the urine and feces.
Terephthalic acid appears to potentiate the biological effects of substances such as antibiotics, thiamine and sulfonamides.

**Carcinogenicity:** NTP - Class 2B, Reasonably anticipated to be a carcinogen, sufficient evidence of carcinogenicity from studies in experimental animals; IARC - Group 2B, Possibly carcinogenic to humans; OSHA - Not listed; NIOSH - Listed as carcinogen; ACGIH - Class A3, Animal carcinogen; EPA - Class B2, Probable human carcinogen based on animal studies; MAK - Not listed.

**Chronic Effects:** Oral studies of 90-days to 2-years in rat, 1-year in guinea pig and up to 1-year in dog have shown a no-effect level of about 60 mg/kg/day. Higher doses produced growth retardation and increased weights of livers and kidneys.
Rats and mice fed on diets containing 6000-12000 (rats) and 3000-6000 (mice) mg/kg body weight for 103 weeks showed an increased incidence of hepatocellular carcinomas in female rats and male and female mice, and an increased incidence of either hepatocellular carcinomas or neoplastic nodules in male rats. About 35% of the hepatocellular carcinomas in mice had metastasised to the lungs.
The substance can cause testicular damage in rats (dietary and gavage studies) with a no-effect level in 0.3% to 0.5% in the diet. Inhalation or dermal exposures did not produce testicular effects. When the substance was fed to pregnant rats (5 mL/kg) it produced slight effects on embryonic and fetal development with skeletal abnormalities more common.
A Russian study describes exposure by workers to mixed phthalates (and other plasticizers) - pain, numbness and spasms in the upper and lower extremities were related to duration of exposures. Symptoms usually developed after the sixth or seventh year of work. Neurological studies revealed the development of polyneuritis in about 30% of the workers involved in this study. About 30% of the workforce showed depression of the vestibular receptors. Because the study described mixed exposures it is difficult to determine what, if any, unique role was played by the phthalates.
Increased incidences of anovulatory reproductive cycles and low estrogen concentrations were reported among Russian women working with phthalate plasticizers; the abnormal cycles were associated with spontaneous abortion. The specific phthalates implicated, dose levels and other data were not reported.
It has been alleged that the phthalates mimic or interfere with sex hormones. Phthalates are added as plasticizers in plastics (including food packaging) and are used as ingredients in paints, inks and adhesives. Their potential for entering the human body is marked. They have been added to a list of chemicals (including alkyl phenolics, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and dioxins) which are implicated in reducing sperm counts and fertility in males a phenomenon which has apparently arisen since the mid 1960s.
Although the human fetus is "bathed" in naturally occurring estrogens during pregnancy it is suggested that it has developed a protective mechanism against natural estrogens but is not safe from synthetic variants. These tend to accumulate in body fats which sets them apart from the natural product. During early pregnancy, fats are broken down and may flood the body with concentrated pollutants.

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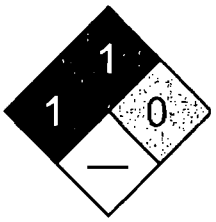
## Section 4 - First Aid Measures

**Inhalation:** Remove to fresh air.
Lay patient down. Keep warm and rested.
If breathing is shallow or has stopped, ensure clear airway and apply resuscitation. Transport to hospital or doctor.
**Eye Contact:** Immediately hold eyes open and flush continuously with running water for at least 15 minutes. Ensure irrigation under eyelids.
Seek medical attention without delay.
**Skin Contact:** Immediately remove all contaminated clothing, including footwear (after rinsing with water).
Wash affected areas thoroughly with water (and soap if available).
Seek medical attention in event of irritation.
**Ingestion:** Contact a Poison Control Center.
If more than 15 minutes from a hospital, induce vomiting, preferably using Ipecac Syrup APF.
Note: DO NOT INDUCE VOMITING in an unconscious person.
***After first aid, get appropriate in-plant, paramedic, or community medical support.***
**Note to Physicians:** Treat symptomatically.

## Section 5 - Fire-Fighting Measures

**Flash Point:** 215 °C Open Cup
**Autoignition Temperature:** 391 °C
**LEL:** 0.3% v/v
**Extinguishing Media:** Water spray or fog; foam, dry chemical powder, or BCF (where regulations permit).
Carbon dioxide.
**General Fire Hazards/Hazardous Combustion Products:** Combustible. Slight fire hazard when exposed to heat or flame.
Heating may cause expansion or decomposition leading to violent rupture of containers.
On combustion, may emit toxic fumes of carbon monoxide (CO).
May emit acrid smoke.
Mists containing combustible materials may be explosive.
Hot organic vapors or mist are capable of sudden spontaneous combustion when mixed with air even at temperatures below their published autoignition temperatures. The temperature of ignition decreases with increasing vapor volume and vapor/air contact times and is influenced by pressure change.
Ignition may occur under elevated-temperature process conditions especially in processes performed under vacuum subjected to sudden ingress of air or in processes performed at elevated pressure, where sudden escape of vapors or mists to the atmosphere occurs.



Fire Diamond

**Fire Incompatibility:** Avoid contamination with oxidizing agents i.e. nitrates, oxidizing acids, chlorine bleaches, pool chlorine etc. as ignition may result.
**Fire-Fighting Instructions:** Contact fire department and tell them location and nature of hazard.
Wear breathing apparatus plus protective gloves. Prevent, by any means available, spillage from entering drains or waterways.
If safe, switch off electrical equipment until vapor fire hazard removed.
Use water delivered as a fine spray to control fire and cool adjacent area.
Avoid spraying water onto liquid pools.
Do not approach containers suspected to be hot.
Cool fire-exposed containers with water spray from a protected location.
If safe to do so, remove containers from path of fire.

## Section 6 - Accidental Release Measures

**Small Spills:** Remove all ignition sources. Clean up all spills immediately.
Avoid breathing vapors and contact with skin and eyes.
Control personal contact by using protective equipment.
Contain and absorb spill with sand, earth, inert material or vermiculite.
Wipe up. Place in a suitable labeled container for waste disposal.
**Large Spills:** Contact fire department and tell them location and nature of hazard.
Clear area of personnel and move upwind.
Shut off all possible sources of ignition and increase ventilation.
Wear breathing apparatus plus protective gloves. Prevent, by any means available, spillage from entering drains or waterways.
Stop leak if safe to do so.
Absorb or cover spill with sand, earth, inert material or vermiculite.
Recover liquid and place in labeled, sealable container for recycling.

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Collect residues and seal in labeled drums for disposal.
Wash spill area with detergent and water.
If contamination of drains or waterways occurs, advise emergency services.
After clean-up operations, decontaminate and launder all protective clothing and equipment before storing and reusing.
**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

## Section 7 - Handling and Storage

**Handling Precautions:** Use good occupational work practices.
Atmosphere should be regularly checked against established exposure standards to ensure safe working conditions are maintained.
Use in a well-ventilated area.
Avoid generating and breathing mist and vapor.
Avoid contact with incompatible materials.
Avoid prolonged and repeated skin contact.
Avoid smoking, bare lights or ignition sources.
Avoid physical damage to containers.
Keep containers securely sealed when not in use.
Wear personal protective equipment when handling.
When handling, DO NOT eat, drink or smoke.
Always wash hands with soap and water after handling. Work clothes should be laundered separately.
**Recommended Storage Methods:** Metal can; metal drum. Packing as recommended by manufacturer.
Check all containers are clearly labeled and free from leaks.
**Regulatory Requirements:** Follow applicable OSHA regulations.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** None under normal operating conditions. OTHERWISE: General exhaust is adequate under normal operating conditions.
If inhalation risk of overexposure exists, wear NIOSH-approved organic-vapor respirator.
If mist is present, use air supplied breathing apparatus.
**Personal Protective Clothing/Equipment**
**Eyes:** Safety glasses with side shields; or as required, chemical goggles.
Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them.
**Hands/Feet:** Barrier cream and Nitrile rubber gloves or Neoprene rubber gloves.
Safety footwear.
**Respiratory Protection:**
Exposure Range >5 to 50 mg/m$^3$: Air Purifying, Negative Pressure, Half Mask
Exposure Range >50 to 500 mg/m$^3$: Air Purifying, Negative Pressure, Full Face
Exposure Range >500 to <5000 mg/m$^3$: Supplied Air, Constant Flow/Pressure Demand, Half Mask
Exposure Range 5000 to unlimited mg/m$^3$: Self-contained Breathing Apparatus, Pressure Demand, Full Face
Cartridge Color: dust/mist filter (use P100 or consult supervisor for appropriate dust/mist filter)
**Other:** Overalls. Eyewash unit.
**Glove Selection Index:**
BUTYL.....Best selection
VITON.....Best selection
NITRILE.....Poor to dangerous choice for other than short-term immersion

## Section 9 - Physical and Chemical Properties

**Appearance/General Info:** Light-colored, odorless and oily liquid. Mixes with mineral oil and most organic solvents.
**Physical State:** Liquid
**Vapor Pressure (kPa):** 0.17 at 200 °C
**Vapor Density (Air=1):** 13.45
**Formula Weight:** 390.54
**Specific Gravity ($H_2O$=1, at 4 °C):** 0.99 at 20 °C
**Water Solubility:** < 0.01% at 25 °C
**Evaporation Rate:** Very Slow
**pH:** Not applicable
**pH (1% Solution):** Not applicable.
**Boiling Point Range:** 230 °C (446 °F) at 5 mm Hg
**Freezing/Melting Point Range:** -50 °C (-58 °F)

## Section 10 - Stability and Reactivity

**Stability/Polymerization/Conditions to Avoid:** Hazardous polymerization will not occur. Stable under normal storage conditions.
**Storage Incompatibilities:** Avoid storage with oxidizers.

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## Section 11 - Toxicological Information

TOXICITY
Oral (rat) $LD_{50}$: 30000 mg/kg
Oral (human) $TD_{Lo}$: 143 mg/kg
Oral (mouse) $LD_{50}$: 1500 mg/kg
Oral (rabbit) $LD_{50}$: 34000 mg/kg
Dermal (rabbit) $LD_{50}$: 25000 mg/kg
Intraperitoneal (rabbit) $LD_{50}$: >31 mL/kg
Oral (guinea pig) $LD_{50}$: 26000 mg/kg
Dermal (g.pig) $LD_{50}$: 10000 mg/kg

IRRITATION
Skin (rabbit): 500 mg/24 hr mild
Eye (rabbit): 500 mg/24 hr mild

Gastrointestinal changes, respiratory system changes, somnolence, hemorrhage, necrotic changes in GI tract, lowered blood pressure, liver, endocrine tumors, feto toxicity, paternal effects, maternal effects, specific developmental abnormalities (hepatobiliary system, musculoskeletal system, cardiovascular system, urogenital system, central nervous system, eye/ear), fetolethality recorded.
NOTE: Substance has been shown to be mutagenic in various assays, or belongs to a family of chemicals producing damage or change to cellular DNA.

See NIOSH, *RTECS* TI 0350000, for additional data.

## Section 12 - Ecological Information

**Environmental Fate:** In water it will biodegrade (half-life 2-3 wk), adsorb to sediments and bioconcentrate in aquatic organisms. Atmospheric material will be carried long distances and be removed by rain.
**Ecotoxicity:** $LC_{50}$ Gammarus pseudolimnaeus more than 32 mg/l/96 hr at 21 °C; juvenile /static bioassay; $LC_{50}$ Ictalurus punctatus (channel catfish) more than 100 mg/l/96 hr at 20 °C; wt 1.5 g /static bioassay; $EC_{50}$ Gymnodinium breve growth rate 3.1% vol/vol/96 hr /Conditions of bioassay not specified; $LC_{50}$ Oncorhynchus kisutch (coho salmon) more than 100 mg/l/96 hr at 16 °C; wt 1.5 g /static bioassay; $LC_{50}$ Daphnia magna: 1,000-5,000 ug/l/48 hr /Conditions of bioassay not specified; $LC_{50}$ Chironomus plumosus (Midge): > 18,000 ug/l/48 hr /Conditions of bioassay not specified
**Henry's Law Constant:** $1 \times 10^{-4}$
**BCF:** fish 2
**Biochemical Oxygen Demand (BOD):** acclimated < 1 lb/lb, 5 days
**Octanol/Water Partition Coefficient:** log $K_{OW}$ = 4.89
**Soil Sorption Partition Coefficient:** $K_{OC}$ = 4 to 5

## Section 13 - Disposal Considerations

**Disposal:** Consult manufacturer for recycling options and recycle where possible.
Follow applicable federal, state, and local regulations.
Incinerate residue at an approved site.
Recycle containers where possible, or dispose of in an authorized landfill.

## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

**Shipping Name:** NONE
**Hazard Class:** None
**ID No.:** None
**Packing Group:** None
**Label:** No class label assigned

## Section 15 - Regulatory Information

**EPA Regulations:**
**RCRA 40 CFR:** Listed U028 Toxic Waste
**CERCLA 40 CFR 302.4:** Listed per RCRA Section 3001, per CWA Section 307(a) 100 lb (45.35 kg)
**SARA 40 CFR 372.65:** Listed
**SARA EHS 40 CFR 355:** Not listed
**TSCA:** Listed

## Section 16 - Other Information

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*Material Safety Data Sheet Collection*
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Issue Date 2002-02

**Hydrogen Sulfide**
**HYD2760**

## Section 1 - Chemical Product and Company Identification 54

**Material Name:** Hydrogen Sulfide **CAS Number:** 7783-06-4
**Chemical Formula:** $H_2S$
**Structural Chemical Formula:** $H_2S$
**Synonyms:** ACIDE SULFHYDRIQUE, ACIDE SULPHHYDRIQUE, DIHYDROGEN MONOSULFIDE, DIHYDROGEN SULFIDE, HYDROGEN SULFIDE, HYDROGEN SULFIDE,LIQUEFIED, HYDROGEN SULFURE, HYDROGEN SULFURIC ACID, HYDROGEN SULPHIDE, HYDROGENE SULFURE, HYDROGENE SULPHURE, HYDROSULFURIC ACID, IDROGENO SOLFORATO, SCHWEFELWASSERSTOFF, SEWER GAS, SIARKOWODOR, STINK DAMP, SULFUR HYDRIDE, SULFURETED HYDROGEN, SULFURETTED HYDROGEN, ZWAVELWATERSTOF
**General Use:** Used in the manufacture of inorganic sulfides In the purification of sulfuric acid and hydrochloric acid, the precipitation of sulfides of metals in metallurgy, a source of hydrogen and sulfide
Also as an analytical reagent and a disinfectant in agriculture

## Section 2 - Composition / Information on Ingredients

| Name | CAS | % |
|---|---|---|
| hydrogen sulfide | 7783-06-4 | >98 |

**OSHA PEL**
Ceiling 20 ppm, 50 ppm, 10-minute maximum peak

**NIOSH REL**
Ceiling 10 ppm, 15 mg/m$^3$, 10-minute

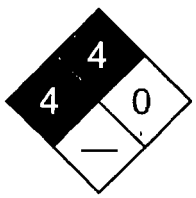
**DFG (Germany) MAK**
TWA 10 ppm, 14 mg/m$^3$, substances having intensive odor

**OSHA PEL Vacated 1989 Limits**
TWA 10 ppm, 14 mg/m$^3$, STEL 15 ppm, 21 mg/m$^3$

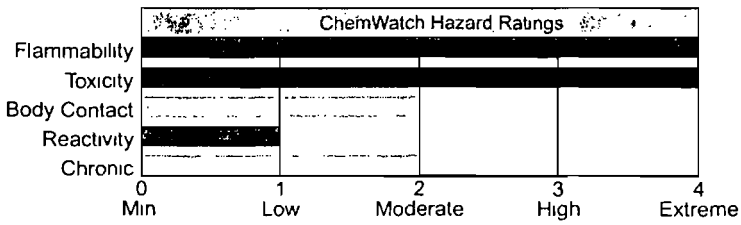
**IDLH Level**
100 ppm

**ACGIH TLV**
TWA 10 ppm, 14 mg/m$^3$, STEL 15 ppm, 21 mg/m$^3$

## Section 3 - Hazards Identification



Fire Diamond



**ANSI Signal Word**
**Danger!**

Poison Flammable Compressed Gas

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Colorless gas, rotten-egg smell Irritating to eyes/skin/respiratory tract Poison! Inhalation causes headache, dizziness, nausea, high levels (>1000 ppm) can be instantly fatal causing respiratory paralysis Cardiac effects may occur Highly flammable

### Potential Health Effects

**Target Organs:** eyes, respiratory system, central nervous system (CNS)
**Primary Entry Routes:** inhalation, eye contact, skin contact
**Acute Effects**
**Inhalation:** The gas is highly toxic if exposure is prolonged

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Symptoms of hydrogen sulfide exposure may include profuse salivation, nausea, vomiting, diarrhea, giddiness, headache, vertigo, amnesia, palpitations, arrhythmia, weakness, muscle cramps, confusion, sudden collapse, unconsciousness and death due to respiratory paralysis (above 300 ppm). Although hydrogen sulfide is extremely odorous, the "rotten egg" odor is not a reliable indicator for warning of exposure since odor fatigue readily occurs. Odor sensation is lost immediately at concentrations exceeding 200 ppm. Case reports suggest that toxic amounts can enter the body through a punctured ear drum, even while wearing some sorts of respiratory protection.

Hydrogen sulfide is primarily a respiratory toxin which inhibits the cytochrome-oxidase system and is probably more potent than hydrogen cyanide. The lifetime of hydrogen sulfide in oxygenated blood is short and sulfmethemoglobin is rapidly detoxified by red blood cells and the liver. Most fatalities due to hydrogen sulfide intoxication occur at the scene of exposure and immediate supportive care is imperative. Ensure such contingencies are addressed as part of the site emergency plan and that operators or other employees who may become accidentally exposed, are made aware of the existence of such a plan.

**Eye:** The gas is discomforting to the eyes and may be harmful following absorption.

Eye irritation may produce conjunctivitis, photophobia, pain, and at higher concentrations blurred vision and corneal blistering.

**Skin:** The gas has little effect on the skin.

The liquid is extremely discomforting and may cause severe cold burns.

The liquid is irritating to the skin if allowed to remain in contact for a period, causing redness and may cause frostbite.

**Ingestion:** Overexposure is unlikely in this form.The liquid is extremely discomforting and toxic if swallowed.

Frost bite of the lips and mouth occurs from contact with the liquid.

**Carcinogenicity:** NTP - Not listed; IARC - Not listed; OSHA - Not listed; NIOSH - Not listed; ACGIH - Not listed; EPA - Not listed; MAK - Not listed.

**Chronic Effects:** Chronic low level exposures to hydrogen sulfide may produce headache, fatigue, dizziness, irritability and loss of libido. These symptoms may also result from damage produced by isolated or repeated unmeasured peak high level exposures in healthy persons or those suffering from pre-existing neurological diseases.

## Section 4 - First Aid Measures

**Inhalation:** Remove to fresh air.

Lay patient down. Keep warm and rested.

If available, administer medical oxygen by trained personnel.

If breathing is shallow or has stopped, ensure clear airway and apply resuscitation. Transport to hospital or doctor, without delay.

**Eye Contact:** Immediately hold the eyes open and flush continuously for at least 15 minutes with fresh running water.

Ensure irrigation under eyelids by occasionally lifting the upper and lower lids.

Transport to hospital or doctor without delay. Removal of contact lenses after an eye injury should only be undertaken by skilled personnel.

**Skin Contact:** In case of cold burns (frost-bite): Bathe the affected area immediately in cold water for 10 to 15 minutes, immersing if possible and without rubbing.

Do not apply hot water or radiant heat. Apply a clean, dry dressing.

Transport to hospital or doctor.

**Ingestion:** Highly unlikely route of exposure but frostbite of lips and mouth may occur from contact with liquid. Treat as with skin.

***After first aid, get appropriate in-plant, paramedic, or community medical support.***

**Note to Physicians:** If exposure has been severe and/or symptoms marked, observation in hospital for 48 hours should be considered due to possibility of delayed pulmonary edema.

Hydrogen sulfide is metabolized by oxidation to sulfate, methylation and reaction with metallic ion- or disulfide containing proteins (principally cytochrome c oxidase). This latter reaction is associated with aerobic, cellular respiration and is largely responsible for the toxic effects.

For exposures involving sulfides and hydrogen sulfide (including gastric acid decomposition products of alkaline sulfides).

1. Hydrogen sulfide anion produces its major toxic effect through inhibition of cytochrome oxidases.
2. Symptoms include profuse salivation, nausea, vomiting and diarrhea.

Central nervous effects may include giddiness, headache, vertigo, amnesia, confusion and unconsciousness.

Tachypnea, palpitation, tachycardia, arrhythmia, sweating, weakness and muscle cramps may also indicate over-exposures.

Treatment involves:

1. If respirations are depressed, application of artificial respiration, administration of oxygen (continue after spontaneous breathing is established).
2. For severe poisonings administer amyl nitrite and sodium nitrite (as for cyanide poisoning) but omit sodium thiosulfate injection.
3. Atropine sulfate (0.6 mg intramuscularly) may contribute symptomatic relief.

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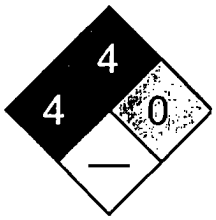
4. Conjunctivitis may be relieved by installation of 1 drop of olive-oil in each eye and sometimes by 3 drops of epinephrine solution (1:1000) at frequent intervals. Occasionally local anesthetics and hot and cold compresses are necessary to control pain.
5. Antibiotics at first hint of pulmonary infection.

## Section 5 - Fire-Fighting Measures

**Flash Point:** Flammable gas
**Autoignition Temperature:** 260 °C
**LEL:** 4.3% v/v
**UEL:** 45% v/v
**Extinguishing Media:** Water spray or fog.
Bromochlorodifluoromethane (BCF) (where regulations permit).
Dry chemical powder.
Foam.
Carbon dioxide.



Fire Diamond

**General Fire Hazards/Hazardous Combustion Products:** Liquid and vapor are highly flammable.
Dangerous hazard when exposed to heat, flame and oxidizers.
Gas may travel a considerable distance to source of ignition.
May form an explosive mixture with air.
Reacts violently with many incompatible materials.
Heating may cause expansion or decomposition leading to violent rupture of containers.
If involved in fire emits toxic fumes of sulfur oxides ($SO_x$).
**Fire Incompatibility:** Avoid contamination with oxidizing agents i.e. nitrates, oxidizing acids, chlorine bleaches, pool chlorine etc. as ignition may result.
**Fire-Fighting Instructions:** Contact fire department and tell them location and nature of hazard.
May be violently or explosively reactive. Wear full body protective clothing with breathing apparatus. Prevent, by any means available, spillage from entering drains or waterways. Consider evacuation.
If safe to do so, switch off electrical equipment until vapor fire hazard is removed.
If safe to do so, remove containers from path of fire.
Do not approach cylinders suspected to be hot.
If flow of gas cannot be stopped, leave gas to burn.
Cool fire-exposed containers with water spray from a protected location.
If safe to do so, stop flow of gas.
Fight fire from a safe distance, with adequate cover.

## Section 6 - Accidental Release Measures

**Small Spills:** Clean up all spills immediately. Clear area of personnel and move upwind.
Avoid breathing vapors and contact with skin and eyes.
If risk of overexposure exists, wear air supplied breathing apparatus.
Shut off all possible sources of ignition and increase ventilation.
Apply leak detection solution to suspected sites in lines and equipment.
Water spray or fog may be used to disperse vapor.
**Large Spills:** Contact fire department and tell them location and nature of hazard.
Clear area of personnel and move upwind.
May be violently or explosively reactive. Wear full body protective clothing with breathing apparatus. Prevent, by any means available, spillage from entering drains or waterways. Consider evacuation.
Shut off all possible sources of ignition and increase ventilation.
Stop leak if safe to do so.
Do not exert excessive pressure on valve; do not attempt to operate damaged valve.
Remove leaking cylinders to a safe place. Fit vent pipes. Release pressure under safe, controlled conditions by opening valve. Burn issuing gas at vent pipes.
Water spray or fog may be used to disperse vapor.
Use extreme caution to avoid a violent reaction.
If contamination of drains or waterways occurs, advise emergency services.
After clean-up operations, decontaminate and launder all protective clothing and equipment before storing and reusing.
**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

## Section 7 - Handling and Storage

**Handling Precautions:** Atmosphere should be regularly checked against established exposure standards to ensure safe working conditions are maintained.
Use good occupational work practices.
Avoid breathing vapors and contact with skin and eyes.

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Avoid all personal contact.
Avoid smoking, bare lights or ignition sources.
Avoid sources of heat.
Wear protective clothing and gloves when handling containers.
Avoid physical damage to containers.
Handle and open container with care.
Local exhaust ventilation may be required for safe working, i.e. to keep exposures below required standards; otherwise, PPE is required.
Use spark-free tools when handling.
Keep containers securely sealed when not in use.
Gas may travel a considerable distance to source of ignition.
Avoid generation of static electricity.
Always wash hands with soap and water after handling. Work clothes should be laundered separately.

**Recommended Storage Methods:** Packaging as recommended by manufacturer.
Check that containers are clearly labeled.
Cylinder. Ensure the use of equipment rated for cylinder pressure.
Ensure the use of compatible materials of construction.
Valve protection cap to be in place until cylinder is secured, connected.
Cylinder must be properly secured either in use or in storage.
Cylinder valve must be closed when not in use or when empty.
Segregate full from empty cylinders.
WARNING: Suckback into cylinder may result in rupture.
Use back-flow preventive device in piping.

**Regulatory Requirements:** Follow applicable OSHA regulations.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** Atmosphere should be regularly checked against established exposure standards to ensure safe working conditions are maintained.
If risk of overexposure exists, wear air supplied breathing apparatus.
Provide adequate ventilation in warehouse or closed storage areas.

**Personal Protective Clothing/Equipment**

**Eyes:** Close fitting gas tight goggles. Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them.

**Hands/Feet:** Butyl rubber gloves; Neoprene gloves.
PVC gloves.
Safety footwear.
Rubber boots.
PVC boots.

**Respiratory Protection:**
Exposure Range >20 to <100 ppm: Supplied Air, Constant Flow/Pressure Demand, Half Mask
Exposure Range 100 to unlimited ppm: Self-contained Breathing Apparatus, Pressure Demand, Full Face
Note: poor warning properties

**Other:** Impervious protective clothing. Eyewash unit.
Ensure there is ready access to a safety shower.

## Section 9 - Physical and Chemical Properties

**Appearance/General Info:** Colorless flammable gas with a rotten egg odor at low concentrations but has no odor above 200 ppm due to olfactory fatigue and may give little warning of exposure.
Burns in air with a blue flame. Usually transported as colorless liquid under pressure. Soluble in Carbon disulfide.

**Physical State:** Liquefied gas
**Vapor Pressure (kPa):** 2026.4
**Vapor Density (Air=1):** 1.2
**Formula Weight:** 34.08
**Specific Gravity ($H_2O$=1, at 4 °C):** 1.54 g/l at 0 °C
**Water Solubility:** 1 g dissolves in 242 ml water at 20 °C
**Evaporation Rate:** Fast

**pH:** Not applicable
**pH (1% Solution):** 4.5 (saturated)
**Boiling Point Range:** -60.33 °C (-77 °F)
**Freezing/Melting Point Range:** -85.49 °C (-121.882 °F)
**Volatile Component (% Vol):** 100

## Section 10 - Stability and Reactivity

**Stability/Polymerization/Conditions to Avoid:** Presence of heat source and ignition source.
Stable under normal storage conditions. Hazardous polymerization will not occur.

**Storage Incompatibilities:** Avoid reaction with oxidizing agents. Avoid strong acids, bases.
Avoid reaction with strong nitric acid, organic compounds, alkalis and metal oxides.

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## Section 11 - Toxicological Information

TOXICITY
Inhalation (human) $LD_{Lo}$: 5.7 mg/kg
Inhalation (human) $LC_{Lo}$: 600 ppm/30M
Inhalation (human) $LC_{Lo}$: 800 ppm/5M
Inhalation (rat) $LC_{50}$: 444ppm

See NIOSH, *RTECS* MX 1225000, for additional data.

IRRITATION
Nil reported

## Section 12 - Ecological Information

**Environmental Fate:** No data found.
**Ecotoxicity:** TLm Lepomis macrochirus (bluegill sunfish) 35 day old fry 0.0131 mg/l/96 hr at 21-22 °C in a flow through bioassay; TLm Pimephales promelas (fathead minnow) 0.0071-0.55 mg/l/96 hr at 6-24 °C in a flow through bioassay; TLm Asellus sp 0.111 mg/l/96 hr /Conditions of bioassay not specified; $LC_{50}$ Fly inhalation 380 mg/cu m/ > 960 min
**Henry's Law Constant:** $5.5 \times 10^2$
**BCF:** none

## Section 13 - Disposal Considerations

**Disposal:** Consult manufacturer for recycling options.
Follow applicable federal, state, and local regulations.
Return empty cylinders to supplier.

## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

**Shipping Name:** HYDROGEN SULPHIDE, LIQUEFIED
**Hazard Class:** 2.3
**ID No.:** 1053
**Packing Group:** None
**Label:** Poison Gas[2],Flammable Gas

**Additional Shipping Information:** SULPHURETTED HYDROGEN

## Section 15 - Regulatory Information

**EPA Regulations:**
**RCRA 40 CFR:** Listed U135 Toxic Waste
**CERCLA 40 CFR 302.4:** Listed per CWA Section 311(b)(4), per RCRA Section 3001 100 lb (45.35 kg)
**SARA 40 CFR 372.65:** Listed
**SARA EHS 40 CFR 355:** Listed
**RQ:** 100 lb
**TPQ:** 500 lb
**TSCA:** Listed

## Section 16 - Other Information

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*Material Safety Data Sheet Collection*
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Issue Date: 2000-07

**Lead**
**MSDS 713**
**LEA1000**

## Section 1 - Chemical Product and Company Identification 54.1

**Material Name:** Lead **CAS Number:** 7439-92-1
**Chemical Formula:** Pb
**Structural Chemical Formula:** Pb
**Synonyms:** C.I. 77575; C.I. PIGMENT METAL 4; GLOVER; KS-4; LEAD; LEAD FLAKE; LEAD INORGANIC; LEAD METAL; LEAD S2; LEAD SZ; OLOW; OMAHA & GRANT; PB-S 100; PLUMBUM
**General Use:** Used as a construction material in chemical reaction equipment (tank piping,etc.); manufacture of tetraethyl lead; pigments for paints.
Used in pottery glazes, glass, ceramics, bearing metal and alloys, solder and other lead alloys.
Also used in metallurgy of steel and other metals, cable sheathing, storage batteries, radiation shielding and ammunition.

## Section 2 - Composition / Information on Ingredients

| Name | CAS | % |
|---|---|---|
| lead | 7439-92-1 | >99 |

**OSHA PEL**
STEL: 0.05 mg/m$^3$; as Pb inorganic.

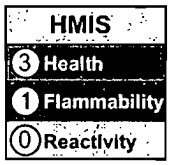
**ACGIH TLV**
TWA: 0.05 mg/m$^3$.

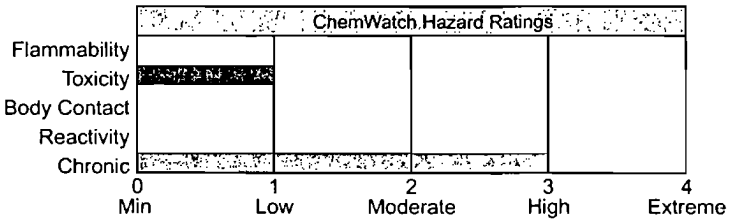
**NIOSH REL**
TWA: 0.1 mg/m$^3$.

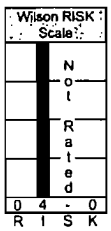
**IDLH Level**
100 mg/m$^3$; as Pb.

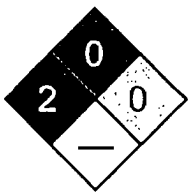
**DFG (Germany) MAK**
TWA: 0.1 mg/m$^3$.

## Section 3 - Hazards Identification



Fire Diamond

**ANSI Signal Word**
**Danger!**

Poison

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Bluish-white, silvery, or gray metal. Cumulative poison. Repeated low exposures causes: severe neurological effects, blood/kidney damage. Possible cancer hazard. Reproductive damage (sterility, decreased fertility) and developmental damage to fetus.

### Potential Health Effects

**Primary Entry Routes:** inhalation, ingestion
**Target Organs:** blood, central nervous system (CNS), peripheral nervous system, kidneys, gastrointestinal (GI) tract
**Acute Effects**
**Inhalation:** The dust may be discomforting to the upper respiratory tract and may be harmful if inhaled.
**Eye:** The dust may be discomforting to the eyes.
**Skin:** The material may be mildly discomforting to the skin.
Prolonged exposure may cause skin reactions.
Skin absorption is not considered a significant route of exposure.
**Ingestion:** The material is moderately discomforting to the gastrointestinal tract and may be harmful if swallowed.
In rats intestinal lead absorption is bidirectional and does not follow a linear relationship with oral dose.

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Acute effects of exposure are generally minor because of its relative insolubility and physical form. Unusual instances of exposure have been reported in inadequately ventilated indoor firing ranges (as fume), in the application of surma, a mascara-like cosmetic agent, to the conjunctival surfaces in Asian countries and in lead-smelting and associated occupations.

In humans lead metabolism fits into a three compartment model. The first compartment in which lead has a half-life of about 35 days includes the blood; it receives blood from the gut and delivers some of it to the urine and communicates with the other two pools. The second compartment in which lead has a similar half-life includes the soft tissues which contain about half the blood level; they share lead with hair, nails, sweat, saliva, bile and other digestive secretions. The skeleton is the third compartment and contains the vast bulk of the total body burden, possesses a very long half-life and demonstrates a difference between the dense and less dense components to bind lead.

**Carcinogenicity:** NTP - Not listed; IARC - Group 2B, Possibly carcinogenic to humans; OSHA - Not listed; NIOSH - Not listed; ACGIH - Not listed; EPA - Class B2, Probable human carcinogen based on animal studies; MAK - Not listed.

**Chronic Effects:** Symptoms of exposure include headache, fatigue, sleep disturbances, abdominal pains and decreased appetite. Overexposure to lead in the form of dust has toxic effects on the lungs and kidneys and on the nervous system resulting in mental disturbances and anemia.

Skin absorption is not considered to be a significant route of exposure.

Worker exposure to lead must be kept to a minimum, especially in cases where lead is worked at temperatures whereby lead vapors are evolved e.g. metal refining.

Lead is an accumulative poison and exposure even to small amounts can raise the body's content to toxic levels.

Potential adverse effects on the offspring of pregnant workers have been cited in the literature.

## Section 4 - First Aid Measures

**Inhalation:** Remove to fresh air.

*Lay patient down. Keep warm and rested.*

If available, administer medical oxygen by trained personnel.

If breathing is shallow or has stopped, ensure clear airway and apply resuscitation. Transport to hospital or doctor, without delay.

**Eye Contact:** Immediately hold the eyes open and flush continuously for at least 15 minutes with fresh running water.

Ensure irrigation under eyelids by occasionally lifting the upper and lower lids.

Transport to hospital or doctor without delay. Removal of contact lenses after an eye injury should only be undertaken by skilled personnel.

**Skin Contact:** Wash affected areas thoroughly with water (and soap if available).

Seek medical attention in event of irritation.

**Ingestion:** Rinse mouth out with plenty of water.

Seek medical attention if irritation or discomfort persist.

***After first aid, get appropriate in-plant, paramedic, or community medical support.***

**Note to Physicians:** 1.Gastric acids solubilize lead and its salts and lead absorption occurs in the small bowel.

2.Particles of less than 1 um diameter are substantially absorbed by the alveoli following inhalation.

3.Lead is distributed to the red blood cells and has a half-life of 35 days.

It is subsequently redistributed to soft tissue & bone-stores or eliminated.The kidney accounts for 75% of daily lead loss; integumentary and alimentary losses account for the remainder.

4.Neurasthenic symptoms are the most common symptoms of intoxication.

Lead toxicity produces a classic motor neuropathy.

Acute encephalopathy appears infrequently in adults.

Diazepam is the best drug for seizures.

5.Whole-blood lead is the best measure of recent exposure; free erythrocyte protoporphyrin (FEP) provides the best screening for chronic exposure. Obvious clinical symptoms occur in adults when whole-blood lead exceeds 80 ug/dL.

6.British Anti-Lewisite is an effective antidote and enhances fecal and urinary excretion of lead. The onset of action of BAL is about 30 minutes and most of the chelated metal complex is excreted in 4-6 hours, primarily in the bile.

Adverse reaction appears in up to 50% of patients given BAL in doses exceeding 5 mg/kg. CaNa2EDTA has also been used alone or in concert with BAL as an antidote.

D-penacillamine is the usual oral agent for mobilization of bone lead; its use in the treatment of lead poisoning remains investigational.

2-3-dimercapto-1-propanesulfonic acid (DMPS) and dimercaptosuccinic acid (DMSA) are water soluble analogues of BAL and their effectiveness is undergoing review.

As a rule, stop BAL if lead decreases below 50 ug/dL; stop CaNa2EDTA if blood lead decreases below 40 ug/dL or urinary lead drops below 2 mg/24 hrs.

BIOLOGICAL EXPOSURE INDEX - BEI

These represent the determinants observed in specimens collected from a healthy worker who has been exposed at the Exposure Standard (ES or TLV):

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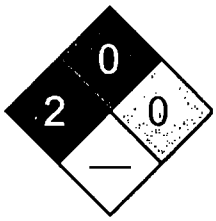
| Determinant | Index | Sampling Time | Comments |
|---|---|---|---|
| Lead in blood | 50 ug/100 mL | Not Critical | B |
| Lead in urine | 150 ug/gm creatinine | Not critical | B |
| Zinc Protoporphyrin in blood | 250 ug/100 mL erythrocytes OR 100 ug/100 mL blood | After 1 month exposure | B |

B: Background levels occur in specimens collected from subjects NOT exposed.

## Section 5 - Fire-Fighting Measures

**Flash Point:** Not available; probably noncombustible
**Autoignition Temperature:** Not applicable
**LEL:** Not applicable
**UEL:** Not applicable
**Extinguishing Media:** There is no restriction on the type of extinguisher which may be used.
**General Fire Hazards/Hazardous Combustion Products:** Noncombustible.
Not considered to be a significant fire risk; however, containers may burn.
Moderate fire hazard, in the form of dust, when exposed to heat or flames.
Decomposition products may include toxic lead dust and lead oxide fumes.



Fire Diamond

**Fire Incompatibility:** Incompatible with strong acids, oxidants, ammonium nitrate, chlorine trifluoride and sodium azide.
**Fire-Fighting Instructions:** Contact fire department and tell them location and nature of hazard.
Use fire fighting procedures suitable for surrounding area.
Wear full body protective clothing with breathing apparatus. Prevent, by any means available, spillage from entering drains or waterways.
If safe to do so, remove containers from path of fire.
Cool fire-exposed containers with water spray from a protected location.
Equipment should be thoroughly decontaminated after use.

## Section 6 - Accidental Release Measures

**Small Spills:** Clean up all spills immediately. Avoid contact with skin and eyes.
Wear protective clothing, gloves, safety glasses and dust respirator.
Use dry clean-up procedures and avoid generating dust.
Vacuum up.
Place spilled material in clean, dry, sealable, labeled container.
**Large Spills:** Clear area of personnel and move upwind.
Contact fire department and tell them location and nature of hazard.
Control personal contact by using protective equipment and dust respirator.
Prevent spillage from entering drains, sewers or waterways.
Recover product wherever possible. Avoid generating dust. Sweep / shovel up.
If required, wet with water to prevent dusting.
Put residues in labeled plastic bags or other containers for disposal.
Wash area down with large quantity of water and prevent runoff into drains.
If contamination of drains or waterways occurs, advise emergency services.
**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

## Section 7 - Handling and Storage

**Handling Precautions:** Limit all unnecessary personal contact.
Wear protective clothing when risk of exposure occurs.
Use in a well-ventilated area.
Avoid contact with incompatible materials.
When handling, DO NOT eat, drink or smoke.
Keep containers securely sealed when not in use. Avoid physical damage to containers. Always wash hands with soap and water after handling.
Work clothes should be laundered separately.

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Use good occupational work practices. Observe manufacturer's storing and handling recommendations. Atmosphere should be regularly checked against established exposure standards to ensure safe working conditions are maintained.
**Recommended Storage Methods:** Check that containers are clearly labeled.
Packaging as recommended by manufacturer.
**Regulatory Requirements:** Follow applicable OSHA regulations.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** General exhaust is adequate under normal operating conditions.
If risk of overexposure exists, wear NIOSH-approved dust respirator.
Correct fit is essential to obtain adequate protection.
**Personal Protective Clothing/Equipment**
**Eyes:** Safety glasses with side shields; or as required, chemical goggles.
Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them.
**Hands/Feet:** Impervious gloves; rubber gloves.
Rubber boots.
Protective footwear.
**Respiratory Protection:**
Exposure Range >0.05 to 0.5 mg/m$^3$: Air Purifying, Negative Pressure, Half Mask
Exposure Range >0.5 to 2.5 mg/m$^3$: Air Purifying, Negative Pressure, Full Face
Exposure Range >2.5 to 50 mg/m$^3$: Powered Air Purifying Respirator, Half or Full Facepiece or Hood
Exposure Range >50 to 100 mg/m$^3$: Supplied Air Respirator with Full Facepiece, Hood, Helmet, or Suit, operated in a Positive Pressure Mode
Exposure Range >100 to unlimited mg/m$^3$: Self-contained Breathing Apparatus, Pressure Demand, Full Face
Cartridge Color: magenta (P100)
**Note:** (29CFR 1910.1025) for general industry
**Other:** Overalls. Eyewash unit. Skin cleansing cream.
Provide adequate ventilation in warehouse or closed storage areas.
General and local exhaust ventilation usually required to maintain airborne dust levels to safety levels.

## Section 9 - Physical and Chemical Properties

**Appearance/General Info:** Bluish-white, silvery-gray metal. Malleable, lustrous when freshly cut and tarnishes when exposed to air. Reacts with strong acids like nitric acid, sulphuric or hydrochloric acid. Attacked by water in presence of oxygen. Poor electrical conductor. Lead fumes are formed at temperatures above 500-700 °C.

**Physical State:** Divided solid
**Vapor Pressure (kPa):** 0.24 at 1000 °C
**Vapor Density (Air=1):** Not applicable
**Formula Weight:** 207.19
**Specific Gravity ($H_2O$=1, at 4 °C):** 11.34
**Water Solubility:** Insoluble in water
**Evaporation Rate:** Not applicable

**pH:** Not applicable
**pH (1% Solution):** Not applicable
**Boiling Point Range:** 1740 °C (3164 °F)
**Freezing/Melting Point Range:** 327.4 °C (621.32 °F)
**Volatile Component (% Vol):** Not applicable

## Section 10 - Stability and Reactivity

**Stability/Polymerization:** Hazardous polymerization will not occur. Stable under normal storage conditions.
**Storage Incompatibilities:** Avoid storage with strong acids, oxidants, ammonium nitrate, chlorine trifluoride and sodium azide.

## Section 11 - Toxicological Information

TOXICITY
Oral (woman) $TD_{Lo}$: 450 mg/kg/6 years
Inhalation (human) $TC_{Lo}$: 0.01 mg/m$^3$

IRRITATION
Nil Reported

WARNING: Lead is a cumulative poison and has the potential to cause abortion and intellectual impairment to unborn children of pregnant workers.

See NIOSH, *RTECS* OF 7525000, for additional data.

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## Section 12 - Ecological Information

**Environmental Fate:** If released or deposited on soil, it will be retained in the upper 2-5 cm of soil, especially soils with at least 5% organic matter or a pH 5 or above. Leaching is not important under normal conditions although there is some evidence to suggest that it is taken up by some plants. Generally, the uptake from soil into plants is not significant. It is expected to slowly undergo speciation to the more insoluble sulfate, sulfide, oxide, and phosphate salts. It enters water from atmospheric fallout, runoff or wastewater; little is transferred from natural ores. It is a stable metal and adherent films of protective insoluble salts form that protect the metal from further corrosion. That which dissolves tends to form ligands. It is effectively removed from the water column to the sediment by adsorption to organic matter and clay minerals, precipitation as insoluble salt (the carbonate or sulfate, sulfide), and reaction with hydrous iron and manganese oxide. Under most circumstances, adsorption predominates. It does not appear to bioconcentrate significantly in fish but does in some shellfish such as mussels. When released to the atmosphere, it will generally be in dust or adsorbed to particulate matter and subject to gravitational settling and be transformed to the oxide and carbonate.

**Ecotoxicity:** $LC_{50}$ Japanese quail (Coturnix japonica), males or females, 14 days old, oral (5-day ad libitum in diet) >5,000 ppm; at 1000, 2236 & 5000 onset of toxic signs began at 7, 7 & 7 days and remissed at 11, 11 & 12 days, respectively, no mortality was observed; control references were dieldrin & dicrotophos; corn oil diluent was added to diet at ratio of 2:98 by wt; (extreme concentrations: 1,000-5,000 ppm)

**BCF:** freshwater fish 1.38 to 1.65

## Section 13 - Disposal Considerations

**Disposal:** Recycle wherever possible. Consult manufacturer for recycling options.
Follow applicable federal, state, and local regulations.

## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

**Shipping Name:** NONE
**Hazard Class:** None
**ID No.:** None
**Packing Group:** None
**Label:** No class label assigned

**Additional Shipping Information:**

## Section 15 - Regulatory Information

**EPA Regulations:**
**RCRA 40 CFR:** Not listed
**CERCLA 40 CFR 302.4:** Listed per CWA Section 307(a) 10 lb (4.535 kg)
**SARA 40 CFR 372.65:** Listed
**SARA EHS 40 CFR 355:** Not listed
**TSCA:** Listed

## Section 16 - Other Information

**Research Date:**.....1999-11 **Review Date:** .....2000-07

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## Section 1 - Chemical Product and Company Identification 44

**Product/Chemical Name:** Mercury
**Chemical Formula:** Hg
**CAS No.:** 7439-97-6
**Synonyms:** colloidal mercury, hydrargyrum, liquid silver, Quicksilver
**Derivation:** Obtained by roasting cinnabar (mercury sulfide) and purified by distillation, or as a by-product of gold mining.
**General Use:** Used in agricultural poisons, anti-fouling paint, dental amalgams, mining amalgamation (to remove gold and other metals from ore), thermometers, barometers, dry cell batteries, chlorine and caustic soda production, electrical apparatus, and as a neutron absorber in nuclear power plants.
**Vendors:** Consult the latest *Chemical Week Buyers' Guide.* (73)

## Section 2 - Composition / Information on Ingredients

Mercury, ca 100 %wt

**OSHA PEL**
Ceiling: 0.1mg/m$^3$ (vapor and inorganic Hg)
8-hr TWA: 0.05 mg/m$^3$ (vapor), skin; (Vacated 1989 Final Rule Limit)

**ACGIH TLVs**
TWA: 0.025 mg/m$^3$ (inorganic compounds), skin

**NIOSH REL**
10-hr TWA: 0.05 mg/m$^3$ (vapor), skin

**DFG (Germany) MAK**
TWA: 0.01 ppm (0.1 mg/m$^3$)
Category III: Substances with systemic effects
Onset of Effect: > 2 hr
Half-life: > shift length (strongly cumulative)

**Peak Exposure Limit:**
0.1 ppm (1 mg/m$^3$), 30 min. average value, 1/shift

**IDLH Level**
28 mg/m$^3$

## Section 3 - Hazards Identification

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Mercury exists as a heavy, odorless, silver-white liquid metal. It is highly toxic by both acute and chronic exposure. Exposure can cause corrosion of the eyes, skin, and respiratory tract and may result in irreversible nervous system damage. It readily forms amalgamations with most metals except iron.

**Wilson Risk Scale**
R 1
I 4
S 2*
K 1
*Skin absorption

**HMIS**
H 4*
F 0
R 0
*Chronic effects
PPE†
†Sec. 8

### Potential Health Effects

**Primary Entry Routes:** Inhalation, eye and skin contact/absorption.
**Target Organs:** Central nervous system, eyes, skin, respiratory system, liver, kidneys.
**Acute Effects**
**Inhalation:** Exposure to high vapor concentrations can cause severe respiratory damage. Other symptoms include wakefulness, muscle weakness, anorexia, headache, ringing in the ear, headache, diarrhea, liver changes, fever, gingivitis, chest pain, difficulty breathing, cough, inflammation of the mouth (stomatitis), salivation, bronchitis, and pneumonitis. Acrodynia (pink or Swifts disease), characterized by redness and peeling of the skin on the toes and fingers, was commonly seen in children in the 1950s and is still *infrequently* seen in workers.
**Eye:** Irritation and corrosion.
**Skin:** Skin can become severely irritated if allowed to remain in contact with mercury. Skin absorption will occur at 2.2% of the rate of absorption through the lungs.
**Ingestion:** Mercury generally passes through the digestive tract uneventfully. However, large amounts may get caught up in the intestine and require surgical removal. If an abscess or other perforation is present along the digestive tract, absorption into the blood stream with subsequent mercury poisoning is possible.
**Carcinogenicity:** IARC, NTP, and OSHA do not list mercury as a carcinogen.
**Medical Conditions Aggravated by Long-Term Exposure:** Central nervous system disorders.
**Chronic Effects:** Chronic exposure appears more common than acute and is primarily associated with central nervous system damage which can be permanent (ex. paresthesia of the hands, lips, feet). Early signs of toxicity include weakness, fatigue, anorexia, weight loss, and gastrointestinal disturbances. If exposure levels are high, characteristic tremors of the fingers, eyelids, and lips occur with progression to generalized tremors of the entire body. Psychic disorders are noticeable and characterized by behavior and personality changes, increased excitability, memory loss, insomnia, and depression. In severe cases, delirium and hallucinations may occur. Kidney damage is observed with oliguria (decreased urine output) progressing to anuria (urine cessation) and may require dialysis. The cornea and lens of the eyes may take on a brownish discoloration and the extraocular muscles may be damaged. This syndrome has been termed *Asthenic-Vegetative Syndrome* or *Micromercurialism.* Chronic symptoms occur increasingly with exposures to 0.1 mg/m$^3$ or higher. *Mutation:* Aneuploidy and other chromosomal aberrations

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have been observed in the lymphocytes from whole blood cultures in workers exposed to mercury. *Reproductive:* Mercury has been detected in stillborn babies of women treated with mercury for syphilis. In a study of six men acutely exposed (occupationally) to mercury levels as high as 44 mg/m$^3$, all suffered impaired sexual function. Repeated skin contact may cause allergic dermatitis in some individuals.

*NOTE*: Spilled mercury will release sufficient vapor over time to produce chronic poisoning.

## Section 4 - First Aid Measures

**Inhalation:** Remove exposed person to fresh air and support breathing as needed.

**Eye Contact:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.

**Skin Contact:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water and then wash exposed area with soap. For reddened or blistered skin, consult a physician.

**Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. In general, mercury will pass through the digestive tract uneventfully.

***After first aid, get appropriate in-plant, paramedic, or community medical support.***

**Note to Physicians:** BEI: *blood* (15 µg/L), *urine*: (35 µg/g creatinine). Extremely high urine levels of 0.5 to 0.85 mg Hg/L are indicative of polyneuropathy. 0.4 to 22 µg/L is reported to be the human lethal blood level. Obtain urinalysis including at a minimum: albumin, glucose, and a microscopic examination of centrifuged sediment. Use BAL or 2, 3-dimercaptosuccinic acid as chelators. *Do not* use calcium sodium EDTA because of nephrotoxicity. An electromyograph may determine extent of nerve dysfunction. It has been noted that exposure to mercury may predispose persons to development of carpal tunnel syndrome.

## Section 5 - Fire-Fighting Measures

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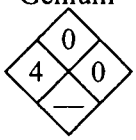


**Flash Point**: Nonflammable

**Autoignition Temperature**: Nonflammable

**LEL**: None reported.

**UEL**: None reported.

**Extinguishing Media:** Use agents suitable for surrounding fire.

**Unusual Fire or Explosion Hazards:** None reported.

**Hazardous Combustion Products:** Toxic mercury vapor and mercuric oxide.

**Fire-Fighting Instructions:** Do not release runoff from fire control methods to sewers or waterways.

**Fire-Fighting Equipment:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode.

## Section 6 - Accidental Release Measures

**Spill /Leak Procedures:** Keep a mercury spill kit readily available in areas where mercury is used. Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind.

**Small and Large Spills:** Follow instructions on mercury spill kit. Most kits come with an aspiration-driven vacuum trap with a mercury "sweeper" (copper or copper-plated brush). Wash spill area with a dilute calcium sulfide or nitric acid solution. If spill cannot be taken up readily, dust the top of the spill with flowers of sulfur or preferably, calcium polysulfide. This will produce a surface coating of mercury sulfide which will reduce mercury vapor dispersion into the air.

**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

## Section 7 - Handling and Storage

**Handling Precautions:** Use appropriate PPE when working with mercury. *Do not* use on porous work surfaces (wood, unsealed concrete, etc.) to prevent spills from lodging in cracks.

**Storage Requirements:** Store in a cool, dry, well-ventilated area away from heat and incompatibles (Sec. 10). Store on non-porous floors and wash them regularly with a dilute calcium sulfide solution. Because mercury will form amalgamations with most metals except iron, metal shelves should be painted with a sufficiently thick coating to prevent this from happening.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** Wherever possible, enclose processes to prevent mercury vapor dispersion into work area.

**Ventilation:** Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103]

**Administrative Controls:** Consider pre-placement and periodic medical exams of exposed workers with emphasis on the skin, eyes, central nervous system, liver, and kidneys.

**Respiratory Protection:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For ≤ 0.5 mg/m$^3$, use any chemical cartridge respirator with cartridges providing protection against mercury and equipped with an ESLI (end of service life indicator), any SCBA, or any SAR (supplied-air respirator). For ≤ 1.25 mg/m$^3$, use any SAR operated in continuous-flow mode, any PAPR (powered, air-purifying respirator) with an ESLI. For ≤ 2.5 mg/m$^3$, use any SCBA or SAR with a full facepiece, any SAR with a tight-fitting facepiece and operated in continuous-flow mode, or any chemical cartridge respirator with a full facepiece, chemical


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cartridges providing protection against mercury, and equipped with an ESLI. For ≤28 mg/m$^3$, use any SAR operated in pressure-demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA with full facepiece and operated in pressure-demand or other positive pressure mode. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

**Protective Clothing/Equipment:** Wear chemically protective gloves, boots, aprons, and gauntlets made of butyl rubber, nitrile rubber, fluorocarbon rubber, neoprene rubber, polyvinyl chloride, chlorinated polyethylene, or polycarbonate to prevent prolonged or repeated skin contact. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.

**Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

**Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment.

**Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

## Section 9 - Physical and Chemical Properties

**Physical State:** Liquid metal
**Appearance and Odor**: Silvery-white, odorless
**Vapor Pressure**: 0.0018 mm Hg at 77 °F (25 °C)
**Formula Weight**: 200.59
**Density ($H_2O$=1)**: 13.534 g/cm$^3$ at 77 °F (25 °C)
**Boiling Point**: 674.09 °F (356.72 °C)
**Freezing Point**: -37.97 °F (-38.87 °C)
**Viscosity:** 15.5 mP at 77 °F (25 °C)
**Electrical Resistivity:** 95.76 µohm at 68 °F (20 °C)
**Water Solubility**: 0.28 µmol/L at 77 °F (25 °C)
**Other Solubilities**: Soluble in boiling sulfuric acid, nitric acid (reacts); slightly in lipids, and 2.7 mg/L in pentane. Insoluble in alcohol, ether, cold sulfuric acid, hydrogen bromide, and hydrogen iodide.
**Surface Tension:** 484 dyne/cm at 77 °F (25 °C)
**Critical Temperature:** 2664 °F (1462 °C)
**Critical Pressure:** 1587 atm

## Section 10 - Stability and Reactivity

**Stability:** Mercury does not tarnish at ordinary temperatures but when heated to near its boiling point, it slowly oxidizes to mercuric oxide.

**Polymerization:** Hazardous polymerization does not occur.

**Chemical Incompatibilities:** Mercury forms alloys (amalgamates) with most metals except iron. It is incompatible with oxidizers such as bromine, 3-bromopropyne, methylsilane + oxygen, chlorine, chlorine dioxide, nitric acid, or peroxyformic acid; tetracarbonyl nickel + oxygen, alkynes + silver perchlorate, ethylene oxide, acetylenic compounds (explosive), ammonia (explosive), boron phosphodiiodide, methyl azide, nitromethane, and ground sodium carbide.

**Conditions to Avoid:** Exposure to high temperatures, metal surfaces or incompatibles.

**Hazardous Decomposition Products:** Thermal oxidative decomposition of mercury can produce mercuric oxide.

## Section 11- Toxicological Information

### Toxicity Data:*

**Reproductive:**
Rat, inhalation: 890 ng/m$^3$/24 hr for 16 weeks prior to mating had an effect on spermatogenesis.

**Acute Dermal Toxicity:**
Man, skin, $TD_{Lo}$: 129 mg/kg for 5 continuous hours caused ringing in the ears, headache, and allergic dermatitis.

**Acute Oral Toxicity:**
Man, oral, $TD_{Lo}$: 43 mg/kg caused tremor and jaundice or other liver changes.

**Acute Inhalation Effects:**
Woman, inhalation, $TC_{Lo}$: 150 µg/m$^3$/46 days caused anorexia, diarrhea, and wakefulness.
Man, inhalation, $TC_{Lo}$: 44300 µg/m$^3$/8 hr caused muscle weakness, liver changes, and increased body temperature.

**Chronic Effects:**
Rat, inhalation: 1 mg/m$^3$/ 24 hr for 5 continuous weeks caused proteinuria.

* See NIOSH, *RTECS* (OV4550000), for additional toxicity data.

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## Section 12 - Ecological Information

**Ecotoxicity:** Catfish, $LC_{50}$ = 0.35 mg/L/96 hr; mollusk (*Modiolus carvalhoi*), $LC_{50}$ = 0.19 ppm/96 hr: tadpole (*Rana hexadactyla*), $LC_{50}$ = 0.051 ppm/96 hr. Mercury is transformed to methyl mercury by bacteria in the environment and undergoes bioaccumulation readily. BCF for freshwater fish = 63,000; for saltwater fish = 10,000; and for marine and freshwater invertebrates = 100,000.

**Environmental Degradation:** Mercury is expected to volatilize rapidly when deposited on soil surfaces. Once in the air, it can be transported long distances before being redeposited on soil or in water. In water, mercury appears to bind to particulates where it eventually becomes deposited on the bed sediment. In general, mercury entering the environment can be deposited and revolatilized several times.

## Section 13 - Disposal Considerations

**Disposal:** Incineration is *not* an appropriate disposal method. Wastewater may be treated by addition of chlorine to oxidize the mercury to its ionic state. The water can then be passed through an absorbent (an activated charcoal concentrate with a sulfur coating or peanut shell charcoal) to collect the ionic mercury, followed by distillation to recover the mercury. Sodium borohydride, a reducing agent, can be used to precipitate mercury from waste solutions. Bioremediation, using *Pseudomonas putida*, has also been suggested. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

**Shipping Name**: Mercury
**Shipping Symbols:** A, W
**Hazard Class**: 8
**ID No.**: UN2809
**Packing Group**: III
**Label**: Corrosive
**Special Provisions (172.102)**: –

**Packaging Authorizations**
**a) Exceptions**: 173.164
**b) Non-bulk Packaging**: 173.164
**c) Bulk Packaging**: 173.240

**Quantity Limitations**
**a) Passenger, Aircraft, or Railcar:** 35 kg
**b) Cargo Aircraft Only**: 35 kg

**Vessel Stowage Requirements**
**a) Vessel Stowage**: B
**b) Other**: 40, 97

## Section 15 - Regulatory Information

**EPA Regulations:**
Listed as a RCRA Hazardous Waste (40 CFR 261.33): U151
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) per RCRA, Sec. 3001; CWA, Sec. 307(a), CAA, Sec. 112
CERCLA Reportable Quantity (RQ), 1 lb (0.454 kg)
SARA 311/312 Codes: 1, 2
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed
**OSHA Regulations:**
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)

## Section 16 - Other Information

**References:** 73, 103, 124, 132, 136, 148, 149, 159, 167, 176, 187, 189

**Prepared By** ..... M Gannon, BA
**Industrial Hygiene Review** ..... RE Langford, PhD, CIH
**Medical Review** ..... T Thoburn, MD, MPH

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*Material Safety Data Sheet Collection*
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Issue Date 2000-07

**Nickel**
**MSDS 723**
**NIC1000**

## Section 1 - Chemical Product and Company Identification 54.1

**Material Name:** Nickel **CAS Number:** 7440-02-0
**Chemical Formula:** Ni
**Structural Chemical Formula:** Ni
**Synonyms:** ALCAN 756, C I 77775, CARBONYL NICKEL POWDER, EL12, FIBREX, FIBREX P, NI 0901-S, NI 4303-S, NI 4303T, NI-4303T, NI 270, NI 0901-S (HARSHAW), NICHEL, NICKEL, NICKEL 200, NICKEL 201, NICKEL 205, NICKEL 207, NICKEL 270, NICKEL CATALYST SYNONYMS OF OTHER NICKEL COMPOUNDS VARY DEPENDING UPON THE SPECIFIC COMPOUND, NICKEL (DUST), NICKEL METAL ELEMENTAL NICKEL, NICKEL PARTICLES, NICKEL SPONGE, NICKEL,METAL, NICKLE CATALYST,WET, NP-2, NP 2, PULVERIZED NICKEL, RANEY ALLOY, RANEY NICKEL, RCH 55/5
**General Use:** Used in the manufacture of Monel metal, stainless steels, and nickel -chrome resistance wire, nickel-plating, various alloys such as new silver, Chinese silver, German silver, for coins, electrotypes, storage batteries Used for magnets, lightning-rod tips, electrical contacts and electrodes, spark plugs, machinery parts, catalyst for hydrogenation of oils and other organic substances, in alloys for electronic and space applications

## Section 2 - Composition / Information on Ingredients

| Name | CAS | % |
|---|---|---|
| nickel | 7440-02-0 | > 99 |

**OSHA PEL**
TWA 1 mg/m$^3$, as Ni

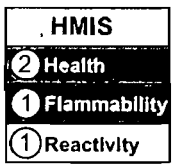
**OSHA PEL Vacated 1989 Limits**
TWA 1 mg/m$^3$, Insoluble as Ni
Other Values soluble as Ni mg/m$^3$, 0 1

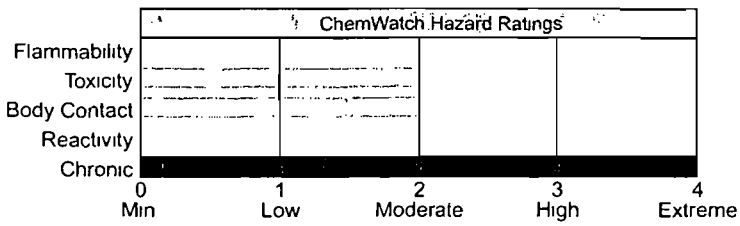
**ACGIH TLV**
TWA 1 mg/m$^3$, as Ni

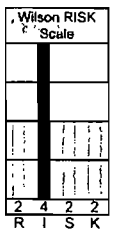
**NIOSH REL**
TWA 1 mg/m$^3$, as Ni soluble & insoluble

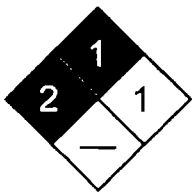
**IDLH Level**
10 mg/m$^3$, as Ni

## Section 3 - Hazards Identification



Fire Diamond

**ANSI Signal Word**
**Warning!**

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Silvery-white metal powder Irritating Also causes exposure to fume metal fume fever, asthma, noninfectious pneumonia, vomiting, abdominal pain, direct contact nickel itch Possible cancer hazard Chronic sensitization, perforation of nasal septum

### Potential Health Effects

**Primary Entry Routes:** inhalation, skin contact, ingestion
**Target Organs:** nasal cavities, lungs, skin

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**Acute Effects**

**Inhalation:** The dust may be discomforting to the upper respiratory tract and may be harmful if inhaled.
Persons with impaired respiratory function, airway diseases, and conditions such as emphysema or chronic bronchitis may incur further disability if excessive concentrations of particulate are inhaled.
Regular exposure to nickel fume, as the oxide, may result in "metal fume fever" a sometimes debilitating upper respiratory tract condition resembling influenza.
Symptoms include malaise, fever, weakness, nausea and may appear quickly if operations occur in closed or poorly ventilated areas.
Pulmonary edema, pulmonary fibrosis and asthma has been reported in welders using nickel alloys; levels of exposure are generally not available and case reports are often confounded by mixed exposures to other agents.
Inhalation of freshly formed metal oxide particles sized below 1.5 microns and generally between 0.02 to 0.05 microns may result in "metal fume fever". Symptoms may be delayed for up to 12 hours and begin with the sudden onset of thirst, and a sweet, metallic or foul taste in the mouth.
Other symptoms include upper respiratory tract irritation accompanied by coughing and a dryness of the mucous membranes, lassitude and a generalized feeling of malaise. Mild to severe headache, nausea, occasional vomiting, fever or chills, exaggerated mental activity, profuse sweating, diarrhea, excessive urination and prostration may also occur. Tolerance to the fumes develops rapidly, but is quickly lost. All symptoms usually subside within 24-36 hours following removal from exposure.

**Eye:** The dust may produce eye discomfort and abrasive eye inflammation.

**Skin:** The material may be mildly discomforting to the skin.
Nickel dusts, fumes and salts are potent contact allergens and sensitizers producing a dermatitis known as "nickel" rash.
In the absence of properly designed ventilation systems or where respiratory protective devises are inadequate, up to 10% of exposed workers are expected to be symptomatic.

**Ingestion:** The material may be mildly discomforting to the gastrointestinal tract if swallowed in large quantity.
The potential to generate small quantities of nickel chloride in the stomach may produce a low order toxic effect.
Nickel salts cause vomiting, following ingestion, as a result of astringent and irritant effects. In common with other irritant-emetics the lethal dose varies widely. Absorption is generally poor and systemic poisoning is rare.
Systemic effects include increased blood sugar levels (hyperglycemia), capillary damage (especially in the brain and adrenals), kidney damage, heart damage (myocardial weakness) and central nervous system depression.

**Carcinogenicity:** NTP - Class 2A, Reasonably anticipated to be a carcinogen, limited evidence of carcinogenicity from studies in humans; IARC - Group 1, Carcinogenic to humans; OSHA - Not listed; NIOSH - Listed as carcinogen; ACGIH - Not listed; EPA - Class A, Human carcinogen; MAK - Class A1, Capable of inducing malignant tumors as shown by experience with humans.

**Chronic Effects:** Metallic dusts generated by the industrial process give rise to a number of potential health problems. The larger particles, above 5 micron, are nose and throat irritants. Smaller particles however, may cause lung deterioration. Particles of less than 1.5 micron can be trapped in the lungs and, dependent on the nature of the particle, may give rise to further serious health consequences.
The most common toxic reaction to nickel is skin sensitization which may produce a chronic eczema called "nickel itch". The first symptom is itching which occurs up to 7 days prior to the appearance of skin eruption.
The primary skin eruption is erythematous or follicular and may be followed by superficial discrete ulcers (which discharge and become crusted), or eczema. In the chronic stages, pigmented or depigmented plaques may be formed. Recovery from the dermatitis usually occurs within 7 days but may take several weeks.
Nickel dusts and several specific compounds are carcinogenic in animals following inhalation or parenteral administration (but not by ingestion or skin contact). Increases in lung and nasal cavity cancers have been observed amongst nickel workers in smelters and refineries.
Respiratory cancer risks primarily relate to chronic exposure to soluble nickels at concentrations in excess of 1 mg $Ni/m^3$ and exposure to the less soluble forms at concentrations greater than 10 mg $Ni/m^3$. Metallic nickel does not appear to pose such a threat.
When injected intramuscularly, nickel induced incidences of fibrosarcomas in rats and hamsters of both sexes, local sarcomas in rats of both sexes and local tumors with some metastases to pre-vertebral lymph nodes in female rats.
When injected intrapleurally, nickel powder induced round cell and spindle cell tumors at the site of injection in female rats.
Inhalation of nickel dusts induced lymphosarcomas in female mice and anaplastic intraalveolar carcinomas in male and female guinea pigs.
Subdermal implantation of nickel pellets induced sarcomas surrounding the pellet in rats of both sexes whilst intramedullar injection into the femur of rats produced neoplasms at or near the site of injection, including fibrosarcomas (neurogenic in origin).

## Section 4 - First Aid Measures

**Inhalation:** Remove to fresh air.
Encourage patient to blow nose to ensure clear breathing passages. Rinse mouth with water. Consider drinking water to remove dust from throat.

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Seek medical attention if irritation or discomfort persist.

**Eye Contact:** Immediately hold the eyes open and flush with fresh running water.
Ensure irrigation under the eyelids by occasionally lifting upper and lower lids. If pain persists or recurs seek medical attention.
Removal of contact lenses after an eye injury should only be undertaken by skilled personnel.

**Skin Contact:** Immediately remove all contaminated clothing, including footwear (after rinsing with water).
Wash affected areas thoroughly with water (and soap if available).
Seek medical attention in event of irritation.

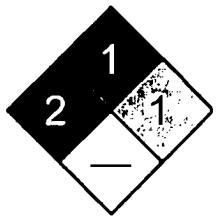
**Ingestion:** Rinse mouth out with plenty of water. Seek medical attention if irritation or discomfort persist.

***After first aid, get appropriate in-plant, paramedic, or community medical support.***

**Note to Physicians:** Long term exposure to high dust concentrations may cause changes in lung function i.e. pneumoconiosis; caused by particles less than 0.5 micron penetrating and remaining in the lung. Prime symptom is breathlessness; lung shadows show on X-ray.
* Preplacement and periodic medical examinations of workers exposed to nickel are recommended. Preplacement examination should evaluate any history of skin allergies or asthma, other exposures to nickel, smoking history, condition of nasal cavity and lungs. Periodic examinations should include chest X-rays.

## Section 5 - Fire-Fighting Measures

**Flash Point:** Not available; probably combustible
**LEL:** Not applicable
**UEL:** Not applicable



Fire Diamond

**Extinguishing Media:** Sand, dry powder extinguishers or other inerts should be used to smother dust fires.
These are the only suitable means for extinguishing metal dust fires.
Do NOT use water.

**General Fire Hazards/Hazardous Combustion Products:** Metal powders, while generally regarded as noncombustible, may burn when metal is finely divided and energy input is high.
Metal dust fires are slow moving but intense and difficult to extinguish. DO NOT disturb burning dust. Explosion may result if dust is stirred into a cloud, by providing oxygen to a large surface of hot metal. DO NOT use water or foam as generation of explosive hydrogen may result.
When heated with sulfur reacts with incandescence.
If involved in fire, may produce toxic fumes of nickel carbonyl and nickel.

**Fire Incompatibility:** Avoid reaction with nitric acid and other strong acids, oxidizing agents and sulfur compounds.
Nickel dust reacts violently with titanium, ammonium nitrate, potassium perchlorate and hydrazoic acid.

**Fire-Fighting Instructions:** Contact fire department and tell them location and nature of hazard.
Wear breathing apparatus plus protective gloves. Prevent, by any means available, spillage from entering drains or waterways.
Use fire fighting procedures suitable for surrounding area.
Do not approach containers suspected to be hot.
If safe to do so, remove containers from path of fire.
Equipment should be thoroughly decontaminated after use.

## Section 6 - Accidental Release Measures

**Small Spills:** Clean up all spills immediately. Avoid contact with skin and eyes.
Wear protective clothing, impervious gloves and safety glasses.
Use dry clean-up procedures and avoid generating dust.
Vacuum up or sweep up.
Place in suitable containers for disposal.

**Large Spills:** Clear area of personnel and move upwind.
Wear breathing apparatus plus protective gloves. Prevent, by any means available, spillage from entering drains or waterways.
Stop leak if safe to do so.
Use dry clean-up procedures and avoid generating dust.
Collect recoverable product into labeled containers for recycling.
Collect residues and seal in labeled drums for disposal.
Wash spill area with large quantities of water.

**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

## Section 7 - Handling and Storage

**Handling Precautions:** Limit all unnecessary personal contact.
Wear protective clothing when risk of exposure occurs.
Use in a well-ventilated area. When handling DO NOT eat, drink or smoke.

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Always wash hands with soap and water after handling.
Avoid physical damage to containers. Use good occupational work practices.
Observe manufacturer's storing and handling recommendations.

**Recommended Storage Methods:** Packaging as recommended by manufacturer.
Check that containers are clearly labeled.
Glass container.
Plastic drum.
Plastic bag.
Polyethylene or polypropylene container.
Metal drum.

**Regulatory Requirements:** Follow applicable OSHA regulations.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** Metal dusts must be collected at the source of generation as they are potentially explosive.

1. Vacuum cleaners, of flame-proof design, should be used to minimize dust accumulation.
2. Metal spraying and blasting should, where possible, be conducted in separate rooms. This minimizes the risk of supplying oxygen, in the form of metal oxides, to potentially reactive finely divided metals such as aluminum, zinc, magnesium or titanium.
3. Work-shops designed for metal spraying should possess smooth walls and a minimum of obstructions, such as ledges, on which dust accumulation is possible.
4. Wet scrubbers are preferable to dry dust collectors.
5. Bag or filter-type collectors should be sited outside the workrooms and be fitted with explosion relief doors.
6. Cyclones should be protected against entry of moisture as reactive metal dusts are capable of spontaneous combustion in humid or partially wetted state.
7. Local exhaust systems must be designed to provide a minimum capture velocity at the fume source, away from the worker, of 0.5 meter/sec.

Special ventilation requirements apply for processes which result in the generation of barium, chromium, lead, or nickel fume and in those processes which generate ozone.
The use of mechanical ventilation by local exhaust systems is required as a minimum in all circumstances (including outdoor work).
In confined spaces always check that oxygen has not been depleted by excessive rusting of steel or snowflake corrosion of aluminum. Local exhaust systems must be designed to provide a minimum capture velocity at the fume source, away from the worker, of 0.5 meter/sec.

**Personal Protective Clothing/Equipment**

**Eyes:** Safety glasses. Chemical goggles.
Full face shield.
Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them.

**Hands/Feet:** Impervious gloves; rubber gloves.
Neoprene gloves.
Safety footwear.
Rubber boots.

**Respiratory Protection:**
Exposure Range >1 to <10 mg/m$^3$: Supplied Air, Constant Flow/Pressure Demand, Half Mask
Exposure Range 10 to unlimited mg/m$^3$: Self-contained Breathing Apparatus, Pressure Demand, Full Face
Note: odor threshold unknown

**Other:** Overalls. Barrier cream. Eyewash unit.

## Section 9 - Physical and Chemical Properties

**Appearance/General Info:** Lustrous silver-white, hard, ferromagnetic metal. Soluble in dilute nitric acid; slightly soluble in hydrochloric acid and sulfuric acid. Insoluble in ammonia. Mohs' hardness:3.8
Welding flux grades typical sieve analysis (cumulative retention %):- 200 um 0, 150 um 2, 100 um 12, 75 um 60, 63 um 80, 43 um 98.

**Physical State:** Solid
**Vapor Pressure (kPa):** 0.13 at 1810 °C
**Formula Weight:** 58.71
**Specific Gravity ($H_2O$=1, at 4 °C):** 8.9
**Water Solubility:** Insoluble in water
**Evaporation Rate:** Non-volatile

**pH:** Not applicable
**pH (1% Solution):** Not applicable
**Boiling Point Range:** 2730 °C (4946 °F)
**Freezing/Melting Point Range:** 1455 °C (2651 °F)
**Volatile Component (% Vol):** Nil at 38 °C

## Section 10 - Stability and Reactivity

**Stability/Polymerization:** Product is considered stable. Hazardous polymerization will not occur.

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**Storage Incompatibilities:** Avoid reaction with oxidizing agents. Reacts with acids producing flammable/explosive hydrogen ($H_2$) gas.

## Section 11 - Toxicological Information

Unless otherwise specified data extracted from RTECS - Registry of Toxic Effects of Chemical Substances

TOXICITY

Oral (rat) $LD_{50}$: 5000 mg/kg

IRRITATION

See NIOSH, *RTECS* QR 5950000, for additional data.

## Section 12 - Ecological Information

**Environmental Fate:** No data found.
**Ecotoxicity:** No data found.

## Section 13 - Disposal Considerations

**Disposal:** Recycle wherever possible. Consult manufacturer for recycling options.
Follow applicable federal, state, and local regulations.
Bury residue in an authorized landfill.
Recycle containers if possible, or dispose of in an authorized landfill.

## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

**Shipping Name:** NONE
**Hazard Class:** None
**ID No.:** None
**Packing Group:** None
**Label:** No class label assigned

**Additional Shipping Information:**

## Section 15 - Regulatory Information

**EPA Regulations:**
**RCRA 40 CFR:** Not listed
**CERCLA 40 CFR 302.4:** Listed per CWA Section 307(a) 100 lb (45.35 kg)
**SARA 40 CFR 372.65:** Listed
**SARA EHS 40 CFR 355:** Not listed
**TSCA:** Listed

## Section 16 - Other Information

**Research Date:**.....1999-11 **Review Date:** .....2000-07

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**Polychlorinated Biphenyls (PCBs)**
**POL2140**

Issue Date: 2002-02

## Section 1 - Chemical Product and Company Identification 54

**Material Name:** Polychlorinated Biphenyls (PCBs) **CAS Number:** 1336-36-3
**Chemical Formula:** Unspecified or Variable
**Structural Chemical Formula:** $(C_{12}H_{10-x})Cl_x$
**Synonyms:** AROCLOR; AROCLOR 1221; AROCLOR 1232; AROCLOR 1242; AROCLOR 1248; AROCLOR 1254; AROCLOR 1260; AROCLOR 1262; AROCLOR 1268; AROCLOR 2565; AROCLOR 4465; AROCLOR 5442; 1,1'-BIPHENYL,CHLORO DERIVS; BIPHENYL,POLYCHLORO-; CHLOPHEN; CHLOREXTOL; CHLORINATED BIPHENYL; CHLORINATED DIPHENYL; CHLORINATED DIPHENYLENE; CHLORO 1,1-BIPHENYL; CHLORO 1,1-BIPHENYL-; CHLORO BIPHENYL; CLOPHEN; CLOPHEN A 60; DYKANOL; EPA PESTICIDE CHEMICAL CODE 017801; FENCLOR; FENCLOR 42; INERTEEN; KANECHLOR; KANECHLOR 300; KANECHLOR 400; MONTAR; MONTER; NOFLAMOL; PCB; PCBS; PHENOCHLOR; PHENOCLOR; POLYCHLORINATED BIPHENYL; POLYCHLORINATED BIPHENYLS; POLYCHLORINATED BIPHENYLS (PCB'S); POLYCHLOROBIPHENYL; PYRALENE; PYRANOL; SANTOTHERM; SANTOTHERM FR; SOVOL; THERMINOL; THERMINOL FR-1
**General Use:** Used as dielectric fluids in transformers and capacitors. Prior to 1972, were used as hydraulic and other industrial fluids (e.g., in vacuum pumps, as lubricants and cutting oils), in paints, inks and fire retardants.
Also used in heat transfer systems; gas-transmission turbines; carbonless reproducing paper; adhesives; as plasticizer in epoxy paints; fluorescent light ballasts; wax extenders; coolants; dedusting agents; pesticide extenders; surface treatment and coatings; sealants; caulking material.
This is one of a group of once widely used industrial chemicals whose high stability contributed both to their commercial usefulness and the long term deleterious environmental health effects. Consequently their use has been phased out. Their manufacture in the U.S.A. was discontinued in 1977.

## Section 2 - Composition / Information on Ingredients

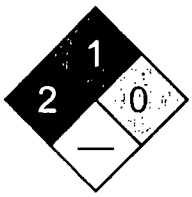
| Name | CAS | % |
|---|---|---|
| polychlorinated biphenyls (PCB's) | 1336-36-3 | 100 |

**OSHA PEL**
No data found.

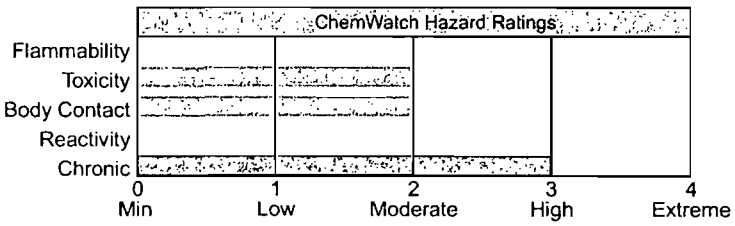
**NIOSH REL**
No data found.

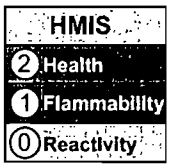
**ACGIH TLV**
No data found.

## Section 3 - Hazards Identification



Fire Diamond




**ANSI Signal Word**

**Warning!**

### ☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Oily liquid, white crystalline solid, or hard resin. Severely irritating. Suspect cancer hazard. Chronic: chloracne, GI disturbances, neurological symptoms, liver enlargement, menstrual changes, bronchitis. Possible reproductive and teratogenic effects.

### Potential Health Effects

**Target Organs:** skin, liver, eyes, mucous membranes, respiratory system
**Primary Entry Routes:** inhalation, skin contact, ingestion

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**Acute Effects**

**Inhalation:** Not normally a hazard due to nonvolatile nature of product. Inhalation of vapor is more likely at higher than normal temperatures.

The vapor/mist is discomforting and may be extremely toxic if inhaled.

**Eye:** The vapor/liquid is moderately discomforting and may be harmful to the eyes.

**Skin:** The liquid is harmful to the skin, it is rapidly absorbed and is capable of causing skin reactions.

Exposure to material may result in a dermatitis, described as chloracne, a persistent acneiform characterized by comedones (white-, and black- heads), keratin cysts, and inflammed papules with hyperpigmentation and an anatomical distribution frequently involving the skin under the eyes and behind the ears. It occurs after acute or chronic exposure to a variety of chlorinated aromatic compounds by skin contact, ingestion or inhalation and may appear within days and months following the first exposure. Other dermatological alterations including hypertrichosis (the growth of excess hair), an increased incidence of actinic or solar elastosis (the degeneration of elastic tissue within muscles or loss of dermal elasticity produced by the effects of sunlight), and Peyrone's disease (a rare progressive scarring of the penile membrane).

**Ingestion:** Considered an unlikely route of entry in commercial/industrial environments.

The material is moderately discomforting to the gastrointestinal tract and may be harmful if swallowed in large quantity.

Ingestion may result in nausea, pain, vomiting. Vomit entering the lungs by aspiration may cause potentially lethal chemical pneumonitis.

Digestion may lead to nausea, vomiting, abdominal pain, anorexia, jaundice and liver damage, coma and death.

Headache, dizziness, lethargy, depression, nervousness, loss of libido, muscle, joint pains may be found.

Symptoms appear after a latent period of 5 to 6 months.

PCB's may appear in breast milk of exposed mothers and in newborn infants.

**Carcinogenicity:** NTP - Class 2B, Reasonably anticipated to be a carcinogen, sufficient evidence of carcinogenicity from studies in experimental animals; IARC - Group 2A, Probably carcinogenic to humans; OSHA - Not listed; NIOSH - Not listed; ACGIH - Not listed; EPA - Class B2, Probable human carcinogen based on animal studies; MAK - Not listed.

**Chronic Effects:** People occupationally exposed to PCB's have relatively high PCB residue levels in blood plasma. Symptoms include chloracne dermatitis and degreasing the skin, pigmentation of skin and nails, excessive eye discharge, swelling of eyelids, transient visual disturbances, distinctive hair follicles, edema of the face and hands.

In common with other polyhalogenated aromatic hydrocarbons, the chlorinated biphenyls exhibit dioxin-like behavior. Polyhalogenated aromatic hydrocarbons (PHAHs) comprise two major groups.

The first group represented by the halogenated derivatives of dibenzodioxins (the chlorinated form is PCDD), dibenzofurans (PCDF) and biphenyls (PCB) exert their toxic effect (as hepatoxicants, reproductive toxicants, immunotoxicants and procarcinogens) by interaction with a cytostolic protein known as the Ah receptor. In guinea pigs the Ah receptor is active in a mechanism which "pumps" PHAH into the cell whilst in humans the reverse appears to true. This, in part, may account for species differences often cited in the literature. This receptor exhibits an affinity for the planar members of this group and carries these to the cellular nucleus where they bind, reversibly, to specific genomes on DNA.

This results in the regulation of the production of certain proteins which elicit the toxic response. The potency of the effect is dependent on the strength of the original interaction with the Ah receptor and is influenced by the degree of substitution by the halogen and the position of such substitutions on the parent compound.

The most potent molecule is 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) while the coplanar PCBs (including mono-ortho coplanars) possess approximately 1% of this potency. Nevertheless, all are said to exhibit "dioxin-like" behavior and in environmental and health assessments it has been the practice to assign each a TCDD-equivalence value.

The most subtle and important biological effects of the PHAHs are the effects on endocrine hormones and vitamin homeostasis. TCDD mimics the effect of thyroxin (a key metamorphosis signal during maturation) and may disrupt patterns of embryonic development at critical stages. Individuals from exposed wildlife populations have been observed to have altered sexual development, sexual dysfunction as adults and immune system suppression.

Immunotoxic effects of the PHAHs (including the brominated congener, PBB) have been the subject of several studies. No clear pattern emerges in human studies however with T-cell numbers and function (a blood marker for immunological response) increasing in some and decreasing in others.

Three incidences have occurred which have introduced abnormally high levels of dioxin or dioxin-like congeners to humans. The explosion at a trichlorophenol-manufacturing plant in Seveso, Italy distributed TCDD across a large area of the country-side, whilst rice-oil contaminated with heat-transfer PCBs (and dioxin-like contaminants) has been consumed by two groups, on separate occasions (one in Yusho, Japan and another in Yu-cheng, Taiwan). The only symptom which can unequivocally be related to all these exposures is the development of chloracne, a disfiguring skin condition, following each incident. Contaminated oil poisonings also produced eye-discharge, swelling of eyelids and visual disturbances. The Babies born up to 3 years after maternal exposure (so-called "Yusho-babies") were characteristically brown skinned, colored gums and nails and (frequently) produced eye-discharges. Delays in intellectual development have been noted. It has been estimated that Yu-cheng patients consumed an average level of 0.06 mg/kg body weight/day total PCB and 0.0002 mg/kg/day of PCDF before the onset of symptoms after 3 months. When the oil was withdrawn after 6 months they had consumed 1 gm total PCB containing 3.8 mg PCDF.

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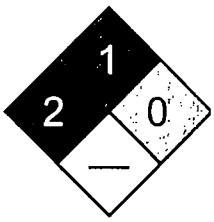
Preliminary data from the Yusho cohort suggests a six-fold excess of liver cancer mortality in males and a three-fold excess in women.
Recent findings from Seveso indicate that the biological effects of low level exposure (BELLEs), experienced by a cohort located at a great distance from the plant, may be hormetic, i.e. may be protective AGAINST the development of cancer.
TCDD induces carcinogenic effects in the laboratory in all species, strains and sexes tested. These effects are dose-related and occur in many organs.
Exposures as low as 0.001 ug/kg body weight/day produce carcinoma.
Several studies implicate PCBs in the development of liver cancer in workers as well as multi-site cancers in animals.
The second major group of PHAH consists of the non-planar PCB congeners which possess two or more ortho-substituted halogens. These have been shown to produce neurotoxic effects which are thought to reduce the concentration of the brain neurotransmitter, dopamine, by inhibiting certain enzyme-mediated processes.
The specific effect elicited by both classes of PHAH seems to depend on the as much on the developmental status of the organism at the time of the exposure as on the level of exposure over a lifetime.

## Section 4 - First Aid Measures

**Inhalation:** Remove to fresh air.
Lay patient down. Keep warm and rested.
If breathing is shallow or has stopped, ensure clear airway and apply resuscitation. Transport to hospital or doctor.
**Eye Contact:** Immediately hold the eyes open and flush continuously for at least 15 minutes with fresh running water.
Ensure irrigation under eyelids by occasionally lifting the upper and lower lids.
Transport to hospital or doctor without delay. Removal of contact lenses after an eye injury should only be undertaken by skilled personnel.
**Skin Contact:** Immediately remove all contaminated clothing, including footwear (after rinsing with water).
Wash affected areas thoroughly with water (and soap if available).
Seek medical attention in event of irritation.
**Ingestion:** Contact a Poison Control Center. DO NOT induce vomiting. Observe the patient carefully. Never give liquid to a person showing signs of being sleepy or with reduced awareness; i.e. becoming unconscious. Give water (or milk) to rinse out mouth. Then provide liquid slowly and as much as casualty can comfortably drink. Transport to hospital or doctor without delay.
***After first aid, get appropriate in-plant, paramedic, or community medical support.***
**Note to Physicians:** Treat symptomatically. If large amounts are ingested, gastric lavage is suggested. For splash in the eyes, a petrolatum-based ophthalmic ointment may be applied to the eye to relieve the irritating effects of PCBs.
If electrical equipment arcs over, PCB dielectric fluids may decompose to produce hydrogen chloride (HCl), a respiratory irritant. [Monsanto] Preplacement and annual medical examinations of workers, with emphasis on liver function, skin condition, reproductive history, is recommended.

## Section 5 - Fire-Fighting Measures

**Flash Point:** > 141 °C
**Autoignition Temperature:** 240 °C
**LEL:** Not applicable
**UEL:** Not applicable
**Extinguishing Media:** Foam.Alcohol stable foam.
Dry chemical powder.



Fire Diamond

**General Fire Hazards/Hazardous Combustion Products:** Noncombustible liquid.
POLLUTANT -contain spillage.
Decomposes on heating and produces acrid black soot and toxic fumes of aldehydes, hydrogen chloride (HCl), chlorides and extremely toxic polychlorinated dibenzofuran (PCDF), polychlorinated dibenzodioxin (PCDD).
**Fire Incompatibility:** Reacts vigorously with chlorine (Cl2).
**Fire-Fighting Instructions:** POLLUTANT -contain spillage. Noncombustible.
Clear area of personnel and move upwind.
Contact fire department and tell them location and nature of hazard.
Wear full body protective clothing with breathing apparatus. Prevent, by any means available, spillage from entering drains or waterways.
Use fire fighting procedures suitable for surrounding area.
Cool fire-exposed containers with water spray from a protected location.
Avoid spraying water onto liquid pools.
If safe to do so, remove containers from path of fire.
Equipment should be thoroughly decontaminated after use.

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## Section 6 - Accidental Release Measures

**Small Spills:** POLLUTANT -contain spillage. Clean up all spills immediately.
Environmental hazard - contain spillage.
Avoid breathing vapors and contact with skin and eyes.
Wear protective clothing, impervious gloves and safety glasses.
Contain spill with sand, earth or vermiculite.
Wipe up and absorb small quantities with vermiculite or other absorbent material.
Place spilled material in clean, dry, sealable, labeled container.
**Large Spills:** POLLUTANT -contain spillage. Clear area of personnel.
Contact fire department and tell them location and nature of hazard.
Wear full body protective clothing with breathing apparatus. Prevent, by any means available, spillage from entering drains or waterways.
Stop leak if safe to do so.
Contain spill with sand, earth or vermiculite.
Collect recoverable product into labeled containers for recycling.
Absorb remaining product with sand, earth or vermiculite.
Collect residues and seal in labeled drums for disposal.
After clean-up operations, decontaminate and launder all protective clothing and equipment before storing and reusing.
If equipment is grossly contaminated, decontaminate and destroy.
If contamination of drains or waterways occurs, advise emergency services.
**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

## Section 7 - Handling and Storage

**Handling Precautions:** Do not allow clothing wet with material to stay in contact with skin Use good occupational work practices. Observe manufacturer's storing and handling recommendations.
Atmosphere should be regularly checked against established exposure standards to ensure safe working conditions are maintained.
Avoid all personal contact, including inhalation.
Wear protective clothing and gloves when handling containers.
Avoid physical damage to containers.
Use in a well-ventilated area and Use only in completely enclosed system.
Avoid contact with incompatible materials.
When handling, DO NOT eat, drink or smoke.
Wash hands with soap and water after handling.
Work clothes should be laundered separately: NOT at home.
**Recommended Storage Methods:** Packaging as recommended by manufacturer.
Check that containers are clearly labeled.
Metal can or metal drum or Steel drum with plastic liner.
**Regulatory Requirements:** Follow applicable OSHA regulations.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** Provide adequate ventilation in warehouse or closed storage areas.
If inhalation risk of overexposure exists, wear NIOSH-approved organic-vapor respirator.
In confined spaces where there is inadequate ventilation, wear full-face air supplied breathing apparatus.
***Personal Protective Clothing/Equipment***
**Eyes:** Safety glasses with side shields; chemical goggles.
Full face shield.
Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them.
**Hands/Feet:** Impervious gloves or Viton gloves or Polyethylene gloves or PVC gloves.
Protective footwear.

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**Other:** Impervious protective clothing. Overalls. Impervious apron.
Eyewash unit.
Ensure there is ready access to a safety shower.

## Section 9 - Physical and Chemical Properties

**Appearance/General Info:** Clear, colorless to yellow-green, mobile oily to viscous liquid, or sticky to hard resin, or white crystalline solid, depending on degree of chlorination. Slightly soluble in glycerol and glycols. Soluble in organic solvents and lipids. Viscosity range: 71 - 2500 Saybolt unit sec. at 38 °C. PCBs are resistant to chemical and biological degradation and because of their solubility in fats and oils they tend to be concentrated in living organisms. The highly chlorinated PCBs are retained in animal's bodies longer and seems to delay the excretion of the lower chlorinated PCB's. They have become widely dispersed in the world-wide environment and in the food-chain since their introduction in 1929. They are now recognized internationally to be a major environmental pollutant, their persistence causing ecological damage via water pollution. Consequently loss of PCBs to the environment is to be avoided at all costs.

**Physical State:** Liquid
**Vapor Pressure (kPa):** Negligible
**Formula Weight:** 188.66 - 395
**Specific Gravity ($H_2O$=1, at 4 °C):** 1.18 - 1.8
**Water Solubility:** Solubility in water extremely low
**Evaporation Rate:** Non Vol. at 38 °C

**pH:** Not applicable
**pH (1% Solution):** Not applicable.
**Boiling Point Range:** 340 °C (644 °F) to 375 °C (707 °F)
**Decomposition Temperature (°C):** 375-550

## Section 10 - Stability and Reactivity

**Stability/Polymerization/Conditions to Avoid:** Product is considered stable. Hazardous polymerization will not occur.
**Storage Incompatibilities:** Avoid storage with oxidizers. Segregate from chlorine.
Avoid contamination of water, foodstuffs, feed or seed.

## Section 11 - Toxicological Information

TOXICITY
Oral (human) $LD_{Lo}$: 500 mg/kg
Oral (rat) $LD_{50}$: 3980 mg/kg

IRRITATION
Nil reported

See NIOSH, *RTECS* TQ1350000, for additional data.

## Section 12 - Ecological Information

**Environmental Fate:** PCBs are mixtures of different congeners of chlorobiphenyl and the relative importance of the environmental fate mechanisms generally depends on the degree of chlorination. In general, the persistence of PCBs increases with an increase in the degree of chlorination. Mono-, di- and trichlorinated biphenyls (Aroclor 1221 and 1232) biodegrade relatively rapidly, tetrachlorinated biphenyls (Aroclors 1016 and 1242) biodegrade slowly, and higher chlorinated biphenyls (Aroclors 1248, 1254, and 1260) are resistant to biodegradation. Although biodegradation of higher chlorinated congeners may occur very slowly on an environmental basis, no other degradation mechanisms have been shown to be important in natural water and soil systems; therefore, biodegradation may be the ultimate degradation process in water and soil.

If released to soil, PCBs experience tight adsorption with adsorption generally increasing with the degree of chlorination. PCBs will generally not leach significantly in aqueous soil systems; the higher chlorinated congeners will have a lower tendency to leach than the lower chlorinated congeners. In the presence of organic solvents PCBs may leach quite rapidly through soil. Vapor loss from soil surfaces appears to be an important fate mechanism with the rate of volatilization decreasing with increasing chlorination. Although the volatilization rate may be low, the total loss by volatilization over time may be significant because of persistence and stability. Enrichment of the low Cl PCBs occurs in the vapor phase relative to the original Aroclor; the residue will be enriched in the PCBs containing high Cl content.

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If released to water, adsorption to sediment and suspended matter will be an important fate process; PCB concentrations in sediment and suspended matter have been shown to be greater than in the associated water column. Although adsorption can immobilize PCBs (especially the higher chlorinated congeners) for relatively long periods of time, eventual resolution into the water column has been shown to occur. The PCB composition in the water will be enriched in the lower chlorinated PCBs because of their greater water solubility, and the least water soluble PCBs (highest Cl content) will remain adsorbed. In the absence of adsorption, PCBs volatilize relatively rapidly from water. However, strong PCB adsorption to sediment significantly competes with volatilization, with the higher chlorinated PCBs having longer half-lives than the lower chlorinated PCBs. Although the resulting volatilization rate may be low, the total loss by volatilization over time may be significant because of persistence and stability. PCBs have been shown to bioconcentrate significantly in aquatic organisms. If released to the atmosphere, PCBs will primarily exist in the vapor-phase; the tendency to become associated with the particulate-phase will increase as the degree of chlorination of the PCB increases. The dominant atmospheric transformation process is probably the vapor-phase reaction with hydroxyl radicals which has estimated half-lives ranging from 12.9 days for monochlorobiphenyl to 1.31 years for heptachlorobiphenyl. Physical removal from the atmosphere, which is very important environmentally, is accomplished by wet and dry deposition.

**Ecotoxicity:** Aquatic toxicity: 0.278 ppm/96 hr/bluegill/TLm/fresh water 0.005 ppm/336-1080 hr/pinfish/TLm/salt water; Waterfowl toxicity: $LD_{50}$ 2000 ppm (mallard duck); Food chain concentration potential: High

**Henry's Law Constant:** $5 \times 10^{-3}$

**BCF:** bioconcentrate in tissue

**Biochemical Oxygen Demand (BOD):** very low

**Soil Sorption Partition Coefficient:** $K_{oc} = 510$ to $1.33 \times 10^{4}$

## Section 13 - Disposal Considerations

**Disposal:** Recycle wherever possible. Consult manufacturer for recycling options.

Follow applicable federal, state, and local regulations.

Due to their environmental persistence and potential health hazards, PCBs cannot be disposed of in landfills or dumped at sea. The only environmentally acceptable method for the disposal of PCBs is by high temperature incineration.

All wastes and residues containing PCB's (e.g., wiping cloths, absorbent material, used disposable protective gloves, contaminated clothing, etc.) should be collected, placed in proper containers, labelled and disposed of in accordance with applicable regulations.

## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

**Shipping Name:** POLYCHLORINATED BIPHENYLS

**Additional Shipping Information:** PCB'S

**Hazard Class:** 9

**ID No.:** 2315

**Packing Group:** II

**Label:** Miscellaneous Dangerous Goods[9]

## Section 15 - Regulatory Information

**EPA Regulations:**

**RCRA 40 CFR:** Not listed

**CERCLA 40 CFR 302.4:** Listed per CWA Section 311(b)(4), per CWA Section 307(a) 1 lb (0.454 kg)

**SARA 40 CFR 372.65:** Listed

**SARA EHS 40 CFR 355:** Not listed

**TSCA:** Listed

## Section 16 - Other Information

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## Section 1 - Chemical Product and Company Identification 51

**Product/Chemical Name:** Zinc **Chemical Formula:** Zn **CAS Number:** 7440-66-6

**Synonyms:** asarco L15; blue powder; C.I. 77945; C.I. pigment black 16; C.I. pigment metal 6; emenay zinc dust; granular zinc; jasad; merrillite; pasco; rheinzink; zinc ashes; zinc dust; zinc powder

**Derivation:** Manufactured by concentrating zinc ore, roasting the concentrate, followed with thermal smelting (reduction with carbon); by reducing the zinc oxide with carbon in retorts from which the resultant zinc is distilled and condensed; or by the hydrometallurgical or electrolytical process where the zinc oxide is leached from the roasted or calcined material with sulfuric acid to form zinc sulfate solution which is then leached from electrolyzed cells to deposit zinc on the cathodes.

**General Use:** Used in alloys (dental amalgams, brass), metallic driers, mixed-metal stabilizers, automotive parts, electrical fuses, storage and dry-cell batteries, in vacuum fluorescence displays, in electrical contact grease, in bearings, in paper defoxing, galvanizing iron and other metals, protective coating, desilverizing agent for lead, deoxidizing bronze, reducing agent in organic chemistry, reagent in analytical chemistry, extracting gold, electroplating, metal spraying, anodic inhibitors, fungicides, nutrition, roofing, gutters, engravers' plates, cable wrappings, railroad car linings, purifying fats, bleaching glue, canteens, and organ pipes.

**Vendors:** Consult the latest *Chemical Week Buyers' Guide.* (73)

## Section 2 - Composition / Information on Ingredients

Zinc, special high-grade (99.990%), high-grade (99.95%), intermediate (99.5%), brass special (99%), prime western (98%).
Trace Impurities: Tin, lead, iron, cadmium, arsenic, cesium, antimony, and zinc chloride (increases corrosion resistance).

| OSHA PEL* | ACGIH TLV* | NIOSH REL* | DFG (Germany) MAK* |
|---|---|---|---|
| None established | None established | None established | None established |

*When working with heated or powdered zinc, consider exposure limits for zinc oxide: OSHA TWA: 15 mg/m$^3$ (total dust), 5 mg/m$^3$ (respirable dust, fume); ACGIH TLV: 5 mg/m$^3$ (fume), 10 mg/m$^3$ (dust - containing no asbestos and <1% crystalline silica); ACGIH STEL: 10 mg/m$^3$ (fume); NIOSH TWA 5 mg/m$^3$ (dust, fume); STEL: 10 mg/m$^3$ (fume), 15 minute ceiling, 15 mg/m$^3$ (dust); DFG MAK: TWA 5 mg/m$^3$ (fume/respirable dust).

## Section 3 - Hazards Identification

**ANSI Signal Word:** Warning!

**☆☆☆☆☆ Emergency Overview ☆☆☆☆☆**

Zinc is a bluish-white lustrous metal that becomes covered with a white oxide coating of basic carbonate on exposure to moist air. Zinc itself is relatively non-toxic, but the presence of impurities such as cesium, antimony, arsenic, and lead, or the production of airborne zinc oxide fumes may cause toxic effects. It is incompatible with many materials and the dust produces explosive hydrogen gas when mixed with water. Zinc dust is flammable and may ignite spontaneously in air when dry.

| Wilson Risk Scale | |
|---|---|
| R | 1 |
| I | 2 |
| S | 1 |
| K | 1 |

| HMIS | |
|---|---|
| H | 1* |
| F | 1 |
| R | 1 |
| PPE† | |

*Chronic effects
†Sec. 8

### Potential Health Effects

**Primary Entry Routes:** Inhalation and eye and skin contact
**Target Organs:** Respiratory system, eyes, and skin
**Acute Effects**

**Inhalation:** Exposure to dust may result in cough. Heated zinc may give off zinc oxide (ZnO) fumes. Characteristics of exposure include sweet taste, dry throat, injury to mucous membrane, cough, weakness, aches, chills, fever, nausea, and vomiting. Concentrations of ZnO particulates at 45 to 870 mg/m$^3$ cause "metal fume fever," a transient condition characterized by fever, chills, muscle pain, and vomiting. Recovery normally occurs within 24 to 48 hours. Tolerance may develop but is generally lost over a weekend.

**Eye:** Zinc dust particles can irritate the eyes. Zinc salts will precipitate eye protein and cause corneal and lens changes.

**Skin:** A human skin irritant.

**Ingestion:** Relatively non-toxic, though significant ingestion (12 g) of metallic zinc was reported to cause lethargy, light headedness, staggering gait, and difficulty writing, suggesting cerebellar dysfunction. Ingestion of acidic food or beverages stored in zinc or galvanized containers can lead to nausea, vomiting, diarrhea, and abdominal pain.

**Carcinogenicity:** IARC, NTP, and OSHA do not list zinc as a carcinogen.

**Medical Conditions Aggravated by Long-Term Exposure:** None reported.

**Chronic Effects:** Abnormally large amounts of zinc may enter and leave the body for years without resulting in symptoms or clinical evidence. Zinc poisoning has been associated with prolonged consumption of water from galvanized pipes. Symptoms

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include irritability, muscular stiffness and pain, loss of appetite and nausea. Ingestion of excessive doses for prolonged periods alters the immune response and causes copper and iron deficiency, anemia, headache, vomiting, chills, fever, malaise, and abdominal pain.

## Section 4 - First Aid Measures

**Inhalation:** Remove exposed person to fresh air and support breathing as needed. Apply artificial respiration if victim is not breathing. Administer oxygen if breathing is difficult.

**Eye Contact:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water for at least 15 minutes. Consult a physician or ophthalmologist if pain or irritation develop.

**Skin Contact:** Remove contaminated clothing and rinse with flooding amounts of water. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.

**Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.

***After first aid, get appropriate in-plant, paramedic, or community medical support.***

**Note to Physicians:** Maintain hydration and observe for metabolic acidosis, hypocalcemic tetany, anuria, liver damage, gastric perforation, and pyloric stenosis. For pulmonary edema (noncardiogenic), maintain ventilation and oxygenation with close arterial blood gas monitoring. Early use of PEEP and mechanical ventilation may be needed to maintain $pO_2$ greater than 50 mm Hg with FI $O_2$ less than 60%. For eye exposure, rinse with 0.05 M neutral sodium edetate to help prevent or reverse a portion of the protein precipitation.

## Section 5 - Fire-Fighting Measures

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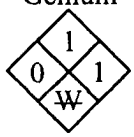


**Flash Point:** Not applicable, combustible solid

**Autoignition Temperature:** Cloud, 1256 °F (680 °C); dust layer, 860 °F (460 °C); powder 650 mJ spark.

**LEL:** Dust cloud explosion, 0.5 oz/ft$^3$

**UEL:** None reported.

**Flammability Classification:** Combustible solid

**Extinguishing Media:** *Do not* use water or foam. Use a Class D fire extinguisher, dry chemical, dry ground limestone, dry clay, soda ash, lime, or sand, or withdraw from area and let fire burn.

**Unusual Fire or Explosion Hazards:** Zinc dust reacts vigorously or explosively on contact with water. It produces flammable gases on contact with water or moist air. It may be ignited by heat, sparks or flames and may re-ignite after fire is extinguished. Dust forms explosive mixtures with air.

**Hazardous Combustion Products:** Fire will produce irritating, corrosive and/or toxic gases. Inhalation or contact with vapors, substance, or decomposition products may cause severe injury or death.

**Fire-Fighting Instructions:** *Do not* get water inside containers. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank as rupture or explosion may be imminent. *Do not* release runoff from fire control methods to sewers or waterways as runoff may create fire or explosion hazard. Corrosive solutions may be produced on contact with water. Move containers from fire area if it can be done without undue risk.

**Fire-Fighting Equipment:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing will only provide limited protection.

## Section 6 - Accidental Release Measures

**Spill /Leak Procedures:** Eliminate all ignition sources (no smoking, flares, sparks or flames). Isolate spill or leak area immediately for at least 160 to 330 feet (50 to 100 meters) in all directions. *Do not* walk through or touch spilled material. For large spills consider downwind evacuation for at least 800 feet (250 meters). Keep unauthorized personnel away, stay upwind, keep out of low areas, and ventilate area before entry.

**Small Spills:** Cover with dry earth, dry sand, or other non-combustible material followed with plastic sheet to minimize spreading or contact with rain. With a clean shovel, carefully scoop material into a dry, sealed container and move container from spill area. Cleanup personnel should protect against dust inhalation and skin and eye contact.

**Large Spills**

**Containment:** For large spills, dike far ahead of liquid spill for later disposal. *Do not* release into sewers or waterways.

**Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

## Section 7 - Handling and Storage

**Handling Precautions:** Bulk dust in damp state may heat spontaneously and ignite on exposure to air.


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**Storage Requirements:** Protect against physical damage. Store in a cool, dry ventilated place away from heat and ignition sources and incompatibles.

## Section 8 - Exposure Controls / Personal Protection

**Engineering Controls:** Routinely evaluate exposure to zinc by collecting personal and area air samples. Prevention of metal fume fever is a matter of keeping exposure of workers below the level of zinc oxide concentration currently accepted as satisfactory for working with metal in the industry (15 mg/m$^3$) by employment of proper local exhaust ventilation to collect fumes at their source.

**Ventilation:** Enclose operations and/or provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.

**Administrative Controls:** Post hazard and warning information in the work area. In addition, educate, train, and communicate all information on the health and safety hazards of zinc to potentially exposed workers.

**Respiratory Protection:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator equipped with particulate (dust/fume/mist) filters. Particulate filters must be checked daily before work for physical damage and replaced as needed. If, while wearing a filter cartridge or canister respirator, you can smell, taste, or otherwise detect zinc, or in the case of a full facepiece respirator you experience eye irritation, leave the area immediately. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

**Protective Clothing/Equipment:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.

**Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

**Contaminated Equipment:** Separate contaminated work clothes from street clothes. *Do not* take contaminated work clothes home. Launder before reuse. Contaminated work clothes should be laundered by individuals who have been informed of the hazards of exposure to zinc dust. Remove this material from your shoes and clean personal protective equipment.

**Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

## Section 9 - Physical and Chemical Properties

**Physical State:** Solid

**Appearance and Odor:** Bluish-white lustrous metal or dark powder

**Vapor Pressure:** 1 mm Hg at 908.6 °F (487 °C); 60 mm Hg at 1292 °F (700 °C)

**Formula Weight:** 65.38

**Specific Gravity ($H_2O$=1, at 4 °C):** 7.14 at 77 °F (25°C)

**Water Solubility:** Insoluble

**Other Solubilities:** Soluble in acid, alkalies, acetic acid

**Boiling Point:** 1666.4 °F ( 908 °C)

**Melting Point:** 787.1 °F (419.5 °C)

**Heat Capacity at Constant Pressure (25 °C):** 6.07 cal/mole deg

**Mohs' Hardness:** 2.5

**Standard Electrode Potential:** +0.761

**Ionizing Potential (eV):** 9.39405

## Section 10 - Stability and Reactivity

**Stability:** Zinc powder is stable at room temperature in closed containers under normal storage and handling conditions. However, moist zinc can react exothermically and ignite spontaneously in air.

**Polymerization:** Hazardous polymerization cannot occur.

**Chemical Incompatibilities:** Avoid contact with acids, alkali hydroxides (e.g., sodium hydroxide), ammonium nitrate, ammonium sulfide, arsenic oxide, barium dioxide, barium oxide, barium nitrate, cadmium, carbon disulfide, catalytic metals, chlorates, chlorides, chlorine, chlorinated rubber, chromium (VI) oxide, ethyl acetoacetate + tribromoneopentyl alcohol, fluorine, halogenated hydrocarbons, hydrazine mononitrate, hydroxylamine, lead azide, lead nitride, magnesium nitrate, manganese chloride, nitric acid, *o*-nitroanisole, nitrobenzene, nonmetals, oxidizing agents (sulfur, oxygen), paint primer base, pentacarbonyliron, performic acid, potassium chlorate, potassium nitrate, potassium peroxide, seleninyl bromide, selenium, sodium chlorate, sodium peroxide, tellurium, transition metal halides, and water.

**Conditions to Avoid:** Avoid exposure to moisture, heat, and ignition sources (flares, sparks, cigarettes, and open flames).

**Hazardous Decomposition Products:** Thermal oxidative decomposition of zinc metal/powder can produce hydrogen gas and zinc oxide fumes (of particle diameter ≤1 μm).

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## Section 11- Toxicological Information

### Toxicity Data:*

**Skin Effects:**
Human, skin, standard Draize test, 300 µg over 3 days intermittently caused mild irritation.

**Acute Inhalation Effects:**
Human, inhalation, 124 mg/m$^3$/50 minutes, resulted in toxic effects on lung, thorax, or respiration - cough and dyspnea, and skin and appendages - sweating.

*See NIOSH, *RTECS* (ZG8600000), for additional toxicity data. Refer to Genium MSDS #45 for toxicity data relevant to exposure to zinc oxide fumes generated from heated zinc metal.

## Section 12 - Ecological Information

**Ecotoxicity:** Chronic aquatic toxicity limits: 0.04 ppm; toxicity to aquatic plants: 25 ppm. Rainbow trout, $LC_{50}$ = 4 ppm/48 hrs; zebrafish (embryo), $LC_{50}$ = 19 ppm/72 hrs. Zinc accumulates in gill tissue and bone. Zinc is thought to exert its toxic action by forming insoluble compounds with the mucous that covers the gills, by damage to the gill epithelium, or by an internal poison.
**Environmental Fate:** Bioaccumulation may be significant (Biological Concentration Factor (BCF) ranges from 85 to 100,000).
**Environmental Degradation:** Zinc can persist in water indefinitely.

## Section 13 - Disposal Considerations

**Disposal:** Reclaim for salvage or reuse. Unsalvageable waste may be buried in an approved landfill. Maximum concentration in effluent to sewer or stream is 1 ppm. Criteria for land treatment or burial disposal practices are under significant review. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

## Section 14 - Transport Information

### DOT Transportation Data (49 CFR 172.101):

**Shipping Name:** Zinc powder
**Shipping Symbols:** –
**Hazard Class:** 4.3
**ID No.:** UN 1436
**Packing Group:** II
**Label:** Dangerous When Wet, Spontaneously Combustible
**Special Provisions (172.102):** A19, B109, N40

**Packaging Authorizations**
a) **Exceptions:** None
b) **Non-bulk Packaging:** 173.211
c) **Bulk Packaging:** 173.242

**Quantity Limitations**
a) **Passenger, Aircraft, or Railcar:** Forbidden
b) **Cargo Aircraft Only:** 15 kg

**Vessel Stowage Requirements**
a) **Vessel Stowage:** A
b) **Other:** –

## Section 15 - Regulatory Information

**EPA Regulations:**
Classified as a RCRA Hazardous Waste (40 CFR 261.21, 23), Characteristics of Ignitability and Reactivity
RCRA Hazardous Waste Number: D001, D003
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) specific per CWA, Sec. 307(a)
CERCLA Final Reportable Quantity (RQ), 1000 lb (454 kg)
Listed as a SARA Toxic Chemical (40 CFR 372.65) as zinc (fume or dust)
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed

**OSHA Regulations:**
Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A): Not listed

## Section 16 - Other Information

**References:** 1, 73, 103, 124, 136, 149, 190, 209, 216, 222, 224, 230

**Prepared By**..... R Reals, MS/HM Spliethoff, MS
**Industrial Hygiene Review**..... PA Roy, MPH, CIH
**Medical Review**..... T Thoburn, MD, MPH

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WASTE MANAGEMENT
CHEMICAL HAZARD INFORMATION

| Substance [CAS Number] | IP[1] (eV) | Odor Threshold (ppm) | Route[2] | Symptoms of Exposure | Treatment | TWA[3] | STEL[4] | Source[5] | IDLH (NIOSH)[6] |
|---|---|---|---|---|---|---|---|---|---|
| Arsenic and soluble inorganic compounds (as As) [7740-38-2] | NA | NA | Inh<br>Abs<br>Ing<br>Con | Ulceration of nasal septum; dermatitis; gastrointestinal disturbances; hyperpigmentation of skin (carcinogenic); peripheral neuropathy; respiratory irritation | Eye: Irrigate immediately (15 min)<br>Skin: Soap wash immediately<br>Swallow: Immediate medical attention | 0.01 mg/m$^3$<br>0.01 mg/m$^3$<br>(Ca-29 CFR 1910.1018) | C0.002 mg/m$^3$ | PEL<br>TLV<br>REL | Ca<br>(5 mg/m$^3$) |
| Bis(2-ethylhexyl) phthalate [117-81-7] | NA | NE | Ing<br>Inh<br>Con | Irritation to eyes and mucous membranes; liver damage; teratogenic effects; carcinogen | Eye: Irrigate immediately<br>Skin: Soap wash immediately<br>Breath: Respiratory support<br>Swallow: Immediate medical attention | 5 mg/m$^3$<br>5 mg/m$^3$ | | PEL<br>TLV<br>REL | 5000 mg/m$^3$ |
| Cadmium dust (as Cd) [7440-43-9] | NA | NA | Inh<br>Ing | Pulmonary edema, dyspnea, cough, chest tightness, substernal pain; headache; chills, muscular aches; nausea, vomiting, diarrhea; anosmia, emphysema, proteinuria, mild anemia – carcinogenic | Eye: Irrigate immediately<br>Skin: Soap wash immediately<br>Breath: Respiratory support<br>Swallow: Immediate medical attention | 0.005 mg/m$^3$<br>0.01 mg/m$^3$<br>Ca, lowest feasible concentration | | PEL<br>TLV<br>REL | Ca<br>(9 mg/m$^3$) |
| Chromium metal (as Cr) [7440-47-3] | NA | NA | Inh<br>Ing | Histologic fibrosis of lungs | Eye: Irrigate immediately<br>Skin: Soap wash immediately<br>Breath: Respiratory support<br>Swallow: Immediate medical attention | 1 mg/m$^3$<br>0.5 mg/m$^3$<br>0.5 mg/m$^3$ | | PEL<br>TLV<br>REL | 250 mg/m$^3$ |
| Coal-tar-pitch volatiles (benzene-soluble fraction)<br><br>(polynuclear aromatic hydrocarbons [PAH])<br><br>[65996-93-2] | ND | ND | Ing<br>Con | Eye sensitivity to light; eye and skin irritation, dermatitis, bronchitis; carcinogenic | Eye: Irrigate immediately<br>Skin: Soap wash immediately<br>Breath: Respiratory support<br>Swallow: Immediate medical attention | 0.2 mg/m$^3$<br>0.2 mg/m$^3$<br>0.1 mg/m$^3$ | | PEL<br>TLV<br>REL | Ca<br>[80 mg/m$^3$] |
| Copper dusts and mists (metal) (copper sulfate) [7440-50-8] | NA | NA | Inh<br>Ing<br>Con | Irritated pharynx and nasal mucous membrane; nasal perforation; eye irritation; metallic taste; dermatitis; in animals: lung, kidney, and liver damage; anemia | Eye: Irrigate immediately<br>Skin: Soap wash immediately<br>Breath: Respiratory support<br>Swallow: Immediate medical attention | 1 mg/m$^3$<br>1 mg/m$^3$<br>1 mg/m$^3$ | | PEL<br>TLV<br>REL | 100 mg/m$^4$ |
| 4,4-DDT [50-29-3] | ND | ND | Inh<br>Abs<br>Ing<br>Con | Irritated eyes and skin; paresthesia tongue, lips, and face; tremor; dizziness, confusion, malaise; headache; fatigue | Eye: Irrigate immediately<br>Skin: Soap wash immediately<br>Breath: Respiratory support<br>Swallow: Immediate medical attention | | | | |
| Hydrogen Sulfide [7783-06-4] | NA | NA | Inh<br>Con | Profuse salivation, nausea, vomiting, diarrhea, giddiness, headache, vertigo, amnesia, palpitations, arrhythmia, weakness, cramps, collapse, unconsciousness, death | Eye: Irrigate immediately<br>Skin: Wash immediately<br>Breath: Respiratory support<br>Swallow: NA | Ceiling: 20ppm:50 ppm, 10-min max peak<br>10ppm<br>Ceiling: 10ppm, 10-min | 15 ppm | PEL<br>TLV<br>REL | 100 ppmI |
| Lead, inorganic dusts and fumes (as Pb) [7439-92-1] | NA | NA | Inh<br>Ing<br>Con | Weakness, lassitude, insomnia; facial pallor; eye pallor; anorexia, low weight, malnutrition; constipation, abdominal pain, colic; anemia; gingival lead line; tremors; wrist and ankle paralysis; brain damage; kidney damage; irritated eyes; hypotension | Eye: Irrigate immediately<br>Skin: Soap wash immediately<br>Breath: Respiratory support<br>Swallow: Immediate medical attention | 0.03 mg/m$^3$<br>0.05 mg/m$^3$<br>0.05 mg/m$^3$<br><0.1 mg/m$^3$<br>See 29 CFR 1910.1025 | | Action Level<br>PEL<br>TLV<br>REL | 100 mg/m$^3$ |

## WASTE MANAGEMENT
## CHEMICAL HAZARD INFORMATION

| Substance [CAS Number] | IP[1] (eV) | Odor Threshold (ppm) | Route[2] | Symptoms of Exposure | Treatment | TWA[3] | STEL[4] | Source[5] | IDLH (NIOSH)[6] |
|---|---|---|---|---|---|---|---|---|---|
| Mercury vapor [7439-97-6] | ND | ND | Inh<br>Abs<br>Con | Coughing, chest pain, dyspnea, bronchial pneumonitis; tremors, insomnia; irritability, indecision; headache; fatigue, weakness, stomatitis, salivation; gastrointestinal disturbance, anorexia, low weight; proteinuria; irritated eyes and skin | Eye: Irrigate immediately<br>Skin: Soap wash immediately<br>Breath: Respiratory support<br>Swallow: Immediate medical attention | 0.05 mg/m$^3$<br>0.025 mg/m$^3$<br>0.05 mg/m$^3$ (skin) | C0.1 ppm<br><br>C0.1 ppm | PEL<br>TLV<br>REL | 2 mg/m$^3$ |
| Nickel, metal, and other compounds (as Ni) [7440-02-0] | NA | NA | Inh<br>Ing<br>Con | Headache, vertigo; nausea, vomiting, epigastric pain; substernal pain; coughing, hyperpnea; cyanosis; weakness; leukocytosis, pneumonitis; delirium, convulsions – carcinogenic | Eye: Irrigate immediately<br>Skin: Water flush immediately<br>Breath: Respiratory support<br>Swallow: Immediate medical attention | 1 mg/m$^3$<br>1.5 mg/m$^3$*<br>0.015 mg/m$^3$ Ca<br><br>*NIC-0.05 A1 | | PEL<br>TLV<br>REL | Ca<br>10 mg/m$^3$ |
| Polychlorinated biphenyls (PCB)<br><br>Aroclor 1242 [53469-21-9] and Aroclor 1254 [11097-69-1] | ND | ND | Inh<br>Abs<br>Ing<br>Con | Aroclor 1242: irritated eyes; chloracne; acne-form dermatitis; mildly toxic by ingestion; poison by subcutaneous route – carcinogenic<br><br>Aroclor 1254: irritated eyes and skin; acne-form dermatitis; poison by intravenous route; moderately toxic by ingestion and intraperitoneal routes – carcinogenic | Eye: Irrigate immediately<br>Skin: Soap wash immediately<br>Breath: Respiratory support<br>Swallow: Immediate medical attention | Aroclor 1242:<br>1 mg/m$^3$ (skin)<br>1 mg/m$^3$ (skin)<br>0.001 mg/m$^3$<br><br>Aroclor 1254:<br>0.5 mg/m$^3$ (skin)<br>0.5 mg/m$^3$ (skin)<br>0.001 mg/m$^3$ | | PEL<br>TLV<br>REL<br><br>PEL<br>TLV<br>REL | Ca<br>(10 mg/m$^3$)<br><br>Ca<br>(5 mg/m$^3$) |
| Selenium compounds (as Se) [7782-49-2] | ND | ND | Inh<br>Abs<br>Ing<br>Con | Irritated eyes, nose, throat; distorted vision; chills, fever, dyspnea; bronchitis; metallic taste, garlic breath; gastrointestinal disturbance; dermatitis; skin and eye burns | Eye: Irrigate immediately<br>Skin: Water flush immediately<br>Breath: Respiratory support<br>Swallow: Immediate medical attention | 0.2 ppm<br>0.2 ppm<br>0.2 ppm | | PEL<br>TLV<br>REL | 1 mg/m$^3$ |
| Silver (metal) [7440-22-4] | NA | NA | Inh<br>Ing<br>Con | Blue-gray eyes, nasal septum, throat, and skin; irritated skin, ulceration; gastrointestinal disturbance | Eye: Irrigate immediately<br>Skin: Water flush immediately<br>Breath: Respiratory support<br>Swallow: Immediate medical attention | 0.01 mg/m$^3$<br>0.1 mg/m$^3$<br>0.01 mg/m$^3$ | | PEL<br>TLV<br>REL | 10 mg/m$^3$ |
| Zinc (as oxide fume) [1314-13-2] | NA | NA | Inh | Sweet metallic taste; dry throat, cough, chills, fever; tight chest, dyspnea, rales, reduced pulmonary function; headache; blurred vision; muscular cramps, low back pain; nausea, vomiting; fatigue, lassitude, malaise | Breath: Respiratory support | 5 mg/m$^3$<br>5 mg/m$^3$<br>5 mg/m$^3$ | 10 mg/m$^3$ | PEL<br>TLV<br>REL | 50 mg/m$^3$ |

| | | |
|---|---|---|
| [1]IP | = | Ionization potential (electron volts). |
| [2]Route | = | Inh, Inhalation; Abs, Skin absorption; Ing, Ingestion; and Con, Skin and/or eye contact. |
| [3]TWA | = | Time-weighted average. The TWA concentration for a normal workday (usually 8 or 10 hours) and a 40-hour work week, to which nearly all workers may be repeatedly exposed, day after day without adverse effect. |
| [4]STEL | = | Short-term exposure limit. A 15-minute TWA exposure that should not be exceeded at any time during a workday, even if the TWA is not exceeded. |
| [5]PEL | = | Occupational Safety and Health Administration (OSHA) permissible exposure limit (29 CFR 1910.1000, Table Z). |
| [5]TLV | = | American Conference of Governmental Industrial Hygiene (ACGIH) threshold limit value – TWA. |
| [5]REL | = | National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit. |
| [6]IDLH (NIOSH) | = | Immediately dangerous to life or health (NIOSH). Represents the maximum concentration from which, in the event of respirator failure, one could escape within 30 minutes without a respirator and without experiencing any escape-impairing or irreversible health effects. |
| NE | = | None established. No evidence could be found for the existence of an IDLH (NIOSH Pocket Guide to Chemical Hazards, Pub. No. 90-117, 1990, 1997). |
| C | = | Ceiling limit value which should not be exceeded at any time. |
| Ca | = | Carcinogen. |
| NA | = | Not applicable. |
| ND | = | Not Determined. |
| LEL | = | Lower explosive limits. |
| $LC_{50}$ | = | Lethal concentration for 50 percent of population tested. |
| $LD_{50}$ | = | Lethal dose for 50 percent of population tested. |
| NIC | = | Notice of intended change (ACGIH). |

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Respirator Selection Guide, 3M Occupational Health and Safety Division, 1993.

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# Incident / Near-Miss Investigation Report

| | | | |
|---|---|---|---|
| ☐ OSHA Recordable | ☐ First Aid Injury | ☐ Fire | Date of Incident: |
| ☐ Lost Workday Injury | ☐ Vehicle Accident | ☐ Spill / Leak | |
| ☐ Restricted Duty Injury | ☐ Equipment Damage | ☐ Near Miss | Incident Number: |

Every employee injury, accident, and near miss must be reported within 24 hours of the injury If the incident results in hospitalization, an immediate report must be made by telephone to the Project Manager and the Health and Safety Officer

## Project Information

| | |
|---|---|
| Project Name | Project # |
| Location of Incident | |

## Employee

| | |
|---|---|
| Name | Employee Number |
| Employment Status ☐ Regular ☐ Part Time | How long in present job? |

## Injury or Illness Information

Where did the incident / near miss occur? (number, street, city, state, zip)

Employee's specific activity at the time of the incident / near miss

Equipment, materials, or chemicals the employee was using when the incident / near miss occurred (e g , the equipment employee struck against or that struck the employee, the vapor inhaled or material swallowed, what the employee was lifting, pulling, etc )

Describe the specific injury or illness (e g , cut, strain, fracture, etc )

Body part(s) affected (e g , back, left wrist, right eye, etc )

| | |
|---|---|
| Name and address of treatment provider (e g , physician or clinic) | Phone No |
| If hospitalized, name and address of hospital | Phone No |
| Date of injury or onset of illness / / | Time of event or exposure ☐ AM ☐ PM |

Did employee miss at least one full shift's work? ☐ No ☐ Yes, 1st date absent (MM/DD/YYYY) / /

Has employee returned to work? ☐ Regular work ☐ Restricted work ☐ No

☐ Yes, date returned (MM/DD/YYYY) / /

| | |
|---|---|
| To whom reported: | Other workers injured / made ill in this event? ☐ Yes ☐ No |

## Description of Incident / Near Miss: (Describe what happened and how it happened.)

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# Incident / Near-Miss Investigation Report

## Motor Vehicle Accident (MVA)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Company Vehicle? | ☐ Yes ☐ No | | | | |
| Accident Location (street, city, state) | | | | | | | | | |
| Vehicle Towed? | ☐ Yes ☐ No | Other Vehicle? | ☐ Yes ☐ No | # Vehicles Towed: | | # of Injuries: | | | |

## Spill

| | | |
|---|---|---|
| Material Spilled: | Quantity: | Source: |
| Agency Notifications: | | |

## Cost of Incident $

## Third Party Incidents

| | | | |
|---|---|---|---|
| Name of Owner: | | Address: | Telephone: |
| Description of Damage: | | | |
| Witness Name: | | Address: | Telephone: |
| Witness Name: | | Address: | Telephone: |

| # | Root Cause and Contributing Factors: Conclusion (Describe in Detail Why Incident / Near Miss Occurred) |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |

## Root Cause(s) Analysis (RCA):

1. Lack of skill or knowledge.
2. Lack of or inadequate operational procedures or work standards.
3. Inadequate communication of expectations regarding procedures or work standards.
4. Inadequate tools or equipment.
5. Correct way takes more time and / or requires more effort.
6. Short-cutting standard procedures is positively reinforced or tolerated.
7. Person thinks there is no personal benefit to always doing the job according to standards.
8. Uncontrollable.

| # | RCA # | Solution(s): How to Prevent Incident / Near Miss From Reoccurring | Person Responsible | Due Date | Closure Date |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

## Investigation Team Members

| Name | Job Title | Date |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

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# Incident / Near-Miss Investigation Report

| | | |
|---|---|---|
| | | |

## Results of Solution Verification and Validation

## Reviewed By

| Name | Job Title | Date |
|---|---|---|
| | Project Manager | |
| | Health and Safety Reviewer | |

# Safe Work Observation

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| Observer Name | Observer Title | Project/Project Number |
|---|---|---|
| | | |

| Date _____<br>Time ____ ☐ AM ☐ PM | Project Type / Task Observed |
|---|---|

**Background Information**

**List Critical Work Procedures**

**List Issue/Items Requiring Corrective Action**

**Root Cause Analysis**

1. Employee lacks the skill or knowledge to carry out duties
2. Procedures, work standards, or expectations were not communicated
3. Procedures or work standards were not developed or were inadequate
4. Equipment, systems, or tools were inadequate
5. Employee chose not to take the time or put forth the effort to do the job properly
6. Supervisor did not require the employee to follow the standard procedure
7. Employee doesn't see any advantage to doing the job to standard.
8. Uncontrollable.

| Criterion # | RCA # | Corrective Action Identified | Responsible Individual | Due Date | Closure Date |
|---|---|---|---|---|---|
| | | | | | |

**Results of Corrective Action**

| Reviewed by | Date | Reviewed by | Date |
|---|---|---|---|
| | | | |

# Environmental Operations

| | PRE-TASK PREPARATION | Correct | Questionable | Comments |
|---|---|---|---|---|
| 1. | Health and Safety Plan / MSDSs on site | | | |
| 2. | Employee familiar / trained on task | | | |
| 3. | OSHA-required training/medical surveillance | | | |
| 4. | Utility mark out / check performed | | | |
| 5. | Traffic hazard addressed / work area marked | | | |
| 6. | Walking / working surfaces free of hazards | | | |
| 7. | Tailgate safety meeting performed | | | |
| 8. | Impact on nearby residence/business evaluated | | | |
| 9. | Communicates intentions to other personnel | | | |
| 10. | Knowledge of emergency procedures | | | |
| 11. | Distance between equipment and power lines | | | |
| 12. | Personal protective equipment | | | |
| 13. | Air monitoring equipment on site, calibrated | | | |
| 14. | First aid kit / fire extinguisher on site | | | |
| 15. | One person trained in first aid / CPR | | | |
| 16. | Work zones established and marked | | | |
| | **PERFORMING TASK** | | | |
| 17. | Employee trained in task to be performed | | | |
| 18. | Correct body positioning | | | |
| 19. | Proper lifting / pushing / pulling techniques | | | |
| 20. | Keep hands / body away from pinch points | | | |
| 21. | Walking / working surfaces kept clear of debris | | | |
| 22. | Faces traffic as appropriate | | | |
| 23. | Vehicles/ barricades to protect against traffic | | | |
| 24. | Drill rig located properly, blocked / chocked | | | |
| 25. | Drill rig moved only with derrick lowered | | | |
| 26. | Excavator located on stable ground | | | |
| 27. | Eye contact made with equipment operator | | | |
| 28. | Spoil at least 2 feet back from edge of excavation | | | |
| 29. | Excavation shored/sloped/benched | | | |
| 30. | Excavation entry controlled | | | |
| 31. | Equipment/tools used properly | | | |
| 32. | Electrical equipment connected through GFCI | | | |
| 33. | Power tools handled properly | | | |
| 34. | Electrical cords inspected / in good condition | | | |
| 35. | Follows lockout / tagout procedures | | | |
| 36. | Air monitoring conducted/action levels understood | | | |
| 37. | Equipment decontaminated properly | | | |
| 38. | Personnel decon prior to eating/drinking/smoking | | | |
| 39. | Decontamination effective | | | |
| | **POST – TASK** | | | |
| 40. | Procedures / JSA adequate | | | |
| 41. | Equipment / tools stored properly | | | |
| 42. | Proper storage of soil / water / waste material | | | |
| 43. | Work area secured | | | |
| 44. | Other | | | |

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# Air Monitoring Log

**Project:** **Date:**

**Monitoring Instruments:**

**Air Monitor:** **Activity:**

**Level of Protection:**

| Time | Location | Instrument Reading | Comments |
|---|---|---|---|
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# Health and Safety Inspection Form

| | |
|---|---|
| **Project Name:** | **Date:** |
| **Project Number:** | **Location:** |
| **Prepared By:** | **Project Manager:** |
| **Auditor:** | **HSS On Site:** |

| | YES | NO | N/A | COMMENTS |
|---|---|---|---|---|
| **GENERAL** | | | | |
| Is the HASP on site? | | | | |
| Is the HASP finalized and approved? | | | | |
| Is the OSHA poster displayed? | | | | |
| Are emergency telephone numbers posted? | | | | |
| Is emergency eyewash immediately available? | | | | |
| Is an emergency shower immediately available? | | | | |
| Are emergency notification means available (radio, telephone)? | | | | |
| Is a first-aid kit immediately available? | | | | |
| Is the first-aid kit adequately stocked? | | | | |
| Is there a proper sanitation facility on site? | | | | |
| **DOCUMENTATION AND RECORDKEEPING** | | | | |
| Are only personnel listed and approved in the HASP on site? | | | | |
| Are all personnel properly trained? (Check company-issued wallet cards ) | | | | |
| Is the daily field log kept by the Site Manager? | | | | |
| Are levels of PPE recorded? | | | | |
| Are contaminant levels recorded? | | | | |
| Are site surveillance records kept by HSS? | | | | |
| Is a copy of current fit test records on site? | | | | |
| Are calibration records maintained for air monitoring equipment? | | | | |
| Are accident / incident forms on site? | | | | |
| Are field team review sheets signed? | | | | |
| Are additional hospital route directions available? | | | | |
| Is the visitors' logbook being accurately maintained? | | | | |
| Are MSDSs available for all chemicals on site? | | | | |
| Are HASP revisions recorded? | | | | |
| Is the first-aid kit inspected weekly? | | | | |
| Are daily safety meetings held? | | | | |
| Are emergency procedures discussed during safety meetings? | | | | |

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# Health and Safety Inspection Form

| | YES | NO | N/A | COMMENTS |
|---|---|---|---|---|
| **EMERGENCY RESPONSES** | | | | |
| Is a vehicle available on site for transportation to the hospital? | | | | |
| Are fire extinguishers on site and immediately available at designated work areas? | | | | |
| Is at least one person trained in CPR and first aid on site at all times during work activities? | | | | |
| Do all personnel know who is trained in CPR / first aid? | | | | |
| **PERSONAL PROTECTIVE EQUIPMENT (PPE)** | | | | |
| Is proper PPE being worn as specified in HASP? | | | | |
| Level of PPE being worn. | | | | |
| Is PPE adequate for work conditions? | | | | |
| If not, give reason. | | | | |
| Upgrade/downgrade to PPE level. | | | | |
| Does any employee have facial hair that would interfere with respirator fit? | | | | |
| If yes, willing to shave, as necessary? | | | | |
| Fit-tested within the last year? (Documentation present) | | | | |
| If Level B, is a back-up / emergency person suited up (except for air)? | | | | |
| Does the HSS periodically inspect PPE and equipment? | | | | |
| Is the PPE not in use properly stored? | | | | |
| Is all equipment required in the HASP on site? | | | | |
| Properly calibrated? | | | | |
| In good condition? | | | | |
| Used properly? | | | | |
| Other equipment needed? | | | | |
| List. | | | | |
| Is monitoring equipment covered with plastic to minimize contamination? | | | | |
| **PERSONNEL AND EQUIPMENT DECONTAMINATION** | | | | |
| Is the decontamination area properly designated? | | | | |
| Is appropriate cleaning fluid used for known or suspected contaminants? | | | | |
| Are appropriate decontamination procedures used? | | | | |
| Are decontamination personnel wearing proper PPE? | | | | |

| | | | | |
|---|---|---|---|---|
| Is the equipment decontaminated? | | | | |

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# Health and Safety Inspection Form

| | YES | NO | N/A | COMMENTS |
|---|---|---|---|---|
| **PERSONNEL AND EQUIPMENT DECONTAMINATION (continued)** | | | | |
| Are sample containers decontaminated? | | | | |
| Are disposable items replaced as required? | | | | |
| **WORK PRACTICES** | | | | |
| Was proper collection and disposal of potentially contaminated PPE performed? | | | | |
| Was proper collection and disposal of decontamination fluid performed? | | | | |
| Is water available for decontamination? | | | | |
| Is the buddy system used? | | | | |
| Is equipment kept off drums and the ground? | | | | |
| Is kneeling or sitting on drums or the ground prohibited? | | | | |
| Do personnel avoid standing or walking through puddles or stained soil? | | | | |
| Are work zones established? | | | | |
| If night work is conducted, is there adequate illumination? | | | | |
| Is smoking, eating, or drinking in the exclusion or CRZ prohibited? | | | | |
| To the extent feasible, are contaminated materials handled remotely? | | | | |
| Are contact lenses not allowed on site? | | | | |
| Is entry into excavations not allowed unless properly shored or sloped? | | | | |
| Is a competent person on site during excavation? | | | | |
| Are all unusual situations on site listed in HASP? | | | | |
| If not, when? | | | | |
| Action taken? | | | | |
| HASP revised? | | | | |
| **CONFINED SPACE ENTRY** | | | | |
| Are employees trained according to 1910 146 – Confined Space Entry? | | | | |
| Are all confined spaces identified? If not, list | | | | |
| Is all appropriate equipment available and in good working order? | | | | |
| Is equipment properly calibrated? | | | | |
| Are confined space permits used? | | | | |
| Are confined space permits completely and correctly filled out? | | | | |

*N/A = Not Applicable

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# Safety Meeting Log

| Project: | Location: |
|---|---|
| Date / Time: | Activity: |

**1. Work Summary**

**2. Physical Chemical Hazards**

**3 Protective Equipment/Procedures**

**4. Emergency Procedures**

**5. Signatures of Attendees**

| | |
|---|---|
| | |
| | |
| | |
| | |
| | |

# Appendix C

# *Appendix C*

# Deep Geotechnical Exploration Logs

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CITY OF PORTLAND, OREGON

# COMMISSION OF PUBLIC DOCKS

JOB No. _____ CONTRACT No. _____

**TERMINAL NO.** 4

TERMINAL Nº 4
TEST BORINGS 1 TO 8

| | |
|---|---|
| SCALE _____ | DRAWN BY BJW |
| DATE 1-2-59 | CHECKED BY H.M.A. |
| | APPROVED _____ ENGINEER |
| Sheet No. _____ of _____ | Dwg. No. 2012 |

| N | Date | By |
|---|---|---|
| | | |

31 H 32 H 33 H 34 H 35 H 36 H 37 H 38 H 39

NEXT 6 PAGES

| | | |
|---|---|---|
| 1 | 3 | 5 |
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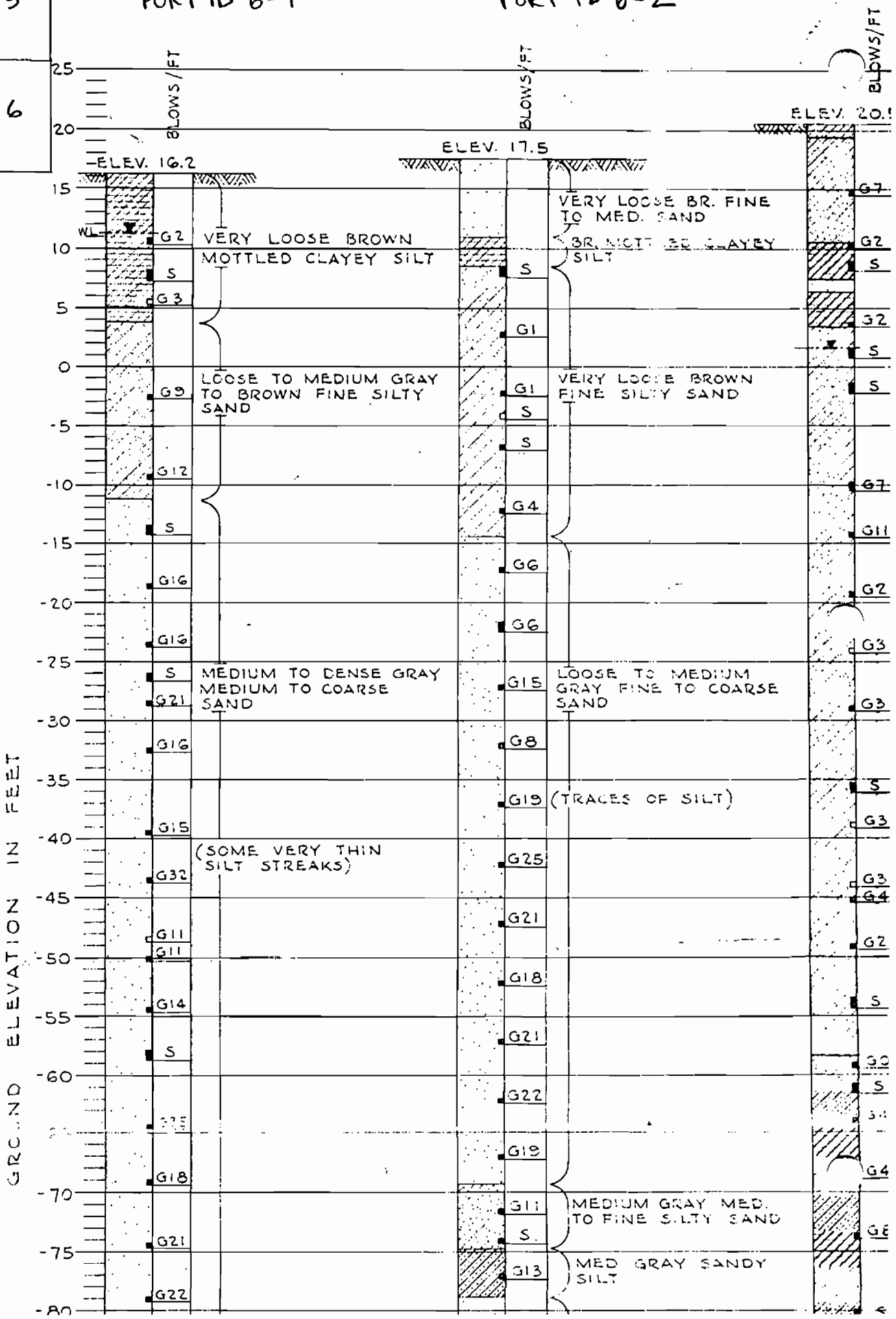

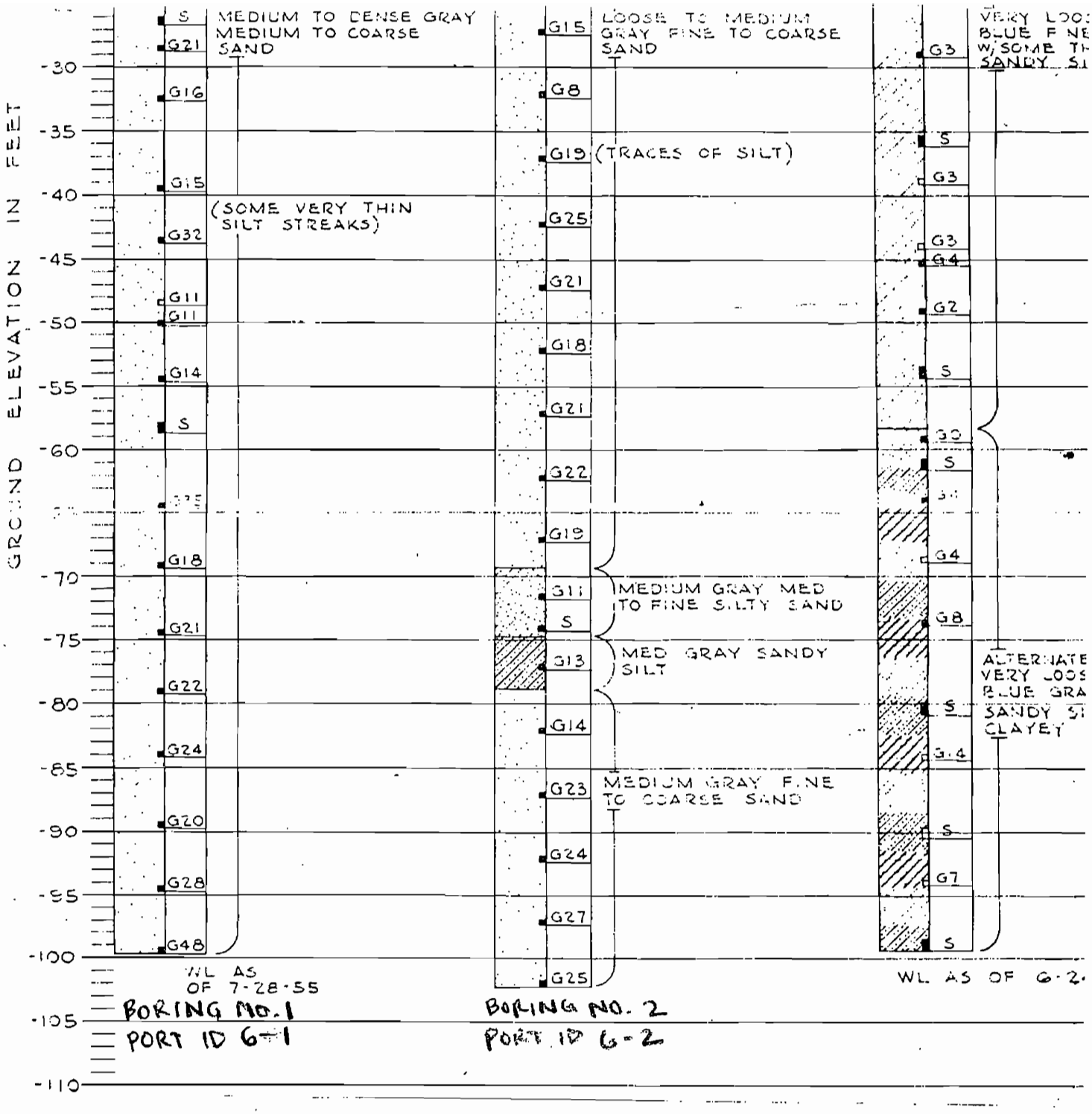


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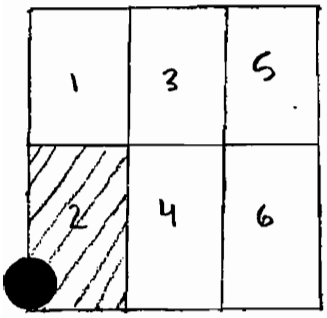



S SOIL SAMPLE TAKEN AT THIS LEVEL

S SOIL SAMPLE NOT RECOVERED

37 INDICATES NUMBER OF BLOWS OF A 140 LB WEIGHT FALLING 30 INCHES REQUIRED TO DRIVE SAMPLER ONE FOOT

G STD 1 3/8" I.D. SPLIT-BARREL PENETRATION SPOON USED

INDICATES GROUND WATER LEVEL

## BORING Nº 3

SUNK JUNE 9 - JULY 29, 1955

PORT ID 6-3

BLOWS/FT

ELEV. 20.5

BR SILTY SAND WITH FINE GRAVEL

G7 — LOOSE BROWN SILTY SAND

G2

S — LOOSE BLUE CL. SILT

BR SAND W/F NE GRAVEL

G2 — LOOSE BLUE CL. SILT

S

S

G7

G11

G2

G3

VERY LOOSE TO LOOSE BLUE F NE SILTY SAND W/SOME THIN LAYERS SANDY SILT

G3

S

G3

G3

G4

G2

S

G0

S

G4

G8

ALTERNATE LAYERS VERY LOOSE TO LOOSE BLUE GRAY SILTY SAND,

## BORING Nº 4

SUNK OCT. 5 - 11, 1955

PORT ID 6-4

BLOWS/FT

ELEV. 21.0

16

WL

3

3

4

3

6

9

13

9

23

22

11

6

5

6

6

6

7

7

7

9

6

7

13

13

5

13

13

14

13

MED. BROWN MED. SILTY SAND W/SOME FINE GRAVEL

SOFT GRAY SILTY CLAY

SOFT LIGHT BROWN SILTY CLAY

LOOSE GRAY FINE SILTY SAND

SOFT GRAY SILTY CLAY

ALT. LAYERS LOOSE GRAY FINE SILTY SAND & SILTY CLAY

GRADING TO

ALT. LAYERS MED. GRAY FINE SILTY SAND & SANDY SILT

MED. TO LOOSE GRAY FINE SILTY SAND

LOOSE GRAY CLAYEY SILT W/SOME THIN LAYERS FINE SAND

ALT. LAYERS LOOSE GRAY SANDY SILT & FINE SILTY SAND (GETS COARSER WITH DEPTH)

MED. GRAY FINE SILTY SAND

## BORING Nº 5

SUNK OCT. 5-11, 1955

PORT ID 6-5

ELEV. 23.0

7

8

4

WL

2

3

4

4

2

2

4

5

5

9

9

5

9

18

22

17

6

9

9

39

8

LOOSE LT. BROWN FINE TO MED. SILTY SAND

LOOSE LT. BR. MED. COARSE SAND

SOFT GRAY SILTY CLAY

SOFT LT. BR. SILTY CLAY

LOOSE GRAY FINE SILTY SAND (SOME CLAY)

ALT. LAYERS VERY LOOSE FINE SILTY SAND & CLAYEY SILT

ALT. LAYERS SOFT GRAY SILTY CLAY & LOOSE FINE SILTY S

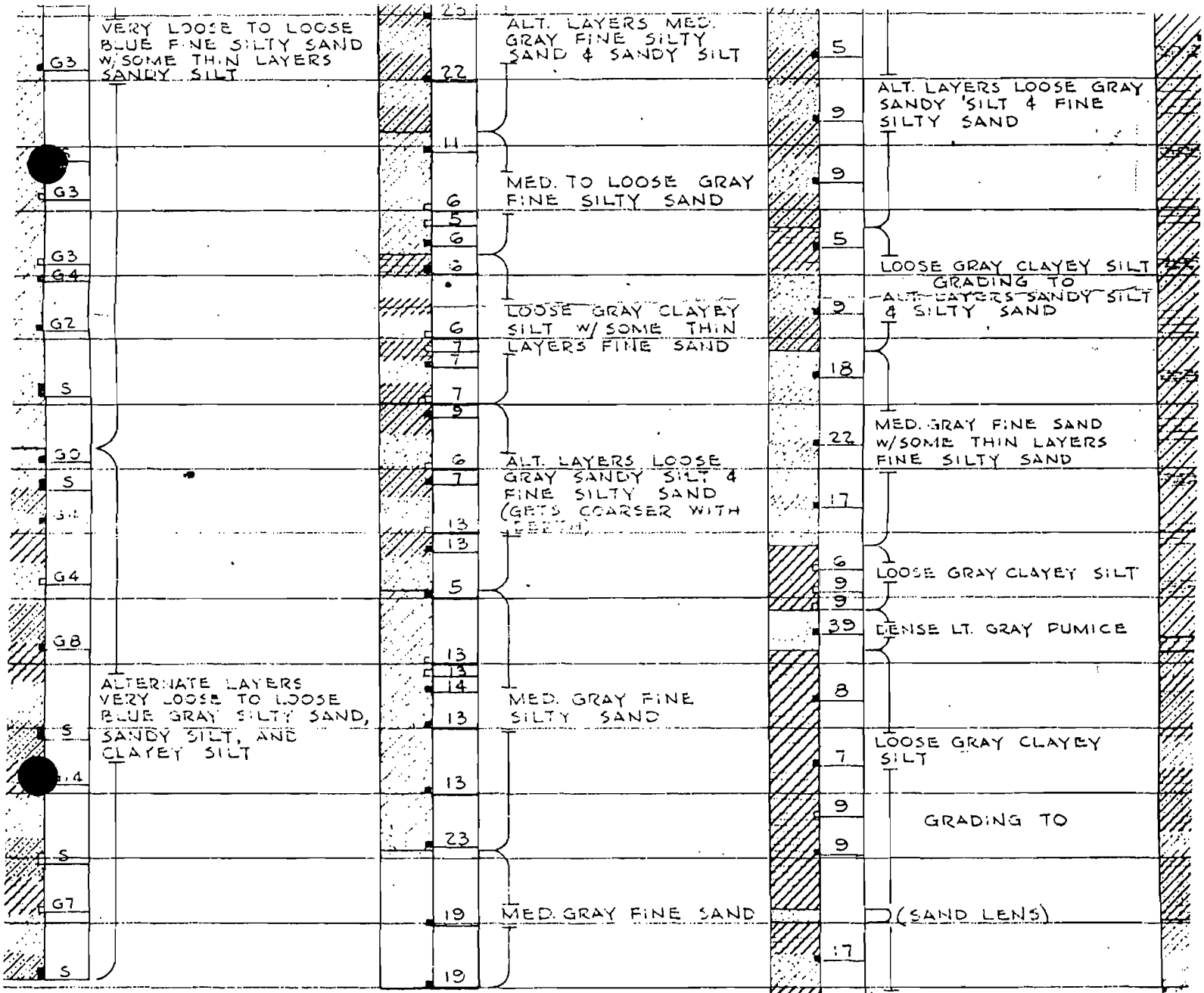
ALT LAYERS LOOSE GRAY SANDY SILT & FINE SILTY SAND

LOOSE GRAY CLAYEY SILT GRADING TO ALT. LAYERS SANDY SIL & SILTY SAND

MED. GRAY FINE SAND W/SOME THIN LAYERS FINE SILTY SAND

LOOSE GRAY CLAYEY LT

DENSE LT. GRAY PUMICE



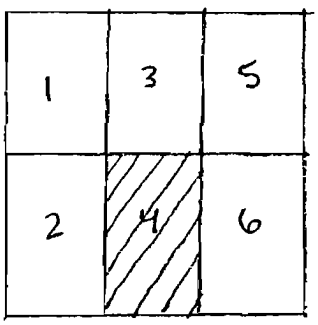

WL AS OF 6-24-55
BORING NO. 3
PORT ID 6-3

WL AS OF 10-11-55
BORING NO. 4
PORT ID 6-4

WL AS OF 10-11-55
BORING NO. 5
PORT ID 6-5

GHT FALLING
E FOOT

USED



[redacted]

5

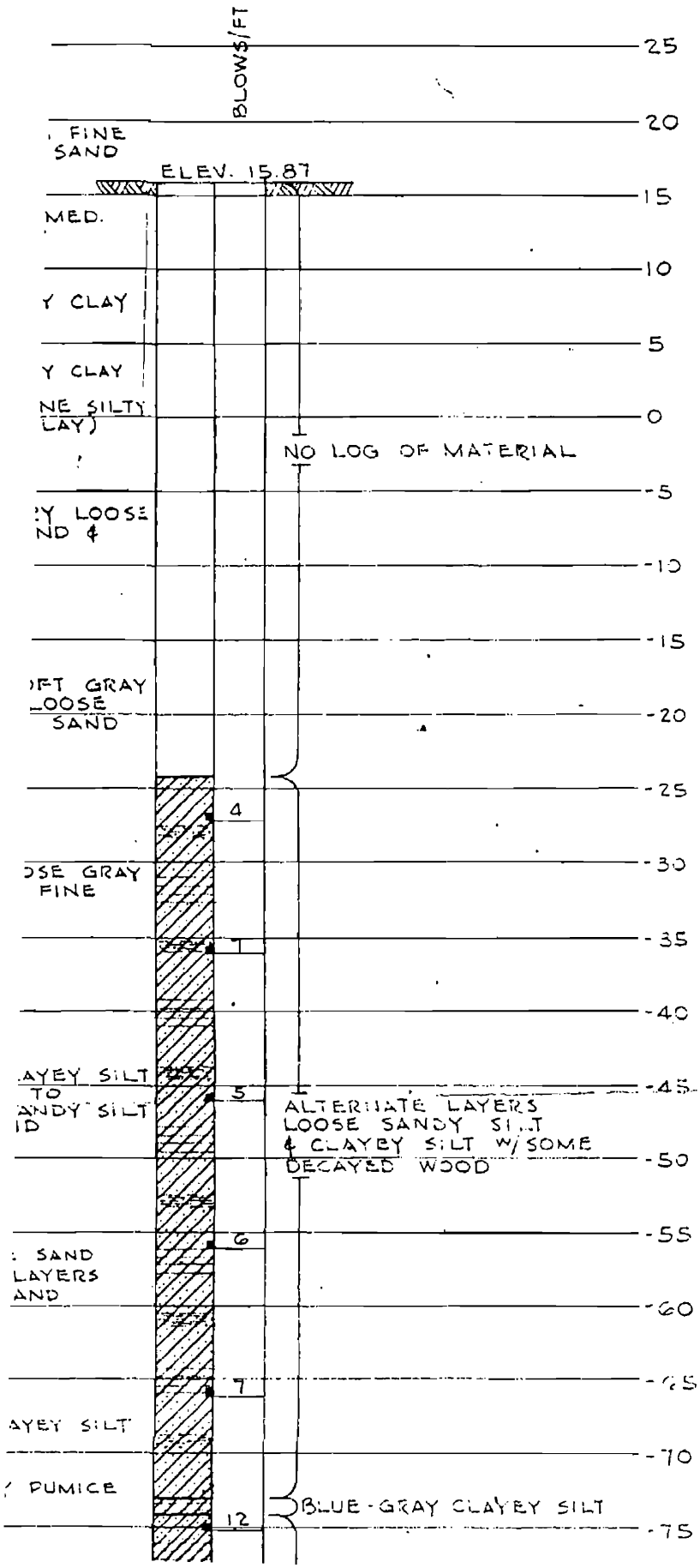
955

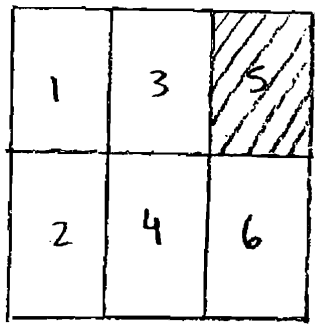
)

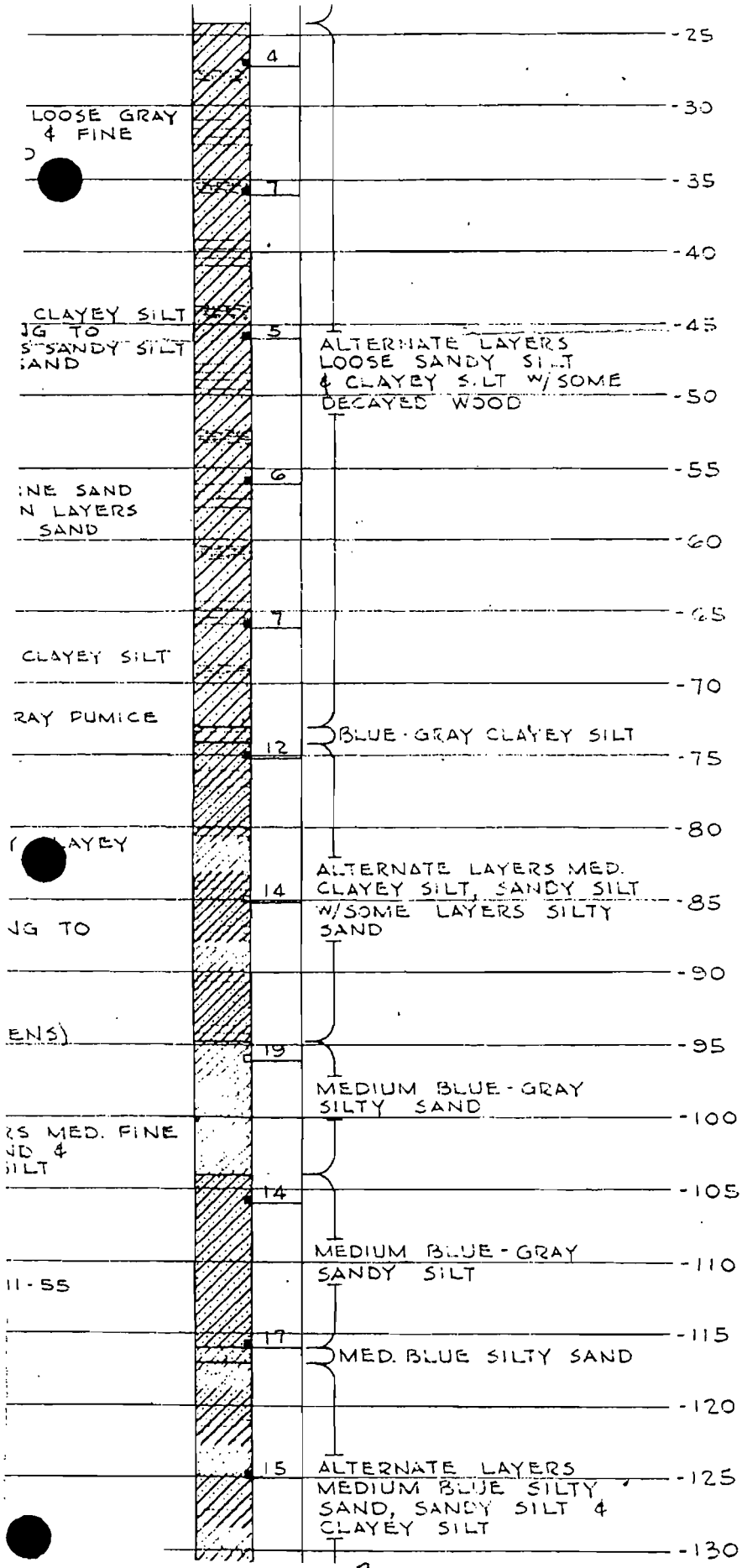
# BORING Nº 6

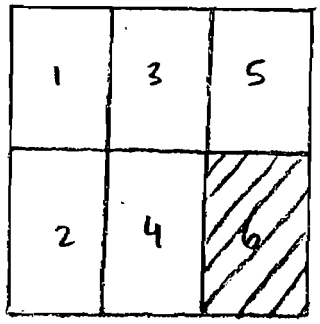
SUNK OCT. 22, 1958

PORT ID 6-6





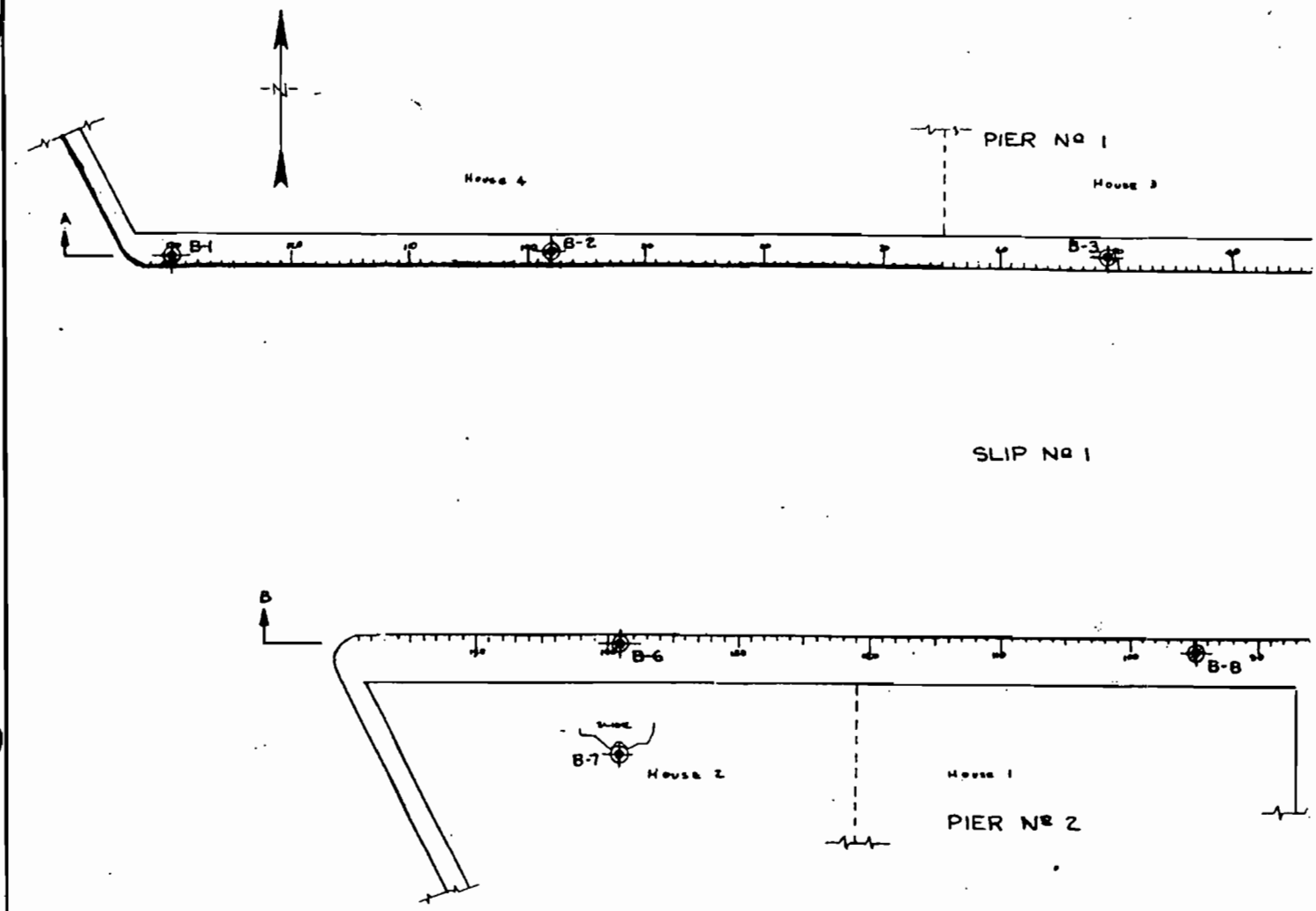




BORING NO. 6
PORT ID 6-6

Shannon & Wilson 10/62
Exhibit 1

PLATES

| | |
|---|---|
| I | SITE PLAN AND LOCATION OF BORINGS |
| II AND III | LOGS OF BORINGS |




SITE PLAN AND LOCAT

SCALE IN FEE

LEGEND

LOCATION OF BORING

LOCATION OF PILE BULKHEAD

LOCATION OF PILE BENT WITH NUMBERING

LOCATION OF GEOLOGIC SECT

2

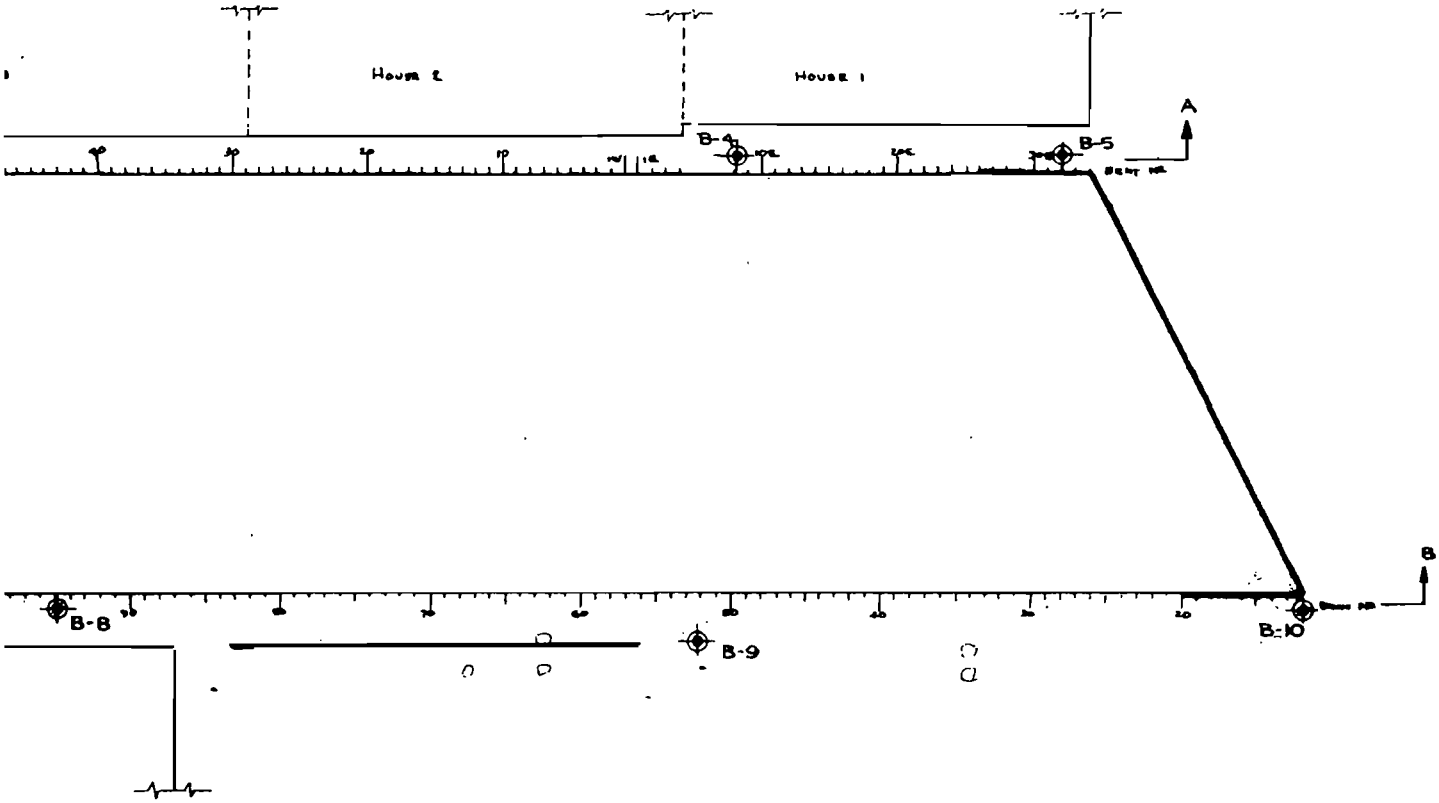
SLIP 1 TERMINAL 4
PORTLAND COMMISSION OF PUBLIC DOCKS
PORTLAND, OREGON

SITE PLAN AND LOCATION OF BORINGS

OCTOBER, 1962 O-33

Shannon and Wilson
Soil mechanics and foundation engineers
Seattle

PLATE I




AND LOCATION OF BORINGS

80 0 80 100
SCALE IN FEET

OF BORING

OF PILE BULKHEAD

OF PILE BENT WITH BENT

OF GEOLOGIC SECTIONS

NOTES:

1. BORINGS ACCOMPLISHED BY RAYMOND CONCRETE PILE DIVISION OF PORTLAND, OREGON, USING ROTARY DRILLING EQUIPMENT BETWEEN AUGUST 22, 1962 AND SEPTEMBER 26, 1962.
2. FOR LOGS OF BORINGS SEE PLATES II & III
3. FOR GEOLOGIC SECTIONS A-A AND B-B SEE FIGURES 5 & 6.

1 | 2

SLIP 1 TERMINAL 4
PORTLAND COMMISSION OF PUBLIC DOCKS
PORTLAND, OREGON

SITE PLAN AND LOCATION OF BORINGS

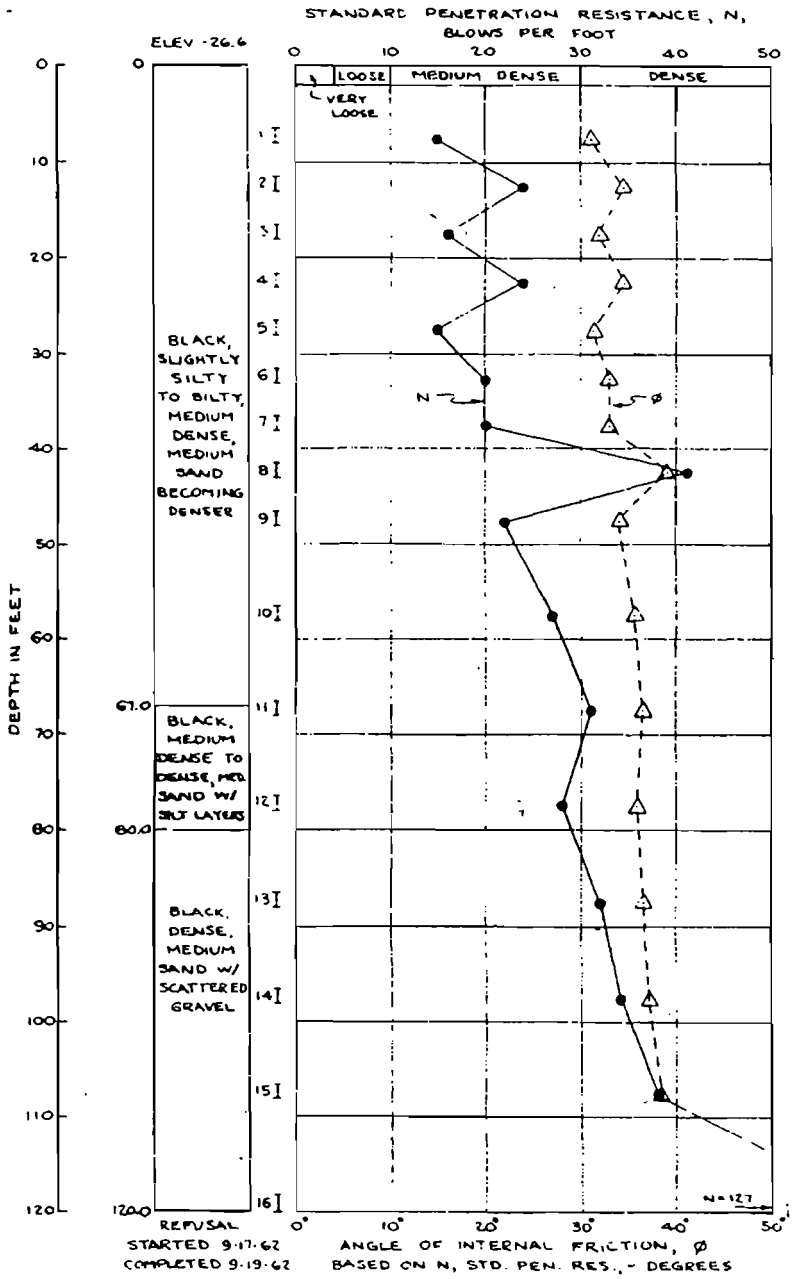
OCTOBER, 1962 D-33

Shannon and Wilson
Soil mechanics and foundation engineers
Seattle

PLATE I

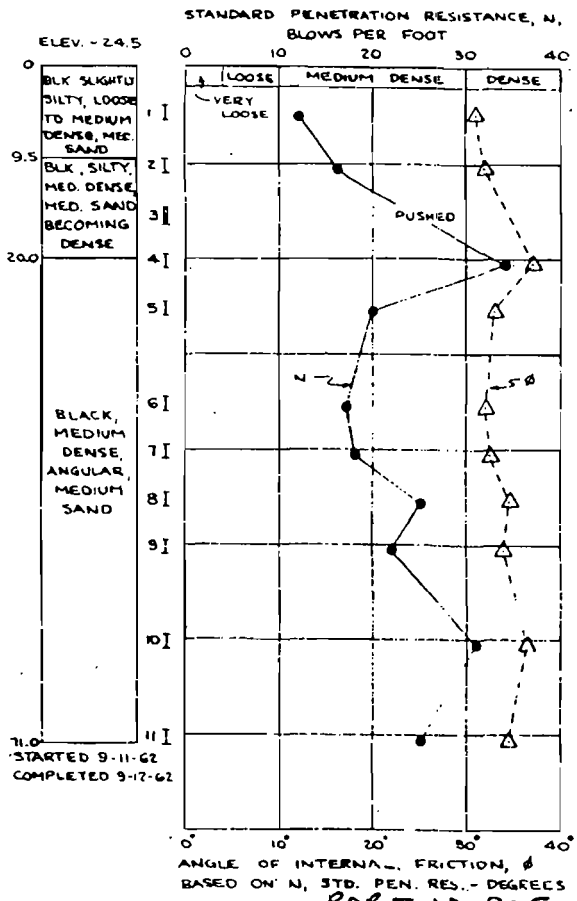
PORT ID B-1

# BORING B-1



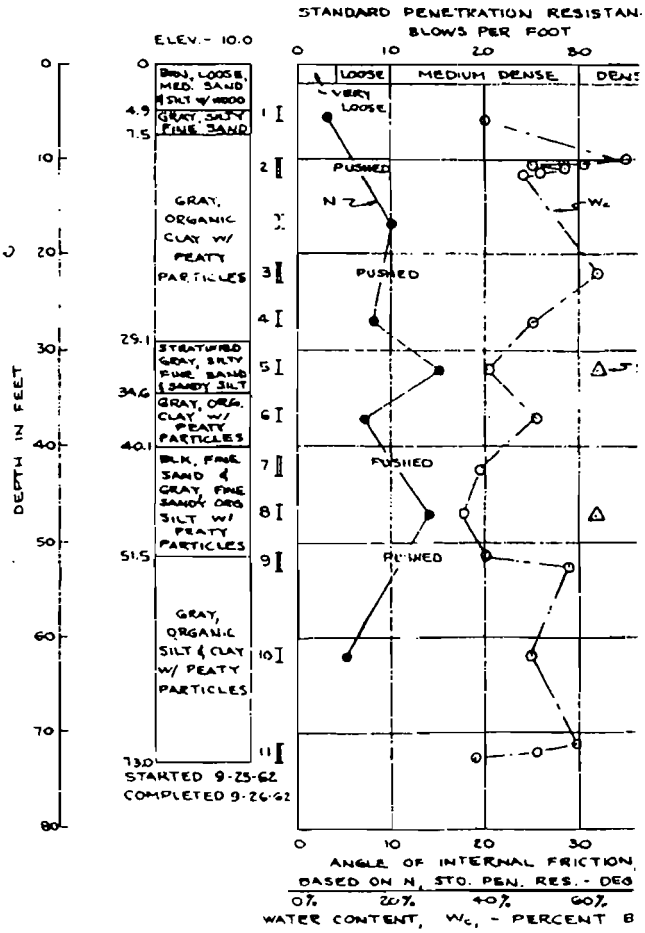

PORT ID B-2

# BORING B-2




PORT ID B-5

# BORING B-5




SLIP 1 TERMINAL 4
PORTLAND COMMISSION OF PUBLIC DOCKS
PORTLAND, OREGON

## LOGS OF BORINGS

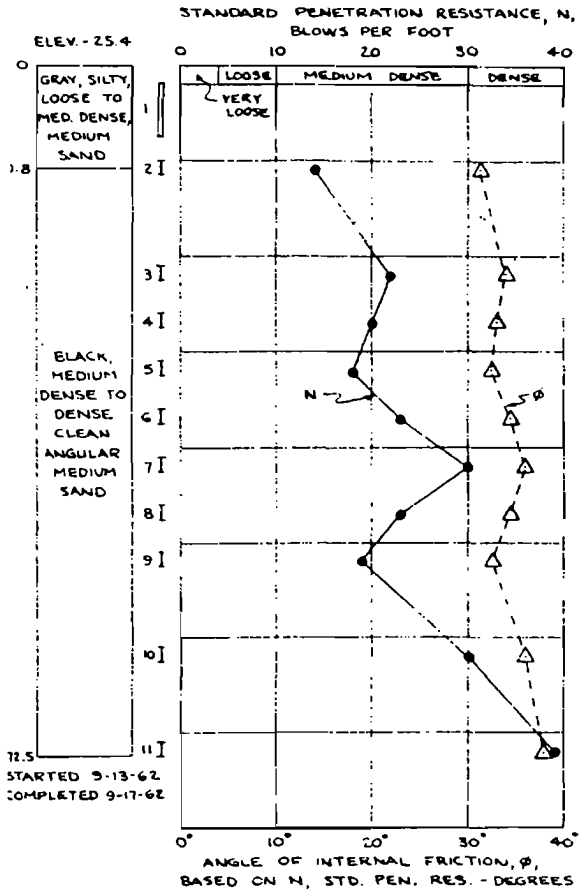
OCTOBER, 1962 — 0-33

**Shannon and Wilson**
**Soil mechanics and foundation engineers**
**Seattle**

PLATE II

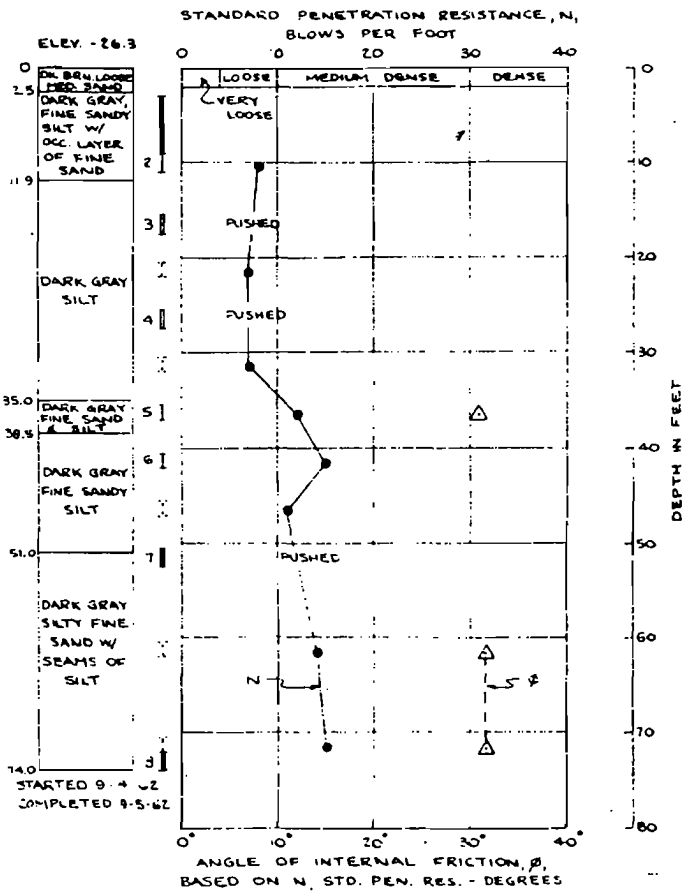
PORT ID 8-3

## BORING B-3




PORT ID 8-4

## BORING B-4




## LEGEND

- DEPTH OF BORING IN FEET
- 2-INCH O.D. SPLIT-SPOON DRIVE SAMPLE. NUMBER DENOTES SAMPLE NUMBER.
- 2-INCH O.D. SEAMLESS STEEL TUBE SAMPLE PUSHED BY HYDRAULIC RAM. NUMBER DENOTES SAMPLE NUMBER.
- 3-INCH O.D. SEAMLESS STEEL OR BRASS TUBE SAMPLE PUSHED BY HYDRAULIC RAM. NUMBER DENOTES SAMPLE NUMBER
- STANDARD PENETRATION TEST MADE, BUT NO SAMPLE RECOVERY.
- STANDARD PENETRATION RESISTANCE N BLOWS PER FOOT REQUIRED TO DRIVE 2-INCH SPLIT-SPOON SAMPLER USING A 140 POUND WEIGHT FALLING 30 INCHES.
- ANGLE OF INTERNAL FRICTION BASED ON STANDARD PENETRATION RESISTANCE
- WATER CONTENT IN PERCENT BY WEIGHT

## NOTES:

1. ANGLE OF INTERNAL FRICTION BASED ON STANDARD PENETRATION RESISTANCE TAKEN FROM PECK, RALPH B., HANSON, WALTER E., AND THORNBURN, THOMAS H, FOUNDATION ENGINEERING, NEW YORK, JOHN WILEY & SONS, INC., 1953, PP 222, FIG. 14.2
2. FOR LOCATION OF BORINGS SEE PLATE I.

SLIP 1 TERMINAL 4
PORTLAND COMMISSION OF PUBLIC DOCKS
PORTLAND, OREGON

# LOGS OF BORINGS

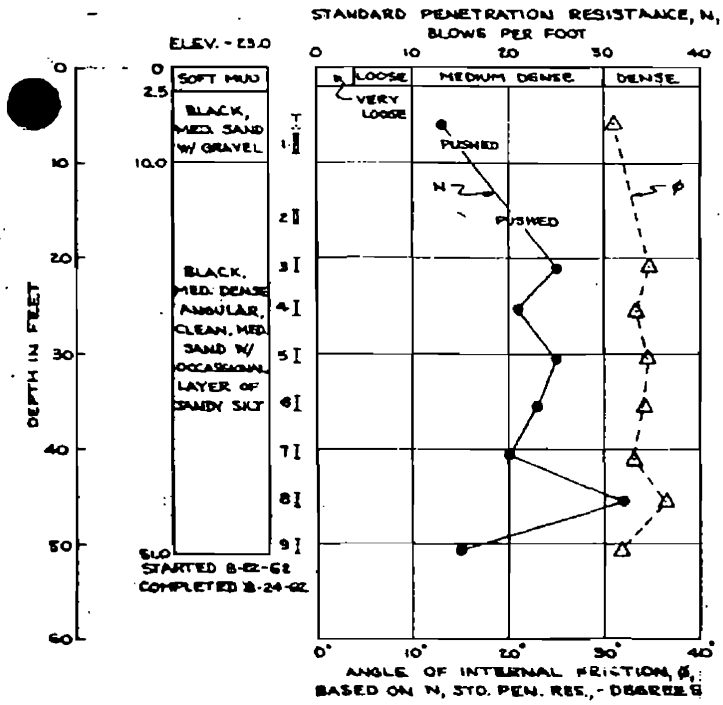
OCTOBER, 1962 — 0-33

**Shannon and Wilson**
**Soil mechanics and foundation engineers**
**Seattle**

PLATE II

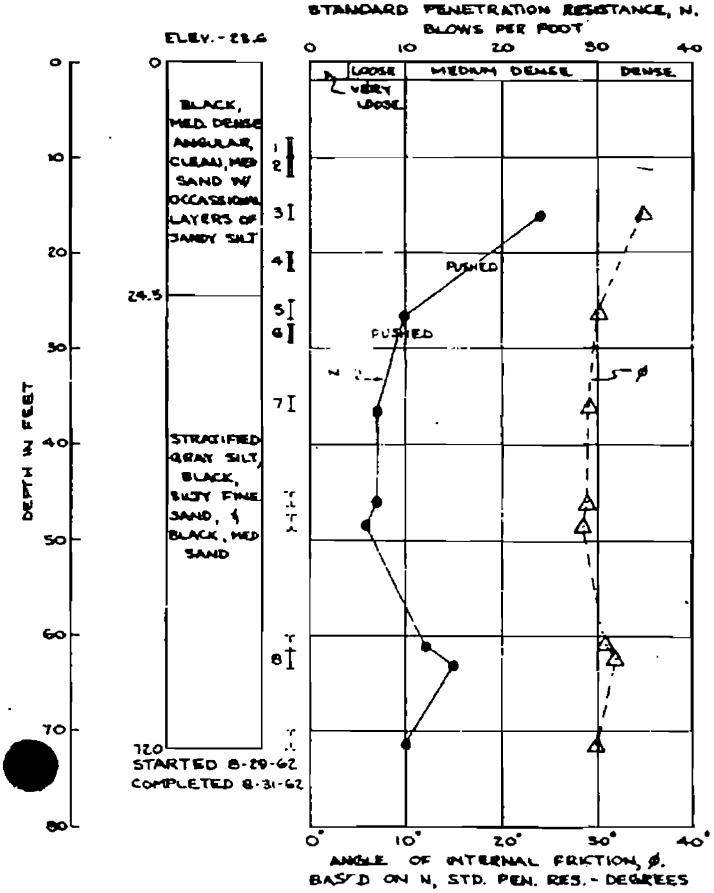
PORT ID 8-6

# BORING B-6



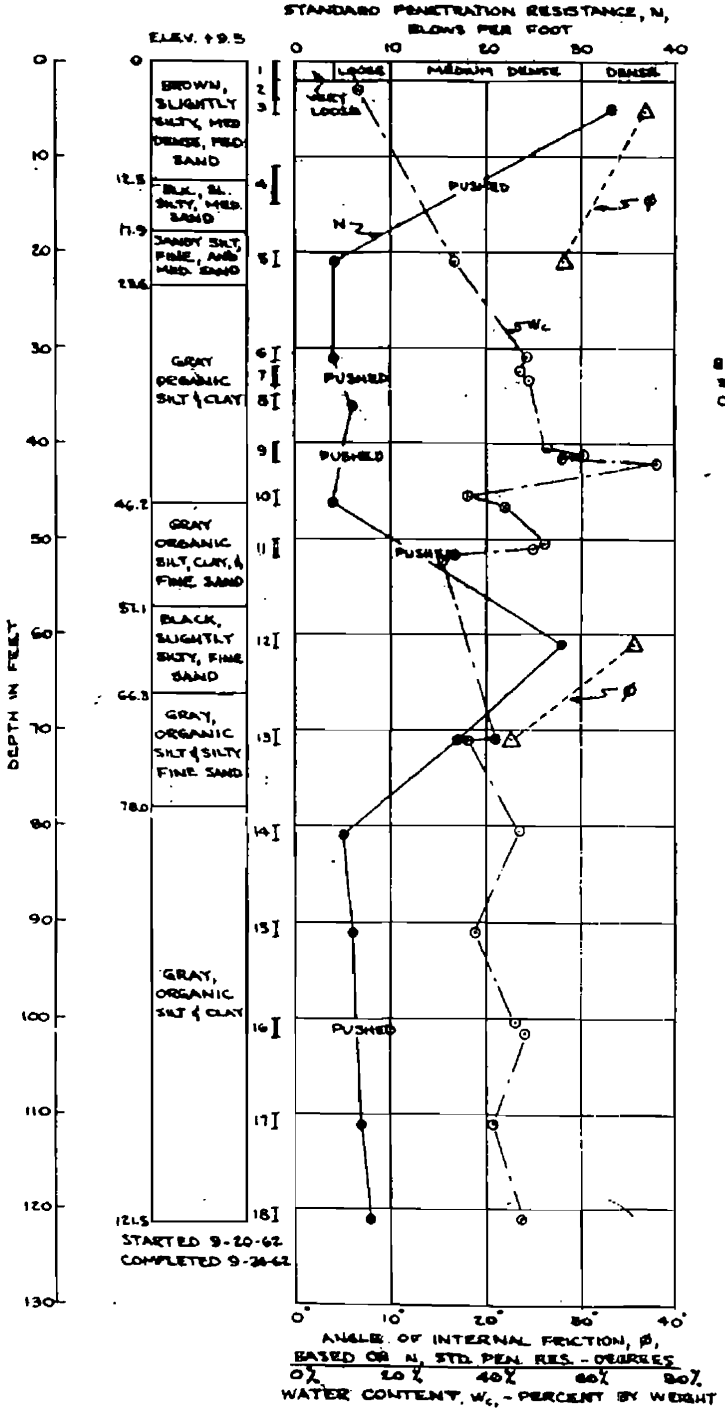

PORT ID 8-9

# BORING B-9



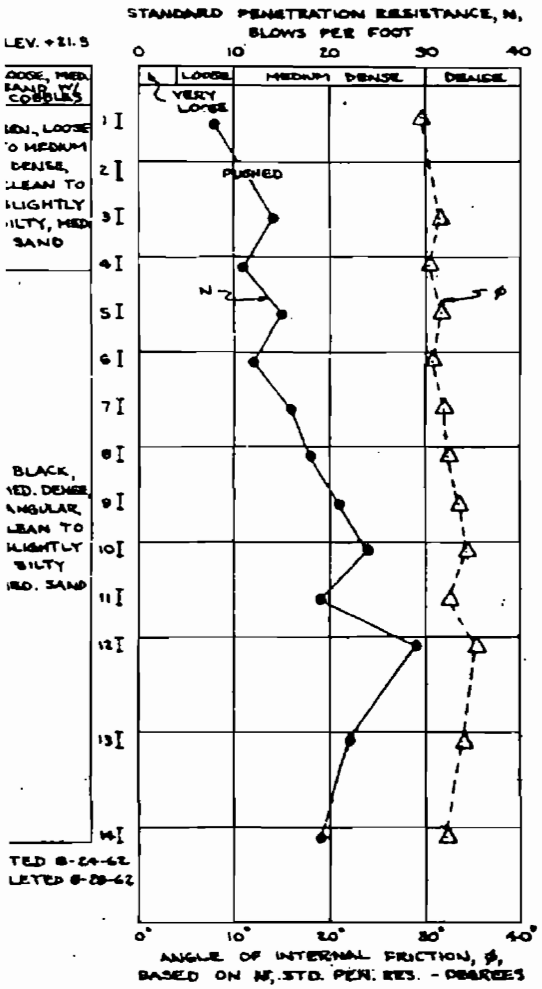

PORT ID 8-10

# BORING B-10



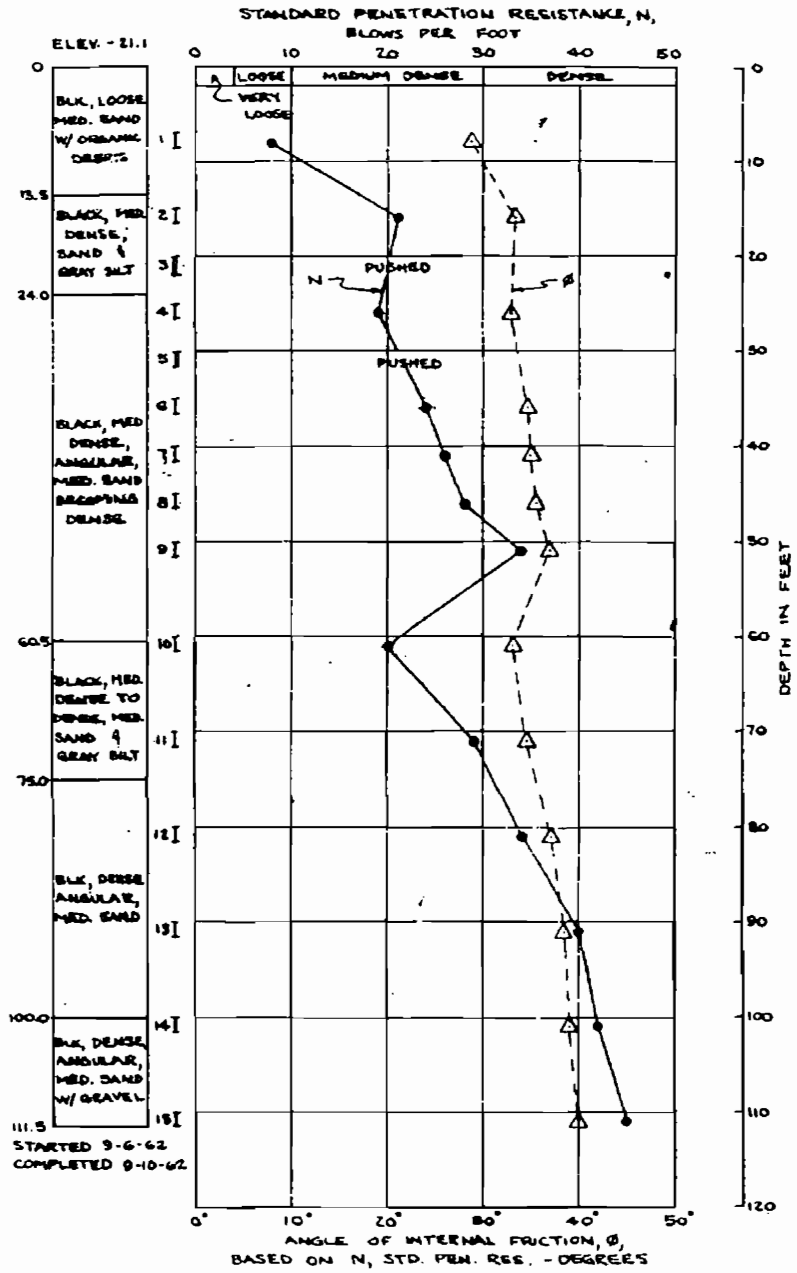
PORT ID B-7

# BORING B-7




PORT ID B-8

# BORING B-8




## LEGEND

- DEPTH OF BORING IN FEET
- 2-INCH O.D. SPLIT-SPOON DRIVE SAMPLE. NUMBER DENOTES SAMPLE NUMBER.
- 3-INCH O.D. SEAMLESS STEEL OR BRASS TUBE SAMPLE PUSHED BY HYDRAULIC RAM. NUMBER DENOTES SAMPLE NUMBER.
- STANDARD PENETRATION TEST MADE, BUT NO SAMPLE RECOVERY.
- STANDARD PENETRATION RESISTANCE IN BLOWS PER FOOT REQUIRED TO DRIVE 2-INCH SPLIT-SPOON SAMPLER USING A 140 POUND WEIGHT FALLING 30 INCHES.
- ANGLE OF INTERNAL FRICTION, BASED ON STANDARD PENETRATION RESISTANCE
- WATER CONTENT IN PERCENT BY WEIGHT

## NOTES:

1. ANGLE OF INTERNAL FRICTION BASED ON STANDARD PENETRATION RESISTANCE TAKEN FROM PECK, RALPH B., HANSON, WALTER E., AND THORNBURN, THOMAS H., FOUNDATION ENGINEERING, NEW YORK, JOHN WILEY & SONS, INC. 1953, PP 222, FIG. 14.2.
2. FOR LOCATION OF BORINGS, SEE PLATE I.

SLIP 1 TERMINAL 4
PORTLAND COMMISSION OF PUBLIC DOCKS
PORTLAND, OREGON

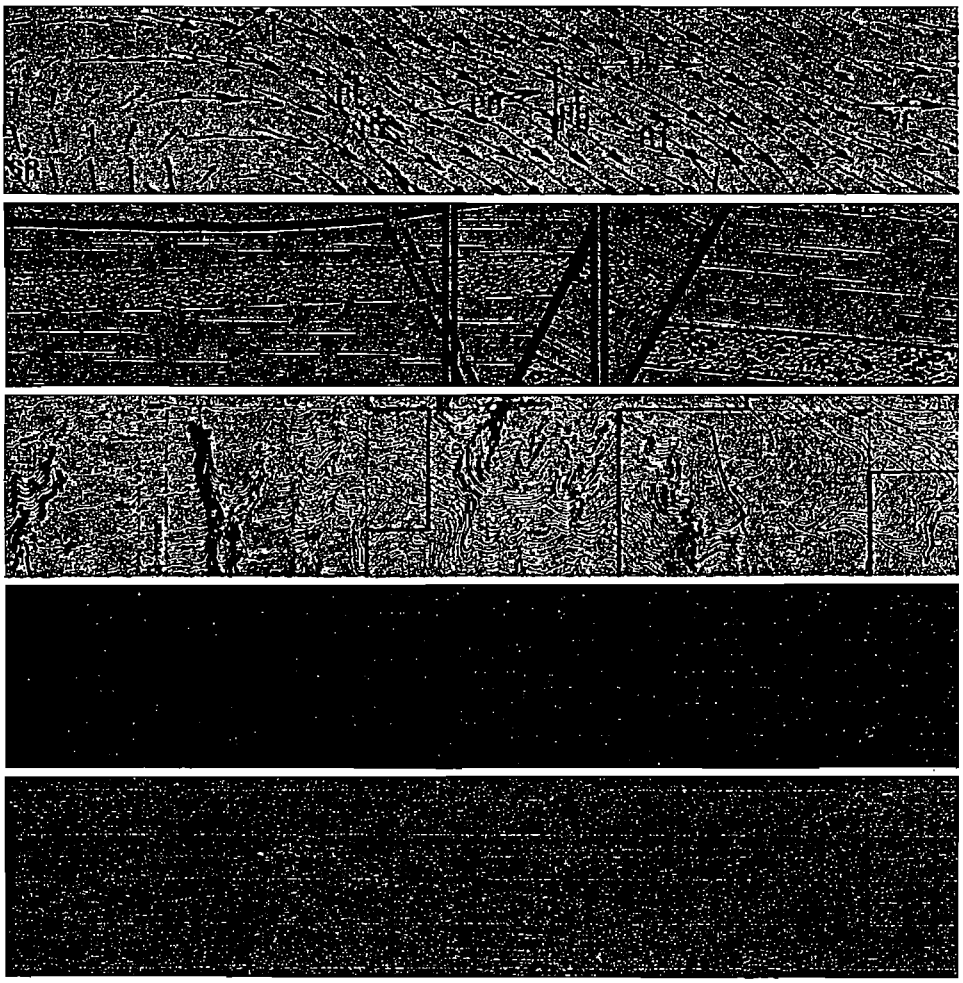
## LOGS OF BORINGS

OCTOBER, 1962 — O-33

Shannon and Wilson
Soil mechanics and foundation engineers
Seattle

PLATE III

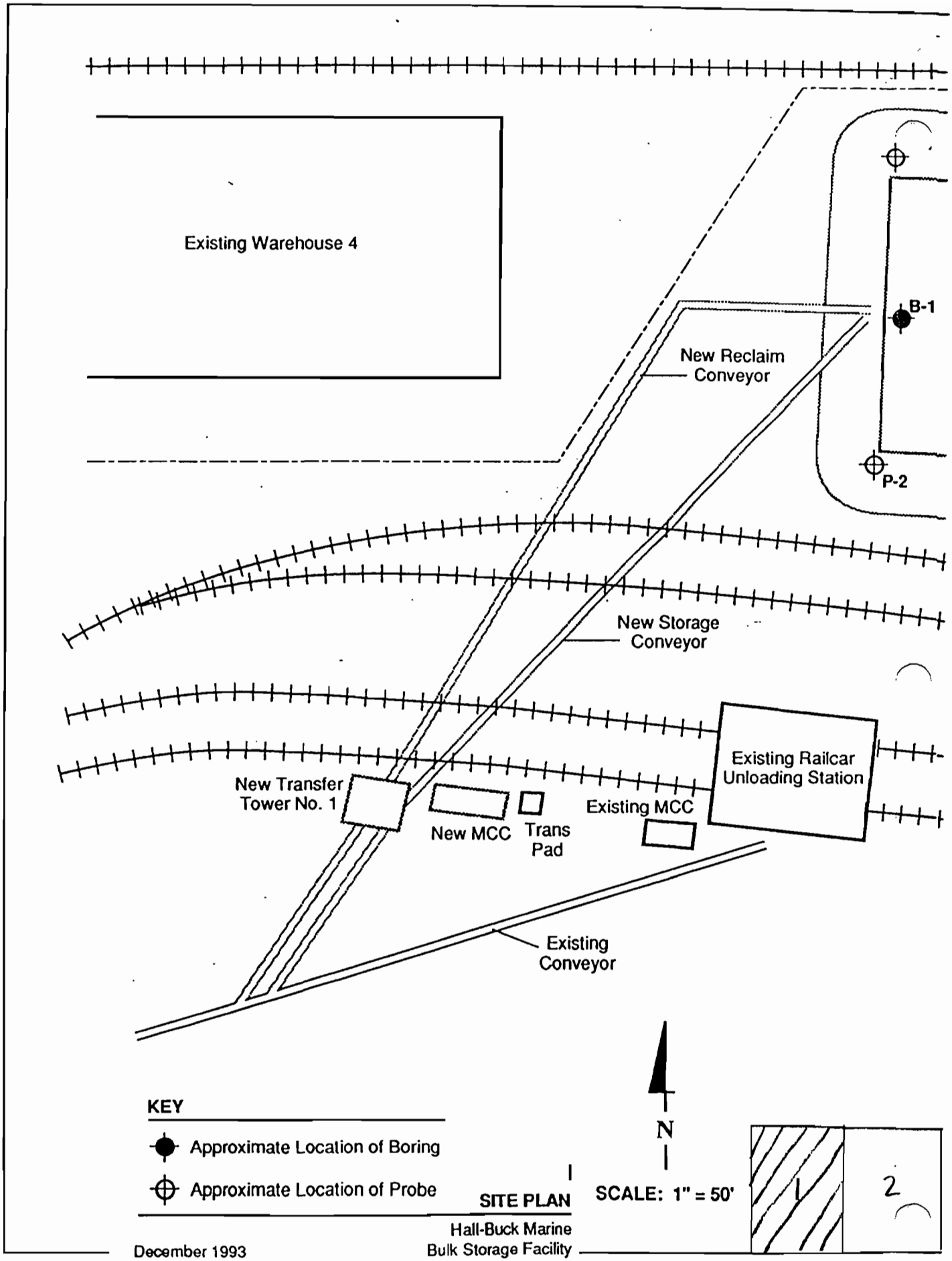
T-84



GEOTECHNICAL INVESTIGATION
PLANNED BULK STORAGE FACILITY
PORT OF PORTLAND, TERMINAL 4
PORTLAND, OREGON

December 15, 1993
Job No. 27218-001-041

# DAMES & MOORE



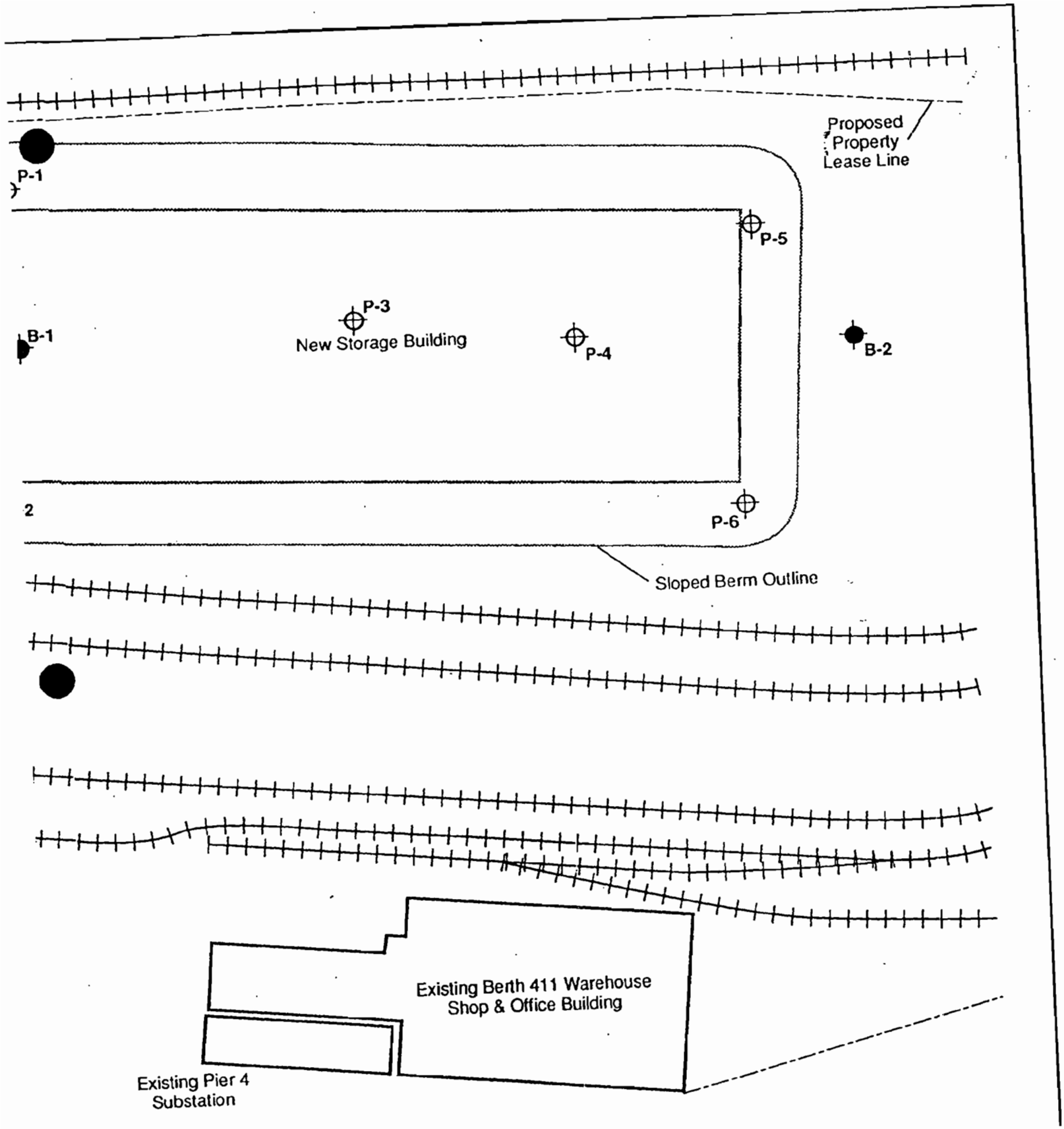

**SITE PLAN**

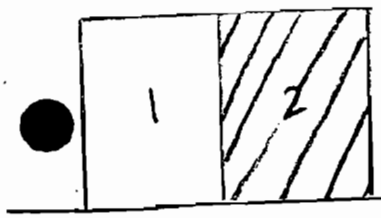
Hall-Buck Marine
Bulk Storage Facility
Portland, Oregon

December 1993
27218-001-041

DAMES & MOORE

FIGURE 2




**SITE PLAN**

Hall-Buck Marine
Bulk Storage Facility
Portland, Oregon

December 1993
27218-001-041

DAMES & MOORE

FIGURE 2

# BORING B-1

DATE DRILLED: 11/29/93

ELEVATION: 30± Feet

| Depth | Dry Density (pcf) | Moisture Content (%) | Sampler Type | Sampling Resistance (Blows/Foot) | Samples | USCS | Lithology | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | 5" ASPHALTIC CONCRETE / 12" AGGREGATE BASE COURSE |
| | | | | | | | SM | REDDISH BROWN SILTY SAND, fine (moist) (loose) [FILL] |
| 5 | | | U | 13 | ■ | | | |
| | | | | | | | | Becomes gray (very loose to loose) |
| 10 | 85 | 17.7 | U | 7 | ■ | | | |
| | | | | | | | SP | GRAY SAND (moist) (loose to medium dense ) |
| 15 | | | U | 16 | ■ | | | |
| 20 | 93 | 11.5 | U | 15 | ■ | | | |
| 25 | | | U | 19 | ■ | | | |
| 30 | | | | | | | | |

*Boring continues on next page*

Drilling Method: Mud Rotary

Sample Method: D&M "U" Type Sampler; 140lb Hammer, 30" Drop

Drill Contractor: GeoTech Explorations

Geologist: DJD

**LOG OF BORING**

Hall-Buck Ma
Bulk Storage Facility
Portland, Oregon

December 1993
27218-001-041

DAMES & MOORE

FIGURE A-2

## BORING B-1 (continued)

DATE DRILLED: 11/29/93

ELEVATION: 30± Feet

| Depth | Dry Density (pcf) | Moisture Content (%) | Sampler Type | Sampling Resistance (Blows/Foot) | Samples | USCS | Lithology | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 30 | | | U | 14 | | | | 6" layer of gravel encountered at 31.5' |
| | | | | | | | SM/SP | GRAY SLIGHTLY SILTY SAND, fine (saturated) (very loose) |
| 35 | 88 | 32.7 | U | 8 | | | | |
| 40 | | | U | 10 | | | | |
| 45 | 89 | 33.9 | U | 11 | | | | |
| | | | | | | | ML | GRAY SANDY SILT (saturated) (soft) |
| 50 | 96 | 27.6 | U | 5 | | | | |
| 55 | | | U | 8 | | | | |
| 60 | | | | | | | | |

*Boring continues on next page*

Drilling Method: Mud Rotary

Sample Method: D&M "U" Type Sampler; 140lb Hammer, 30" Drop

Drill Contractor: GeoTech Explorations

Geologist: DJD

**LOG OF BORING**

December 1993
27218-001-041

Hall-Buck Marine
Bulk Storage Facility
Portland, Oregon

## BORING B-1 (continued)

DATE DRILLED: 11/29/93

ELEVATION: 30± Feet

| Elevation | Dry Density (pcf) | Moisture Content (%) | Sampler Type | Sampling Resistance (Blows/Foot) | Samples | USCS | Lithology | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 60 | | | U | 7 | ■ | | | |
| 65 | 76 | 41.6 | U | 3 | ■ | | CL | GRAYISH BROWN SILTY CLAY (saturated) (soft) |
| | | | | | | | ML | GRAY SANDY SILT, fine, with trace clay (saturated) (medium stiff) |
| 70 | | | U | 7 | ■ | | | |
| | | | | | | | ML | GRAY CLAYEY SILT with fine sand (saturated) (soft) |
| 75 | 72 | 47.8 | U | 4 | ■ | | | |
| | | | | | | | SM | GRAY SILTY SAND, fine (moist) (loose) |
| 80 | | | U | 7 | ■ | | | |
| 85 | 84 | 35.3 | U | 11 | ■ | | | |
| 90 | | | | | | | | |

*Boring continues on next page*

Drilling Method: Mud Rotary

Sample Method: D&M "U" Type Sampler; 140lb Hammer, 30" Drop

Drill Contractor: GeoTech Explorations

Geologist: DJD

**LOG OF BORING**

Hall-Buck Ma
Bulk Storage Facility
Portland, Oregon

December 1993
27218-001-041

## BORING B-1 (continued)

DATE DRILLED: 11/29/93

ELEVATION: 30± Feet

| Depth | Dry Density (pcf) | Moisture Content (%) | Sampler Type | Sampling Resistance (Blows/Foot) | Samples | USCS | Lithology | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 90 | | | U | 5 | | | | |
| 95 | 58 | 62.2 | U | 16 | | | | LIGHT GRAY VOLCANIC ASH (saturated) (loose) |
| | | | | | | CL | | GRAY SILTY CLAY (saturated) (soft) |
| 100 | | | U | 5 | | | | |
| | | | | | | CL | | GRAY SILTY CLAY with trace fine sand (saturated) (medium stiff) |
| 105 | | | U | 8 | | | | |
| 110 | | | U | 7 | | | | |
| 115 | | | U | 6 | | | | |
| 120 | | | | | | | | |

*Boring continues on next page*

Drilling Method: Mud Rotary

Sample Method: D&M "U" Type Sampler; 140lb Hammer, 30" Drop

Drill Contractor: GeoTech Explorations

Geologist: DJD

**LOG OF BORING**

December 1993
27218-001-041

Hall-Buck Marine
Bulk Storage Facility
Portland, Oregon

## BORING B-1 (continued)

DATE DRILLED: 11/29/93

ELEVATION: 30± Feet

| Elevation | Dry Density (pcf) | Moisture Content (%) | Sampler Type | Sampling Resistance (Blows/Foot) | Samples | USCS | Lithology | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 120 | | | U | 10 | ■ | | | Sand content increases |
| 125 | | | U | 20 | ■ | | SM | GRAY SILTY SAND (saturated) (loose to medium dense) |
| 130 | | | U | 26 | ■ | | | |
| 135 | | | U | 15 | ■ | | | |
| 140 | | | U | 26 | ■ | | ML | GRAY SANDY SILT, fine, with widely scattered gravels (saturated) (medium stiff) |
| 145 | | | U | 11 | ■ | | | |
| 150 | | | | | | | | |

*Boring continues on next page*

Drilling Method: Mud Rotary

Sample Method: D&M "U" Type Sampler; 140lb Hammer, 30" Drop

Drill Contractor: GeoTech Explorations

Geologist: DJD

**LOG OF BORING**

Hall-Buck M[illegible]
Bulk Storage Fa[illegible]y
Portland, Oregon

December 1993
27218-001-041

DAMES & MOORE FIGURE A-2 (continued)

## BORING B-1 (continued)

DATE DRILLED: 11/29/93

ELEVATION: 30± Feet

| Elevation | Dry Density (pcf) | Moisture Content (%) | Sampler Type | Sampling Resistance (Blows/Foot) | Samples | USCS | Lithology | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 150 | | | U | 11 | ■ | | | |
| 155 | | | U | 17 | □ | | | |
| 160 | | | U | 26 | ■ | | | |
| | | | | | | | CL | GRAY SILTY CLAY with scattered wood pieces to 1.5" (moist) (medium stiff to stiff) |
| 165 | | | U | 6 | ■ | | | |
| | | | | | | | SP | GRAY SAND (saturated) (dense) |
| | | | U | 51 | ■ | | GP | GRAY SANDY GRAVEL (saturated) (dense) |
| 170 | | | | | | | | |
| 175 | | | | | | | | |
| 180 | | | | | | | | |

***Boring completed at a depth of 169.5'***
***A piezometer was installed to a depth of 30.0'***

NOTES:
1. Boring log indicates interpreded subsurface conditions only at the location and the time the boring was drilled.
2. For an explanation of terms used see the Soils Classification Chart and Key to Test Data, Figure A-1.

Drilling Method: Mud Rotary

Sample Method: D&M "U" Type Sampler; 140lb Hammer, 30" Drop

Drill Contractor: GeoTech Exploration

Geologist: DJD

**LOG OF BORING**

December 1993
27218-001-041

Hall-Buck Marine
Bulk Storage Facility
Portland, Oregon

# BORING B-2

DATE DRILLED: 12/1/93

ELEVATION: 30± Feet

| Depth | Dry Density (pcf) | Moisture Content (%) | Sampler Type | Sampling Resistance (Blows/Foot) | Samples | USCS | Lithology | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | 5" ASPHALTIC CONCRETE / 12" AGGREGATE BASE COURSE |
| | | | | | | | SM | REDDISH BROWN SILTY SAND with scattered fine organics (moist) (loose) [FILL] |
| 5 | | | U | 8 | ■ | | | |
| | | | | | | | SM / SP | REDDISH BROWN SILTY SAND (moist to wet) (loose to medium dense) |
| 10 | 93 | 15.8 | U | 16 | ■ | | | |
| 15 | | | U | 20 | ■ | | | |
| 20 | 95 | 27.2 | U | 12 | ■ | | | |
| | | | | | | | ML | MOTTLED GRAY & YELLOWISH RED SANDY SILT (saturated) (very soft) |
| 25 | | | U | 2 | □ | | | |
| 30 | | | | | | | | |

*Boring continues on next page*

Drilling Method: Mud Rotary

Sample Method: D&M "U" Type Sampler; 140lb Hammer, 30" Drop

Drill Contractor: GeoTech Explorations

Geologist: DJD

**LOG OF BORING**

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Bulk Storage Facility
Portland, Oregon

December 1993
27218-001-041

DAMES & MOORE

FIGURE A-3

## BORING B-2 (continued)

DATE DRILLED: 12/1/93

ELEVATION: 30± Feet

| Depth | Dry Density (pcf) | Moisture Content (%) | Sampler Type | Sampling Resistance (Blows/Foot) | Samples | USCS | Lithology | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 30 | | | U | 2 | ■ | | | |
| | | | | | | | CL | GRAY SILTY CLAY (saturated) (very soft) |
| 35 | 82 | 41.2 | U | 2 | ■ | | | |
| 40 | | | U | 3 | ■ | | | |
| | | | | | | | SM | GRAY SILTY SAND (saturated) (loose) |
| 45 | 80 | 41.3 | U | 4 | ■ | | | |
| 50 | — | — | U | 4 | □ | | | |
| | | | | | | | CL | OLIVE-GRAY SILTY CLAY with trace sand (saturated) (soft) |
| 55 | 69 | 54.9 | U | 6 | ■ | | | |
| 60 | | | | | | | | |

*Boring continues on next page*

Drilling Method: Mud Rotary

Sample Method: D&M "U" Type Sampler; 140lb Hammer, 30" Drop

Drill Contractor: GeoTech Explorations

Geologist: DJD

**LOG OF BORING**

December 1993
27218-001-041

Hall-Buck Marine
Bulk Storage Facility
Portland, Oregon

## BORING B-2 (continued)

DATE DRILLED: 12/1/93

ELEVATION: 30± Feet

| Depth | Dry Density (pcf) | Moisture Content (%) | Sampler Type | Sampling Resistance (Blows/Foot) | Samples | USCS | Lithology | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 60 | | | U | 5 | ■ | | ML | GRAY SANDY SILT, fine (saturated) (medium stiff) |
| 65 | 69 | 52.4 | U | 5 | ■ | | | Sand content decreases |
| 70 | | | U | 5 | ■ | | | Sand content increases |
| | | | | | | | CL | BROWNISH GRAY SILTY CLAY (saturated) (soft) |
| 75 | 65 | 59.7 | U | 5 | ■ | | | |
| 80 | | | U | 12 | ■ | | SM | GRAY SILTY SAND (saturated) (loose) |
| 85 | 85 | 34.4 | U | 16 | ■ | | | Silt content decreases |
| 90 | | | | | | | | |

*Boring continues on next page*

Drilling Method: Mud Rotary

Sample Method: D&M "U" Type Sampler; 140lb Hammer, 30" Drop

Drill Contractor: GeoTech Explorations

Geologist: DJD

**LOG OF BORING**

December 1993
27218-001-041

Hall-Buck Mar
Bulk Storage Facility
Portland, Oregon

## BORING B-2 (continued)

DATE DRILLED: 12/1/93

ELEVATION: 30± Feet

| Elevation | Dry Density (pcf) | Moisture Content (%) | Sampler Type | Sampling Resistance (Blows/Foot) | Samples | USCS | Lithology | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 90 | | | U | 11 | ■ | | | |
| 95 | | | U | 10 | ■ | | | Silt content increases to very silty sand |
| 100 | | | U | 7 | □ | | | |
| 105 | | | U | 6 | ■ | | ML | DARK GRAY SANDY SILT (saturated) (soft) |
| 110 | | | U | 16 | ■ | | | LIGHT GRAY VOLCANIC ASH |
| 115 | | | U | 6 | ■ | | CL | GRAY SILTY CLAY (saturated) (soft to medium stiff) |
| 120 | | | | | | | | |

*Boring continues on next page*

Drilling Method: Mud Rotary

Sample Method: D&M "U" Type Sampler; 140lb Hammer, 30" Drop

Drill Contractor: GeoTech Explorations

Geologist: DJD

**LOG OF BORING**

December 1993
27218-001-041

Hall-Buck Marine
Bulk Storage Facility
Portland, Oregon

## BORING B-2 (continued)

DATE DRILLED: 12/1/93

ELEVATION: 30± Feet

| Elevation | Dry Density (pcf) | Moisture Content (%) | Sampler Type | Sampling Resistance (Blows/Foot) | Samples | USCS | Lithology | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 120 | | | U | 5 | ■ | | ML | DARK GRAY SILT (saturated) (soft) |
| 125 | | | U | 5 | ■ | | | |
| 130 | | | U | 6 | □ | | | |
| 135 | | | U | 7 | □ | | | Consistency increases to medium stiff |
| 140 | | | U | 13 | □ | | SM | GRAY SILTY SAND (saturated) (loose) |
| | | | | | | | ML | DARK GRAY SANDY SILT with trace of clay (saturated) (medium stiff) |
| 145 | | | U | 9 | ■ | | | |
| 150 | | | | | | | | |

*Boring continues on next page*

Drilling Method: Mud Rotary

Sample Method: D&M "U" Type Sampler; 140lb Hammer, 30" Drop

Drill Contractor: GeoTech Explorations

Geologist: DJD

**LOG OF BORING**

December 1993
27218-001-041

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Portland, Oregon

## BORING B-2 (continued)

DATE DRILLED: 12/1/93

ELEVATION: 30± Feet

| Elevation | Dry Density (pcf) | Moisture Content (%) | Sampler Type | Sampling Resistance (Blows/Foot) | Samples | USCS | Lithology | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 150 | | | U | 6 | ■ | | | Clay content increases; few organics |
| 155 | | | U | 9 | ■ | | | |
| 160 | | | U | 12 | ■ | | ML | DARK GRAY CLAYEY SILT with abundant small pieces of wood (stiff) |
| 165 | | | U | 10 | ■ | | | |
| | | | | | | | SP | DARK GRAY SAND (saturated) (medium dense) |
| | | | | | | | ML | GREENISH DARK GRAY SANDY SILT (very stiff) |
| 170 | | | U | 21 | ■ | | SP/SM | DARK GRAY SILTY SAND TO SAND, fine (saturated) (loose) |
| 175 | | | U | 19 | ■ | | | |
| 180 | | | | | | | | |

*Boring continues on next page*

Drilling Method: Mud Rotary

Sample Method: D&M "U" Type Sampler; 140lb Hammer, 30" Drop

Drill Contractor: GeoTech Explorations

Geologist: DJD

**LOG OF BORING**

December 1993
27218-001-041

Hall-Buck Marine
Bulk Storage Facility
Portland, Oregon

## BORING B-2 (continued)

DATE DRILLED: 12/1/93

ELEVATION: 30± Feet

| | Dry Density (pcf) | Moisture Content (%) | Sampler Type | Sampling Resistance (Blows/Foot) | Samples | USCS | Lithology | LITHOLOGIC DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 180 | — | — | U | 12 | ■ | | | |
| | | | | | | | GM | DARK GRAY SILTY SANDY GRAVEL (saturated) (dense) |
| 185 | | | | | | | | |
| 190 | | | | | | | | |
| 195 | | | | | | | | |
| 200 | | | | | | | | |
| 205 | | | | | | | | |
| 210 | | | | | | | | |

***Boring completed at a depth of 182.5'***
***A piezometer was installed to a depth of 30.0'***

NOTES:
1. Boring log indicates interpreded subsurface conditions only at the location and the time the boring was drilled.
2. For an explanation of terms used see the Soils Classification Chart and Key to Test Data, Figure A-1.

Drilling Method: Mud Rotary

Sample Method: D&M "U" Type Sampler; 140lb Hammer, 30" Drop

Drill Contractor: GeoTech Exploration

Geologist: DJD

**LOG OF BORING**

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Portland, Oregon

December 1993
27218-001-041

Appendix D

# *Appendix D*

# NOAA Figures

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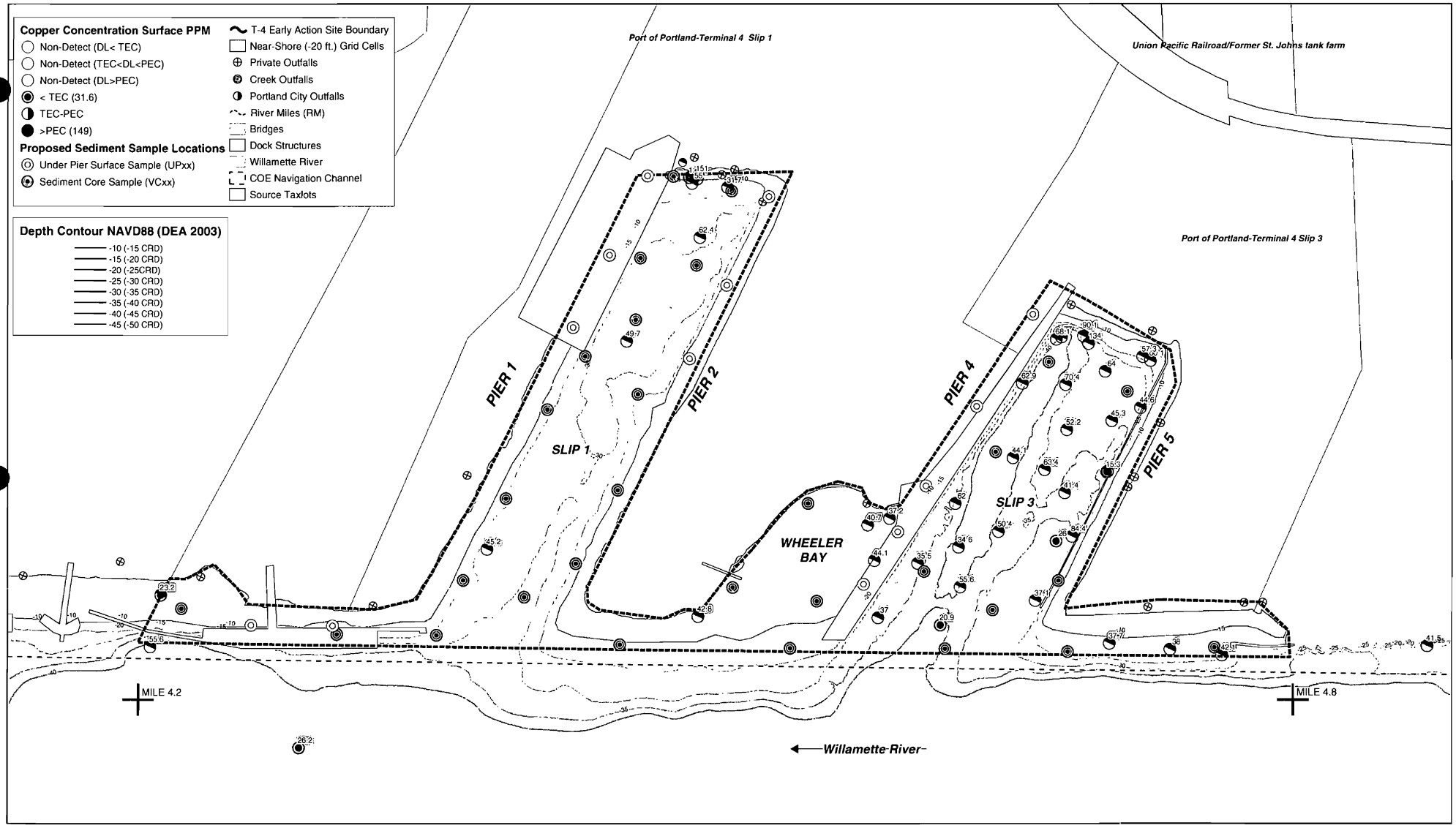
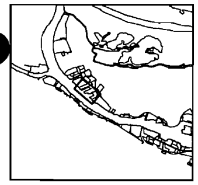


T4 Sample Coordinates from BBL Inc. 01/22/04
Oregon State Plane North, NAD83/91 Intl. Feet

Contaminant Data from NOAA Query Manager (09.24.03)
Source: Striplin E.A.

Suface Data = 0 - 30 cm
Subsurface Data = Max per location

Consensus Based Freshwater Sediment Quality Guidelines:
Threshold Effect Concentration (TEC)
Probable Effect Concentration (PEC)

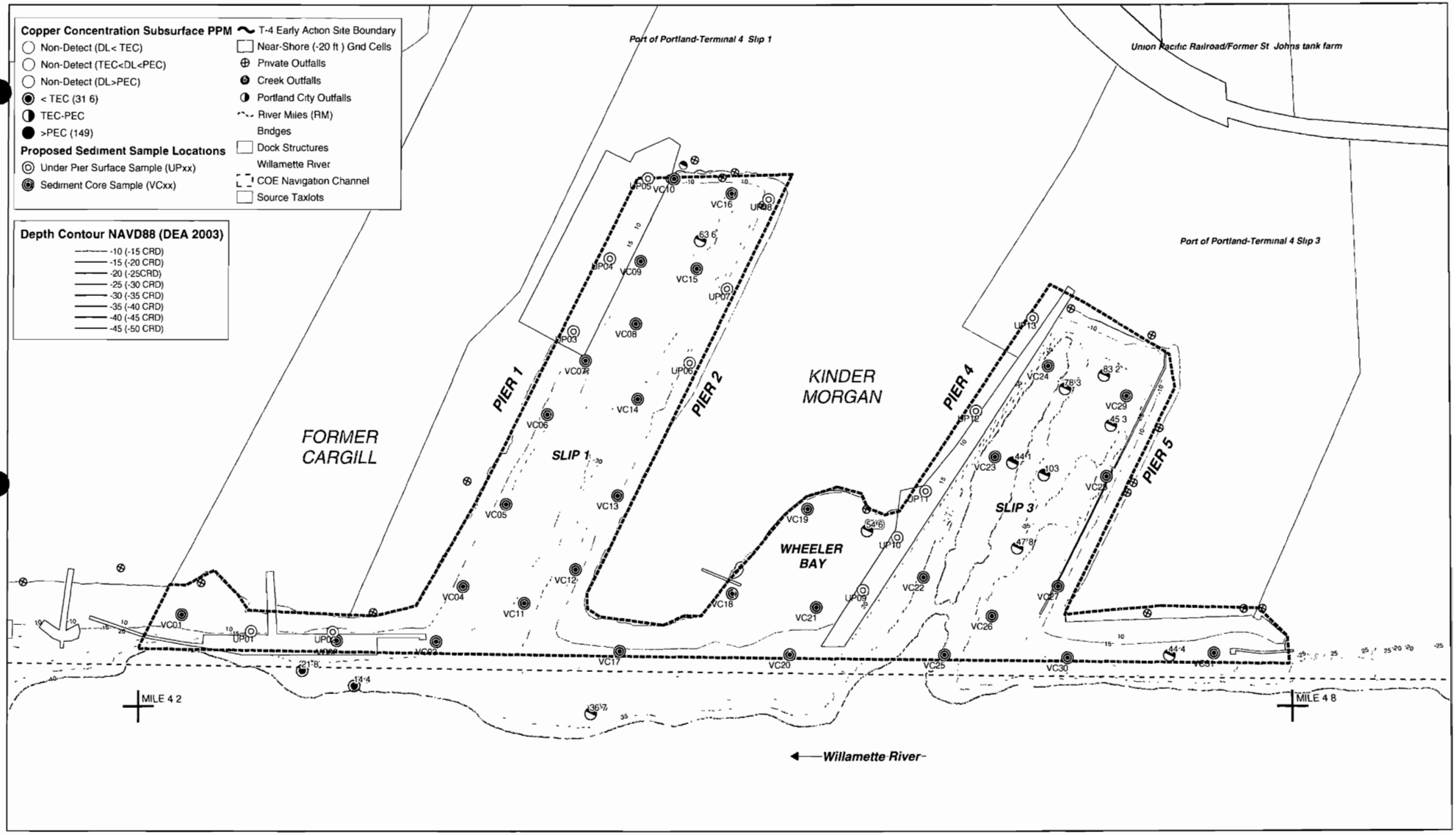
0 500 1,000 Feet

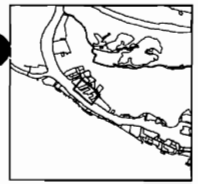
## Copper Concentration Surface PPM

Portland Harbor: T-4 Early Action Site
Category 1 Sediment Chemistry Data &
Proposed T4 Sediment Sampling Locations

Figure 1a

Map: c:\gis\projects\portlandharbor\ph_020204_t4.mxd
Plot Date: 02.03.2004 B. Shorr NOAA CPRD



T4 Sample Coordinates from BBL Inc 01/22/04
Oregon State Plane North, NAD83/91 Intl Feet

Contaminant Data from NOAA Query Manager (09 24 03)
Source Stnplin E A

Suface Data = 0 - 30 cm
Subsurface Data = Max per location

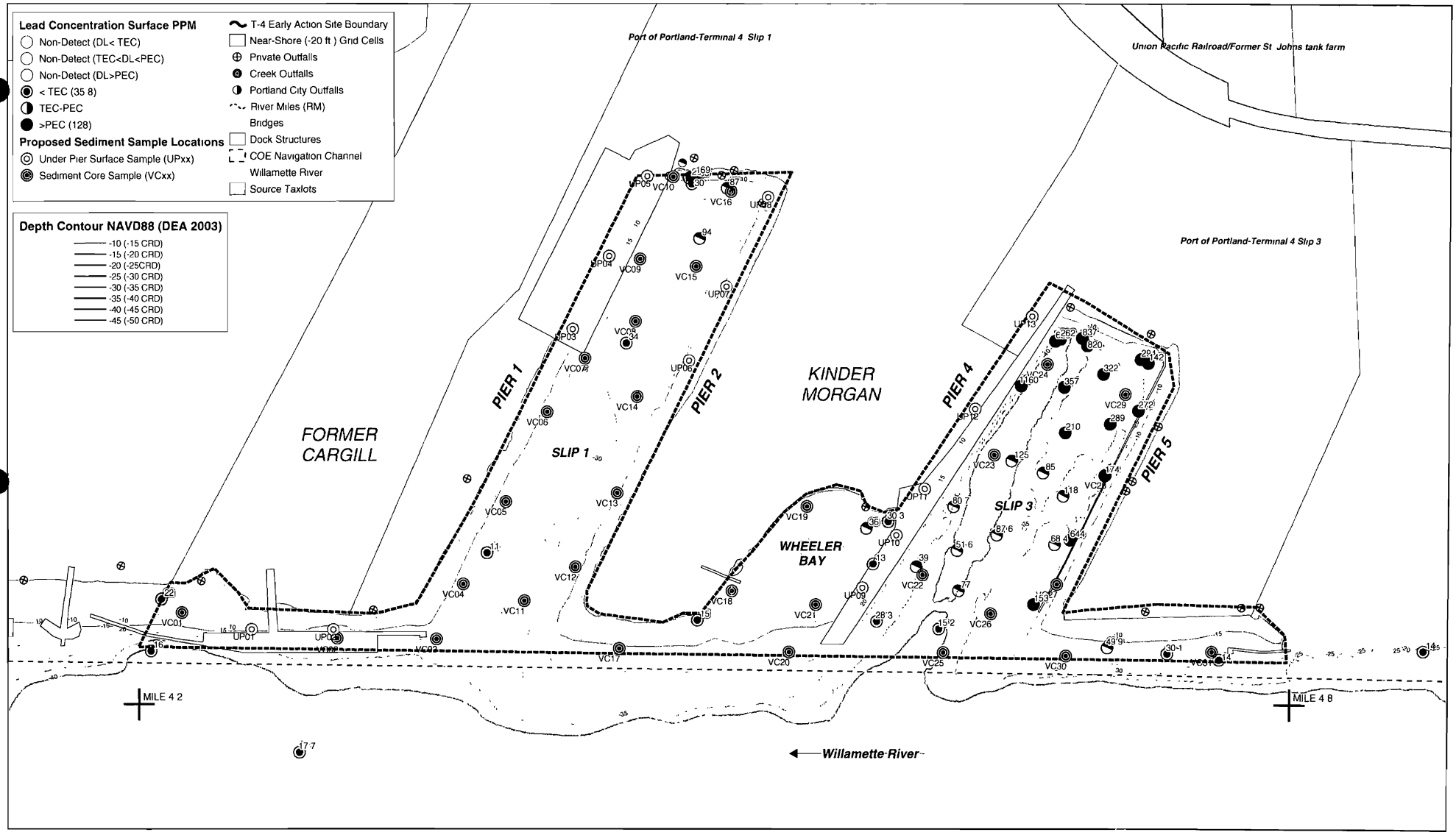
Consensus Based Freshwater Sediment Quality Guidelines
Threshold Effect Concentration (TEC)
Probable Effect Concentration (PEC)

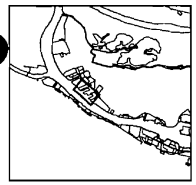
0 500 1,000 Feet

Map c \gis\projects\portlandharbor\ph_020204_t4 mxd
Plot Date 02 03 2004 B Shorr NOAA CPRD

Figure 1b
Copper Concentration Subsurface PPM

Portland Harbor: T-4 Early Action Site
Category 1 Sediment Chemistry Data &
Proposed T4 Sediment Sampling Locations



T4 Sample Coordinates from BBL Inc 01/22/04
Oregon State Plane North, NAD83/91 Intl Feet

Contaminant Data from NOAA Query Manager (09 24 03)
Source Striplin E A

Suface Data = 0 - 30 cm
Subsurface Data = Max per location

Consensus Based Freshwater Sediment Quality Guidelines
Threshold Effect Concentration (TEC)
Probable Effect Concentration (PEC)

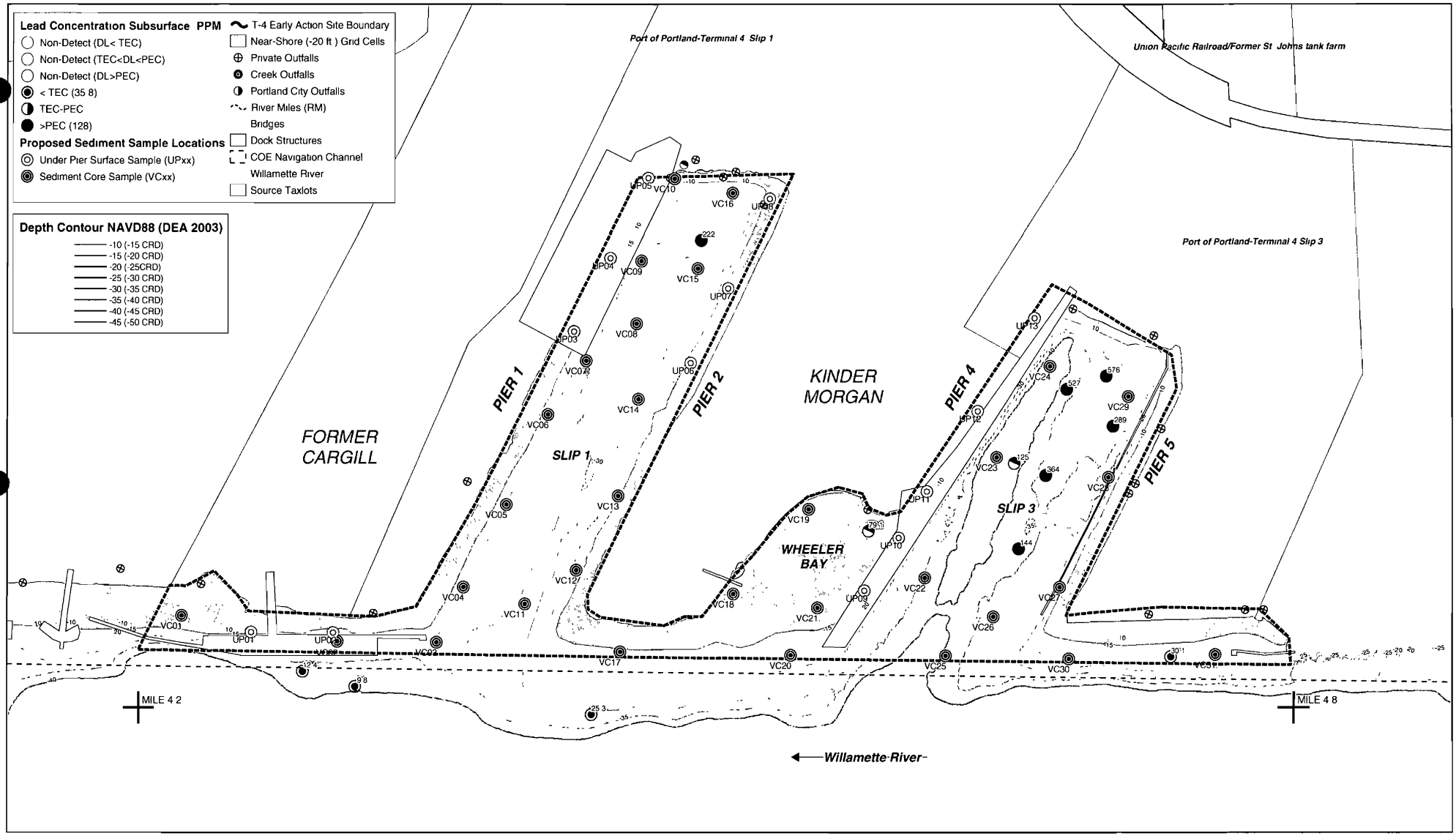
0 500 1,000 Feet

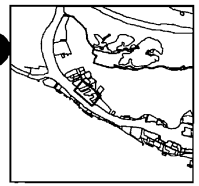
Map c \gis\projects\portlandharbor\ph_020204_t4 mxd
Plot Date 02 03 2004 B Shorr NOAA CPRD

Figure 2a

Lead Concentration Surface PPM

Portland Harbor: T-4 Early Action Site
Category 1 Sediment Chemistry Data &
Proposed T4 Sediment Sampling Locations



T4 Sample Coordinates from BBL Inc 01/22/04
Oregon State Plane North, NAD83/91 Intl Feet

Contaminant Data from NOAA Query Manager (09 24 03)
Source Stnplin E A

Suface Data = 0 - 30 cm
Subsurface Data = Max per location

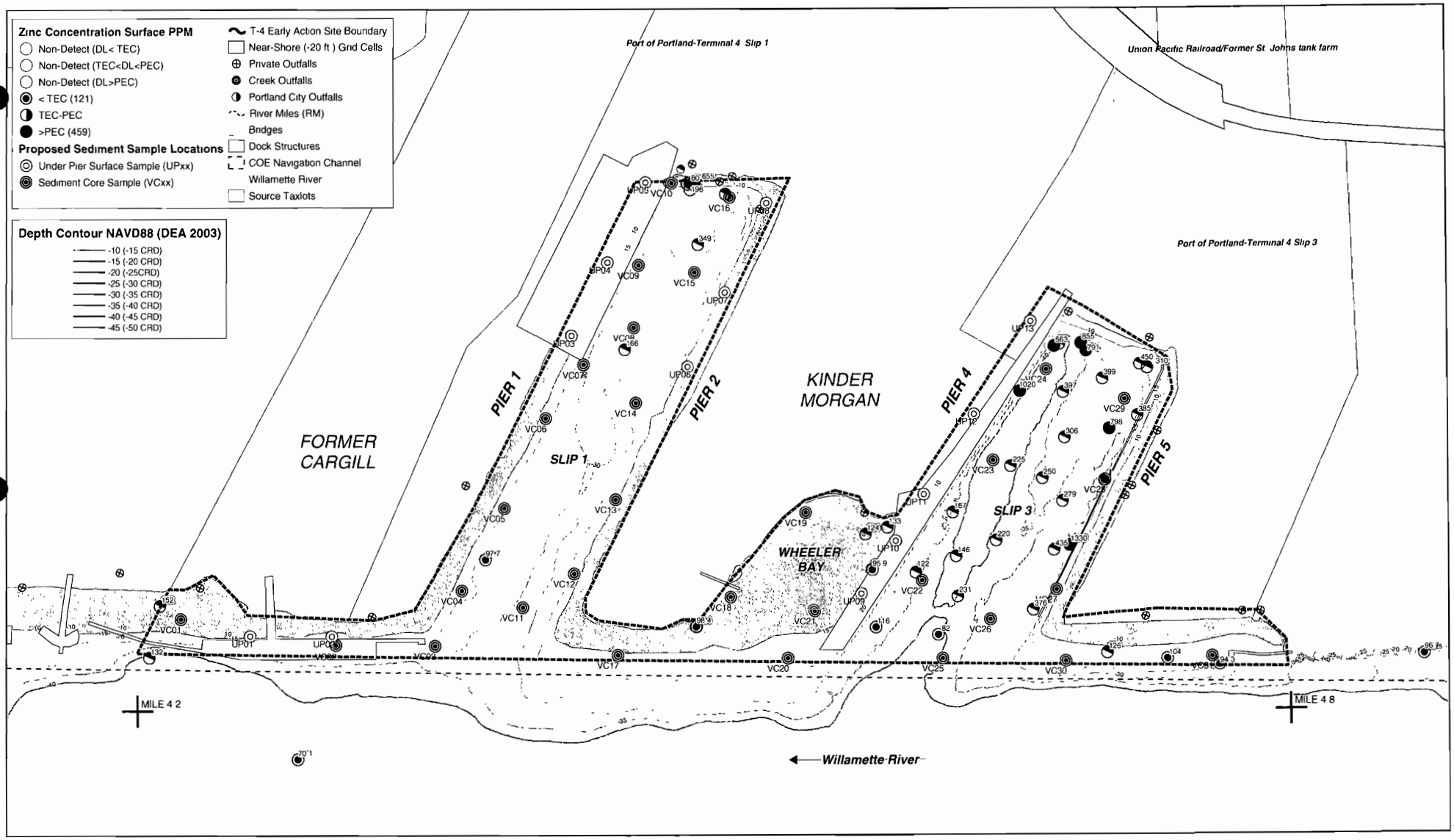
Consensus Based Freshwater Sediment Quality Guidelines
Threshold Effect Concentration (TEC)
Probable Effect Concentration (PEC)

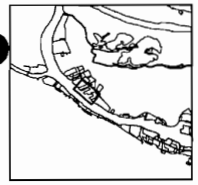
0 500 1,000 Feet

Map c \gis\projects\portlandharbor\ph_020204_t4 mxd
Plot Date 02 03 2004 B Shorr NOAA CPRD

Figure 2b
Lead Concentration Subsurface PPM

Portland Harbor: T-4 Early Action Site
Category 1 Sediment Chemistry Data &
Proposed T4 Sediment Sampling Locations



T4 Sample Coordinates from BBL Inc 01/22/04
Oregon State Plane North, NAD83/91 Intl Feet

Contaminant Data from NOAA Query Manager (09 24 03)
Source Stinplin E A

Suface Data = 0 - 30 cm
Subsurface Data = Max per location

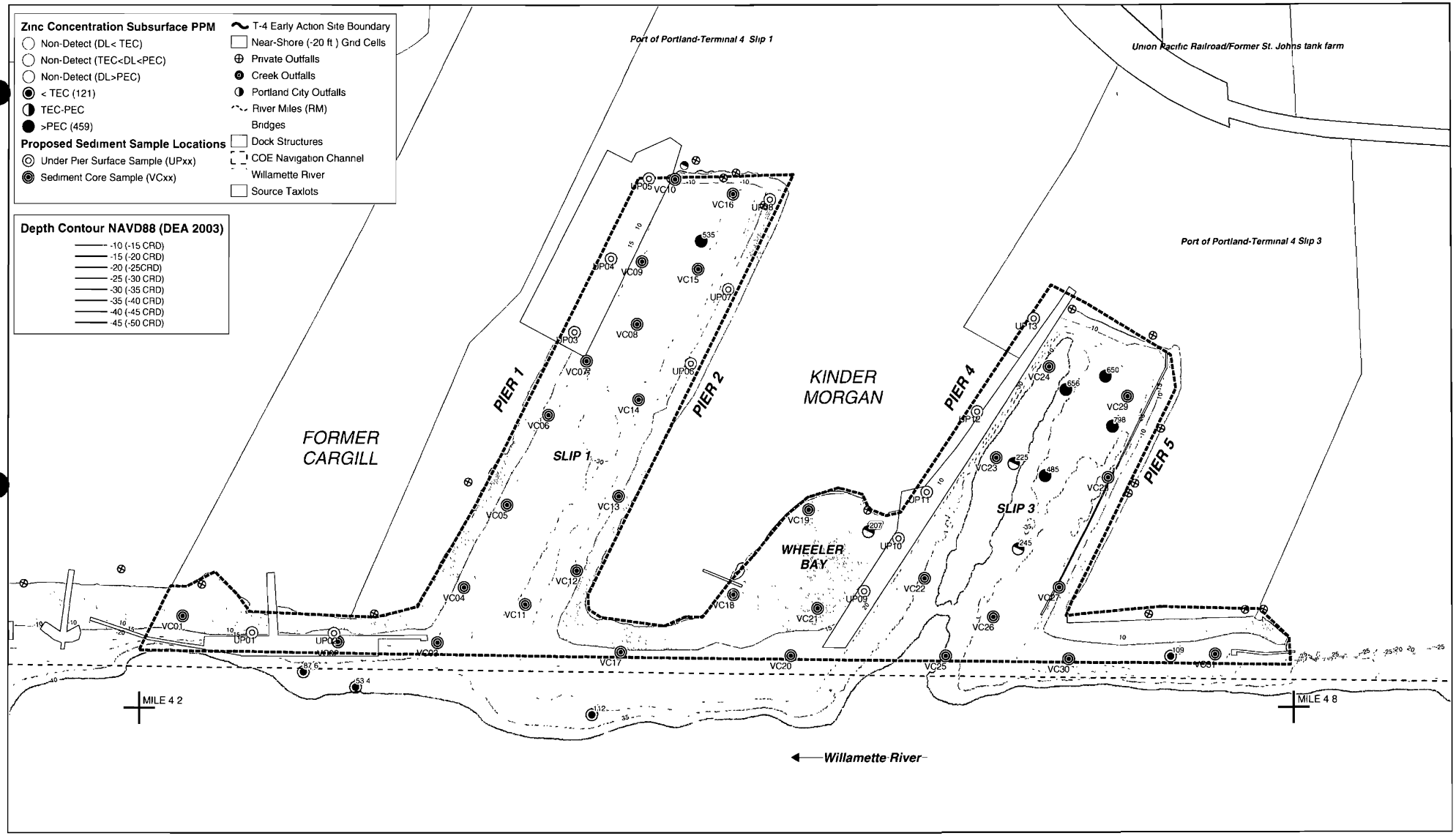
Consensus Based Freshwater Sediment Quality Guidelines
Threshold Effect Concentration (TEC)
Probable Effect Concentration (PEC)

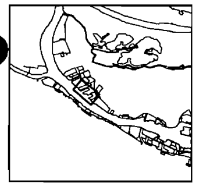
Map c:\gis\projects\portlandharbor\ph_020204_t4 mxd
Plot Date 02 03 2004 B Shorr NOAA CPRD

0 500 1,000 Feet

Figure 3a
Zinc Concentration Surface PPM

Portland Harbor· T-4 Early Action Site
Category 1 Sediment Chemistry Data &
Proposed T4 Sediment Sampling Locations



T4 Sample Coordinates from BBL Inc 01/22/04
Oregon State Plane North, NAD83/91 Intl Feet

Contaminant Data from NOAA Query Manager (09 24 03)
Source Stinplin E A

Suface Data = 0 - 30 cm
Subsurface Data = Max per location

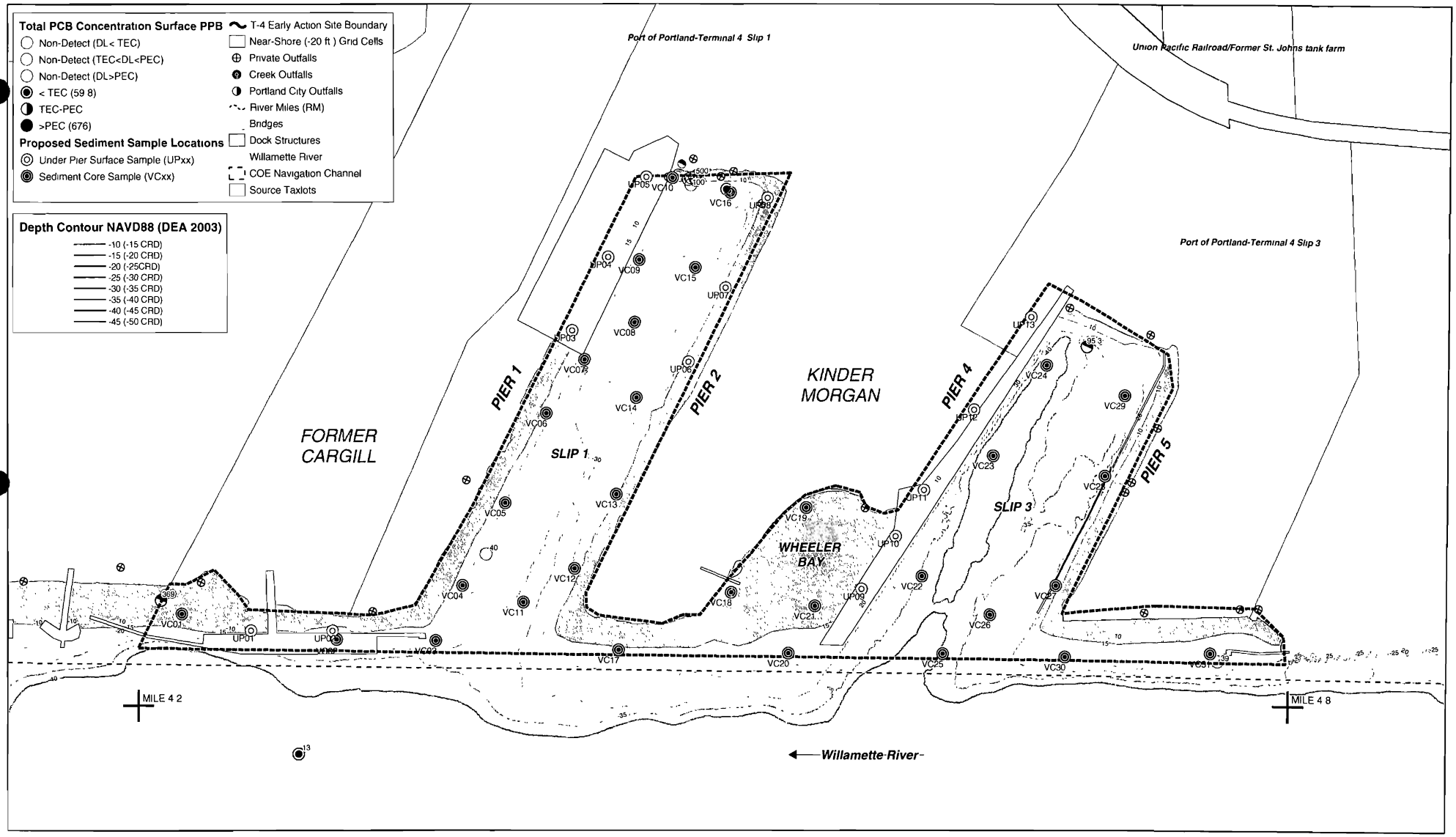
Consensus Based Freshwater Sediment Quality Guidelines
Threshold Effect Concentration (TEC)
Probable Effect Concentration (PEC)

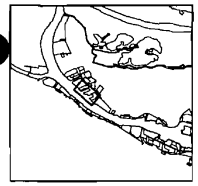
0 500 1,000 Feet

Map c \gis\projects\portlandharbor\ph_020204_t4 mxd
Plot Date 02 03 2004 B Shorr NOAA CPRD

Figure 3b
Zinc Concentration Subsurface PPM

Portland Harbor: T-4 Early Action Site
Category 1 Sediment Chemistry Data &
Proposed T4 Sediment Sampling Locations



T4 Sample Coordinates from BBL Inc 01/22/04
Oregon State Plane North, NAD83/91 Intl Feet

Contaminant Data from NOAA Query Manager (09 24 03)
Source Stripin E A

Surface Data = 0 - 30 cm
Subsurface Data = Max per location

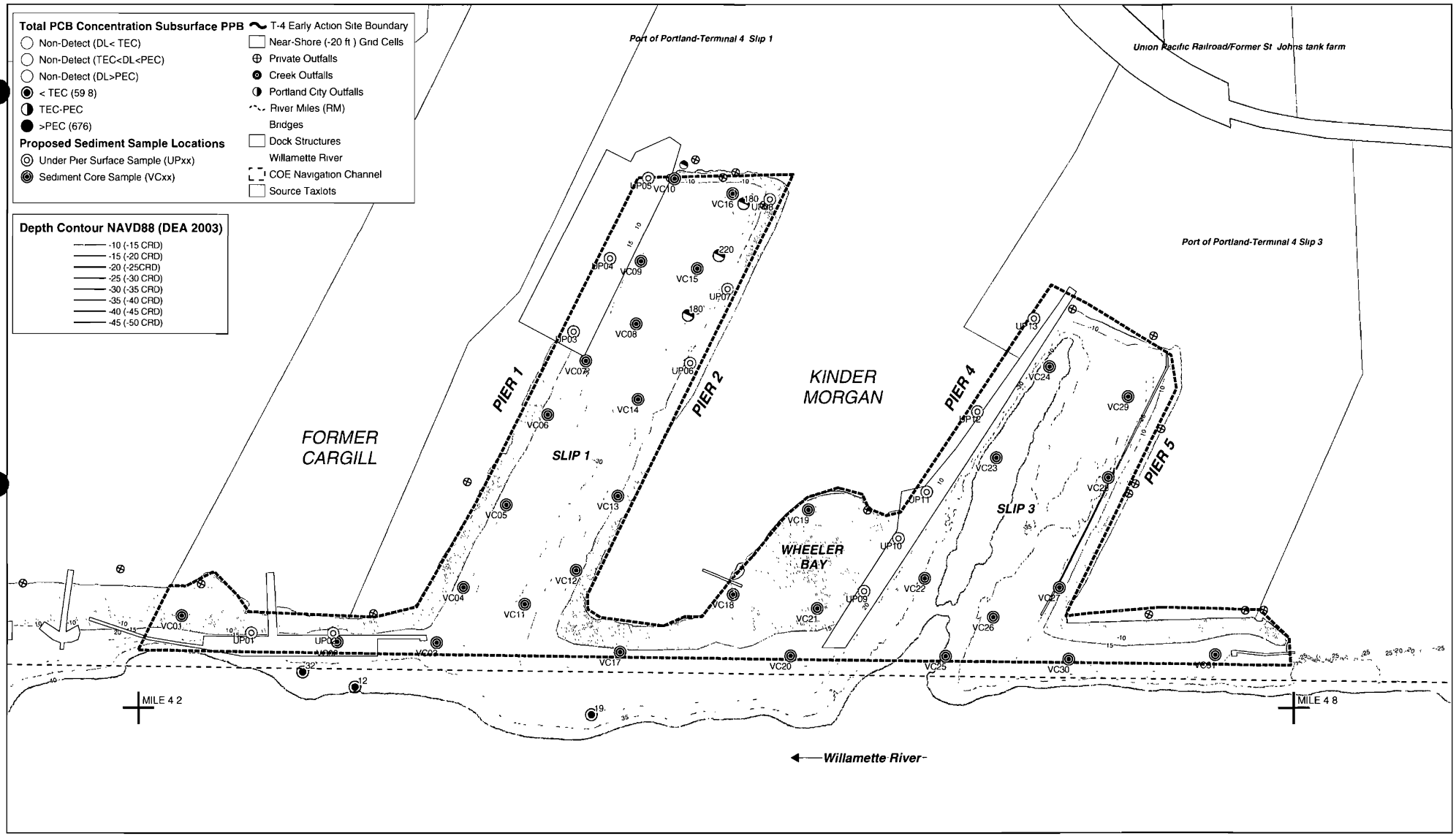
Consensus Based Freshwater Sediment Quality Guidelines
Threshold Effect Concentration (TEC)
Probable Effect Concentration (PEC)

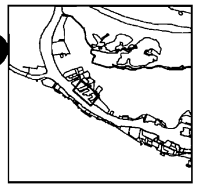
0 500 1,000 Feet

Map c:\gis\projects\portland\harbor\ph_020204_t4.mxd
Plot Date 02 03 2004 B Shorr NOAA CPRD

Figure 4a
Total PCB's Concentration Surface PPM

Portland Harbor: T-4 Early Action Site
Category 1 Sediment Chemistry Data &
Proposed T4 Sediment Sampling Locations



T4 Sample Coordinates from BBL Inc 01/22/04
Oregon State Plane North, NAD83/91 Intl Feet

Contaminant Data from NOAA Query Manager (09 24 03)
Source Stnplin E A

Sulace Data = 0 - 30 cm
Subsurface Data = Max per location

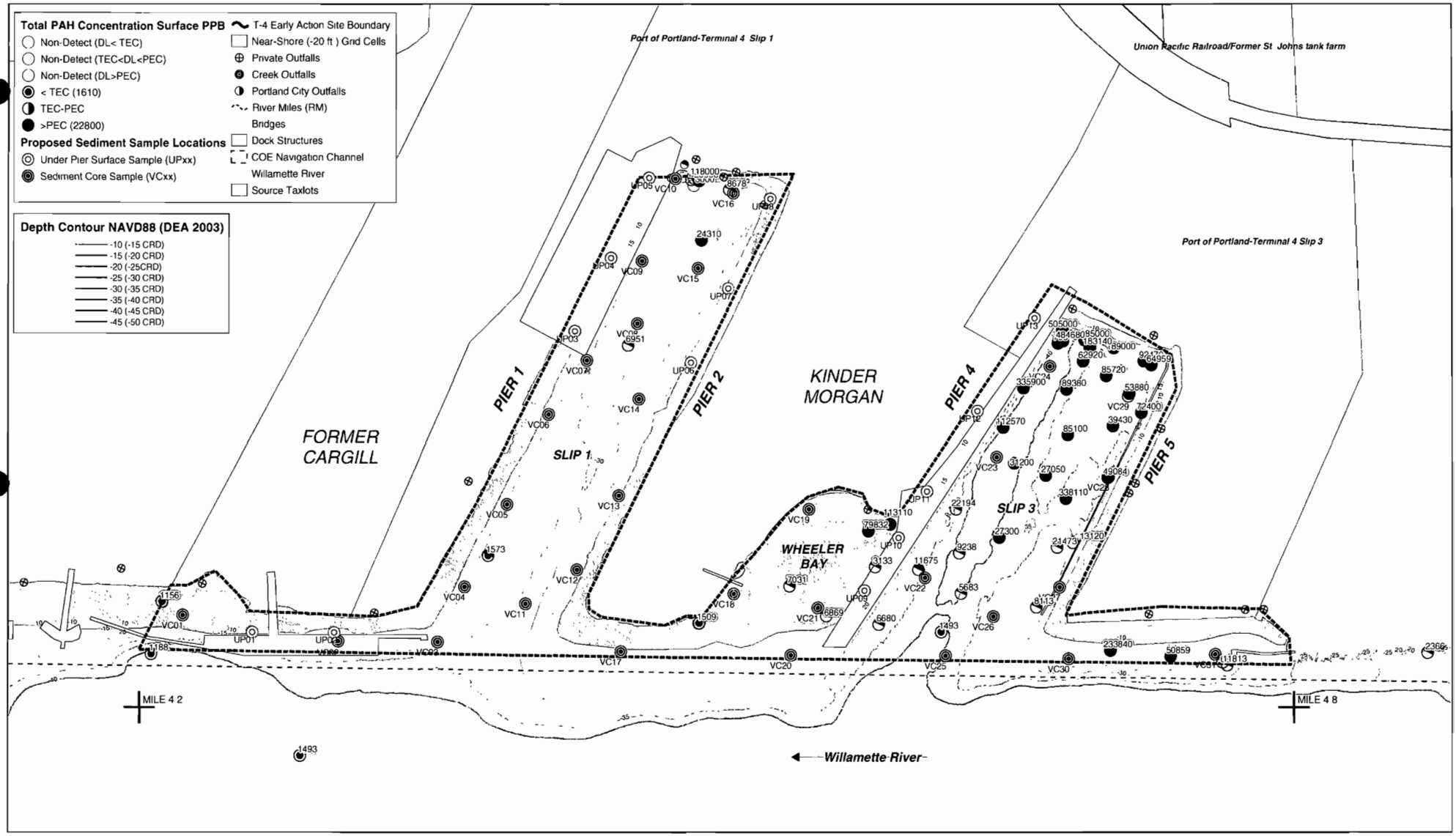
Consensus Based Freshwater Sediment Quality Guidelines
Threshold Effect Concentration (TEC)
Probable Effect Concentration (PEC)

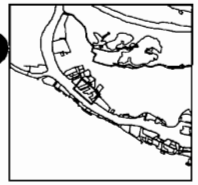
0 500 1,000 Feet

Map c:\gis\projects\portlandharbor\ph_020204_t4 mxd
Plot Date 02 03 2004 B Shorr NOAA CPRD

Figure 4b
Total PCB's Concentration Subsurface PPM

Portland Harbor. T-4 Early Action Site
Category 1 Sediment Chemistry Data &
Proposed T4 Sediment Sampling Locations



T4 Sample Coordinates from BBL Inc 01/22/04
Oregon State Plane North, NAD83/91 Intl Feet

Contaminant Data from NOAA Query Manager (09 24 03)
Source Stinplin E A

Suface Data = 0 - 30 cm
Subsurface Data = Max per location

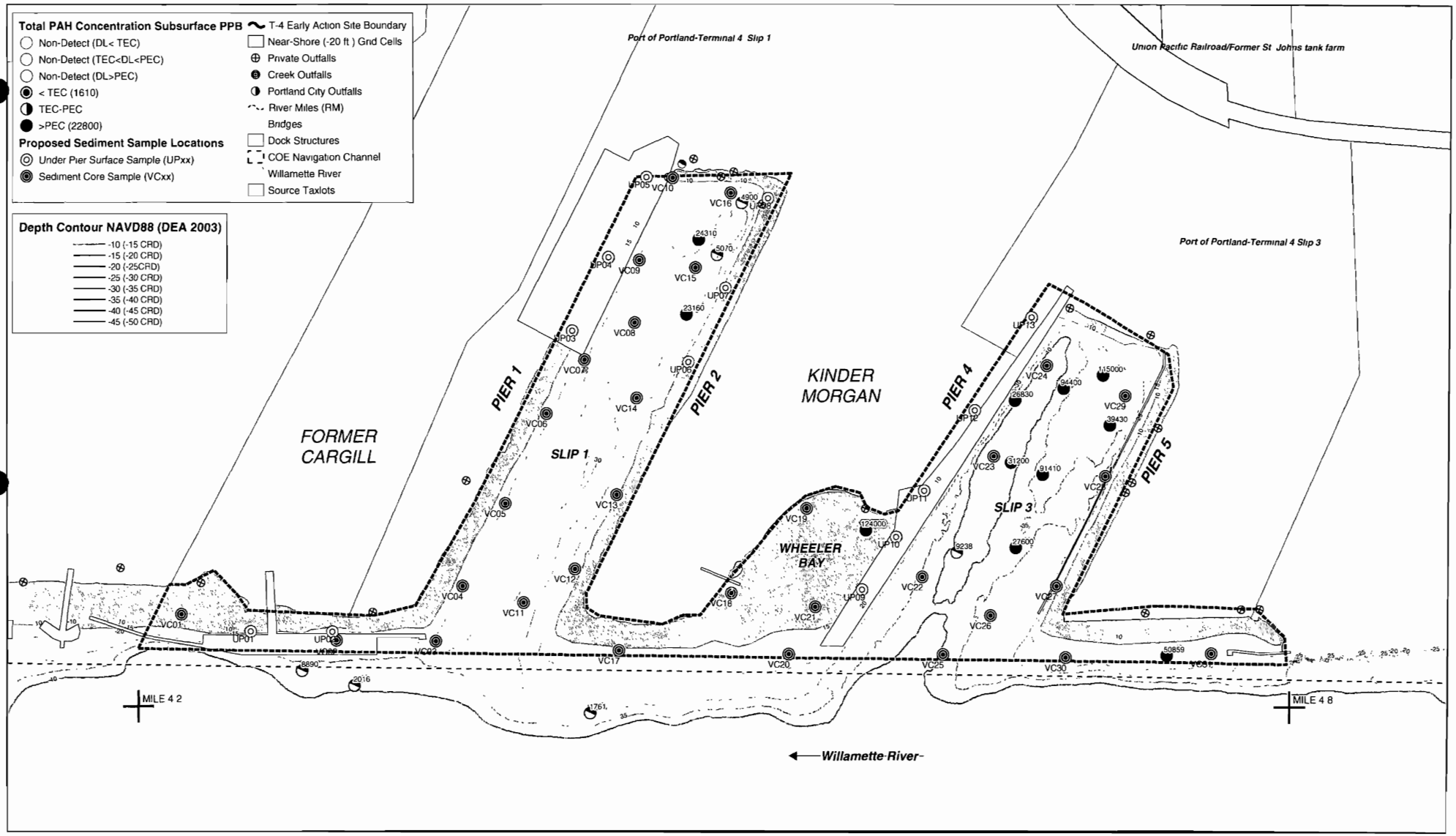
Consensus Based Freshwater Sediment Quality Guidelines
Threshold Effect Concentration (TEC)
Probable Effect Concentration (PEC)

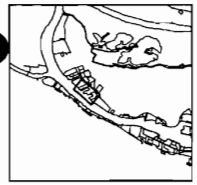
0 500 1,000 Feet

Map c \gis\projects\portlandharbor\ph_020204_t4 mxd
Plot Date 02 03 2004 B Shorr NOAA CPRD

Figure 5a
Total PAH's Concentration Surface PPM

Portland Harbor: T-4 Early Action Site
Category 1 Sediment Chemistry Data &
Proposed T4 Sediment Sampling Locations



T4 Sample Coordinates from BBL Inc 01/22/04
Oregon State Plane North, NAD83/91 Intl Feet

Contaminant Data from NOAA Query Manager (09 24 03)
Source Stnplin E A

Suface Data = 0 - 30 cm
Subsurface Data = Max per location

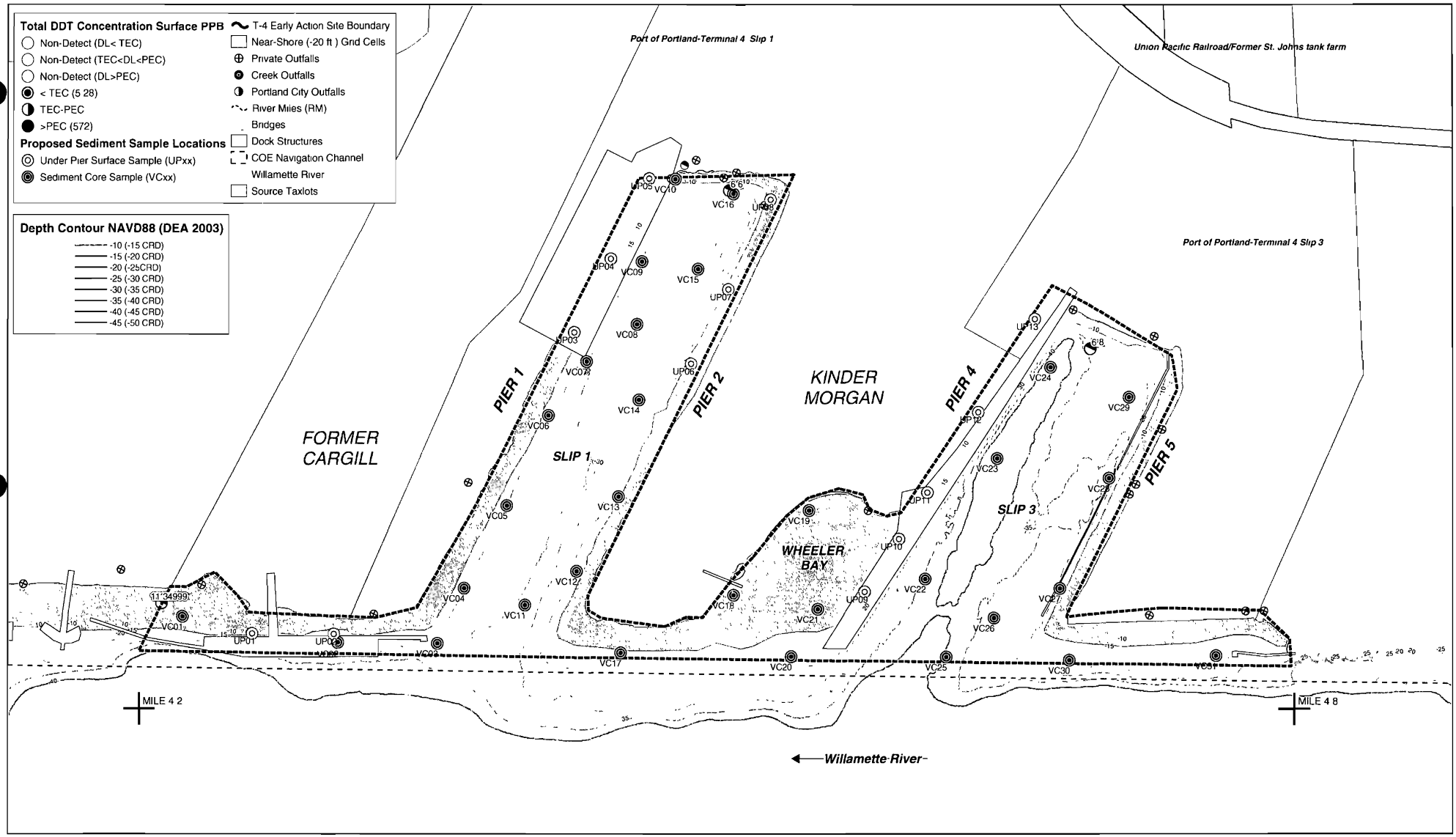
Consensus Based Freshwater Sediment Quality Guidelines
Threshold Effect Concentration (TEC)
Probable Effect Concentration (PEC)

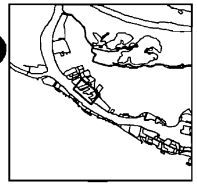
0 500 1,000 Feet

Map c:\gis\projects\portlandharbor\ph_020204_t4 mxd
Plot Date 02 03 2004 B Shorr NOAA CPRD

Figure 5b
Total PAH's ConcentrationSubsurface PPM

Portland Harbor T-4 Early Action Site
Category 1 Sediment Chemistry Data &
Proposed T4 Sediment Sampling Locations



T4 Sample Coordinates from BBL Inc 01/22/04
Oregon State Plane North, NAD83/91 Intl Feet

Contaminant Data from NOAA Query Manager (09 24 03)
Source Stnplin E A

Suface Data = 0 - 30 cm
Subsurface Data = Max per location

Consensus Based Freshwater Sediment Quality Guidelines
Threshold Effect Concentration (TEC)
Probable Effect Concentration (PEC)

Map c \gis\projects\portlandharbor\ph_020204_t4 mxd
Plot Date 02 03 2004 B Shorr NOAA CPRD

0 500 1,000 Feet

Figure 6a
DDT (Total 6 isomers)
ConcentrationSurface PPM
Portland Harbor: T-4 Early Action Site
Category 1 Sediment Chemistry Data &
Proposed T4 Sediment Sampling Locations

# Appendix E

# *Appendix E*

# Historical Aerial Photographs

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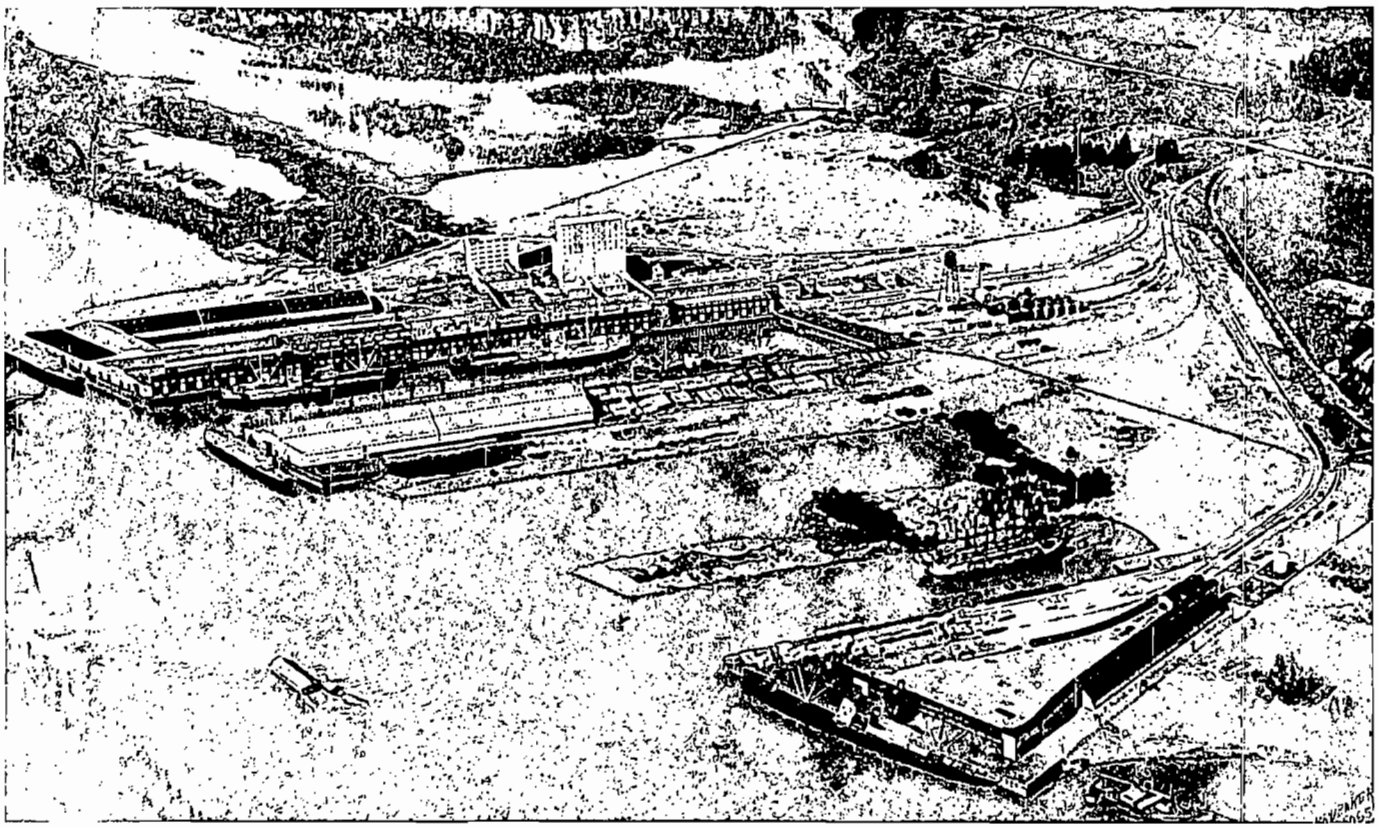

PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

1925 AERIAL PHOTOGRAPH

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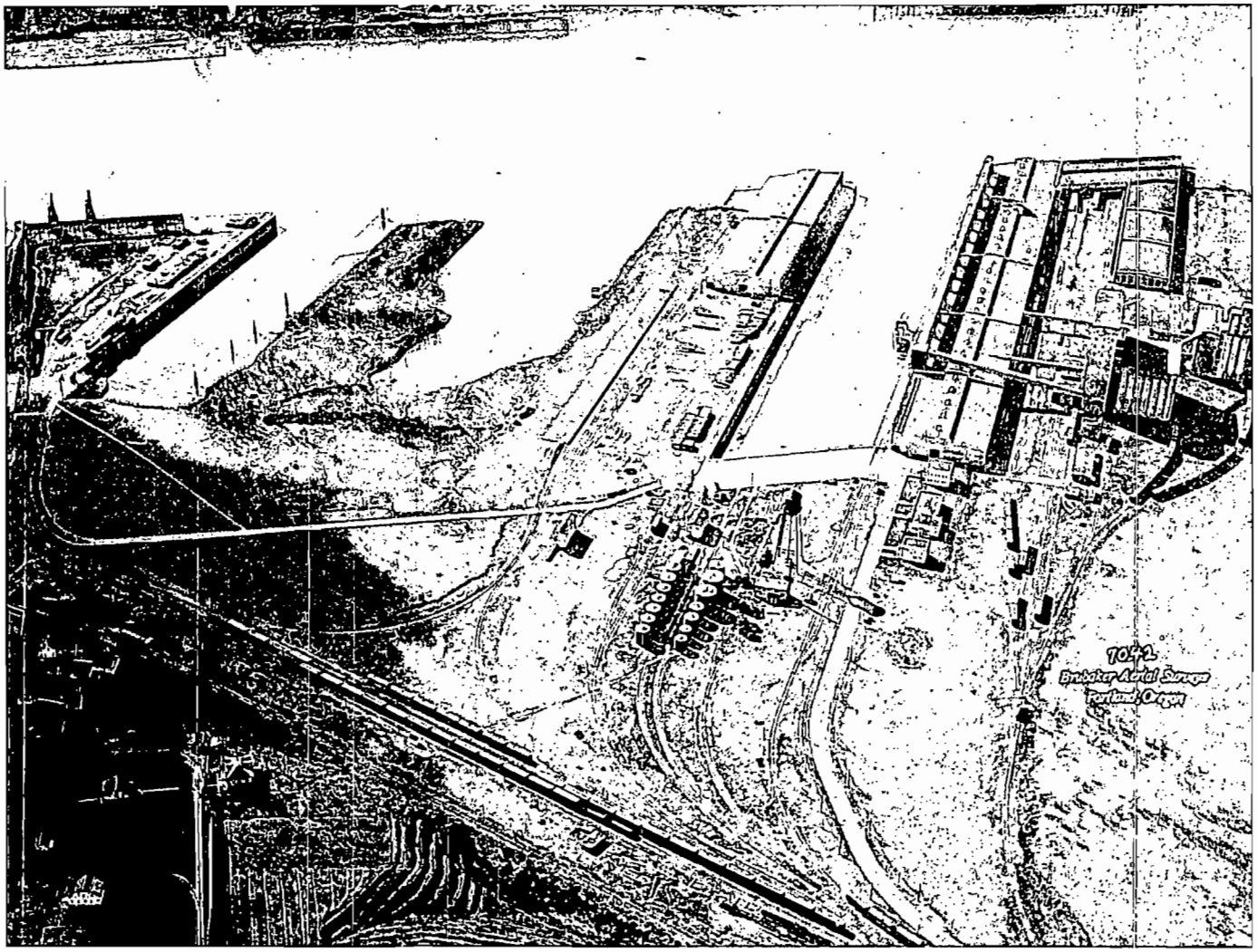
engineers & scientists

FIGURE
E-1




PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

1939 AERIAL PHOTOGRAPH

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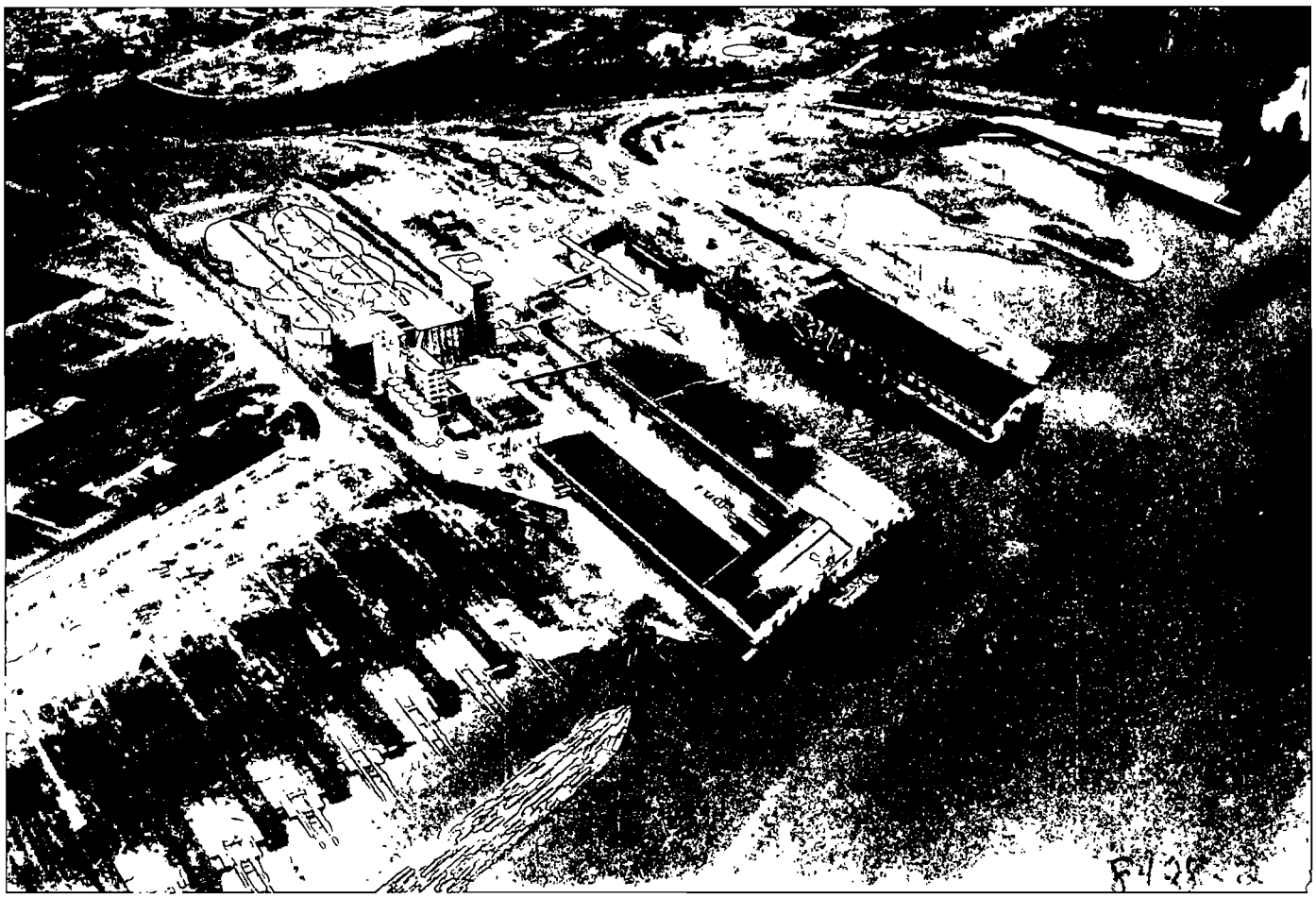
FIGURE
E-2



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1957 AERIAL PHOTOGRAPH

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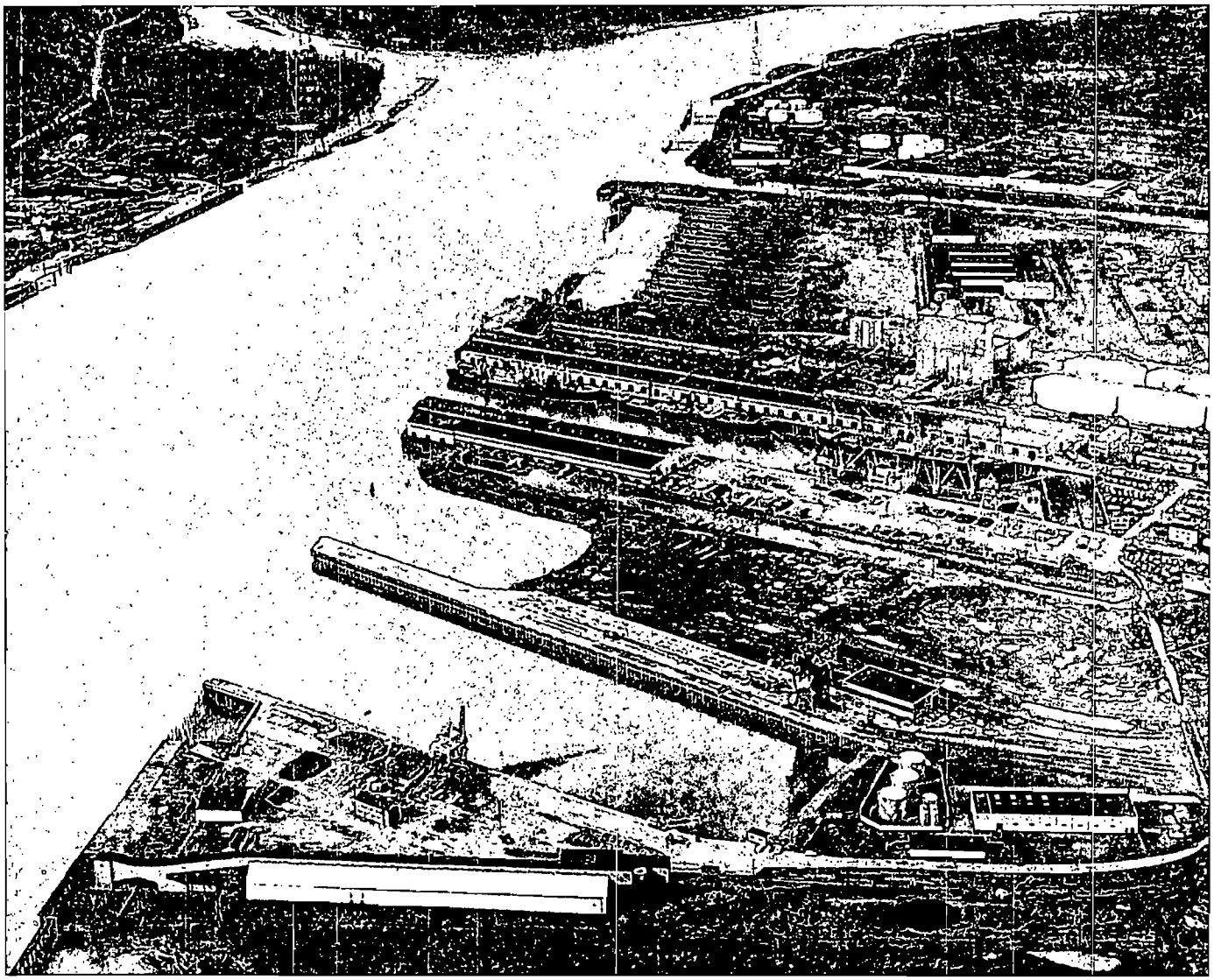
FIGURE
E-3



PORT OF PORTLAND
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TERMINAL 4 EARLY ACTION WORK PLAN

1961 AERIAL PHOTOGRAPH

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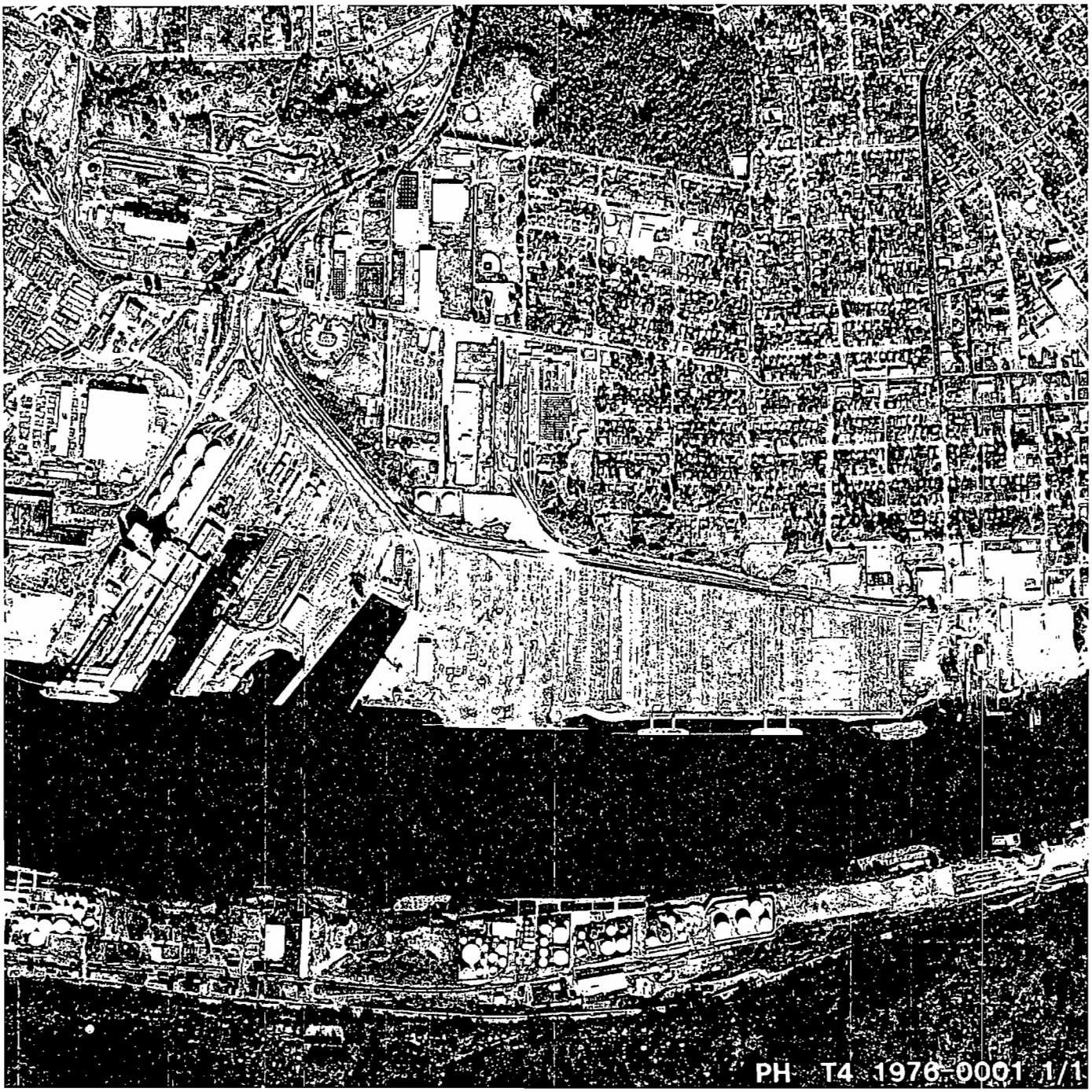
FIGURE
E-4




PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

1976 AERIAL PHOTOGRAPH

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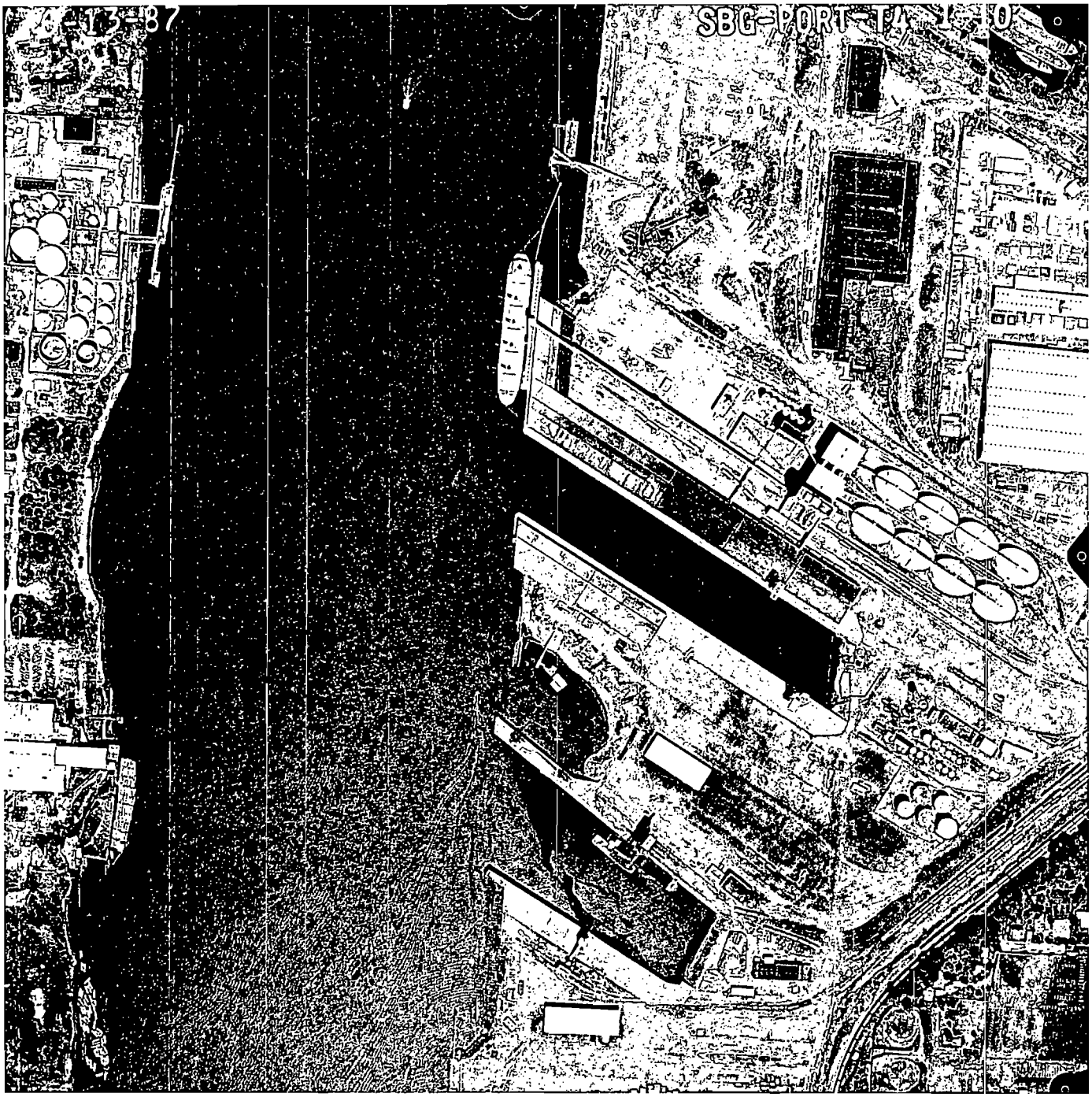
FIGURE
E-5




PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

1987 AERIAL PHOTOGRAPH

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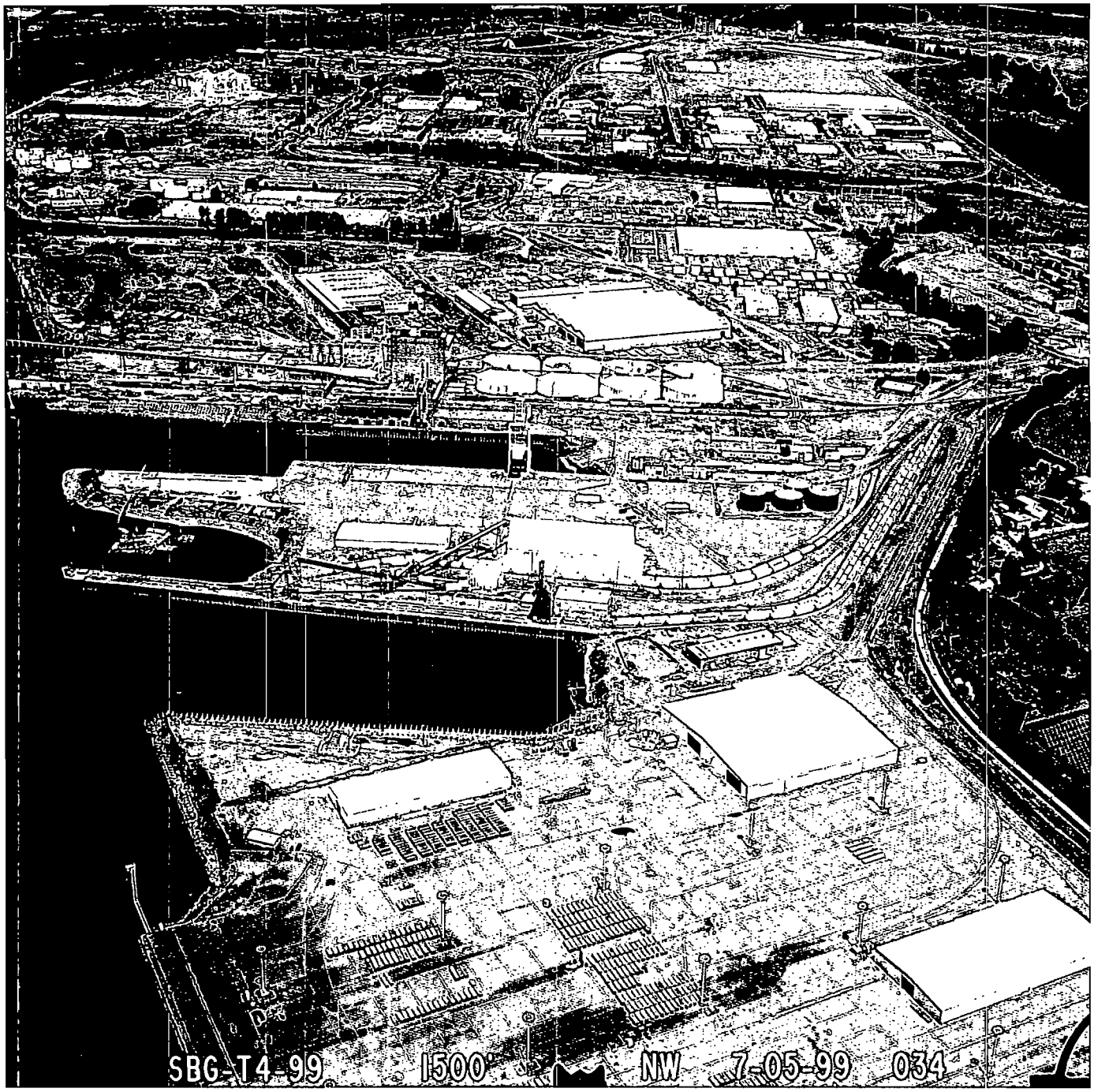
FIGURE
E-6




PORT OF PORTLAND
PORTLAND, OREGON
TERMINAL 4 EARLY ACTION WORK PLAN

1999 AERIAL PHOTOGRAPH

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FIGURE
E-7

Appendix F

# *Appendix F*

# Tabulated Responses to USEPA Comments on 12/30/03 Draft EE/CA Work Plan

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Responses to USEPA Comments on Terminal 4 Early Action Engineering Evaluation/Cost Analysis (EE/CA) Draft Work Plan Submittal dated 12/30/2003

| | ✓ | COMMENTS | RESPONSES |
|---|---|---|---|
| | | **LORI CORA/USEPA COMMENTS:** | |
| 1) | | 1. Section 1 - Introduction and Purpose. There should be a brief explanation of the objective/scope of the removal action and how it relates to the long-term remedial action ongoing for the harbor. In a few places in the work plan the Port makes very clear statements that the only media it is addressing in this removal action is contaminated sediment.<br><br>In accordance with my comment above, the second paragraph on page 1-1 should be revised as follows:<br><br>Ten potentially responsible parties (PRPs)and USEPA entered into an ~~The~~ Administrative Order on Consent (AOC) for Remedial Investigation/Feasibility Study (RI/FS), CERCLA-10-2001-0240 ~~entered into by the USEPA and the Superfund Site's potentially responsible parties (PRPs)~~ in the fall of 2001. ~~allows for the conduct of Early Actions.~~ The RI/FS will characterize the nature and extent of contamination and assess the biological and human health risks at the Portland Harbor Superfund Site. The Port is conducting this removal action under an AOC for Removal Action, CERCLA 10-2004-0009, dated October 2003. This ~~These~~ actions is ~~are~~ intended to address known risks from contaminated sediments at ~~specific locations within the Superfund Site~~ the Terminal 4 Removal Action Area. The Terminal 4 Removal Action Area, which is defined in the AOC and in Section 2.1, is shown on Figure 1-3. Contaminants found in Terminal 4 sediment samples led to a determination that a removal action at Terminal 4 is necessary to protect the public health, welfare, or the environment. ~~Accordingly, the Port and USEPA signed an AOC for Removal Action, CERCLA 10-2004-0009, in October 2003.~~ The AOC requires the Port to conduct an engineering evaluation and cost analysis (EE/CA) on various alternatives for the Terminal Removal Action. ~~This type of evaluation is intended to streamline the Superfund cleanup.~~ The Terminal 4 removal action is addressing contaminated sediment only. The Port intends to address contaminated surface water and groundwater migrating to the river from the uplands at Terminal 4 prior to cleanup of the sediment under the oversight of the Oregon | Acknowledged; Sections 1, 2 and 3 have been revised to incorporate and respond to this comment. |

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| | | Department of Environmental Quality (ODEQ). Although it is desired that the sediment cleanup will be a final response action for the removal action area, information learned from the Portland Harbor risk assessments and RI/FS may require that additional response action be taken. Data collection under the EE/CA will focus on acquiring only the information necessary and sufficient to compare Removal Action alternatives, select a preferred alternative, prepare a design, and implement the selected alternative. Broad-based characterization studies and general assessments are not necessary. ~~The Terminal 4 Removal Action Area, which is defined in the AOC and in Section 2.1, is shown on Figure 1-3.~~ | |
| 2) | | 2. Page 1-1, the third paragraph, second sentence should be revised to delete the word "must" and replace with the word "will." | Acknowledged; this change has been made. |
| 3) | | 3. Table 1-1. The summary of where and how the work plan addresses the SOW requirement for a process for reaching agreement on a cultural resources survey and procedures for addressing cultural resources is inadequate. See comments below on Section 2.2.1. and other sections of the work plan discussing cultural resources. | Acknowledged; however, no change has been made. The "SOW Requirement" column of Table 1-1 contains a complete and accurate statement of the SOW's requirements for the EE/CA work plan regarding cultural resources.<br><br>Also see response to Comment 4. |
| 4) | | 4. Section 2, subsection 2.2.1.1. - Native American Cultural Resources. Section 6, subsection 6.3 and Section 7, subsection 7.2 The SOW required that the work plan indicate that the tribes have accepted a previous cultural resources survey or contain a process for reaching agreement with the Tribes on a survey and process for developing procedures to protect and address such cultural resources during the sampling and performance of the removal action. The work plan does not meet this requirement. Sections 6.3 and 7.2 indicate that the Port is not going to do anything more. It does not indicate the Tribes have accepted previous surveys or accepts what the Port thinks it knows about the use of Terminal 4 for religious or cultural uses in the past. Thus, the work plan does not achieve the requirement in the SOW, nor does it meet the federal ARAR requirements under the National Historic Preservation Act or Archaeological Resources Protection Act. Please incorporate additional language into this section to document agreement to the survey, or a process through which the Port expects to reach agreement. | Acknowledged; language has been added to Subsection 2.2.1.1 describing the consultation the Port has undertaken to date with the Tribes regarding cultural resources and a process for addressing any further Tribal concerns for cultural resources at Terminal 4. The new language reads:<br><br>"Copies of the draft cultural resources report for Terminal 4 were provided to all six Tribes on August 11, 2003, and a meeting was held with Tribal representatives to discuss the Terminal 4 cultural resources report on October 7, 2003. No comments or concerns regarding the report or cultural resources at Terminal 4 were expressed at the October 7 |

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| | | | meeting nor have any comments been received subsequently. Letters requesting Tribal concurrence with the report and its findings were sent to the Tribes on February 10, 2004, and follow-up telephone contacts will be made with each of the Tribes. In addition, no comments have been received from the Tribes regarding the proposed Archaeological Monitoring Protocol outlined in the Terminal 4 field sampling plan. The Port will be further coordinating with the Tribes regarding the proposed protocol to ensure that it addresses Tribal concerns. As needed and appropriate, the Port will revise the cultural resources report or modify the Archaeological Monitoring Protocol after additional Tribal consultation as defined above." |
| 5) | | 5. Sections 5.1 and 5.2. Both of these sections seem to discount the presence of transformers on Terminal 4 as a possible source of PCBs in the removal action area. Why? They also discount that the higher subsurface levels of PAHs could mean contaminated groundwater is moving through the subsurface. Please explain why in the text, e.g. Cargill audit revealed no transformers containing PCBs via serial number checks with GE, etc. | Acknowledged; however, no change has been made. The work plan presents the best information currently available regarding the use of, hazardous substance releases on, and remedial investigations of the Terminal 4 Removal Action Area uplands. The Port is working with DEQ to identify contaminant sources in the Terminal 4 Slip 1 and Slip 3 uplands and perform appropriate source control activities. As part of that work, the Port is investigating and compiling information regarding the use of, releases at, and investigations of those areas. Such information may augment or supersede the information currently contained in the work plan. The Port will incorporate into the |

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| | | | EE/CA any new information developed during the uplands work and will provide access to the documents containing such information. |
| 6) | | 6. Section 5.3, first paragraph. Add the words "or orders." to end of last sentence. Also this paragraph illustrates how limited an action the Port intends to take, thus, the importance of the work plan to acknowledge this may not be a final action. | Acknowledged; the text in Section 5.3 has been revised as requested. However, the fact that this may not be a final action is acknowledged in Section 1 and therefore not represented in Section 5.3. |
| 7) | | 7. Section 6.2.1 and Section 8-1. The NTC Removal Guidance states that "Removal action objectives generally consist of environmental medium-specific goals for protecting human health and the environment. The objectives should be as specific as possible, but not so specific that the range of alternatives that can be developed is unduly limited. Removal action objectives should identify, for example, the contaminants of concern and exposure route(s) and receptor(s)." Page 20, "Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA." For the first RAO, it seems we need some other more measurable standard than "acceptable levels." If there will be a process in the EE/CA to devise the acceptable levels, that should be more clearly stated. The second RAO is a land use goal that is not a removal action objective. There are other places in the work plan that state that Terminal 4 will remain an active shipping terminal. It is not appropriate to repeat this in the RAOs. Please delete. | The comment regarding the first RAO is acknowledged; however, no change has been made. Inherent to the comment is the idea that agreement on specific concentration thresholds is possible at this time. However, this topic has been discussed extensively with USEPA, and it is the Port's belief that USEPA has agreed to the more general RAOs stated in the work plan. Pursuing specific concentration thresholds now would be redundant of work being conducted by the LWG and would jeopardize the schedule for the Early Action.<br><br>The comment regarding the second RAO is also acknowledged; the second RAO has been deleted. Note that the RAO was originally included because the Port believes it is necessary to emphasize the continued marine use of Terminal 4 to avoid the perception that other use scenarios are possible and, therefore, that other risk scenarios should be analyzed. |
| 8) | | 8. Section 6.10.2. The work plan is deficient in addressing several issues and aspects of a CDF alternative. Due to the significant ARAR issues associated with any amount of filling in the Willamette River, which is a flood-prone river, there should be some early regulatory (FEMA, City of Portland, USACE) and public outreach on the issue | Acknowledged; clarification has been made in Section 8.2. Evaluation is ongoing as to whether Portland ordinance Ch. 24.50.0060 is an ARAR. If it is an ARAR, it is an action– |

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| | | to see if it is even a viable alternative to pursue. Likewise, significant mitigation for aquatic impacts and flood level mitigation would be required for a CDF which the Port will need to have some early assessment of where, what, how, and how much it would cost to determine implementability and viability. I did not see in the work plan where or when an analysis of the impacts on the floodplain, or base flood level would be conducted on all alternatives (both removal and disposal). | specific ARAR. Per NTCRA guidance, action-specific ARARs are not addressed at this time. However, the text has been clarified to state that certain action-specific ARARs (i.e., Flood Insurance Act and cut and fill issues) will be addressed before removal and disposal alternatives are identified to allow for sufficient analysis. |
| 9) | | 9. Table 8-1 - Proposed ARARs Only substantive standards of the Oregon Hazardous Substance Remedial Action Rules are applicable or relevant and appropriate to the removal, not the "procedures to be used to implement the cleanup law." | Acknowledged; change has been made to Table 8-1. |
| 10) | | 10. Table 8-1 **Add** Portland Ordinance, Ch. 24.50.060(D) & (F)(8) to the federal location-specific ARAR list along with Executive Order 11988, 40 CFR Part 6, App. A, and 40 CFR 6.302(b). Part of the federal floodplain management requirements are implemented through Portland's ordinance. | Acknowledged; see response to Comment 8. Evaluation is ongoing as to whether the referenced Portland ordinance is an ARAR. If it is, it is an action-specific ARAR, which per NTCRA guidance is not addressed at this time. However, the text in Section 8.2 has been clarified to state that certain action-specific ARARs will be addressed before removal and disposal alternatives are identified. |
| 11) | | 11. Section 8 - Removal Action Evaluation Approach. Section 8.6.3 - Clean Water Act Section 404(b)(1) Evaluation. This section infers that only the preferred alternative would be evaluated under the 404(b)(1) guidelines. 404(b)(1) requires that any proposed dredging or filling action be analyzed through application of the guidelines' criteria. Thus, the EE/CA needs to include appropriate 404(b)(1) standards and criteria as a part of the comparative evaluation of alternatives (e.g. less environmentally-damaging practical alternative, cost, long and short term impacts, minimizing adverse effects, etc. should be noted in the comparative alternative analysis as being applicable to both the CERCLA and CWA processes). Additionally, divergent issues such as mitigation needs should be noted and included as part of any alternative's cost which would require it. By "appropriate 404(b)(1) standards and criteria" noted above, we are only distinguishing those standards and criteria related to alternatives evaluation and selection from those more depend on design details, which | Acknowledged; text has been added to Section 8.5.1.2 stating that a CWA 404 (b)(1) evaluation will be conducted for each alternative. |

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| | | would be analyzed and to be developed later. | |
| | | **DAWN SANDERS/CITY OF PORTLAND COMMENTS:** | |
| 12) | | 1. **Figure 2-22**. The City has delineated the basin boundary for the Outfall 52A conveyance system using stormline information and plumbing records. This information has been provided to the Port. Please add this to Figure 2-22. | Acknowledged; the City's delineated basin boundary, i.e., "catchment," has been used to revise the figure. |
| 13) | | 2. **Table 2-1 Chronology of Facility Development at Terminal 4:** Please add to the table that the properties and functions of the Commission of Public Docks were transferred to the Port of Portland in 1971. | Acknowledged; change has been made. |
| 14) | | 3. **On page 2-17, First paragraph under <u>City of Portland Fire Boat Station</u>:**<br><br>***Current text:***<br>When the Port of Portland and the City CPD merged in 1972, the fire boat station parcel was specifically exempted from the transfer of property.<br><br>***Substitute with:***<br>"When the Port of Portland and the City CPD were consolidated, the properties and functions of the Commission of Public Docks were transferred to the Port of Portland in 1971. The fire boat station parcel was specifically exempted . . ." | Acknowledged; change has been made using the revised text provided. |
| | | **SEAN SHELDRAKE/USEPA COMMENTS:** | |
| 15) | | 1. Appendix B, Health and Safety Plan. Suggest that you not limit diving to SCUBA operations as surface supply may increase safety/flexibility of diving in this type of environment. | Acknowledged; other diving protocols have been evaluated and the text has been amended per the comment. |
| 16) | | 2. "" Suggest that a requirement be added for USCG MSO notification of dive operations as well as a ship safe procedure/checklist requirement if dive operations are to be conducted while a ship is in port. | Acknowledged; the text in Section B-3.3.2.6 has been revised to read: "For field efforts that require using divers for river bottom observations, appropriate protocols such as notifying the USCG Marine Safety Office of the upcoming activity and dive flagging will be used to alert boaters where diving operations are under way." In addition, the following text has been added to the bulleted list of planning elements in Section B-3.3.2.5: |

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| | | | "vessel use of waterway (use of ship's safe procedure checklist if dive operations are conducted while a ship is in port)". Section B-3.3.2.5 also now states that when possible, dive operations will be restricted to those times when vessels are not in port. |
| 17) | | 3. "" Aside from sediment contact issues, coliform counts are high in the river during much of the year. Suggest that drysuits, drygloves, and full face masks be required. | Acknowledged; the requirement for use of PPE for protection from coliform has been added in a new Section B-3.4.2 titled Biological Hazards. |
| 18) | | 4. "" Some level of decontamination for divers contacting sediments should be specified. | Acknowledged; diver decontamination has been added as a planning element in Section B-3.3.2.5 and as one method for addressing biological hazards in Section B-3.4.2. |
| 19) | | 5. Section 8.3.3 This section should briefly discuss alternatives that have been screened out and why--for example, on-site, upland disposal. | Acknowledged; the text in Section 8.3.3 has been revised to indicate that onsite upland disposal was not considered because there's no available land area for such disposal. |
| 20) | | 6. "" It's unclear how disposal options are to be compared with respect to cost (this may be addressed in a later document); however, costs such as mitigation and long-term CDF-specific monitoring need to be included to compare cost of a CDF to upland disposal to ensure it is a comparison of the full cost of this alternative. | Acknowledged; the text has been clarified to reflect the fact that the cost of each alternative will be developed as the full implementation cost, including the costs of mitigation, disposal, and long-term monitoring, so that total implementation costs can be compared among alternatives. |
| | | **RENE FUENTES/USEPA COMMENTS:** | |
| 21) | | **General Comments**<br>Overall the draft document meets the proposed outline and general format. In addition, the report does seem to substantially be in agreement with concepts previously discussed between the Port and its consultants and EPA, and is well done and complete. | Acknowledged. |
| 22) | | 1. There are a number of comments, but most are relatively minor. A few which may be a problem and I want to highlight are included in both the general comments and the specific comments below. The first issue I want to highlight is the need to have a very clear | Acknowledged; Section 2.4 has been modified to include a brief explanation of the datums shown on the figures. |

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| | | discussion, explanation, and conversion table for the multiple datums used in this geographical area (these include Columbia River Datum, mean sea level, ordinary high water, City of Portland datum, and North American Vertical Datum). I suggest that these datums be explained as to the historical basis for use here, the datum reference itself, how they are related to each other, and that a conversion table be included (as has already been done in Figure 1-3 and most others). | |
| 23) | | 2. Another major issue is the need to have more complete maps which indicate where of the tanks, pipes, wells, etc. that are mentioned in the plan and tables are located. While some are available in the figures in this plan, many are not located in any figure. I understand that this may need to be done in the final plan if the information is not available now. If the material is not available yet, then this plan should indicate where that material will be included later in the process. | Acknowledged; however, no change has been made because the necessary information is not yet available. See response to Comment 5 for reasoning; the work plan presents the best information currently available regarding the use of, hazardous substance releases on, and remedial investigations of the Terminal 4 Removal Action Area uplands. The Port will incorporate into the EE/CA any new information developed during the uplands work and will provide access to the documents containing such information. |
| 24) | | 3. There are several mentions of a deep boring at the Terminal 4 (Shannon and Wilson, 1962). The boring logs should be included into the report since they may be some of the few deep well/boring logs available for the Portland Harbor project area, and may be of use in this and other projects. Similarly, if the log for the Cargill facility deep well is available, it should be included into the plan and/or in other subsequent reports, and referenced in detail here. | Acknowledged; available boring logs that will be used during the EE/CA have been added as an appendix to the work plan. |
| 25) | | 4. One additional issue which came up after reading the appendices at the end of the report is that the combination of the chemical parameters list (which is only <u>a subset of what is used for the Portland Harbor sampling</u>), and the higher detection levels proposed (again compared to the Portland Harbor Quality Assurance sampling plan), will make it impossible to make risk assessment calculations comparable to those done for the main Portland Harbor Remedial Investigation (RI). I do not see a problem with the sampling for the proposed cleanup volume, but mostly with the new sediment surface created. The proposed sampling interval of two feet will not provide the same sampling interval used for Portland Harbor, and again it will make comparability of the new exposed sediment surface quality difficult. | Acknowledged; with regard to reporting limits, reporting limit goals in Table A2-1 have been revised to match the method reporting limits in Table A7-4 of the Portland Harbor RI/FS Round 1 Quality Assurance Project Plan Final Report (November 22, 2002). However, the list of analytes presented in Table A2-1 is based on the evaluation of existing data presented in Section 4 of the work plan. The |

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| | | This would require that the bottom core sample, where the new sediment surface is expected to occur after the dredging, would need to be a one foot deep sample, with a more comprehensive list of parameters and with the same detection limits as the Portland Harbor RI. This will be hard to predict during the coring event. I suggest that it is much easier and more reliable to have the T4 dredging occur first, and then to obtain a set of (the new) surface sediment samples for verification done using the same depth, methods and detection limits as the Portland Harbor RI. These data would be more comparable to the overall Portland Harbor project, and also may resolve any concerns about contaminants which were not detected in the core samples, but which drifted to the sediment surface from the disturbances during the dredging activities. | Port does not propose to revise the list of analytes.<br><br>With regard to post-dredging sampling, if dredging is selected as the Removal Action, post-dredging surface sediment samples will be collected and analyzed to confirm that the dredging met the Removal Action goals. However, post-dredging samples are to be specified in the Removal Action work plan, not in the EE/CA work plan. |
| | | Specific Comments: | |
| 26) | | 1. Figure 1-2. It may be useful to include some historical aerial photos to supplement the maps and other information presented in the plans. | Acknowledged; historical aerial photographs have been added in an appendix to the work plan. |
| 27) | | 2. Figure 1-3. First encounter with the issue of multiple datums. Small figure may be fine but need more explanation in text. | Acknowledged and addressed; see response to Comment 22. |
| 28) | | 3. Page 2-3. This is the first mention of Gatton's Slough. It may be useful to include a figure which indicates where the Slough was located, and also some more text as to what is known about this historic surface feature (depth, drainage area, material in channel, etc.) in this section and the next section. | Acknowledged; Figure 2-20 has been revised to depict the inferred location of Gatton's Slough. In addition, the text has been modified to summarize available information regarding the characteristics of this feature. |
| 29) | | 4. Page 2-5 and others. The concept of "head of slip" and "mouth of slip" are used throughout the report. These should be defined or indicated in one of the figures to avoid confusion when contaminant distributions are discussed. | Acknowledged; the text has been revised as suggested. |
| 30) | | 5. Page 2-9. Mention of the Union Pacific abandonment of "the pipeline because of leaks". There should be more details on this, and similar other known or potential sources, as to the abandonment, cleanup, or unknown conditions of the area of concern. | Acknowledged; however, no change has been made. See response to Comment 5 for reasoning; the work plan presents the best information currently available regarding the use of, hazardous substance releases on, and remedial investigations of the Terminal 4 Removal Action Area uplands. The Port will |

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| | | | incorporate into the EE/CA any new information developed during the uplands work and will provide access to the documents containing such information. |
| 31) | | 6. Page 2-12. The materials used and disposed from the NW Pesticide Company (and related pesticide businesses) needs to be discussed in more detail. There should be a detailed list of what pesticides and insecticides this company handled and where they were used and disposed. Describe how the area of the footprint of this company has been defined and sampled. | Acknowledged; however, no change has been made. See response to Comment 5 for reasoning; the work plan presents the best information currently available regarding the use of, hazardous substance releases on, and remedial investigations of the Terminal 4 Removal Action Area uplands. The Port will incorporate into the EE/CA any new information developed during the uplands work and will provide access to the documents containing such information. |
| 32) | | 7. Page 2-13. Another comment similar to the one about the pipeline above. Unclear if the UST had any formal decommissioning, testing, leaks, etc. Please include more details, and if unknown state that. This comment should be considered generic for other sites or sources in this section. | Acknowledged; however, no change has been made. See response to Comment 5 for reasoning; the work plan presents the best information currently available regarding the use of, hazardous substance releases on, and remedial investigations of the Terminal 4 Removal Action Area uplands. The Port will incorporate into the EE/CA any new information developed during the uplands work and will provide access to the documents containing such information. |
| 33) | | 8. Page 2-14. Terminal Flour Mills USTs and Quaker State UST decommissioning also need more detail as to locations and what is known about their impacts on the area. This comment should be considered generic for other sites or sources in this section. | Acknowledged; however, no change has been made. See response to Comment 5 for reasoning; the work plan presents the best information currently available regarding the use of, hazardous substance releases on, and remedial investigations of the Terminal 4 |

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| | | | Removal Action Area uplands. The Port will incorporate into the EE/CA any new information developed during the uplands work and will provide access to the documents containing such information. |
| 34) | | 9. Page 2-16. If methyl bromide was used at the facility for disinfestation, there should be a plan to sample for effluents and remnants of that process, or some discussion as to why that is not necessary. | Acknowledged; however, no change has been made. Methyl bromide is a gas at ambient temperature and pressure. It is highly unlikely that residuals of this compound would be found in environmental media. |
| 35) | | 10. Section 2.2.5. Adjacent Properties are all defaulted to the Schnitzer Steel Products investigation. It is unclear if this will later be incorporated into the Terminal 4 work, either in the uplands or the slips. Please clarify what the expectations are for incorporating these new data into the T4 EE/CA. | Acknowledged; only two properties are adjacent to the Removal Action Area sediments at Terminal 4, including property leased by Toyota on the upstream side and Schnitzer Steel on the downstream side. The purpose of the discussion of the adjacent properties is to reference their locations and status.<br><br>The adjacent properties north of the Terminal 4 uplands are undergoing independent investigations and are not included in the Terminal 4 upland or in-water investigations, with the exception of evaluation for potential offsite sources onto Port property. Defaulting to the Schnitzer Steel site is relevant for two properties that are owned by Schnitzer and were at one time considered separate sites by DEQ. |
| 36) | | 11. Section 2.2.5.2. Northwest Pipe and Casting. The other references I have to this facility indicate that they are named Northwest Pipe and Casing (no "t"). Please check on the spelling of the name. | Acknowledged; "Casting" has been replaced with "Casing" throughout the work plan. In addition, the discussion of NW Pipe and Casing has been modified to correct the |

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| | | | erroneous statement that it is included in the Schnitzer Steel investigation. |
| 37) | | 12. Page 2-30. The statement that no lamprey were identified in the harbor may be misleading in that it does not imply that they do not inhabit the area, but that they were not found during that particular sampling event. Consider rewriting this sentence or adding some more details. | Acknowledged; the text has been edited as requested. |
| 38) | | 13. Page 2-38. Deep geotechnical log should be included in report. It is unclear how many deep borings were done in this area. From the two paragraphs it appear that there are more than one near the Slough. Please clarify how many, the log name and date, and the locations of these borings. | Acknowledged; Figure 2-17 shows the locations of deep geotechnical borings, and the boring logs have been added as an appendix to the work plan. The site exploration plans from original reports have also been provided, if available, to further clarify the number and locations of these borings. |
| 39) | | 14. Page 2-40. Unconsolidated Alluvial Deposits. The locations of the 17 monitoring well installations and the logs of these should be included in the report if they are near the slips and to a useful depth. Similarly the Century West well logs, and the deep geotechnical borings (Gerwick 1959). | Acknowledged; the generalized locations of the shallow monitoring wells are presently shown on Figure 2-20, and the figure has been edited to identify these wells. Available deep geotechnical boring logs have also been added as an appendix to the work plan. Monitoring wells are generally shallow (refer to Hart Crowser, 2000c for logs and original study) and are not considered essential for the work plan document. |
| 40) | | 15. Page 2-41. The "seventeen groundwater monitoring wells..... were survey-located by a licensed surveyor and referenced to Columbia River Datum." Is that the commonly used datum for upland work and wells? Please clarify what the different datums used for the upland work and the river work are to assure that all the work done can be correlated with previous data. | Acknowledged; datums have been clarified as indicated in response to Comment 22. |
| 41) | | 16. Page 2-41. Please indicate what is known about the supply wells at the Port facility and any adjacent facilities. As presented in the last paragraph it is not clear whether the wells do exist or not, whether they are in use or not, and what the reason is that "status was not determined". | Acknowledged; Section 2.7.1 has been modified to reflect the absence of supply wells at Terminal 4. |

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| 42) | | 17. Page 2-44. It is unclear why the sedimentation of the slips is more during the low flow. Is that considering a time-weighted calculation? | Acknowledged; the modeling study to be conducted as part of the Terminal 4 EE/CA will attempt to address the question of relative importance of short-term events and long-term deposition during lower flows. The bathymetric analysis conducted by the Port of Portland concluded that deposition in the slips was greater at low flow based on a correlation of observed sediment accumulation volumes to the total time flows exceeding a given value (e.g. 20th percentile) during the survey interval. Although elevated sediment transport occurs during high flows, the long-term effect of low flows (which occur most of the time) can in some cases yield higher long-term deposition rates than do high-flow events. High-flow events may also remobilize sediments in circulation eddies within the slips if these sediments are much finer-grained than the sediments near the berths parallel to the river. |
| 43) | | 18. Table 3-1. There are many cases where there is not enough detail about the "Known Spills and Releases" similarly to the previous comments on pipelines and USTs. Please add detail to clarify whether the spills and releases have been investigated, or cleaned up, or not, for each case where there are potential large spills or sources. | Acknowledged; however, no change has been made. See response to Comment 5 for reasoning; the work plan presents the best information currently available regarding the use of, hazardous substance releases on, and remedial investigations of the Terminal 4 Removal Action Area uplands. The Port will incorporate into the EE/CA any new information developed during the uplands work and will provide access to the documents containing such information. |
| 44) | | 19. Chapter 4. This section needs to discuss the difference between category 1 or 2 data and Quality Assurance 1 and Quality Assurance 2 data. This is not mentioned in this section, | Acknowledged; text has been added describing in further detail the proposed Level III and |

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| | | and it could potentially be a major problem if the data is needed for the risk assessment. Having a clear definition of the data and what the limitations of its use are in this plan would help to minimize conflicts later on. | Level IV data validation that will be performed on chemical data collected for the EE/CA. A comparison of CLP Level III and Level IV data validation and PSDDA QA1 and QA2 data validation has also been provided. The text now describes the difference between Category 1 and Category 2 classifications and the CLP and PSDDA methods of data validation. |
| 45) | | 20. Table 4-1. The issue of Category 1 and 2, and of data QA1 and QA2 needs to be resolved in this table also. | Acknowledged; however, no change has been made. The Port is not proposing to perform data validation on existing data at this time, beyond what has been done for Portland Harbor (presented in the Portland Harbor RI/FS Revised Draft Final Programmatic Work Plan, November 13, 2003), which is considered adequate for the purpose of proposing sampling locations and analyte lists. New data collected for the EE/CA will undergo Level III or Level IV data validation (comparable to PSDDA QA1 and QA2 data validation) as presented in the EE/CA QAPP. However, the Port may perform additional data validation on existing data if those data are to be used in the analysis of Removal Action alternatives and if it is determined that additional data validation is required. |
| 46) | | 21. Figure 4-4 The lower PAHs graph seems to have an error. The "Max 124,000" is below the axis maximum value. Either the value is incorrect or it was not plotted. | Acknowledged; an explanation has been added to the figure. The maximum detected concentrations for total PAH and total PAH reported were not plotted on the figure. Instead, the phrases "Max 124,000" and "Max 208,000" were included on the figure to allow |

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| | | | for an expanded scale. |
| 47) | | 22. Page 5-2. Section 5.1.1. "...sediment tend to be great(er?) than..." | Acknowledged; text has been revised as suggested. |
| 48) | | 23. Page 5-2. Section 5.1.2 " sediment are generally great (er?) than ..." | Acknowledged; text has been revised as suggested. |
| 49) | | 24. Figure 5-1. Figure seems fine overall, but in our recent discussion it was mentioned that there was no easy way to get samples under the armored slopes. If in fact the slopes are as depicted in these figures, rather than a more pyramid type rip-rap design, then it should not be hard to take some angled borings from the uplands to get samples below the armored portion of the slopes. | Acknowledged; however, no change has been made. Figure 5-1 is a pictorial and general representation of the conceptual model of the Removal Action Area. Figure 5-1 is not intended to accurately represent physical conditions at the site. Also see the response to Comment 85, which discusses the collection of sediment cores from the sediment above the riprap area. It is not our intent to collect sediment below the riprap. |
| 50) | | 25. Figure 7-4 and A1-2. The proposed two (2) feet long bottom core samples which will be used to determine the sediment quality of the "new post-dredging sediment surface" may be a problem when compared to the Portland Harbor one foot samples. See general comments above for more detail. | Acknowledged; however, no change has been made. See the response to Comment 25. |
| 51) | | 26. Figure 7-5. There are no deep borings in the middle of Slip 3, except near the mouth. I would suggest considering adding about three (3) more samples along the center of Slip 3, and one or two more along centerline of Slip 1, unless assumptions will be made based on the worst case of the borings at either side of the slip as now proposed. | Acknowledged; one additional boring has been added to the center of Slip 3. Interpolations of sediment quality will be based on the borings at either side of the slips in areas where there are no borings in the center. Interpolations will be made based, in part, on sediment chemistry, stratigraphy, and dredge history. |
| 52) | | 27. Appendix A2. Table A2-1. The analytical methods detection levels do not seem to be the same ones used for the Portland Harbor RI/FS. In addition, the list of compounds seems to be a much smaller subset than the Portland Harbor list. I am comparing this list to the PORTLAND HARBOR RI/FS ROUND 1 QUALITY ASSURANCE PROJECT PLAN FINAL REPORT November 22, 2002, table A7-4. Also see general comments section of this memo. This is not a problem with the removal work, but mostly with the final (new) surface confirmation sampling for the risk assessment. | Acknowledged; reporting limit goals in Table A2-1 have been revised to match the method reporting limits in Table A7-4 of the Portland Harbor RI/FS Round 1 Quality Assurance Project Plan Final Report (November 22, 2002). However, the list of analytes presented in Table A2-1 is based on the evaluation of |

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| | | | existing data presented in Section 4 of the work plan. The Port does not propose to revise the list of analytes.<br><br>With regard to post-dredging sampling, if dredging is selected as the Removal Action, post-dredging surface sediment samples will be collected and analyzed to confirm that the dredging met the Removal Action goals. However, post-dredging samples are to be specified in the Removal Action work plan, not in the EE/CA work plan. |
| | | **DANA DAVOLI/USEPA COMMENTS:** | |
| | | General Comments: | |
| 53) | | (1) Throughout the document, reference is made to Category 1 and Category 2 data categories "in accordance with the Portland Harbor RI/FS protocols". As the Portland Harbor draft RI/FS Work Plan is now written, Category 1 data are of known quality and are considered to be acceptable for use in decision making. These data have undergone a QA1 level of review. Category 2 data are of generally unknown or suspect quality. As a part of our comments to the LWG for the Portland Harbor RI/FS Work Plan (to be sent at the end of January), EPA will be informing the LWG that data that will be used for some parts of the RI/FS (e.g., the baseline risk assessments) will need to undergo QA2 level of review, which is a more in-depth quality assurance review (The list of items/ purposes for which a QA2 data review will be needed is not completely defined). To be consistent, the T4 EE/CA should have the same language that's in the Portland Harbor RI/FS. | Acknowledged; text has been added describing in further detail the proposed Level III and Level IV data validation that will be performed on chemical data collected for the EE/CA. A comparison of CLP Level III and Level IV data validation and PSDDA QA1 and QA2 data validation has also been provided. See responses to Comments 44 and 45. |
| 54) | | (2) The number of semi-volatiles and pesticides that are being analyzed in sediments is less than that required in the Portland Harbor RI/FS QAPP for sediments; and, for many chemicals that are being proposed for analysis in the EE/CA, the analytical limits of detection are higher than the Portland Harbor RI/FS QAPP. For example, the only chlorinated pesticides being analyzed for are the DDT series (DDT, DDE, and DDD). For Slip 3, this may be warranted given the fact that this is an EE/CA and the history of the slip seems to point toward a limited list of contaminants. It is also less worrisome for Slip 3 since it seems that most of it will be dredged. For Slip 1, however, the remedial actions are less | (1) The portion of the comment having to do with fumigants used by the Defense Department is acknowledged; however, no change has been made. See response to Comment 5 for reasoning; the work plan presents the best information currently available regarding the use of, hazardous substance releases on, and remedial |

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| | | certain and there is little existing data. Of particular concern are the many unknowns about Cargill and Schnitzer and the fact that fumigants were manufactured by Leckenby and used by the Defense Department. I suggest that: (1) the Port attempt to get more information on the fumigant that was manufactured, including how it was processed and the wastes disposed of, and more information on the materials used by the Defense Department (2) EPA consider requiring a more extensive list of analytes for Wheeler Bay and Terminal 1 as well as the areas in Slip 3 where a residual risk will be done, and (3) require the same detection limits that were attained for Portland Harbor. | investigations of the Terminal 4 Removal Action Area uplands. The Port will incorporate into the EE/CA any new information developed during the uplands work and will provide access to the documents containing such information.<br><br>(2) The portion of the comment having to do with the list of pesticide analytes is also acknowledged; however, based on the available data (as summarized in work plan Tables 4-3 and 4-5), total DDT appears to be the only pesticide of potential concern in the site sediment.<br><br>Thirty-five pesticides (besides total DDT) have been analyzed for in a number of surface sediment samples (typically about 20 samples) from Slip 1. In addition to total DDT, only five pesticides (gamma-chlordane, alpha-chlordane, aldrin, endosulfan sulfate, and beta-hexachlorocyclohexane) were detected in Slip 1 surface sediment samples. Of these, gamma-chlordane was the most frequently detected in Slip 1 surface sediment samples; it was detected in four samples at concentrations slightly above the detection limit. Alpha-chlordane was the second most frequently detected pesticide; it was detected in two samples at concentrations slightly above the detection limit. Aldrin, endosulfan sulfate, and beta-hexachlorocyclohexane were each detected in one surface sediment sample from |

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| | | | Slip 1 at concentrations slightly above the detection limit.<br><br>Twenty-one pesticides (besides total DDT) were analyzed for in one to three subsurface sediment samples from Slip 1. In addition to total DDT, methoxychlor was the only pesticide detected in Slip 1 subsurface sediment samples; it was detected in one sample at an estimated concentration below the detection limit.<br><br>Although, on the basis of this information, the Port does not believe additional pesticide analyses are necessary, the Port proposes to instruct the lab to analyze for the full list of pesticides but report only DDT for the sediment samples collected for the EE/CA. DDT and PCB sediment data collected for the EE/CA will then be evaluated. If elevated concentrations of DDT are observed, the lab will be asked to report the full pesticide list for a select number of Slip 1 sediment samples. The specific samples and the number of samples which will have the full pesticide list reported will be discussed with the USEPA once the DDT data have been evaluated.<br><br>(3) The portion of the comment having to do with detection limits is acknowledged; reporting limit goals in Table A2-1 have been revised to match the method reporting limits in Table A7-4 of the Portland Harbor RI/FS |

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| | | | Round 1 Quality Assurance Project Plan Final Report (November 22, 2002). See response to Comment 52. |
| 55) | | (3) It is not very clear from the RI or FSP as to what criteria were used to select the sediment sample locations and if/how existing data were used. There are no figures which have both the existing data points as well as the proposed sampling points so it's difficult to tell how the new data will complement the old. Unless the existing data already provide the information and they can meet QA2 validations levels, I would suggest that more sediment surface/core samples be added down the middle of both Slip 1 and Slip 2. Two or 3 additional cores should be added between the head of the Slip 1 and VC25. Three cores should be added in Slip 1- one between VC08 and the head of the Slip and 1 or 2 between VC08 and VC11.<br><br>The other sampling issue relates to post-remediation sediment levels. From our phone call on January 9, it was not clear how post-remediation levels would be determined (i.e., will sampling be done after sediment is removed or will the Port rely on the core samples that are a part of the current FSP?). To be consistent with the Portland Harbor RI/FS, sediment data from the top 1 foot of the surface after remediation would be that used for estimating residual risk and compliance. The two foot core intervals being used in this FSP will not provide that interval, plus it would seem that during remediation, sediments will move around and surface levels will not be the same as those estimated for the cores. Therefore, some post remediation sampling of surface sediments is warranted. | The portion of the comment having to do with sample locations is acknowledged. Figure 7-3 presents existing and proposed surface sediment sample locations. Figure 7-5 presents existing and proposed subsurface sediment sample locations. Proposed sediment sample locations were selected to fill gaps in the existing data on the vertical and horizontal extent of contamination. See response to Comment 51 with regard to the collection of additional cores.<br><br>The portion of the comment having to do with post-remediation sediment levels is acknowledged; see the response to Comment 25. |
| 56) | | (4) The language in the EE/CA that addresses how risks will be assessed is very open-ended and vague. My understanding thus far is that: After the data from the next round of sampling are complete, the data will be compared to sediment screening values that are based on benthic toxicity (sediment quality screening guidelines, SQGs); the various remedial actions alternative will be compared to each other using these benthic SQGs (where do the bioassay results fit in here?). For each remedial action alternatives, the sediment remaining after remediation will be evaluated by other methods/remedial goals in addition to a comparison to the benthic SQGs. These other methods/remedial goals are not defined in the EE/CA Work Plan but will be determined after the data analysis are complete. Discussions on these will begin in August and culminate in a Technical Briefing at the end of October. These methods/remedial goals will be consistent with what has been developed by the Portland | Acknowledged; no specific action not otherwise discussed in responses to subsequent comments appears required to address this comment.<br><br>The understanding expressed in Comment 56 of the Port's proposed process is largely correct. Initial RAOs will be developed on the basis of existing information, including sediment chemistry and existing bioassay results. |

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| | | Harbor RI/FS (e.g., methods, SQGs, PRGs). If methods/ remedial goals have not been developed as a part of the Portland Harbor RI/FS process at that time (which is likely), they will be developed specifically for the EE/CA in consultation with EPA. For human health, I am assuming that the risk evaluation and development of remedial goals would be limited to a consideration of human health risks resulting from bioaccumulation of contaminants through the food chain (i.e., consumption of biota) and direct contact with in-water sediments by fishers (Although the current draft of the Portland Harbor RI Risk Assessment Workplan does not include an assessment of direct exposure for humans for in-water sediments, in our comments that will be submitted to the LWG in the next few weeks, EPA is asking that this pathway be added for fishers). As discussed in my comments on the Conceptual Site Model (see page 5-5 below), risks from exposure to surface water and to beach sediments would be assessed in the Portland Harbor risk assessment. | Once Removal Action alternatives have been developed, specific risk assessment needs will be determined and implemented, including the collection of additional data if necessary to support the selection of alternatives.<br><br>The human health risk assessment will incorporate relevant pathways, including bioaccumulation pathways and direct contact with sediments. The methods identified for risk assessment will take into account information that may be available from the harborwide RI/FS process, including fish tissue sampling and analysis and any risk-based criteria approved for use by the Agencies. |
| | | Specific Comments: | |
| 57) | | 1. page 3-1, Potential Sources of Contamination - It would be useful to add photos of historical overflies to this chapter. They can provide a lot of good information as to sources, processes, waste piles, discharge areas, discharge points, etc. | Acknowledged; historical aerial photographs have been provided in an appendix to the work plan. |
| 58) | | 2. page 4-1, Summary of Existing Data - The comparisons in Figure 4-3 are not very useful because these do not show how contaminants vary laterally or vertically within the slips. Language in this section which describes qualitatively how contaminants vary in the slips is also not very useful. On Monday (01/12/04) I received a copy of Figures 11 through 16 from the Hart-Crowser Report (April 18, 2000). I found these helpful. However they did raise some other questions. These figures are concentration contour maps of Slip 3 for lead, zinc, HPAH, LPAH, pencil pitch, and diesel. The bioassay results are also shown. There does not seem to be a good correlation between the contaminant levels and the areas where the toxicity tests failed (i.e., the areas of highest concentration for the five contaminants were not the same as the areas where the bioassays failed). Is there an explanation for this? Are there some other contaminants | Acknowledged; however, no change has been made. As the commentor indicated, brief inspection of correlation between laboratory toxicity test results and slip sediment chemistry does not reveal a strong correlation. This could result from multiple causes, including different mixtures of chemicals (e.g., PAHs) in different parts of the slip, the lack of a bioavailable measure in the sediment analysis results, and the expression of results in a binary "hit/no hit" fashion instead of the |

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| | | that the Port thinks may be resulting in the bioassay failures? How will the decision be made to use the bioassay data versus concentration data in deciding on areas to remediate? | degree of toxicity. It could also be due unknown contaminants in the slip. The analyte suite used for the EE/CA characterization is more broad than that used in the Slip 3 RI and will help us discern whether other contributors to toxicity are present.<br>We will consider this issue as part of our evaluation of the data to be acquired under the EE/CA.<br><br>The Removal Action alternative will be identified using primarily concentration data from sediment chemical analyses, with supporting information from the prior toxicity tests. |
| 59) | | 3. Page 5-5, Pathways and Receptors/Conceptual Model "Trespassers" should be replaced with "transients." Although transients are unlikely in Slip 3, this could be a pathway in Slip 1 if current operations cease and are not replaced with new companies (a footnote can be added to clarify this). For transients, ingestion and direct contact with surface water; ingestion and direct contact with beach sediments, and ingestion of biota are all potentially complete pathways (but ingestion of biota is only being evaluated quantitatively under the fishing receptors). It is my understanding that the beach sediments and surface water pathways will be dealt with in the Portland Harbor RI. Therefore, all of the boxes pertaining to sediment and surface water would be colored blue and none would be assessed in the EE/CA. Fish ingestion should be colored green (but would not be assessed in the EE/CA quantitatively since fishing is covered under the fisher categories).CSM. Three sediment samples will be collected by the LWG in Slip 1 to assess shorebird exposure (none in Slip 3) but as of now these would not be used for human health since transients have not been seen in this area. (If future land use should change to make Slip 1 more attractive to transients the shorebird data would be used for the human health assessment). Two surface water samples have been proposed by EPA for the Terminal 4 area - one at the head of Slip 1 and one at the head of Slip 3. | Acknowledged; the Port will specify that risk analysis for transients is to be conducted in the future if land use under the Port's ownership changes or of the property is sold by the Port. Currently, however, the Port anticipates future land use at Slip 1 to be industrial or commercial operations that include the level of security now in place. As a result, the transient scenario does not appear to be currently applicable.<br><br>The comment regarding analysis of risk from fish consumption is also acknowledged, and that language has been clarified. The Port's intent in the conceptual site model was to show relevant pathways, not necessarily the suite of pathways for each receptor scenario. |

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| | | | Ingestion of fish will be evaluated in each scenario for which it is appropriate. The exposure parameters (i.e., intake rates, frequency, duration, etc.) will be identified when detailed risk analysis procedures are developed. These procedures will be consistent with those adopted for the harborwide RI/FS. However, the Port asks that the exposure be scaled to potential access and use levels appropriate to the conditions at Terminal 4. |
| 60) | | 4. CSM. "Recreational beach user" should be added and dealt with the same way as transients. Terminal 4 has not been selected as an area to be evaluated for this pathway in the Portland Harbor RI, but this could change depending on future land use. This can be noted in a footnote. | Acknowledged; no change has been made. Recreational beach use at Terminal 4 is inconsistent with the current and planned land use at Terminal 4. Aside from the security at the site, which alone precludes recreational beach use, commercial/industrial activities and the aesthetics of the site are not conducive to recreational beach use. If, as discussed in the response to Comment 59, the transient scenario is deemed appropriate in the future, it would include the beach activities and contact envisioned with recreational use. The Port proposes that the transient scenario will be included if land use or ownership at the site changes from that currently envisioned. |
| 61) | | 5. CSM. "Site worker" should be changed to "dockside worker" and the symbols should be the same as those in the Portland Harbor RI/FS. | Acknowledged; the requested changes have been made. |
| 62) | | 6. CSM. For fishers, all three fishing categories - Native Americans, recreational, and non-tribal fishers - should be included because future land use is uncertain for Terminal 1 as of now. Also, any remedial goals developed for the Portland Harbor site could consider all three groups. The closed and open circles should be the same as those for the Portland Harbor RI/FS. Rather than change the CSM by adding three columns for the | Acknowledged; the potential scenarios have been added as a footnote to the conceptual site model. However, as noted in the response to Comment 59, the current conceptual site model is largely intended to identify the |

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| | | different potential fishing populations, just add a footnote that clarifies that "Fisher/Consumer" are all 3 groups. As the Portland Harbor CSM Draft Risk Assessment Work Plan is now written, the pathways that will be quantitatively evaluated for fishers include direct contact with surface water and sediments as well as fish ingestion. Although, the direct contact with sediments is now limited in the RI Work Plan to beach sediments, not in-water sediments, EPA will be requesting that direct contact with in-water sediments be added for fishers. Therefore, for the EE/CA the fish ingestion pathway and direct contact with in-water sediments would be quantitatively assessed for the residual risk assessment. CSM. This limits the exposure pathways to be quantitatively assessed in the EE/CA in the residual risk phase to ingestion of biota by fishers and direct contact to in-water sediments by fishers. Direct contact with beach sediment and surface water by all human receptors would be dealt with in the Portland Harbor RI/FS. | potential exposure pathways, not to provide a comprehensive definition of exposure scenarios. When the detailed risk assessment needs are identified, the scenarios should also be identified. |
| 63) | | 7. CSM. Exposure during diving is a pathway that may be added the Portland Harbor RI Work Plan - I am in the process of getting log data on dives done by the Multnomah County Sheriff's Department. There is also concern for other types of occupational divers that may be in the river for other purposes such as repairing underwater structures. | Acknowledged; the diving scenario will be added to the risk assessment scenarios if it is included in the harborwide RI, deemed appropriate for the Terminal 4 project, and is necessary for making Removal Action decisions. |
| 64) | | 8. CSM. Remove the word "recreational" in front of "fishers" on page 5-5 and change other language in Section 5.3 to make it consistent with the CSM. Also, clarify what will be assessed as a part of the EE/CA versus the Portland Harbor RI. | Acknowledged; the term "recreational" has been removed, and the text has been revised to clarify the scopes of the Terminal 4 and harborwide assessments. |
| 65) | | 9. Page 6-6, Section 6.5.2 - As discussed above, only 2 pathways would likely be assessed for humans as a part of the EE/CA - ingestion of biota and direct contact with in-water sediments by fishers. Change the language in this section to make it consistent with the CSM and the fact that only two exposure pathways for humans will be assessed for residual risk in the EE/CA. | Acknowledged; the text and associated figures have been edited as requested. |
| 66) | | 10. Table 6-1, DQOs for Human Health - "Acceptable" residual risk should more specifically defined, if not in the body of the table, then as a footnote. According to the EE/CA guidance, "Acceptable " would be defined differently if the non-critical removal is an interim step versus if it is expected to be the last action taken. It seems that for this EE/CA, "acceptable" for the interim step is defined as sediment levels below the benthic | Acknowledged; the text has been revised to reflect this definition of acceptable risk. Although technically an interim measure associated with the harborwide RI, the Removal Action for Terminal 4 is intended to |

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| | | SQGs (which ones?). For final actions (i.e., the "residual risk evaluation"), the following language, adapted from the NCP, may be appropriate to define "acceptable": "Remediate contaminated sediment to ensure that contaminant levels are not above ARARS or above risk based goals when ARARS are not available or are not protective. Other factors (e.g., detection limits, background) and uncertainties may also be considered. For carcinogenic effects in humans, EPA's Superfund Program uses $10^{-6}$ to $10^{-4}$ as an acceptable cancer risk range; for non-cancer effects, the goal is to limit exposures to levels below the RfD. Protective is defined as a cancer risk of less than or equal to $10^{-4}$; for non-cancer effects, protective is defined as exposures equal to or less that the RfD." Clarify what is meant by "relevant criteria". | meet the requirements for a permanent remedy. |
| 67) | | 11. Page 7-2 and 7-3, Human Health Risk Assessment- It should be clear that while the initial screening for the removal actions alternatives will be based upon comparison to existing SQGs based upon benthic toxicity, the analysis of residual risk for both human and eco effects will include an assessment of risk resulting from bioaccumulation of contaminants through the food chain. Therefore, it is possible, depending upon the COCs selected for the site, that SQGs for bioaccumulation may need to be developed and used, assuming that none will be available from the PH RI. Also, change language in the first few sentences of page 7-3 to clarify that the EE/CA residual risk analysis will consider biota consumption and direct contact with in-water sediments for fishers. | Acknowledged; the text has been clarified to reflect that bioaccumulation in fish is a potentially important pathway evaluation for the Removal Action decision. However, it is also possible that the Removal Action alternatives will not require development of bioaccumulation-based SQGs to support Removal Action decisions. In addition, Section 7.4.1 has been revised as requested. |
| 68) | | 12. Page 7-13, Water Quality Data - I am not that familiar with the DRET evaluation but it would seem that since the concentrations of contaminants are much higher in that part of the slips closest to the mouth, a more conservative approach would be to do 2 DRETs for each slip - one being a composite of samples from the mouth to the middle of the slip and the other being a composite form the middle of the slip to the river. | Acknowledged; however, no change has been made. The DRET simulates the release of sediment-bound and porewater constituents into the receiving water column at the point of hydraulic dredging. The DRET generally conservatively predicts (i.e., over predicts) the release of constituents at the point of dredging. Because the DRET conservatively predicts the release of constituents from a hydraulic dredge, the Port does not recommend an additional layer of conservatism for the DRET that would result from performing two DRETs for each slip. |

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| | | **JOE GOULET/USEPA COMMENTS:** | |
| 69) | | 1. Section 4.4, Constituents of Potential Concern, the last two sentences of the second paragraph, sediment chemistry that falls in the gray area in which toxicity effects may occur may cause toxicity and may need removal. Sediment chemistry concentrations above the probable effects SQGs require further delineation and investigation to determine they are likely to cause toxicity and likely require removal. Will sediment containing chemistry concentrations in the "gray area" require further delineation and investigation as well as the those above the probable effects SQGs? What does further delineation and investigation entail? Will this be described later? | Acknowledged; the text has been clarified. Further delineation and investigation means that a cost analysis will be performed to compare the cost of possibly dredging the sediment that contains chemistry concentrations in the "gray area" versus the cost of capping such sediments. |
| 70) | | 2. Table 6-1, Ecological Health/Decision Rule, a UCL95 for mean post-action surface sediment concentration in each unit (each slip) should not exceed chemical specific SQGs. An exposure unit of the entire slip may be too large for benthic exposure. A smaller unit should be considered. | Acknowledged; however, no change has been made. To be consistent with a population-level approach, the baseline assumption has been that each slip represents the extent of the benthic populations. This approach seems conservative in terms of protecting the benthic community and populations therein. |
| | | **HELEN HILLMAN/NOAA COMMENTS:** | |
| | | **General Comments:** | |
| 71) | | Overall, BBL did a nice job preparing this document, and most of our comments are minor ones. We are somewhat concerned by a general lack of detail in the EE/CA workplan. A lot of important decisions, such as the methodology for evaluating residual risk, are being put off until the "Technical Briefing that will initiate the EE/CA." This language appears in several places throughout the document, including Section 6.5.1, and we assume it comes straight from the AOC. This process seems odd to us, but may be a normal practice removals; we are more accustomed to the remedial process. If EPA is comfortable moving ahead without agreement on exactly how the data will be used, then we should move ahead. However, I worry that we are just putting arguments off to the future. | Acknowledged; no change required by the comment. The approach described in the work plan is as agreed in the AOC. |
| | | **Specific Comments:** | |
| 72) | | 1. Table of Contents. Page numbers need to be added to the Table of Contents. | Acknowledged; however, no change has been made. Page numbers for the body of the report are included in the table of contents. As a matter of corporate style, BBL does not paginate tables and figures. |

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| 73) | | 2. Section 2.1, Area Setting and Boundaries. Please explain somewhere in this section why the sediment adjacent to the auto storage area is not included in the early action. | Acknowledged; the text has been clarified. The auto storage area is not part of the Removal Action Area as defined in the AOC. |
| 74) | | 3. Section 2.2.1.1, Native American Cultural Resources. The text in this section mentions Gatton's Slough. The approximate location of the old slough should be shown on one of the figures in this section. The location of the former slough is interesting because it is more likely to contain archeological resources than other parts of the site, but also because it may serve as a preferential pathway for groundwater transport. | Acknowledged; Figure 2-20 has been revised to depict the inferred location of Gatton's Slough. In addition, the text has been modified to summarize available information regarding the characteristics of this feature. |
| 75) | | 4. Figure 2-6, Removal Action Area Site Plan. What is the point of this figure? The Removal Action Area Boundary and the location of existing piers are shown on previous figures. The text on page 2-27 says that this figure shows the boundaries of the Slip 1 and Slip 3 uplands, but the uplands are more clearly shown on Figure 2-1. | Acknowledged; the text has been modified to refer to Figure 2-1 for the upland site boundaries. Figure 2-6 shows Port versus state-owned land within the Removal Action Area for general reference purposes. |
| 76) | | 5. Section 3, Potential Sources of Contamination. It would be very helpful to have a figure showing the location of the known spills or releases that are listed in Table 3-1. For example, I would like to know the location of the Cargill deep water well that had 7 feet of oil in it in 1992. Knowing the location of likely sources in the uplands could help guide the in water sampling. | Acknowledged; however, no change has been made. See response to Comment 5 for reasoning; the work plan presents the best information currently available regarding the use of, hazardous substance releases on, and remedial investigations of the Terminal 4 Removal Action Area uplands. The Port will incorporate into the EE/CA any new information developed during the uplands work and will provide access to the documents containing such information. |
| 77) | | 6. Section 4.0, Summary of Existing Data on Sediment Quality and Toxicity. The discussion of the definition of "surface" sediment in this section (0 to 6 inches) is confusing, because it conflicts with the project definition of surface (0 to 1 foot). Please clarify in this section that although the project definition of surface is 0 to 1 foot, in the existing data set, surface samples only went down to 6 inches. | Acknowledged; the text has been revised as suggested. |
| 78) | | 7. Section 4.0, Summary of Existing Data on Sediment Quality and Toxicity. It would be helpful to have a few figures showing the location of sediment quality guideline exceedances. I would like to see both surface and subsurface chemistry maps for copper, lead, zinc, total PAHs, DDT and PCBs, screened against the same values used in Figures | Acknowledged; NOAA has created figures showing the location of SQG exceedances for existing data. In response to this comment, these figures are now included in the EE/CA |

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| | | 4-3 and 4-4. However, I can map the data myself, so it might not be necessary to require the Port to generate 12 new figures. | work plan. The Port will create figures showing SQG exceedances for the EE/CA. |
| 79) | | 8. Section 6.2.1, Removal Action Objectives. The second bullet, "Allow for continued use of the area as a marine terminal consistent with the Port's Master Plan" is not an appropriate RAO. Allowing for continued use of the facility is not a remedial objective; it is a business objective. I suggest pulling this bullet out of the list and adding a sentence that explains that the Port wants to achieve the RAOs while allowing for continued use of the marine terminal and minimizing disruptions to operations. This same comment applies in Section 8.1. | Acknowledged; the second RAO has been deleted. Note that the RAO was originally included because the Port believes it is necessary to emphasize the continued marine use of Terminal 4 to avoid the perception that other use scenarios are possible and, therefore, that other risk scenarios should be analyzed. |
| 80) | | 9. Section 6.9.2, Under-Pier Sediment Quality. I am somewhat concerned about getting only surface data under the piers. If significant slumping from under the piers is possible during dredging, then the sampling should also address subsurface sediment conditions under the piers, or explain why subsurface sample collection is not feasible. | Acknowledged; the Port now proposes to collect two additional sediment cores from the sediment above the riprap area. It is not our intent to collect sediment below the riprap. Every effort will be made by the divers to obtain the longest cores possible. See also the response to related Comment 85. |
| 81) | | 10. Table 6-1, Ecological Health and Human Health rows. The table describes comparing post-action surface concentrations to ecological and human health cleanup levels. It is not clear whether the post-action surface concentrations will be determined through post-action sampling, or whether the Port intends to rely on the section data from the cores collected for the EE/CA. We strongly suggest that post-action confirmation samples be collected to determine the final surface concentrations. Relying on the pre-action data from the appropriate core segment in not reliable, due to uncertainties in the actual dredge depth, resuspension during dredging or capping, and possible slumping from areas adjacent to dredge cuts. | Acknowledged; we agree that post-action confirmation sampling is more reliable than cores or modeled concentrations. However, it will be necessary to use core or modeled data to evaluate the residual risk of each Removal Action alternative during the EE/CA process, because post-removal results will not yet be available. See also the response to Comment 25. |
| 82) | | 11. Figure 6-2, Geochemical Conceptual Model. This figure belongs in Section 5. | Acknowledged; however, no change has been made. We considered including this figure in Section 5, but left it in Section 6 for increased clarity. |
| 83) | | 12. Section 7.4.2.1, Ecological Characterization. The text in this section describes the sediment in Slips 1 and 3 as "highly disturbed in nature" and suggests that "the development of benthic communities in the slips has probably been limited." The Sediment Profile Image Survey conducted by the Lower Willamette Group contradicts | Acknowledged; the text has been revised to reflect the SPI results. However, physical disturbance of surface sediments is an important part of the conceptual site model and |

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| | | this suggestion – it shows stage 3 benthic infaunal succession in all of Slip 3 and in the head of Slip 1. Terminal 4 is apparently providing habitat for a functioning benthic community, despite active marine operations. | would affect benthic community development in affected areas of the slip. This is most pertinent to Slip 3 because of the extensive activity. |
| 84) | | 13. Figure 7-4, Summary of Proposed Sediment Samples and Analyses. This is a very nice figure – it gives the reader a quick, visual explanation of how the cores will be sectioned and analyzed. | Acknowledged; no response required. |
| 85) | | 14. Figure 7-5, Existing and Proposed Subsurface Sediment Sample Locations. NOAA is concerned about the lack of samples from the area of dense pilings at pier 5. This area is adjacent to the former diesel pipeline that leaked, prompting an extensive upland removal action. It is reasonable to assume that the contamination extends under the old pier. If this area is not being addressed as part of the upland investigation, then it should be sampled as part of the EE/CA. We recognize that access will be an issue, but the area could certainly be hand-cored. If it is contaminated, it will serve as an ongoing source of contamination to Slip 3. | Acknowledged; the Port now proposes to collect two additional diver-collected surface sediment samples from within the pilings at the former Pier 5. As described in the response to Comment 80, it is our intent to collect sediment cores from the sediment above the riprap area. It is not our intent to collect sediment below the riprap. Every effort will be made by the divers to obtain the longest cores possible. In addition, divers will probe the surface sediment in the pilings area to evaluate the depth of the soft sediment overlying riprap. |
| 86) | | 15. Table 8-1, ARARs. The Federal Flood Insurance Act may be an ARAR if capping or other types of filling that could impact the floodrise are considered. | Acknowledged; action-specific ARARs will be evaluated when alternatives are identified, as discussed in response to Comment 8. |
| 87) | | 16. Appendix A, Section A2-7.3, Data Management Procedures. The data should be provided to the Lower Willamette Group for inclusion in the Portland Harbor wide assessment. | Acknowledged; the text has been changed to indicate that after the USEPA approves the Removal Action characterization report, the Port will release the data to the Lower Willamette Group. |
| | | **JIM ANDERSON/DEQ COMMENTS:** | |
| | | **General Comments:** | |
| 88) | | 1) Total Petroleum Hydrocarbons (TPH)- The Work Plan states that sediment has been impacted by TPH, and that TPH will be one of the analytes in both sediment and surface water. Currently DEQ hasn't accepted any TPH generic screening levels or sediment | Acknowledged; the text has been revised as suggested. Based on the site history, the likely form of TPH in the sediment, if present, is |

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| | | quality guidelines (SQGs) for ecological receptors or habitat. The Work Plan doesn't address how detected levels of TPH in sediment or surface water will be evaluated.<br><br>Furthermore, TPH is not included in the list constituents of potential concern (COPC, page 5-1, second paragraph), and should be. However, TPH is listed a COPC in the last paragraph of Section 4.4. | diesel. Specific PAHs will be used to evaluate the quality of sediment impacted with TPH. The TPH data will be used to screen sediment quality and for evaluation of upland disposal as a possible Removal Action alternative. |
| 89) | | 2) Bioaccumulation Screening Levels- Section 4 describes how sediment chemistry data will be compared to SQGs. None of the listed SQGs consider bioaccumulation. The Work Plan should be revised to address bioaccumulation. | Acknowledged; bioaccumulation is explicitly identified as a potential mechanism for exposure and will be evaluated, as appropriate, for the EE/CA. However, bioaccumulation-based SQGs are not widely available. Therefore, the Port has proposed that the specific nature of the evaluation be identified after the Removal Action alternatives have been set forth in the Technical Briefing on Proposed Removal Alternatives. |
| 90) | | 3) Risk Screening before Site Characterization- The Work Plan describes (Section 4.4) how certain chemicals of interest (COI) that were detected only infrequently and at low concentrations were not carried forward as COPC. It is not appropriate to eliminate facility COI from further consideration until the site has been adequately characterized. | Acknowledged; however, we disagree for two reasons: (1) This would be the case were there not already considerable data available for the sediments; and (2) moreover, most analytical fractions are still being analyzed. |
| | | **Specific Comments:** | |
| 91) | | 1) Section 1, Risk from Sediment Contamination- The Work Plan states (in the second bullet on the bottom of page 1-2), investigation activities will result in data to evaluate potential human health and ecological risks resulting from sediment contamination. We understand that existing sediment contamination will be compared to certain human health and ecological screening levels, but a formal risk assessment will not be conducted. Rather the BBL will identify RAAs to achieve removal action objectives (RAOs), and the residual risk associated with the individual RAAs will be evaluated in the Feasibility Study (FS). The text in the referenced bullet does not reflect this understanding. | Acknowledged; however, the text in the referenced bullet is a quotation from the AOC and is not intended to describe how risk will be addressed. Refer to Sections 6 and 7 of the work plan for that discussion. In addition, note that no FS will be performed. Rather, the residual risk of each proposed Removal Action alternative will be evaluated in the EE/CA. |
| 92) | | 2) Page 2-16, Possible Facility Source of DDT- DDT was introduced during the WWII as a delousing agent. Since delousing was one of the uses of Terminal 4, this may have been | Acknowledged; language in the work plan attributing DDT concentrations in Removal |

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| | | a source of contamination. It is stated on page 2-16 that "*Between May and September 1943, the USATS constructed a disinfection (fumigation) plant to the east of Warehouse 1 for delousing soldiers and prisoners of war prior to their embarkation or debarkation. Maps and drawings from the war years refer to a House 1 on both Piers 1 and 2.*" The text states that a February 1944 report notes the plant was located in the former Water Division repair shop, but that this has not been verified. The disinfestation plant was designed to delouse 150 men and their clothing and belongings per hour. This big of an operation, most likely using DDT (it was commonly used for this purpose) may have been a source of the DDT to sediment. The Work Plan attributes the concentrations of DDT in sediment as solely coming from an upstream source, which may not be accurate. | Action Area sediments solely to an upstream source has been modified to reflect that potential upland sources are being proposed for investigation as part of the upland RI. DDT is a constituent of concern being evaluated as part of the Terminal 4 Slip 1 Upland Source Control project. |
| 93) | | 3) Figure 2-19, Cross Section- The location of this cross section shown be shown on Figure 2-17, or at least described in Section 2.6.2.1. | Acknowledged; Figure 2-17 has been modified to show the cross section location. |
| 94) | | 4) Section 3.2, Storm Water Evaluation- The Port is planning on conducting a T4 facility-wide, storm water evaluation as part of the upland effort. The EE/CA Work Plan should describe this planned effort. | Acknowledged; the text has been clarified (assuming this comment refers to Section 3.3.2) to indicate that evaluation of stormwater at Terminal 4 is included in the Voluntary Agreement for the Terminal 4 Slip 1 Upland Facility and is being addressed as part of the RI. The approach to stormwater evaluation will be included in the RI work plan, which is anticipated for submittal to DEQ in May 2004. |
| 95) | | 5) Section 3.4, RI at Slip 1 Uplands- We have a good understanding of potential sources of contamination in the upland portion of T4 at the Auto Storage Area (ASA) and Slip 3. However, the RI at Slip 1 uplands is only beginning, and potential sources have not been fully identified or evaluated. | Acknowledged; we agree with the comment and see no need to revise the text. |
| 96) | | 6) Section 4.1.2.5, TPH - The referenced section describes TPH as a "miscellaneous" chemical of concern, which suggests TPH may be considered a relatively minor contributor to in-water impact. Diesel-range TPH is a primary contaminant of concern at Slip 3. Hart Crowser's preliminary interpretation of the bioassay results from Slip 3 sediments (April 18, 2000 RI Report, Terminal 4, Slip 3 Sediments) indicates that there is a better correlation of benthic organism toxicity to diesel fuel than to LPAHs or HPAHs associated with pencil pitch. | Acknowledged; the text has been clarified to define how "miscellaneous" is being used. The term "miscellaneous" and the other constituent class terminology (metals, PAHs, semivolatile organic compounds, pesticides and PCBs, volatile organic compounds, and conventionals) were taken from the NOAA Query Manager database, the source of the |

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| | | | existing sediment data. The term "miscellaneous" is meant to represent compounds that do not fall into one of the other constituent classes, but is not meant to diminish the importance of compounds within the miscellaneous class. |
| 97) | | 7) Section 5.3, Upland Sources of Contamination- The Work Plan states that "*Sources of contamination to groundwater and surface water, and any associated exposure risks not associated with sediments, are being addressed through other activities*". The Work Plan should include a reference or more detailed explanation of the upland investigation and cleanup work being done under DEQ oversight. | Acknowledged; the text has been revised to more specifically reference the orders under which upland investigation is being conducted. |
| 98) | | 8) Section 5.4, Dermal Exposure Pathways- Dermal exposure to sediment may be minimal for biomagnifying chemicals when compared with dietary intake. However, since sediment is defined in the Work Plan as bulk sediment and pore water, this may not be the case for other classes of contaminants. Toxicity may also result from direct contact (i.e., other than dietary intake) with porewater. | Acknowledged; our approach includes dermal exposure to sediment for ecological receptors and, based on comments from Hillman and Davoli, will also be assessed for human exposures. |
| 99) | | 9) Figure 5-2, Benthic Filter Feeders- Benthic filter feeders may ingest surface water (and suspended particles) as a major route of exposure. | Acknowledged; the text in Section 5.3.1 has been revised to clarify this point. |
| 100) | | 10) Figure 5-2, Trespassers- Biota ingestion for trespassers is listed minor. It seems like fishing could be a major reason for trespassing. | Acknowledged; as discussed in the response to Comment 59, trespasser has been replaced with transient, and fish ingestion has been added as a pathway. |
| 101) | | 11) Section 6.5.1, Receptors- In the 2nd paragraph of page 6-6, the Work Plan states the purpose of the 1st component to the proposed ecological risk evaluation is to identify contaminants, potentially complete exposure pathways, and exposure points. The list should also include receptors. | Acknowledged; the text has been revised as requested. |
| 102) | | 12) Section 7.4.2.2, Benthic Community- The referenced text appears to write-off areas that may be disturbed by ship movement in the area. This should be proven and not assumed, because some benthic assemblage may exist that can mobilize bioaccumlatives up the food chain. Since it appears no further studies will be done to characterize the benthic community, can we assume that a community may exist? Does any sediment profile imaging (SPI) data exist to support or discount this issue? | Acknowledged; however, no change has been made. Sediment data will be compared to SQGs regardless of assumptions about habitat function. High-traffic areas are largely in Slip 3, and we are anticipating extensive dredging and capping in Slip 3. Therefore, quantitative knowledge of benthic community may not be |

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| | | | necessary to make removal decisions. |
| 103) | | 13) Section 7.6, Monitoring Well Construction- Monitoring well construction should also conform to DEQ guidance (see http://www.deq.state.or.us/wmc/tank/documents/monwell.pdf). | Acknowledged; the text has been modified to include a reference to the DEQ guidance document for monitoring well installation and construction and to clarify the need to maintain conformance with the applicable requirements of the guidance document. |
| 104) | | 14) Section 8.3.2.2, Treating Wash Water- In the discussion of Chemical Treatment, the Work Plan should briefly discuss the possible need to treat wash water in the Sediment Washing technology. | Acknowledged; the text has been modified to reflect that the effluent from the sediment washing will be treated to meet discharge requirements. We agree that when treatment technologies are considered, all media involved in the treatment need to be considered. |
| 105) | | 15) Section 8.3.3, Disposal Options- Two disposal options are presented elsewhere in the Work Plan for sediment dredging (onsite/CDF and upland), yet this section only discusses upland sediment disposal. The onsite/CDF option should be discussed. | Acknowledged; the text in Section 8.3.3 has been revised to briefly discuss the onsite disposal of dredge material in a confined disposal facility. |
| 106) | | 16) Section 8.4, Accuracy of Costs- The accuracy of cost estimates should be defined here (e.g., +50%/-30% is typical for such projects). | Acknowledged; the accuracy of the cost estimate is usually +50% to -30% and this range has been incorporated into the text. |
| 107) | | 17) Section 8.6.1, Level of Design- Section 8.4 states that each alternative will be described as a "15% conceptual design." The level of design for the preferred RAA description, which provides further details, should be defined in Section 8.6.1. | Acknowledged; the text has been clarified. The level of design for the preferred Removal Action alternative is envisioned at a level somewhat greater than 15%, probably at a level of 25% level, which would also support the 404b permit compliance and the Section 7 consultation. |
| 108) | | 18) Table 8-1, State ARARs-<br>A) Hazardous Waste Regulations- Change to more comprehensive: ORS 466.005-225 and add OAR 340-101 concerning residues that are hazardous waste.<br>B) OR Hazardous Substance Remedial Action Rules- Typo: should be OAR 340- not "OAR 430-". | Acknowledged; with respect to item A, the requested change has been made and OAR 340-101-0033 has been added; with respect to item B, the typo has been corrected; with respect to items C-F, these action-specific |

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| | | C) Air Quality- Add: ORS 468A and OAR 340-226-0100 concerning fugitive emissions.<br>D) Noise Control- Add: OAR 340-035-0035 .<br>E) Visible Air Contaminant Limitations- Add: OAR 340-208-0110.<br>F) Fugitive Emission Requirements- Add: OAR 340-208-0200, 0210. | ARARs may need to be added when alternatives are evaluated. |
| 109) | | 19) Table A2-1, Reporting Limit Goal for Sediment- The reporting limit goal units for metals are listed as "mg/kg" and should be presented as ug/kg. | Acknowledged; the table has been revised as suggested. |
| 110) | | 20) Table A2-2, Units- No units are given for phthalates and miscellaneous SVOCs. | Acknowledged; the units appear under the head "semivolatile organic compounds." Units have been added to the subheads for clarification. |
| | | **GINA GREPO-GROVE/USEPA COMMENTS:** | |
| | | **General Comments:** | |
| 111) | | 1. Existing sediment chemistry data sets relevant to T4 are categorized the same way as the Draft Work Plan for Portland Harbor. Four data sets listed in T4 EE/CA Table 4-1 have a category 1 and a QA1 level of data review, one with category 1 and QA2 level of data review and one with a category 2 and no QA or sampling information available. Definitely, data set with a category 2 cannot be used until more information about the data are obtained and data are reviewed and validated. Category 1 and QA2 data are acceptable for use for all purposes (Roy F Weston - 1998). There had been concerns however, with category 1 data with QA1 level of data review. QA1 data has limited uses and may be sufficient for screening and scoping purposes, trend analysis, making decisions where to collect additional samples and/or for removal activities. | Acknowledged. See the responses to Comments 44 and 45. |
| 112) | | 2. For risk assessment and RI/FS, however, QA1 data review is not sufficient to determine the acceptability of the data for the following reasons: (1) QA1 data quality review is based solely on the checklist or QA summaries provided by the laboratory, (2) None of the data are verified with instrumentation data acquisition output and other hard copy laboratory information like chromatograms, instrument performance, calibrations, calculations by a third party/independent reviewer, (3) Bias and usability of the data is not assessed in the QA1 review, and (4) As stated in the PSDDA QA Manual, QA1 review process does not determine the acceptability of the data for incorporation into the sediment quality values database. | Acknowledged; the text has been clarified. Data collected under the EE/CA work plan may be used for a residual risk assessment, depending on the Removal Action alternative selected. All data collected under the EE/CA work plan will undergo an independent, third-party data validation as proposed in the QAPP. In addition, see the response to Comment 45 regarding data validation for existing data. |

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| | | Recommendation: As listed in Table 4-1, the number of samples per project applicable to T4 EE/CA is very small. For RI/FS and risk assessment, Category 1- QA1 data, should be fully validated by an independent third party reviewer in accordance with the project specific QC control limits, the analytical method and the Functional Guidelines for Organic and Inorganic Data Review at these recommended frequency: 100% full data validation for data sets with samples ≤10; 30% for data sets with samples >10. If problems are encountered during data review, all of the data may need full data validation. Because pesticides and PCB compound identification is very interpretative, all pesticides and PCB data are recommended to undergo full data validation.<br><br>Background for QA1: QA1 data review level was developed by the Environmental Procedures Work Group comprised (EPWG) of the Puget Sound Dredge Disposal Analysis (PSDDA) agencies, i.e., Washington Department of Ecology, US Army Corps of Engineers, Seattle District (Corps), US EPA and Washington Department of Natural Resources. QA1 is an abbreviated data review designed to determine the acceptability of the data for dredge disposal permitting activities.<br><br>QA1 data review has a fast turn-around time of about 2-4 hours review for a typical 20 sample data set .<br><br>General QA1 approach: A complete sample collection checklists (COCs and other documentation) are submitted with the samples to the laboratory. After sample analyses, individual chemistry QA checklists are prepared by the laboratory for each data type generated. The QA1 checklists used for data validation include information on<br><br>▸ data completeness<br>▸ holding times<br>▸ data format (e.g., significant figures, units)<br>▸<br>QA sample summaries (blanks, matrix spikes, matrix spike duplicates and/or laboratory replicates/duplicates) | |

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| | | QA2 data review process is a more detailed and rigorous data review which determines the acceptability, bias and usability of data for all or specific purposes. In general, QA2 data review process requires at least 1- 5 hours (PSDDA Manual estimates as 8-10 hours) of effort per sample depending on the reviewer's expertise, data type and laboratory performance. QA2 data review is performed by an independent/third party reviewer and requires raw data instrumentation output and other considerable amount of information from the laboratory. QA2 data validation involves the evaluation of the following QA elements and determine their effects on the quality and usability of the data:<br><br>▸ Data completeness evidentiary audit<br>▸ Holding times exceedances<br>▸ Instrument Performance before, during and at the end of the analytical sequence<br>▸ Initial and Continuing Calibrations<br>▸ Sample Processing/Preparation and Clean-ups<br>▸ Instrument Detection Limits and Sample Quantitation Limits<br>▸ Deviations from the analytical methods<br>▸ Compounds identification and confirmation<br>▸ Laboratory Calculations<br>▸ Method Blanks<br>▸ QC Sample Results<br>  ▸ surrogate recoveries<br>  ▸ matrix spikes, matrix spike duplicates (MS/MSD)<br>  ▸ laboratory control samples and duplicates (LCS/LCSD)<br>  ▸ field duplicates/replicates<br>  ▸ laboratory duplicates<br>  ▸ method analytical spikes (Method 7000)<br>▸ Overall Data Assessment<br><br>Analytical results are qualified based on the data review and validation report is prepared for each data set reviewed. | |

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| | | **Specific Comments:** | |
| 113) | | 1. Table 4-1 Summary of Existing Sediment Investigation Reports for Terminal 4.<br><br>• It is recommended that only data sets collected after the great flood of 1996 be considered for use for T4 EE/CA.<br><br>• The Draft Portland Harbor Work Plan Attachment F1 lists a comprehensive list of historical data collected in Portland Harbor including T4 with summaries of data quality reviews, parameter groups, analytical methods, number of samples per parameter group and other QA related information about the data sets listed. These QA details are not included in the T4 EE/CA existing data Table 4-1. T4 Work Plan should be a stand alone document. Since not all of the readers and reviewers of the T4 work plan have access to the Draft Portland Harbor Work Plan and since cross - referencing the T4 list with that of Portland Harbor is difficult due to mis-matched and truncated References/Project Descriptions and/or other incomplete data set information, it is highly recommended that Table 4-1 be revised to include Reference/Project Description, Survey_CD, Data Category, Number of Samples Collected for the Project, Number of Samples for T4 EE/CA Use, Parameter Groups, Analytical Methods, Level of QA Review and Summary of Data Quality review as listed in the Draft Portland Harbor Work Plan Attachment F1.<br><br>• Per Table 4-1 and maps, the existing data for Slip 1 is very limited. The following sediment chemistry data set for Slip 1 is listed in the Portland Harbor Attachment F1 but is not listed Table 4-1of the T4 EE/CA, explain why: Port of Portland- (2/1/99) Terminal 4, Slip 1 Sediment Characterization Study of Local Sponsors' Berths - Terminal 4, Slip 1 Preliminary Assessment- 34 sediment samples were collected from Slip 1 and analyzed for conventionals, diesel and lube oil (NWTPH-Dx), metals and mercury( 200.8 and 7471); chlorinated pesticides/PCB (8080 and 8082), SVOCs (8270- SIM), VOCs (8260B) and 12 samples for TBT (Krone, et al). Laboratory - CAS. All Category 1 data with QA1 data review. | Acknowledged; however, no change has been made. The existing data are considered adequate for the purposes of proposing sampling locations and analyte lists. See the response to Comment 45 regarding the use of existing data in the EE/CA.<br><br>For the purposes of the work plan, the existing data were used to propose sampling locations and analyte lists. The existing data were extracted from NOAA's Query Manager database, which used slightly different sample identifiers than did the Draft Portland Harbor Work Plan. For ease of reference back to the data source, the sample identifiers used in NOAA's Query Manager database were retained. The Port does not propose adding the Draft Portland Harbor Work Plan identifiers to the table. The Port would be happy to provide the NOAA Query Manager database to USEPA for review.<br><br>These data are in the work plan in Table 4-1 under "Hart Crowser, 1999."<br><br>See the response to Comment 45 regarding data validation for existing and new data. This response is directed at the bullet commenting on the Hart Crowser 2000e data.<br><br>The Port does not propose collecting additional borings in Slip 1. The borings |

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| | | • The data generated from the "*The Hart Crowser, 2000e. Terminal 4-Slip 1 and Berth 401 Sediment Characterization Study, May 31, 2000*" has no existing information regarding data quality and acceptability and therefore is classified as Category 2. Recommendation: The Port should further investigate this study and search for the report, including the validation report and possibly the availability of raw data for future full data validation (QA2).<br><br>• The proposed 17 surface sediment samples that will be collected from Slip 1for the T4 EE/CA may not be sufficient to determine the extent of contamination (see next page)<br><br><u>Summary of Category 1 data applicable to Slip 1</u> (Note: Category 2 data with 10 samples and ACOE one sample are not included in this summary due to lack of QA information)<br><br>▸ 10 surface samples analyzed for metals and mercury<br><br>▸ 5 surface samples analyzed for titanium, SVOCs, chlorinated pesticides, PCB as Aroclors, TBT, grain size, TOC and other conventional parameters.<br><br>▸ 3 sub-surface samples analyzed for metals, mercury, SVOCs, chlorinated pesticides, PCB as Aroclors, TBT, grain size, TOC and other conventional parameters.<br><br><u>Summary of Category 1 data applicable to Slip 3:</u><br><br>▸ 51 surface samples analyzed for metals, mercury, SVOCs, chlorinated pesticides, TOCs and conventionals<br><br>▸ 7 surface samples analyzed for titanium, TBT, and grain size | proposed in the work plan are believed adequate to evaluate the extent of contamination for the purposes of a removal action. |

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| | | ▸ 44 surface samples analyzed for chlorinated VOCs, BETX, diesel and lube oil<br>▸ 10 subsurface samples analyzed for metals, mercury, SVOCs, chlorinated pesticides, TOCs and conventionals<br>▸ one subsurface sample analyzed for PCB as Aroclors, titanium, TBT and grain size<br>▸ 9 subsurface samples analyzed for chlorinated VOCs, BETX, diesel and lube oil | |
| 114) | | 2. Tables 4-3 to 4-6. In addition to these Tables, it will be very useful if the T4 EE/CA Work Plan provided maps showing the sediment sample locations collected within the vicinity and areas adjacent to T4 for each existing data set and highlight the sample locations that will be applicable and used for T4 EE/CA. Also, to clearly illustrate the patterns and concentration distribution of detected compounds (Tables 4-3 to 4-6) in T4, it is recommended that the highest concentrations of detections and sample location for each suite of parameters be presented on transparencies for overlay on the T4 EE/CA removal area and proposed sample collection map. | Acknowledged; however, only existing data presented in Table A-1 and Figures 4-1 and 4-2 will be used in the work plan and may be used in the EE/CA. Also see the response to Comment 78 regarding the NOAA figures that show the locations of SQG exceedances for existing data (now added to the work plan as an appendix) and future exceedance figures for the EE/CA. |
| | | **FSP Comments/General Comments:** | |
| 115) | | 1. Target Compounds: Since there is not sufficient chlorinated pesticide data for T4, pesticides analysis of surface and sub-surface sediment samples should not be limited to the analysis of total DDT only. In addition, except for the 5 samples collected for the Roy F Weston 1998 project, none of the existing pesticides and PCB data applicable to T4 were validated/reviewed by a third party reviewer. Table 4-3 indicates that where there are detections of Aroclors, there are also detections of DDTs which should be further looked into during QA2 data validation. False positives/negatives and bias on pesticides and PCB data are common occurrences for the following reasons: (1) identification is based only on the dual column peak elutions at the specified retention time windows and pattern recognition (very interpretative), (2) most of the single-component pesticides (like DDTs, dieldrin, | Acknowledged; see the responses to Comments 52 and 54. |

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| | | endrin) co-elute with the PCB peaks in both columns and (3) matrix interferences interferes with identification and concentration calculations.<br><br>Recommendations: Surface and sub-surface samples for T4 EE/CA should be analyzed for a full list of chlorinated pesticides and at the reporting limits listed in the EPA approved Portland Harbor Round 1 QAPP. | |
| 116) | | 2. Verify if porewater samples will be collected for DRET analysis. | Acknowledged; porewater samples will not be collected for DRET analysis. Supernatant from the DRET will be collected for analysis. Section A1-3.3.3 of the FSP provides a summary of the DRET. |
| | | **FSP Comments/Specific Comments:** | |
| 117) | | Table A1-6 - The holding times for SVOCs, pesticides and PCBs are: extraction -14 days form sample collection; analytical- 40 days from extraction date. | Acknowledged; the table has been revised as suggested. |
| | | **QAPP Comments/General Comment:** | |
| 118) | | 1. The QAPP submitted for T4 EE/CA was prepared by BBL, Inc. in accordance with the ANSI/ASQC E4_1994 American National Standard 's Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs but not in accordance with the EPA-QA/R5 - EPA Requirements for Quality Assurance Project Plans, 2001.<br><br>Although the information about the site and EE/CA sampling strategies and schemes are discussed in the work plan, FSP, still, the QAPP should be a stand alone document and all of the required content and format requirement of EPA-QA/R5 document should be discussed.<br><br>Recommendation. T4 EE/CA QAPP should be revised to reflect the content and format requirements of the EPA-QA/R5 document (see list below). If any of the sections will be referenced to either the FSP or work plan, a brief description of the section is still necessary in the QAPP to give the data users a more definitive picture of the tasks and activities that will be conducted for the project. | Acknowledged; however, the Port does not propose revising the QAPP as suggested. Cross-references to the work plan will be removed, and the applicable work plan text will be copied and included in the QAPP. References to the FSP will remain. So that the work plan is succinct, and to avoid repetition in the work plan, the QAPP will reference sections in the FSP. The QAPP will not be distributed separately from the FSP. A warning note will be included in the QAPP notifying the reader that the QAPP should remain attached to the FSP. |

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| | | A. Title and Approval Page<br>B. Table of Contents<br>1.0 Project Management Elements<br>1.1 Distribution List<br>1.2 Project/ Task Organization<br>1.3 Problem Definition/ Background<br>1.3.1 Background<br>1.3.2 Objectives/Scope<br>1.4 Project/ Task Description and Schedule<br>1.4.1 Project/Task Description<br>1.4.2 Schedule of Tasks<br>1.5 Quality Objectives and Criteria for Measurement Data<br>1.6 Special Training Requirements/ Certification<br>1.7 Documentation and Records<br><br>2.0 Measurement/ Data Acquisition<br>2.1 Sampling Process Design (Experimental Design)<br>2.2 Sampling Methods Requirements<br>2.3 Sample Handling and Custody Requirements<br>2.3.1 Sampling Procedures<br>2.3.2 Sample Custody Procedures<br>2.3.3 Shipping Requirements<br>2.3.4 Decontamination Procedures<br>2.4 Analytical Methods Requirements<br>2.5 Quality Control Requirements<br>2.6 Instrument/Equipment Testing, Inspection and Maintenance Requirements<br>2.7 Instrument Calibration and Frequency<br>2.8 Inspection/Acceptance Requirements for Supplies and Consumables<br>2.9 Data Acquisition Requirements (Non-direct Measurements)<br>2.10 Data Management<br><br>3.0 Assessment/Oversight<br>3.1 Assessments and Response Actions | |

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| | | 3.2 Reports to Management<br><br>4.0 Data Validation and Usability<br>4.1 Data Review, Validation, and Verification Requirements<br>4.2 Validation and Verification Methods<br><br>For more information, BBL is referred to this website:<br>http://www.epa.gov/r10earth/offices/oea/epaqar5 | |
| | | **Specific Comments:** | |
| 119) | | 1. Section A2-1 - Introduction "Chemistry analytical work will be performed in accordance with the USEPA's EPA Requirements for Management Plans (USEPA 2001b)". The referenced QA document is not applicable to chemistry analytical work. A Quality Management Plan (QMP) is a QA document that describes the organization's quality assurance goals and objectives and the role and responsibilities of the management and staff in the implementation of the associated quality assurance activities specified in the QMP.<br><br>Suggestion: Chemistry analytical work will be performed in accordance with the technical specifications and DQO requirements of the T4 EE/CA QAPP and the analytical methods used in the analysis. | Acknowledged; the text has been revised as suggested. |
| 120) | | 2. Section A2-2. Project Management - Specify who will be responsible for ensuring that sample collection and analytical activities are implemented in accordance with the T4 EE/CA FSP and QAPP.<br><br>Project QA Manager should also be responsible for ensuring that data of known and acceptable quality are generated by providing oversight in the data validation/review process. | Acknowledged; the text has been revised as suggested. |
| 121) | | 3. Section A2-3.2. Measurement Quality Objectives for Chemical Use or from the EPA_QA/R5, Quality Control Requirements - For consistency, the data quality objectives, analytical chemistry QC limits and reporting limits requirements for T4 EE/CA should be the same as the ones set for Portland Harbor Round 1 QAPP. | Acknowledged; however, the Port does not propose to revise the EE/CA quality control requirements to match the Portland Harbor Round 1 QAPP quality control requirements. Although the quality control requirements for the EE/CA and the Portland Harbor Round 1 |

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| | | | QAPP (Appendix E of the Portland Harbor Round 1 QAPP) are similar, there are some differences that reflect the differences between an EE/CA and an RI/FS.<br><br>The Portland Harbor Round 1 QAPP states that precision and accuracy percent recoveries are based on laboratory-generated statistical limits (footnote c to Table A7-6 of the Portland Harbor Round 1 QAPP). The EE/CA QAPP proposes using laboratory control limits established under the USEPA method for the particular analysis, with the exception that if a sample or duplicate concentration is within five times the reporting limit, the alternative precision control limited recommended by USEPA (1999 and 2002) of +/- the reporting limit for water samples and two times +/- the reporting limit for sediment samples will be used. Because the Port may select to use a different laboratory than the laboratory that provided the precision and accuracy control limits for the Portland Harbor Round 1 QAPP, the Port does not propose changing the control limits presented in the EE/CA QAPP. However, the QA/QC limits for representativeness and comparability for the EE/CA and the Portland Harbor Round QAPP are similar. In addition, the EE/CA QAPP's goal for completeness will be revised to 90% to match the completeness goal in the Portland Harbor Round 1 QAPP. |

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| | | | Also see the response to Comment 52 with regard to reporting limits. |
| 122) | | 4. Section A2-4. Analytical Methods - Because most of the QC activities in the SW846 methods are 'recommended" and/or "optional", commercial laboratories do not necessarily have the same interpretation of the QC requirements and data deliverables for SW846 analytical methods. Sometimes, SW846 in-house laboratory SOPs do not contain sufficient QCs and data deliverables necessary to facilitate data review and assessment at a reasonable amount of time. To save time during the data review process and for consistency, the contract laboratory for this project should be required to apply all of the QC requirements imposed by the Superfund's Contract Laboratory Program's (CLP) Statement of Work (OLMO4.1 and ILM05.2) for inorganic and organic analyses. In addition, the laboratory should be required to submit a CLP-equivalent data package deliverables for each suite of parameters analyzed.<br><br><u>Additional instructions to the laboratory performing the analyses:</u><br><br><u>Metals analysis (cadmium, arsenic, chromium, antimony, lead, selenium and thallium) following the SW846 Method 7000s.</u> Analytical spike analysis shall be performed after each sample analysis to check for matrix interferences. Analytical spike recoveries shall be reported. Dilutions, re-analyses and Method Standard Addition (MSA) decision tree specified in the inorganic CLP SOW shall be followed by the laboratory.<br><br><u>SVOC Analysis</u> - the QAPP needs to make it clear if the SVOC analyses for T4 EE/CA will be a full scan Method 8270 or a selected ion monitoring (SIM) Method 8270C. <u>Differences:</u> Full scan Method 8270, this method is used if tentatively identified compounds (TICs) will be needed by the project- usually for future source control. SIM-Method 8270C is used to achieve lower reporting limits specially for PAHs. TICs cannot be determined from SIM -Method 8270C.<br><br><u>Pesticides/PCB Analyses</u>. All of the samples and standards analyzed for pesticides and PCBs shall be spiked with surrogates, TCX and DCB. The laboratory shall have the option of performing one extraction for pesticides and PCBs, however, extracts must be split to allow for extract clean-ups for PCBs (acid clean-up). To minimize | Acknowledged; the text has been revised as suggested.<br><br>Acknowledged; the QAPP will be revised to include a requirement that an analytical spike will be analyzed after each sample analysis for metals analyzed by graphite furnace.<br>Acknowledged; the text has been revised to state that SVOCs will be analyzed by 8270-SIM. |

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| | | interferences and misidentification, PCBs will be analyzed separately from the single-component pesticides.<br><br>For PCB analysis, a minimum of five- point initial calibration curve using Aroclors 1016/1260 and single- point for the rest of the Aroclors will be performed for initial calibration. Surrogate retention time shifts shall be monitored from the beginning to the end of each analytical sequence for both columns. Chromatograms for the standards and the samples shall be displayed in a full page with the same scale and range. For PCB analysis, the areas and/or heights of the peaks detected >2.5 signal to noise ratio will be integrated and reported on the quantitation list. If PCBs are detected in the sample, the type of Aroclor detected must be analyzed in the continuing calibration within 72 hours of detection in the sample. PCB and/or pesticide detections at concentrations >0.5 g/Kg (ppm) level shall be confirmed using a GC/MS and raw and background subtracted spectra of the compound detected in the sample as compared to the spectra of the compound from the standard shall be submitted as part of deliverables. | Acknowledged; the text has been revised as suggested. |
| 123) | | 5. Section A2-4.1. Reporting Limits. The reporting limits listed in this QAPP are much higher than the Portland Harbor. For consistency, it is highly recommended that the reporting limits required for this project be the same as the Portland Harbor Round 1 QAPP. | Acknowledged; see the response to Comment 52. |
| 124) | | 6. Section A2-5.1. Sample Containers, Preservation and Holding Time Requirements - Specify who will provide "certified clean" sample containers for this project. | Acknowledged; language stating that the laboratory will provide certified clean containers has been added. |
| 125) | | 7. Section A2-5.2. Sample Packaging, Handling and Shipping - Include a temperature blank inside each cooler shipped to the laboratory. | Acknowledged; the text has been revised as suggested. |
| 126) | | 8. Section A2-6.1. Preventive Maintenance - The laboratory should follow routine and non-routine instrument maintenance schedules and procedures specified in their Laboratory's Quality Assurance Manual. | Acknowledged; the text has been revised as suggested. |
| 127) | | 9. Section A2-6.2. Calibration Procedures and Frequency - see comments on section A2-4.1. | Acknowledged; see the response to Comment 52. |
| 128) | | 10. Section A2-6.3.2 - Data quality objectives for precision and accuracy. QC sample acceptance control limits should be the same as the Portland Harbor Round 1 QAPP. | Acknowledged; see the response to Comment 121. |
| 129) | | 11. SectionA2-8. Data Assessment Procedures ( Data Validation and Verification). The | Acknowledged; the text has been revised to |

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| | | QAPP proposes full data validation of 10% of the data and partial data validation (validation using COC and QC summary forms) for 90% of the data.<br><br>Recommendation: Full data validation shall be conducted on the first 20% of the data generated by an independent third party data reviewer. The first sample delivery group (SDG) submitted by the lab for PCB and pesticide analyses shall be fully validated by EPA. Validation reports and qualified Forms I for the first SDGs shall also be submitted to EPA QA for review. Based on EPA's review, the percentage of data that will need full or partial data validation will be decided. If problems were not encountered with the data, the Port may proceed to conduct a partial data review on the rest of the samples. | match the Level IV (full validation) data validation procedures in the Portland Harbor Round 1 QAPP (10-20% full validation based on the results of USEPA's data validation). An explanation has been added to the text that all data validation will be performed by an independent, third-party reviewer. The data from the first sediment SDG submitted for PCB and pesticide analysis will be provided to USEPA for full validation. However, given the strict schedule constraints the EE/CA work is under, the Port will not suspend data validation pending the USEPA's review. Data validation will proceed, with 10% of the data undergoing Level IV validation (full validation) and the remaining 90% of the data undergoing Level III validation. If the USEPA determines, upon completion of the full data validation, that additional Level IV data validation is required, the Port will submit additional SDGs for Level IV data validation. |
| | | **MARK BRADY/ENVIRONMENT INTERNATIONAL:** | |
| 130) | | This letter is submitted on behalf of the Confederated Tribes of the Grand Ronde Community of Oregon, the Confederated Tribes of Siletz Indians of Oregon, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, the Nez Perce Tribe and the Confederated Tribes and Bands of the Yakama Nation (the Tribes). The letter transmits the Tribes' comments on the Port of Portland's (Port's) Draft Work Plan (Work Plan) for the Terminal 4 (T4) Early Action Engineering Evaluation/Cost Analysis (EE/CA), which was prepared by BBL and dated December 30, 2003. This letter first details the Tribes' general comments, which represent the Tribes' biggest concerns with the Work Plan, and then explains the Tribes' specific comments, which are laid out according to the sequence of the Work Plan. | Acknowledged; no response required. |

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| | | Much of the document was well prepared. The general comments reflect the major areas of concern for the Tribes. These are things that require special attention from EPA and the Port in order to develop a comprehensive Work Plan for the EE/CA. The specific comments are mainly editorial revisions or attempts to ensure the Work Plan is internally consistent. | |
| | | **General Comments:** | |
| 131) | | Conceptual Site Model<br><br>1. The Work Plan would benefit from additional figures that give a clearer picture of the conceptual site model (CSM). The Port and its consultants clearly expended considerable effort collecting and recording available information in tables, text and figures; however, additional figures would give the reader a better idea of what data gaps exist. Information that should be presented in figures are:<br><br>• location of Gatton's Slough<br>• location of the original shoreline<br>• location of historic spills, seeps, discharges, pipelines, USTs, etc., that were potential sources to T4, particularly Slip 1 and Wheeler Bay<br>• concentration gradients or contours of contaminants<br>• location of upland monitoring wells<br><br>Having the location of Gatton's Slough and the original shoreline on the site figures is extremely important to the Tribes for two reasons. The slough potentially creates a preferential pathway for groundwater and contamination, and the Tribes are very concerned that relevant people are aware of this if sampling or excavation activities occur in this area. Please revise accordingly. | Acknowledged; Figure 2-20 now shows the original shoreline and Gatton's Slough. However, other items called for in the comment are upland issues and will be covered by the Terminal 4 Slip 1 Upland RI/FS. |
| 132) | | 2. The Port has indicated that some of the aforementioned figures are being prepared as part of upland source control efforts at T4. The Port has also indicated that figures showing contaminant concentrations would be produced after the proposed sampling for the EE/CA. Regardless, additional figures in the Work Plan would have better informed the placement of samples for the EE/CA. As you realize, it may be necessary to collect additional samples beyond those proposed in the Work Plan; and the Tribes reserve the right to ask for additional samples at a future date. | Acknowledged. |
| 133) | | 3. Another helpful revision would be to Tables 4-3, 4-4, 4-5 and 4-6 (the tables that give the | Acknowledged; because Figures 4-3 and 4-4 |

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| | | maximum and minimum detected concentrations, number of detections, etc., in the historic data). These tables should have included at least one relevant sediment quality guideline. This would allow quick comparison of detected concentrations and detection limits to help identify problems at the site or with the historic data. In addition, the Work Plan should include a description of previous investigations at the site. This will lead to a better understanding of what was found at the site, both contaminated and clean areas; what was cleaned up; and what was left. Finally, some areas of the Work Plan's text should be expanded, especially with respect to historical terminal operations. In particular the former UPRR pipeline, which was abandoned "because of leaks" (p. 2-9) and the Quaker State operation deserve further discussion. Please revise accordingly. | do compare the existing data to sediment quality guidelines, the Port does not propose to add the SQGs to Tables 4-3 through 4-6.<br><br>NOAA has created figures showing the location of SQG exceedances for existing data, and those figures have been added to the EE/CA work plan as an appendix. The Port will create figures showing SQG exceedances for the EE/CA.<br><br>The comment regarding previous investigations is also acknowledged; Section 3 describes previous investigations at the site, both sediment and upland, and remedial activities that have occurred at the site.<br><br>The comment regarding historical terminal operations is also acknowledged; however, no change has been made. See response to Comment 5 for reasoning; the work plan presents the best information currently available regarding the use of, hazardous substance releases on, and remedial investigations of the Terminal 4 Removal Action Area uplands. The Port will incorporate into the EE/CA any new information developed during the uplands work and will provide access to the documents containing such information. |
| 134) | | **Extent of Contamination in Slip 3**<br>1. The language in Section 6.9.1 appears to be inconsistent by first saying that available information is sufficient to evaluate the lateral extent of contamination in Slip 3 then | Acknowledged; the text has been revised as suggested. |

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| | | saying that additional information in Slip 3 is necessary. This language should be corrected. The Tribes do ***not*** believe that available information is sufficient for two reasons: the complete lack of data in the former Berth 412 area and the continuing marine activity in the Slip causing resuspension of sediments. Please revise accordingly. | |
| 135) | | 2. Based on review of the Work Plan and the Slip 3 RI report, it is quite clear that the Berth 412 area has contamination; however, the extent of this contamination is not known. Several pieces of information point to contamination in the area of Berth 412:<br><br>♦ the Work Plan describes numerous historic operations at this berth that could have caused contamination in this area, especially the UPRR pipeline, which serviced this berth and was eventually abandoned because of leaks (see Figure 3 of the Slip 3 RI report, Table 2-1 and other parts of the Work Plan).<br>♦ the Slip 3 RI report showed potential pencil pitch contamination (Figure 11) and diesel contamination (Figure 12) in this area.<br>♦ other figures from the Slip 3 RI report (13, 14, 15) showed that other types of contamination are likely in this area.<br>♦ the Work Plan (pp. 2-43 and 2-44) states that there is a West-tending depression in this area that was identified as a preferential pathway for groundwater flow and LNAPL migration.<br><br>Thus, not only is the area likely to be contaminated but it could also serve as a recontamination source to Slip 3 and beyond. It is not clear whether the Port considers this area as part of Slip 3 when it discusses dredging Slip 3. The Berth 412 area deserves serious consideration when evaluating data gaps and removal alternatives for Slip 3.<br><br>To address the data gaps, surface and subsurface samples should be collected in the area of the Berth 412. In addition, the text of Section 6.9 should be revised to identify this area as a data gap of sediment quality characteristics. At least one sample should be collected from the area around the former UPRR pipeline. In addition, at least three other samples should be collected in this area. Please revise accordingly. | Acknowledged; the area of the former Berth 412 is considered part of Slip 3. See the responses to Comments 80 and 85. |
| 136) | | **Lack of Confirmational Sampling**<br>The Tribes do not support the approach described in the Work Plan to assess residual risk using data from cores collected prior to the removal action. The Port's proposed approach is | Acknowledged; however, no change has been made. Confirmation sampling will be conducted after implementation of the |

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| | | to use the two-foot composite from the depth just below the dredge prism as representative of the "new surface." Human health and ecological risk would then be assessed at this new surface using the existing core data. The Tribes have several problems with this approach.<br><br>♦ First, using a "surface" sample from a two-foot composite is not appropriate for a risk assessment. This will not truly capture the risk presented by surface sediment.<br>♦ Second, any dredging that occurs will disturb this proposed "new surface" so that whatever was collected in the two-foot composite from the core will no longer be representative of what is actually on the surface after dredging.<br>♦ Third, this approach would result in problematic inconsistencies between work at T4 and that conducted on the Portland Harbor Superfund Site (Portland Harbor).<br><br>The best way to address this issue is to conduct a round of confirmational sampling after dredging. This will ensure that the residual risk assessment is based on representative site conditions. Please revise accordingly. | Removal Action. However, the EE/CA work plan addresses only the process needed to evaluate and select a Removal Action alternative. Therefore, confirmation sampling results cannot be available for the EE/CA. |
| 137) | | **Analyte Lists and Detection Limits**<br>Analyses proposed in the T4 Work Plan are not the same as those proposed for Portland Harbor, and the detection limits required for Portland Harbor are much lower (orders of magnitude lower) than those proposed for T4. Antimony and aluminum need to be added to the analyte list for metals. Historic practices indicate that these metals may be present in T4 sediments at levels of concern. The Tribes do not have a problem with other analytes in the T4 Work Plan if the analyses are conducted ***only*** on sediments that are removed from the site. If sediments remain onsite and especially if the sediments will be on the surface, the analyses must be more consistent with those for Portland Harbor. The Tribes would like to see the confirmational sampling that was discussed in the previous comment include the larger analyte list and lower detection limits to verify that known contamination was removed and that contaminants for which historic data are lacking are not present. Please revise accordingly. | Acknowledged; however, no change has been made and the Port does not propose to analyze sediment samples for aluminum and antimony. Existing data do not indicate aluminum and antimony are constituents of potential concern. Although bauxite (aluminum ore) was one of the ores handled at the site, aluminum is also a common element in the Earth's crust and in soil. Aluminum concentrations in sediment at the site display no spatial trend, indicating the concentrations are representative of background soil concentrations. Antimony may have been present in ore handled at the site but it was unlikely to be present at elevated concentrations, given that antimony is typically a minor element in other metal ores. |

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| | | | Based on existing data and the nature of these metals, it is unlikely that aluminum or antimony will be constituents of potential concern that drive cleanup at the site. |
| 138) | | **Category 1 and Category 2 Data**<br>The Tribes agree with Dana Davoli's comment on Category 1 and Category 2 data and support her recommendation that the Work Plan's language be made consistent with the Portland Harbor Work Plan. In general, the use of historical data requires that the data quality be appropriate and the original data objectives (including detection limits) be consistent with the objectives of the EE/CA. In addition, the Work Plan should elaborate on exactly how historical data are intended to be used. Please revise accordingly. | Acknowledged; see the responses to Comments 44 and 45. |
| | | **Specific Comments:** | |
| 139) | | 1. **p. 1-1** The Work Plan states "The Superfund Site, which encompasses about 6 miles of the Willamette River in Portland, Oregon includes the Terminal 4 facility (see Figure 1-1)." The word "currently" should be added to this sentence before the word "encompasses." | Acknowledged; the text has been revised as suggested and to reflect the definition of the Superfund Site set forth in Section 2.1. |
| 140) | | 2. **Sec. 2** There are numerous references in this section to decommissioning of USTs. The Work Plan states in only two places (p. 2-13 and 2-21) that ODEQ issued an NFA for the USTs. The descriptions of the other UST removals are silent with respect to NFAs or other findings. Final status of all USTs should be explicitly stated in the Work Plan. Anne Summers indicated the Port was working with ODEQ to address this issue and whatever information is uncovered should be incorporated into the Work Plan. | Acknowledged; however, no change has been made. See response to Comment 5 for reasoning; the work plan presents the best information currently available regarding the use of, hazardous substance releases on, and remedial investigations of the Terminal 4 Removal Action Area uplands. The Port will incorporate into the EE/CA any new information developed during the uplands work and will provide access to the documents containing such information. |
| 141) | | 3. **p. 2-30** The last sentence of the paragraph on lamprey on this page should be deleted or revised as it is incorrect as it is currently written. The ammocoete survey conducted by the Lower Willamette Group (LWG) was limited in scope and conducted at a time that was not optimal for finding lamprey ammocoetes. In addition, adult lamprey have been found in the Lower Willamette in other studies. "Farr and Ward (1992) and Beak (2000) reported collecting a few Pacific lamprey in the LWR." (quoted from the LWG's | Acknowledged; the text has been revised. |

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| | | Work Plan) | |
| 142) | | 4. **Tab. 2-6** This table should be corrected to match the table used in the Portland Harbor Work Plan. Specifically, bull trout was left out of Table 2-6 in the T4 Work Plan. | Acknowledged; bull trout has been added to the table. The table is also being checked against Table 2-8 of the Portland Harbor RI/FS Work Plan and will be made consistent with it. |
| 143) | | 5. **p. 2-44 - 7** The discussion of sedimentation patterns says that 3 things affect sedimentation – Willamette River, outfalls & ship scour. The Work Plan discusses the Willamette River and outfalls in detail but avoids discussion of ship scour for the most part. This needs to be discussed in at least some depth. | Acknowledged and agreed. Ship scour that redistributes sediments is an important factor in considering both recontamination potential and requirements for maintenance dredging. Published scientific studies on the bottom shear stresses generated by ship prop wash and tugboat activities will be used to assess the importance of ship scour in Slip 3. In addition, bathymetric survey maps showing localized impacts from ships will be evaluated and used to support conclusions regarding the area and spatial extent of large impacts to the sediment from ships (e.g., scour areas). Also, the near-bottom velocity meters and turbidity sensor data will be evaluated in comparison with shipping activity (times of berthing and departure) to evaluate the effect of vessel movement. |
| 144) | | 6. **Sec. 2.9** The Work Plan on pp. 2-47 and 2-48 and Figure 2-22 is inconsistent with respect to catchment basins. The text on p. 2-48 matches Figure 2-22 and seems to be the correct description. The text on p. 2-48, specifically the portion describing where outfalls discharge at T4, appears to be incorrect. | Acknowledged; the text and Figure 2-22 have been revised to be consistent and to provide appropriate clarification of catchment areas. |
| 145) | | 7. **p. 2-48** The text states "Three outfalls drain the 16.8-acre area south of Slip 3. An additional outfall in this area drains into the Willamette River. Two other outfalls previously drained this area into the Willamette River previously, but they have since been plugged and abandoned." Figure 2-22 shows that only one of these two was plugged and abandoned while it lists the other as "Abandoned (?)". The text and figure should be consistent. | Acknowledged; the text and figure have been revised to be consistent and to provide appropriate clarification of outfall status. |

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| 146) | | 8. **Tab. 3-2 & 4** Both of these tables list "USEPA Administrative Order on Consent for Remedial Action/Feasibility Study" as the reference for the 2000 Portland Harbor Superfund Site listing. Both should be corrected to say Remedial Investigation/Feasibility Study. | Acknowledged; the tables have been corrected. |
| 147) | | 9. **p. 3-13** The text states "Investigation performed since the Record of Decision was issued indicates that local soil and groundwater conditions, as well as the extent of LNAPL contamination, may be different than previously assumed." The differences to which this statement alludes should be explained as much as possible in the Work Plan. This information may inform the placement of samples. | Acknowledged; the text has been clarified to explain changed conditions, i.e., the LNAPL contamination appears to be less extensive than previously thought. The Port does not propose to change sampling locations based on this information. |
| 148) | | 10. **Sec. 3.3.2** This section's discussion of the outfalls at T4 should be expanded. It would be helpful to know if any exceedances of permit limits have occurred at any outfalls and if any outfalls have been identified as priority outfalls. | Acknowledged; however, no change has been made. This information will be collected as part of the Terminal 4 Upland RI. The RI will identify whether any additional investigation of outfalls is warranted. |
| 149) | | 11. **p. 4-4** The first sentence of Section 4.1.1.1 is very confusing and could mislead the reader. Similar sentences begin Sections 4.1.2.1, 4.3.1.1 and 4.3.2.1. These sentences should be revised to be clearer and more straightforward. | Acknowledged; the text has been revised as suggested. |
| 150) | | 12. **p. 4-15** The Work Plan states "Metals, PAHs, phthalates, tDDT, tPCB, and petroleum hydrocarbons are generally the COPCs for sediment in the Removal Action Area." Explain or remove the word generally. | Acknowledged; the text has been revised to explain that, based on existing data, these compounds are considered COPCs. The list of COPCs may be revised when data collected for the EE/CA have been reviewed. |
| 151) | | 13. **p. 5-1** The Work Plan states Constituents of potential concern in the Removal Action Area sediment are generally metals, PAHs, phthalates, tDDT, and tPCBs. Although other constituents, such as VOCs and butyltins, were occasionally detected in the Removal Action Area sediment, they tend to be detected infrequently and at concentrations near the detection limit (see Section 4). For that reason, the discussion of primary and secondary sources of contamination focuses on metals, PAHs, phthalates, tDDT, and tPCBs. There are two problems with this statement. It is unclear why petroleum hydrocarbons were left off this list of constituents of potential concern. Petroleum hydrocarbons should be added to this list. In addition, as was stated in the last comment, "generally" should be explained or removed. | Acknowledged; the text has been revised as suggested. |

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| 152) | | 14. **Sec. 5 & Fig. 6-2** The CSM described in Section 5 does not exactly match the geochemical site model in Figure 6-2, and the CSM of Section 5 is not consistent with Table 3-1. The pictorial CSM in Figure 5-2 does not show seepage directly entering the surface water as Figure 6-2 does. In addition, the text in Section 5 does not include seeps as a source. Table 3-1 describes a seep at the head of Slip 3 that was discovered in 1991. Thus, seeps should be added to the text in Section 5 as a primary source and to Figure 5-2. | Acknowledged; however, no change has been made to Figure 6-2. Figure 6-2 is generalized for the purpose of outlining a potential geochemical model for Terminal 4. The simplification does not imply that various specific sources will be ignored, but rather they may be incorporated into overall source loading terms if they still exist after the Removal Action.<br><br>The comment on Figure 5-2 is also acknowledged; Figure 5-2 and the text have been made consistent, including the seep pathway to surface water. |
| 153) | | 15. **Sec. 5-1 & 5-2** These sections both discuss offsite, in-river sources. It is not clear whether these sources are considered possible primary or secondary sources. This discussion needs to be clarified. | Acknowledged; these sources are considered secondary sources, and the discussion has been clarified to indicate that they will be evaluated primarily for their potential to recontaminate the site after implementation of the Removal Action. |
| 154) | | 16. **Sec. 5.2** It is also not clear why offsite sources are the only source identified on p. 5-3 as the secondary source of metals to the slips. Why would upland surfaces not be considered a secondary source of metals? | Acknowledged; however, no change has been made. Runoff from the upland is a secondary source and the text states this. |
| 155) | | 17. **Sec. 5.2.2** The Work Plan states that sediment from offsite will likely settle out at the east end of Slip 3. This does not agree with the sedimentation patterns for Slip 3 as they are described elsewhere in the Work Plan. The inconsistency should be resolved. | Acknowledged; the text has been clarified and the inconsistency with Section 6 resolved. |
| 156) | | 18. **Sec. 5.3 & Fig 5-2** To be consistent with the Portland Harbor Site, "Trespassers" should be replaced with "transients." The discussion of transients needs to be revised. The Port is evaluating future operations at Slip 1 so it is possible that future alterations in this area or its operations would make the area attractive to transients. If this happens, the surface water (and resuspended sediment) ingestion pathway would become a complete pathway as information collected as part of work in Portland Harbor indicates that transients drink the water from the Willamette River. Figure 5-2 and relevant text should be revised to | Acknowledged; please see the response to Comment 59. The text has been revised to reflect the possibility that transient exposures may become important in the future if the land use and/or ownership of the site changes. |

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| | | indicate this as a complete pathway and the pathway should be evaluated in the risk assessment. | |
| 157) | | 19. The Tribes agree with Dana Davoli's comment on the categories of fishers. Native American fishers should be included and pathways of exposure should match those of Portland Harbor. | Acknowledged; the text has been revised in accord with Davoli's comment. |
| 158) | | 20. According to Figure 5-2 no exposure pathway is to be considered for site workers. It is not appropriate to entirely eliminate this receptor from consideration. At least one of the pathways should be evaluated even if it is assumed to be a minor source of exposure. The Tribes suggest evaluating the T4 RAA sediment (including porewater) direct contact/uptake pathway as this is the one that would likely result in the highest exposure. If necessary, other sections of the Work Plan that discuss risk assessments should also be revised to reflect these revisions. | Acknowledged; revisions to the text requested by Davoli and Hillman address this issue. |
| 159) | | 21. **p. 6-5** The Work Plan in Section 6.5.1 states "Data from Slip 1, Slip 3, and Wheeler Bay indicate concentrations of PAHs, zinc, and DDT in surface sediments that exceed commonly used SQGs." It is unclear why these constituents were singled out versus the rest of the COPCs identified in Section 4.4. Please explain this statement. | Acknowledged; the text specified in this comment refers to general results and has been clarified to indicate that these chemicals represent only a partial list. |
| 160) | | 22. **p. 6-6** The text currently states the following "However, if risk calculations being developed by the Lower Willamette Group become available during this process, those values will be used instead of SQGs." This text should be rephrased as follows "However, if risk calculations being developed by the Lower Willamette Group are approved by EPA and its partners during this process, those values will be used instead of SQGs." Similar text is found elsewhere in the Work Plan (as on p. 8-8), and all this text should be revised appropriately. | Acknowledged; the text has been revised as requested. |
| 161) | | 23. **p. 7-4** The section on fish resources should be revised. One cannot draw the conclusion that fish resources will not be affected in the absence of data regarding the contribution of contaminants to resident and non-resident fish from T4. These statements should either be removed or data should be presented to support them. In addition, the reference to Section 8.5.1.5 should be removed as it is not relevant to the discussion in this section. | Acknowledged; the text has been revised to clarify the statements. |
| 162) | | 24. **Sec. 7.9** This section describes the approach to sampling to fill data gaps with respect to dredged sediment quality characteristics. The described approach of compositing one sample for Slip 1, one for Slip 3 and another for all sample locations may not give sufficient information to meet future needs. This approach is valid if the same removal action is applied to the entire slip, e.g., all of Slip 3 is dredged, or if the contamination is | Acknowledged; however, no change has been made. The Port believes that the current compositing approach is sufficient to characterize the sediment for the purposes of establishing dredge characteristics and STLC |

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| | | the same throughout. This approach is a problem if a removal alternative only requires dredging part of the slip or if the contamination varies in the slips as is described in the Work Plan. A possible solution is to composite samples from ½ of each slip and another in Wheeler Bay or make two composites from Slip 1, one from Wheeler Bay and one from Slip 3 because it appears to be extensively contaminated. | limits. Should additional characterization needs be identified following analysis of the data, the Port will seek regulatory input and propose secondary testing, as necessary.<br><br>See also the response to Comment 68. |
| 163) | | 25. **Sec. 7.9.4** The Tribes are concerned about the description in this section of the Work Plan on data quality validation. The Tribes want to discuss this issue with a validation expert in EPA before deciding whether or not a comment should be made to the Port. The data quality validation approach should be consistent with that taken in Portland Harbor. | Acknowledged; no response required. |
| 164) | | 26. **p. 7-13** In the discussion of the Column Settling Test, the Work Plan appears to contain an error. In every other discussion of dredged sediment quality characteristics testing, the Work Plan describes composites as being from 0 to 11 feet. In the case of CST, the composites are described as being from the 0 to 7 feet. Appendix A (Table A1-10) lists the interval as 0 to 7 feet as well. All references to depth range of the composites should be revised as appropriate. | Acknowledged; all references to depth range have been revised to 0 to 11 feet. |
| 165) | | 27. **p. 7-16** The section on Moored Arrays describes considerations that must be taken to address potential impacts of ship activity on the arrays. In case it was not already planning to do so in future reports, the Tribes request that the Port include brief descriptions of ship activity in and around data collection efforts. | Acknowledged; a more detailed description of ship activity has been provided in the revised work plan. The Port of Portland's engineers have been contacted by BBL to discuss shipping activity and potential limitations on field work and diver operations. The tenants of Slip 3, Kinder Morgan, will be contacted so that a description of vessel movement in and out of Slip 3 can be prepared. Our current understanding is that approximately 100 ships per year are serviced at Slip 3, typically of the 50,000-ton class, and never more than one ship at a time. Ships are berthed bow toward the river and are maneuvered with tugboat tenders during berthing and departure. |

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| 166) | | 28. **Fig. 7-3 and 7-5** The Port has proposed to collect only samples VC18, 19, 20 and 21 in Wheeler Bay. This coverage is insufficient given the available historic data and additional samples should be taken. The historic samples in the southeastern portion of Wheeler Bay showed high levels of contamination; however, these samples were only taken to a depth of four feet. This means we only have limited information for what appears to be a fairly highly contaminated section of the bay and no information for the middle of the bay. Additional information (both lateral and vertical) in Wheeler Bay would be very beneficial to the future design and evaluation of removal alternatives. Unless the Port has information not clearly detailed in the Work Plan that shows that samples VC18, 19 and 21 are going to return high levels of contamination thereby subjecting the whole bay to removal, two more samples should be collected in Wheeler Bay – one in the middle of the bay and one near the southeastern corner. This will help everyone in the future by avoiding an argument over the extent of dredging that is warranted in Wheeler Bay given the limited data. | Acknowledged; although the Port does not propose to collect additional borings in Wheeler Bay beyond what is proposed in the work plan, sample location VC19 will be moved to the southeast, and sample location VC21 will be moved closer to the center of the bay. Interpolations of the analytical results will be used to determine the extent of contamination in Wheeler Bay. |
| 167) | | 29. Slips 1 and 3 could also benefit from additional sample locations; specifically, the center of the slips. The Port should collect two additional samples in the center of Slip 3 and one additional sample in the center of Slip 1 to provide a much more comprehensive picture of the site and a better evaluation of removal action alternatives. The sampling explained here is in addition to the sampling identified as necessary for the Berth 412 area that was discussed in the general comments. | Acknowledged; one additional boring has been added to the center of Slip 3. See the response to Comment 51. |
| 168) | | 30. **Sec. 8.5.2.4** The title of this section should be changed from State Acceptance to State and Tribal Acceptance, which more closely reflects the text of the section. | Acknowledged; the title of the section has been revised as suggested. |
| 169) | | 31. **Table 8-1** The ARARs identified in the T4 Work Plan should match the ARARs compiled for Portland Harbor, especially with respect to Tribal regulations. | Acknowledged; when the Terminal 4 ARARs are complete, the Portland Harbor ARARs document will be reviewed and additions will made where appropriate, with a particular focus on Tribal regulations. |
| 170) | | 32. **Tab. A1-10** It is unclear why this table says 7 composite samples will be used in the engineering properties test but then only gives one composite ID (T4-CM3). In addition, it is unclear why the table identifies the composite depth as 0-7 ft. This is different from what was stated elsewhere in the Work Plan. These discrepancies should be explained. | Acknowledged; the table has been revised to indicate one composite sample, and composite depths have been revised to 0 to 11 feet. |
| 171) | | 33. **Sec. A1-6.3** This section on ADCP does not appear to agree with other sections of the Work Plan on sedimentation. Section 2.8 (especially pp. 2-46 and 2-47) of the Work | Acknowledged; this is a good point. The circulation patterns in the slips during low- and |

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| | | Plan describes sedimentation in the slips. Deposition is said to occur in Slip 1 during periods of low flow, and Slip 3 is said to exhibit flow and sedimentation patterns that are "quite variable." Section A1-6.3 states, however, that ADCP will focus on high river flows because "flow and sedimentation patterns during these periods are of most interest." Section A1-6.3 also states that mobilization will occur three times, if possible; and the survey during low flow appears to be the lowest priority. Although it is certainly of interest to conduct a survey during high flow, it appears from the text in Section 2.8 that conducting a survey during low flow would be at least, if not more, important. At least one of the three proposed ADCP mobilizations should occur during a period of low flow. ACDP surveys during low and high flows would provide much better inputs to the hydrodynamic model described on pp. 7-14 through 7-16. | high-flow conditions, and associated deposition rates and patterns during these conditions, are of particular interest. The field work will occur in the spring; however, an effort will be made to capture a "low"- and a "high"-flow event, although the flow range during the period when field work is being conducted may preclude capturing a wide range of flow conditions. |
| 172) | | 34. **p. A2-4-1** The QAPP lists the analytes for sediment and surface water samples: the metals to be analyzed are the same, as are the methods for SVOCs, tDDT, PCBs and TPH. In Tables A2-1 and A2-2, which detail the list of analytes for sediment and surface water, respectively, the analyte lists are not the same. The chemical analyses should be the same for metals, SVOCs, tDDT, PCBs and TPH in surface water and sediment. This error in the Work Plan should be corrected. | Acknowledged; an explanation for this apparent discrepancy has been added to the text. There are additional metals, semivolatile organic compounds, pesticides, herbicides, and volatile organic compounds in Table A2-2 that are not included in Table A2-1. The additional compounds are for the TCLP analyses that will be performed for upland disposal characterization. |
| 173) | | **35.** The QAPP needs to explain the rationale for analyzing dissolved metals versus total metals in surface water. | Acknowledged; an explanation has been added to Section A2-4. Surface water samples will be analyzed to provide data on the initial conditions of water used in the elutriate tests. The methods for the elutriate tests recommend analyzing the dissolved fraction. To be consistent, the surface water samples will also be analyzed for the dissolved fraction. |

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WORK PLAN
TERMINAL 4 EARLY ACTION

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# Transmittal

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To: Mr. Sean A. Sheldrake
USEPA Region 10
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Mailstop: ECL-113
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Date: February 23, 2004

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Re: T4 Work Plan

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Remarks:

Enclosed please find the above-referenced work plan. We look forward to EPA's approval of this document and commencement of field activities on March 1, 2004.

Sincerely,

BLASLAND, BOUCK & LEE, INC.

cc: See distribution list attached

Philip A. Spadaro
Project Manager

02/23/04
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