Appendix N

Recontamination Analysis

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Appendix N – Recontamination Analysis

This appendix presents the methodology for assessing the potential for post-Removal Action recontamination of surface sediment within the Removal Action Area. The recontamination analysis will be conducted using the methodology described herein and the predicted post-Removal Action surface sediment characteristics; data collected during the 2004 field characterization program; and additional data (wet-weather sediment trap and stormwater) currently being collected. Updates of the recontamination analysis will occur during the detailed design phase of the project and again prior to implementation of the removal action.

A technical memorandum, presenting the methodology for assessing the potential for post-Removal Action recontamination, is provided as Attachment N-1 to this appendix.

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Attachment N-1

Technical Memorandum

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MEMORANDUM

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To: Anne Summers, Port of Portland Project Manager **Date:** January 21, 2005 (as revised May 3, 2005)

From: Philip Spadaro, BBL, Inc.
Jennifer Deters, BBL, Inc. **cc:**

Re: Recontamination Assessment Methodology
Terminal 4 Early Action

This technical memorandum presents a proposed methodology for assessing the potential for post-Removal Action recontamination of sediment in the Port of Portland Terminal 4 Removal Action Area. The recontamination assessment will be performed based on this methodology as part of the engineering evaluation and cost analysis (EE/CA) to be submitted in draft form in January 2005. Findings of the recontamination assessment will be considered in the evaluation of long-term effectiveness of the removal action alternatives included in the EE/CA.

Introduction and Purpose

The Terminal 4 Removal Action is being conducted by the Port of Portland (Port) under an Administrative Order on Consent for Removal Action (AOC), CERCLA 10-2004-0009, executed by the Port and USEPA in October 2003. Figure 1 provides a plan view of the Removal Action Area. The AOC and associated Statement of Work (SOW) attached to the AOC as Appendix B require the Port to conduct an EE/CA on various alternatives for the Terminal 4 Removal Action. The SOW also requires the preparation of a work plan to describe the activities to be performed during the EE/CA in order to fulfill the requirements specified in the SOW. The *Terminal 4 Early Action Engineering Evaluation/Cost Analysis Work Plan* (BBL, 2004a; work plan) was submitted to USEPA by the Port in February 2004.

Specific requirements for the work plan were outlined in Section II-1 of the SOW, including a requirement to provide:

> *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.*

However, to allow discussions with other interested parties and the incorporation of data collected during the 2004 EE/CA field program, a methodology for assessing the potential for post-

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Removal Action recontamination was not included in the work plan. This technical memorandum is therefore intended to address that requirement.

Following review of this memorandum by the Port, USEPA, and other interested parties, the recontamination assessment methodology will be finalized and the assessment will be performed in conjunction with the ongoing EE/CA. The findings of the recontamination assessment will be presented in the EE/CA report. The SOW also allows the recontamination assessment to be updated as part of the prefinal (60%) design analysis report and/or at the preconstruction phase of the project, as appropriate.

Objectives

The objectives of this technical memorandum are to:

- identify and perform an initial screening of potential sources of post-Removal Action recontamination of the Removal Action Area;

- establish the methodology and approach for the identification of chemicals of potential concern (COPCs) for the recontamination assessment, characterization of retained sources, estimation of COPC loading and mass deposition rates for ongoing sources, and delineation of potential recontamination spatial patterns and recontamination trends; and

- identify data needs for the recontamination assessment and provide a proposed methodology for data collection and integration of new data into the existing data set.

Identification and Initial Screening of Potential Sources

Potential sources of Removal Action Area recontamination are summarized conceptually on Figure 2. An initial screening of these potential sources was conducted to promote a more focused assessment of recontamination potential in the EE/CA report. The potential sources were screened based on a preliminary assessment of their potential to contribute contamination to the Removal Action Area. The following factors were considered in the initial screening:

- available data associated with each source;

- magnitude and frequency of source activity (e.g., estimated flow rates);

- anticipated future source trends (increasing, staying the same, or declining) and rationale (e.g. planned source control); and

- approximate spatial scale of source impacts (e.g., slip-wide or localized).

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The initial screening of potential sources was also influenced by how well the potential impacts associated with each source are understood. Sources for which further evaluation will be required before recontamination potential can be fully assessed were retained for consideration in the recontamination analysis. Results of the initial screening are summarized in Table 1 and are described in the following subsections for each source category.

Potential Upstream Sources

Contaminants associated with particles transported to the Removal Action Area by the Willamette River represent a potential source of recontamination by deposition. Examples of potential upstream sources include:

- resuspended sediment from potentially contaminated areas upstream;
- upstream point-source stormwater discharges (e.g., upstream outfalls);
- upstream point-source industrial discharges;
- upstream non-point-source discharges; and
- over-water activities (e.g., material handling, construction activities).

Other indirect urban source mechanisms (e.g., potential spills, overland flow, and wind-blown material entering the Willamette River) may be also present, but are essentially unquantifiable and are assumed to be relatively minor sources compared to the potential sources listed above.

Available data from similar river systems indicate that contaminant loading from upstream sources is typically dominated by the transport and deposition of particle-bound contaminants or suspended sediments. Contaminant loadings from potential upstream sources are integrated in the river upstream of the Removal Action Area. As a result, the combined impact of these sources can be measured using techniques such as sediment trap sampling.

Four sediment traps were deployed within and upstream of the Removal Action Area during two deployment periods in April and May 2004 (Figure 3). During the April 2004 deployment period, one trap was placed near the center of Slip 1 (Slip 1), two traps were placed near the head (Slip 3 East) and mouth (Slip 3 West) of Slip 3, and one trap was located near Berth 414 (Toyota Dolphin). The sediment traps were redeployed at the same locations in May 2004, except for the trap at location Slip 3 West, which was relocated upstream of Berth 416 (Berth 416).

Sediment chemistry data obtained from the sediment trap samples are summarized in Section 4.5 of the characterization report (BBL, 2004b). The sediment trap chemistry data were compared to TECs and PECs. The TECs and PECs provide a useful screening tool for identifying constituents of interest (COIs) and potential areas of concern. Based on this comparison, concentrations of select metals, PAHs, and pesticides were present above PECs and/or TECs in samples collected from the sediment traps deployed within Slips 1 and 3. In general, during the April deployment period, concentrations of metals, PAHs, and pesticides measured in Slip 3 East were comparable to or higher than concentrations measured in Slip 1 or Slip 3 West. There were no PEC or TEC exceedances measured in the April Toyota Dolphin sample. During the May deployment period, concentrations of metals and PAHs in the Slip 3 East and Slip 1 samples exceeded the PECs

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and/or TECs. Concentrations were generally higher in the Slip 3 East sample than in the Slip 1 sample. Slight exceedances of the TECs for copper, nickel, total DDT and Σ DDTs were measured in the Toyota Dolphin sample collected in May and slight exceedances of the TECs for copper and nickel were measured in the Berth 416 sample.

Concentrations of metals measured in the April Slip 3 East sample were generally comparable to the May Slip 3 East sample. Detected concentrations of PAHs and pesticides in the April sample from this location were generally higher than in the May sample. The samples collected from Slip 1 indicate a similar trend. Detected concentrations of metals, PAHs, and pesticides were generally higher in the April sample than in the May sample. In the Toyota Dolphin sample, there were no exceedances of TECs or PECs during the April sampling event and only slight exceedances of the TEC for copper, nickel, total DDT and Σ DDTs during the May sampling event. Generally, the two Toyota Dolphin data sets were comparable.

The sediment trap data collected in April and May 2004, combined with corresponding measurements of current velocity and direction within the river and slips, provide useful information related to sediment transport and deposition within the Removal Action Area during low-flow conditions. However, these data appear to reflect a number of potential influences, including resuspension due to vessel activity, stormwater outfalls discharging directly into the Removal Action Area, as well as upstream sources. The velocity and directional data collected by current meters moored in Slip 3 during the study period suggest that currents within Slip 3 were largely dominated by localized vessel activity as opposed to river influences. Visible banding of sand and silt layers within many of the traps also suggest periodic resuspension and redistribution of sand by vessel activity and other factors, including stormwater outfalls.

In addition, because of unusually dry weather conditions during the spring deployment periods, the existing data likely do not represent all source mechanisms (e.g., high rainfall events and potential resuspension during higher flows). Based on the information summarized above, the existing data are not sufficient to fully evaluate potential upstream contaminant contributions and upstream sources are retained for further data collection and analysis in the recontamination assessment.

Stormwater Outfalls to the Removal Action Area

Available storm drainage system drawings (HDR, 2004; and Port of Portland, 2000) indicate that stormwater discharged directly to the Removal Action Area is derived from 11 catchment basins (Figure 4). Stormwater runoff from approximately four additional basins drains into the river immediately upstream of the Removal Action Area. Outfalls discharging directly to the Removal Action Area may potentially recontaminate portions of the Removal Action Area at outfall locations through localized deposition. Discharges from outfalls that discharge both directly into and upstream of the Removal Action Area may also affect broader areas due to the dispersion of fine particulate matter. As a result, stormwater outfalls represent potential sources of recontamination to the Removal Action Area.

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Stormwater outfall locations, identification numbers, and associated catchment basins are shown on Figure 4 for stormwater outfalls discharging directly to, and immediately upstream of, the Removal Action Area. Table 2 summarizes relevant information available for each catchment basin, including identification letter, approximate catchment basin size, general description of historic and current land uses, associated outfall ID numbers and pipe size, and the accessibility of each outfall and associated manholes.

Limited stormwater discharge and chemistry data are currently available for directly assessing the recontamination potential associated with each outfall. Surface sediment chemistry data collected during the 2004 field program in areas where stormwater outfalls directly discharge were compared to the TECs and PECs. Surface sediment sampling locations and sediment chemistry results are provided in the Characterization Report (BBL, 2004b) and are summarized for select constituents on Figures 5 through 8.

The data summarized on Figures 5 through 8 do not allow a complete assessment of the recontamination potential associated with stormwater outfalls within and upstream of the Removal Action Area. As a result, additional information related to stormwater outfalls will be needed to fully assess the potential for post-Removal Action recontamination and this source is retained for further analysis in the recontamination assessment.

Groundwater Discharges

Two potential pathways for the transport of contaminants associated with groundwater to the Removal Action Area are: the seepage of nonaqueous-phase liquid (NAPL) from historical upland releases and the transport of dissolved-phase constituents present in groundwater discharges. These two potential pathways are discussed below.

Nonaqueous-Phase Liquid

Light nonaqueous-phase liquid (LNAPL) is present in the subsurface east of Slip 3 as a result of petroleum product releases that occurred from historical operations by Union Pacific Railroad, ExxonMobil (formerly General Petroleum), and Chevron (formerly Standard Oil). In 1970, Union Pacific Railroad identified five leaks in their pipeline system. Beginning in 1971, petroleum hydrocarbon seeps and sheens were observed within Slip 3 as a direct result of releases from the Union Pacific Railroad pipelines (Hart Crowser 2004a). A feasibility study (FS) was prepared by Hart Crowser in 2002 to evaluate alternatives for addressing the observed LNAPL in order to mitigate human exposure and potential risks to aquatic ecological receptors. Based on the FS results, a recommended remedy was approved by Oregon DEQ and included the following two primary components:

- Excavating LNAPL-containing soil adjacent to the east side of Slip 3 and backfilling the excavation with soil amended with organoclay to prevent future petroleum hydrocarbon migration to the slip in concentrations that could adversely impact beneficial uses; and

- Removing LNAPL present in the subsurface east of Slip 3 (Oregon DEQ, 2003).

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To assist in the design of the LNAPL removal system, a product extraction well and two additional monitoring wells were installed in 2002 in a location that historically contained the thickest accumulations of product. When no product was observed in any of the three new wells over an eight-month period, the conceptual hydrogeologic model of the site was re-evaluated. Water- and LNAPL-level monitoring and LNAPL removal were performed in the area from August 27, 2003 through April 1, 2004 to better evaluate the presence and distribution of LNAPL at the facility. Only 56 gallons of product could be removed during this period, and LNAPL was not observed in most of the wells. The conceptual hydrogeologic model was revised based on the results of the additional site work. The revised model indicates that only a small volume of LNAPL is present in the subsurface of the facility. Most of this product is present in localized areas and is not likely to migrate into Slip 3.

The proposed remedy for the site was approved and ordered by Oregon DEQ in an October 2004 Consent Judgment between the Oregon DEQ and the Port (Oregon DEQ, 2004). The Port has implemented the bank excavation and backfill remedial action (BEBRA) portion of the remedy and will initiate continued LNAPL removal and monitoring in December 2004. These actions will serve as ongoing upland source control for the facility to mitigate future recontamination of Slip 3 sediments from residual petroleum hydrocarbons in the subsurface of the Terminal 4 Slip 3 Upland facility.

The historically observed LNAPL seepage will be considered in the evaluation of existing sediment chemistry data obtained for Slip 3. However, the Slip 3 BEBRA (also referred to herein as the Slip 3 Upland Source Control Project) is expected to effectively mitigate the potential for future LNAPL seepage. As a result, this source was not retained for further evaluation in the recontamination assessment.

Dissolved-Phase Contaminants

The potential transport of dissolved-phase contaminants from groundwater to surface sediment can occur through two primary mechanisms: (1) the partitioning of contaminants present in the groundwater to the surface sediment, and (2) the transport of dissolved-phase contaminants from groundwater to surface water within the Removal Action Area, subsequent partitioning onto particulate matter suspended in the water column, and deposition onto the sediment surface.

BBL's current understanding related to Terminal 4 hydrogeology is summarized in Section 5.2 of the *Terminal 4 Early Action Characterization Report* (BBL, 2004b). Generally, the area appears to be characterized by three hydrostratigraphic units: (1) the sands of the upland fill material; (2) the finer-grained sands, silts, and clays of the Unconsolidated Alluvial Deposits; and (3) the gravels of the Troutdale Gravel. The finer-grained materials of the Unconsolidated Alluvial Deposits act as an aquitard for the Troutdale Gravel. In the western portion of Terminal 4 (west of the former shoreline), the two geologic units of upland fill material and Unconsolidated Alluvial Deposits combine as essentially one hydrostratigraphic unit that is above the underlying Troutdale Gravel. If there were ongoing contaminant transport to sediment from groundwater, it would most likely occur in the upland fill material.

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For groundwater in all three hydrostratigraphic units, the net horizontal hydraulic gradient was observed to be toward the river. Horizontal hydraulic gradients in the upland fill material were observed to range from 0.002 to 0.02 ft/ft. In general, horizontal hydraulic gradients were steeper in the upland portions and shallower in the near-river portions of Terminal 4. Short-duration (i.e., 1-hour) gradient reversals were recorded for all three units and were associated with tidal changes in the river. Estimated horizontal groundwater velocities likely vary significantly in the various soil types encountered at Terminal 4. However, the average horizontal groundwater velocity was estimated to be approximately 2 ft/day for sand in the upland fill material. Vertical hydraulic gradients ranged from 0.213 ft/ft upward to 0.17 ft/ft downward and were primarily upward at some locations and primarily downward at others, while gradient reversals were observed at several near-river locations. Variations in river stage may have caused the observed gradient reversals between hydrostratigraphic units at some near-river locations.

Available groundwater chemistry data summarized in the *Phase 1 Data Summary Report, Remedial Investigation, Terminal 4 Slip 1 Upland Facility* (Hart Crowser, 2004b) indicate concentrations of pesticides, PAHs, total petroleum hydrocarbons (TPH), or arsenic slightly above potential screening criteria in wells screened in the upland fill material and Unconsolidated Alluvial Deposits at Slip 1. The BEBRA is expected to mitigate dissolved-phase petroleum hydrocarbon migration to Slip 3 from the northern portion of the Slip 3 Upland Facility. Dissolved-phase petroleum hydrocarbons and PAHs were measured in an isolated portion of the facility south of the BEBRA area, according to recent data provided in the *Product Removal and Groundwater Monitoring Report, Terminal 4 Slip 3 Upland Facility* (Hart Crowser, 2004a). Additional groundwater monitoring is planned for 2004 and 2005 as part of ongoing work to better evaluate the presence, distribution, and concentrations of these constituents at Slip 1 and Slip 3.

Available hydrogeologic and groundwater chemistry data indicate that groundwater is likely not a potential source of recontamination to the Removal Action Area. However, to allow for the evaluation of historical and forthcoming groundwater data (from upland remedial investigations and ongoing monitoring at Slips 1 and 3), groundwater has been retained for further consideration in the recontamination assessment.

Direct Runoff and Bank Erosion

Direct surface water runoff and bank erosion are not expected to represent significant sources of ongoing area-wide recontamination to the Removal Action Area. Areas with significant overland surface water runoff have not been observed at Terminal 4. However, bank erosion observed in the area to the west of Berth 408 in Slip 1 and in Wheeler Bay (Figure 9) may present a potential source of localized recontamination in these two areas.

Limited upland soil data exist near the eroding banks in Slip 1 and Wheeler Bay. Available sediment chemistry data collected adjacent to the eroded banks in Slip 1 (from locations T4-VC12 and T4-VC13) were compared to the TECs and PECs. The surface and subsurface chemistry data from these samples indicate concentrations of metals, PAHs, pesticides, and total

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PCBs above PECs and/or TECs. There are no historical data related to material handling, pipelines, outfalls, or if dredge material may have been used as fill in this area.

Available sediment chemistry data for Wheeler Bay indicate concentrations of metals, PAHs, pesticides, and total PCBs above associated PEC and/or TEC values. There is historical documentation of fill being placed in the vicinity of Wheeler Bay.

Based on the information summarized above, the potential for localized recontamination as a result of bank erosion has been retained for further consideration in the recontamination assessment. The collection of additional upland soil samples near the eroding banks is also planned for January 2005 as part of ongoing remedial investigation activities at Slip 1. These additional data will be considered in the recontamination assessment.

Resuspension of Removal Action Area Sediment

The redistribution of sediment is a concern during the implementation of any removal action that combines approaches (e.g., partial dredging and capping of other areas) or that occurs partially or in sequence (e.g., multiple pass dredging). The potential for sediment redistribution during implementation of the Removal Action will be taken into account in the EE/CA when estimating the post-Removal Action surface sediment concentrations. The estimated post-Removal Action concentrations will be used as the baseline for the recontamination calculations.

The sediment trap and Acoustic Doppler Current Meter (ADCM) data collected from Slip 3 during the 2004 field program suggest that vessel activity may have a significant influence on sediment redistribution in the Removal Action Area. The redistribution of sediment within the slips due to vessel activity will be considered during the evaluation of sediment transport and deposition within the Removal Action Area and in the evaluation of existing sediment chemistry data.

Resuspension and redistribution of Removal Action Area sediment was not retained as a potential source of recontamination. Although sediment resuspension due to vessel activity within Slip 3 appears to be significant, the potential for future recontamination caused by the redistribution of contaminated sediment will be addressed through the removal and/or capping of impacted areas and the use of containment measures, as needed, during the Removal Action.

Atmospheric Deposition

Precipitation and dry deposition of regional atmospheric contaminants, as well as wind-blown particles from nearby, are potential sources of recontamination to the Removal Action Area. Although this factor is not considered significant because of the relatively small air catchment associated with Terminal 4, additional data related to atmospheric deposition are needed to fully assess the recontamination potential of this source.

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Existing Structures

Treated timber may contribute some PAHs to the Removal Action Area, although likely not at significant levels. Structures in the Removal Action Area potentially constructed of creosote-treated timbers include the timber pilings for Piers 1 and 2 in Slip 1 (below pile caps and below visible pier timber framework); Berth 410 of the Kinder Morgan pier; and the Slip 3 timber pile field along former Pier 5.

Surface and subsurface sediment chemistry data collected from locations in the vicinity of these structures are summarized in the *Terminal 4 Early Action Characterization Report* (BBL, 2004b). Sediment chemistry data collected from locations near potential creosote-treated timber were compared to the average of concentrations measured within each subarea (e.g., Slip 1, Slip 3). This comparison did not indicate a strong correlation.. However, although a correlation was not evident, PAHs released into the water column from treated timber may disperse over a larger area and may not result in apparent localized contamination. As a result, this source has been retained for further consideration in the recontamination assessment.

Operations, Material Handling, and Spills

Terminal 4 operations, material handling, and spills are not expected to present a significant source of ongoing contamination to Terminal 4 because of the low likelihood of a spill, as well as the unpredictability of spill frequency or impact. No current or planned bulk handling of materials containing COIs has been identified for the Terminal 4 Removal Action Area. Additionally, if a spill did occur, there is a high likelihood that it would be detected and subsequently addressed under an emergency response action. As a result, this potential source was not retained for further evaluation in the recontamination assessment.

General Recontamination Evaluation Framework

The general recontamination framework will employ a mass balance approach for estimating post-Removal Action COPC concentrations over time in the top 1 foot of sediment in the Removal Action Area. A conceptual graphic illustrating this approach is provided on Figure 10. The use of a 1-foot depth for purposes of the assessment is consistent with the ongoing risk evaluations being conducted as part of the EE/CA and with work being performed by the Lower Willamette Group (LWG).

Based on a review of available sediment chemistry data, a preliminary list of COIs was identified for sediment sampling performed during the 2004 EE/CA field program. The preliminary COIs were metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc); semivolatile organic compounds (including PAHs and phthalates); select pesticides and their metabolites (including 2,4'-DDD, 4,4'-DDD, 2,4'-DDE, 4,4'-DDE, 2,4'-DDT, and 4,4'-DDT); polychlorinated biphenyls (PCBs as Aroclors); TPH; gasoline-range organics; diesel-range organics; and residual-range organics. A subset of these COIs will be identified as COPCs for the EE/CA, and the same COPCs will be used for the recontamination assessment. The COPCs will be selected in accord with the streamlined risk evaluation methodology outlined in the Risk

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Assessment Methods Technical Memorandum (NewFields, 2004). The list of COPCs may be further refined during the EE/CA on the basis of additional data or findings of the residual risk analysis.

The recontamination framework will involve estimating the post-Removal Action mass depositional flux of COPCs to surface sediment, contaminant fate and transport within the surface sediment, and long-term COPC concentrations for each subarea. The spatial scale and variation of COPC loading rates will also be considered. Spatial scales may be Removal Action Area-wide, such as the deposition of fine-grained sediment from an upstream source, or localized, such as a depositional delta from a stormwater outfall or an area affected by bank erosion. The spatial scale for each source will be established based on an evaluation of sedimentation patterns in the Removal Action Area using a sediment transport model to be developed for this purpose.

Contaminant loadings from potential sources such as stormwater outfalls, upstream sources, and bank erosion is typically dominated by the transport and deposition of contaminants associated with fine-particulate matter. As a result, the evaluation of these sources will focus on particle transport (i.e., sediment transport) to surface sediment. The recontamination analysis will include the following general steps:

- estimate COPC loading rates from each potential ongoing source on an annual, seasonal, or flow-regime basis;
- estimate future trends in COPC loading for each source (increasing, staying the same, or decreasing) based on ongoing or planned source control programs and any available time-trend data;
- estimate sediment deposition rates based on sediment transport modeling results, sediment accumulation studies conducted by the Port, and sediment trap data;
- calculate COPC depositional fluxes to surface sediment in each subarea based on estimates of average COPC concentrations on suspended sediment and sediment deposition rates;
- estimate COPC transport rates via groundwater; and
- perform mass balance and contaminant fate and transport calculations for the top 1 foot of sediment in the Removal Action Area (i.e., the recontamination trend).

The general methodology for evaluating COPC loading rates and future trends associated with each source retained from the initial screening is described below, followed by a description of the sedimentation analysis methodology and the methodology for evaluating COPC depositional fluxes and surface sediment concentrations.

Methodology for Evaluating Upstream Sources

To reiterate, examples of potential upstream sources include:

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- resuspended sediment from potentially contaminated areas upstream;
- upstream point-source stormwater discharges (e.g., upstream outfalls);
- upstream point-source industrial discharges;
- upstream non-point-source discharges; and
- over-water activities (e.g., material handling, construction activities).

The impact of these sources will be manifested as concentrations of COPCs associated with particulate matter in river water flowing by the Removal Action Area. As a result, the combined mass loading/depositional flux from potential upstream sources will be estimated on a seasonal basis using hydrodynamic and sediment transport modeling, in conjunction with sediment trap chemistry data collected during low-flow conditions in March, April and May 2004 and additional data being collected during what are anticipated to be wet-weather, higher flow conditions in January and February 2005. Sediment trap deployment locations for 2004 and 2005 are shown on Figure 3.

In river systems like the Willamette, contaminant transport from upstream sources is typically dominated by the transport and deposition of suspended sediments and associated particle-bound contaminants within the area of concern. The amount of suspended sediment carried by the river that is retained within the Removal Action Area because of deposition will be estimated using a two-dimensional hydrodynamic model coupled with a sediment transport model. The estimates of deposition will ignore resuspension, thereby allowing for a conservative estimate of COPC loads being transported into the Removal Action Area. The effect of ships on the depositional patterns will be approximated by estimating the area over which ship scour resuspends sediment, assuming zero net deposition in this area and assuming the material is distributed to areas adjacent to the scour zones, as is indicated by bathymetric data and sediment trap data.

The mass of COPCs associated with sediment transported into the Removal Action Area from upstream will be estimated using available sediment trap chemistry data, as well as estimates of potential loading due to erosion and transport of sediment from upstream areas using the hydrodynamic and sediment transport model. The latter evaluation would consider (1) the spatial distribution in upstream sediment contaminant levels and (2) estimates of erosion potential for a range of flow events. The analysis would assume that any resuspended sediment reaching the Removal Action Area is in suspended transport mode and that reequilibration of phase partitioning (sorption) will occur. These estimates may take the form of simple bounding calculations because a detailed analysis of sediment transport in upstream areas will not be conducted.

For purposes of the recontamination assessment, the estimated depositional flux of COPCs from upstream sources will be held constant into the future. This assumption is likely conservative, because the load should decrease over time through the use of improved pollution control technologies, new development and redevelopment projects, and the cleanup of historically impacted sites. This assumption may be modified for future iterations of the assessment, as

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appropriate based on information related to significant changes in industrial practices or remediation of upstream sites.

Methodology for Evaluating Stormwater Outfalls

The evaluation of the recontamination potential associated with stormwater outfalls that discharge into and upstream of the Removal Action Area will include:

- sampling a select number of outfalls within and upstream of the Removal Action Area;
- estimating annual runoff volumes for each outfall using the USEPA Stormwater Management Model (SWMM) based on catchment characteristics and available precipitation data; and
- estimating mass loadings for a range of total suspended solids and contaminant concentrations based on available direct sampling data and land use for outfalls that are not directly sampled.

Outfalls Q-SJ15PP (Slip 1), City of Portland 52-C (Slip 1), O-SJ17PP (Slip 1), L-SJ19PP (Wheeler Bay), D-SJ24PP (North of Berth 414), C-SJ25PP (Upstream), and City of Portland 53 (Upstream) have been selected for direct sampling during the spring of 2005 based on a review of the following factors:

- whether the current or former land use and location of the catchment area indicate the outfall may present a potential source of recontamination;
- whether available sediment chemistry data indicate the outfall may present a potential source of recontamination;
- the size of the catchment area;
- whether the catchment area is representative of other, similar catchments at Terminal 4; and
- the accessibility and configuration of associated manholes for sampling.

The rationale for outfall selection is summarized on Table 3.

For each of the selected outfalls, in-line sediment traps will be installed within manholes located as far downgradient in the stormwater basin as practicable to integrate runoff from the majority of the basin without being impacted by the Willamette River. In addition to the in-line sediment traps, one round of stormwater samples will be collected to obtain measurements of total suspended solids and total dissolved solids. These data will be used in conjunction with estimates of annual stormwater runoff to calculate the mass loading of particle-bound COPCs to the Removal Action Area. The use of sediment traps will not provide an estimate of potential dissolved-phase loading associated with stormwater outfalls. However, dissolved phase loading

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is anticipated to present a relatively low potential for contaminant loading to the Removal Action Area compared to particle-bound constituents. Direct sampling of outfall COP-52C will be coordinated with the City of Portland (City). The Port and City are still evaluating the need for sampling of COP-53 based on its potential influence on the RAA and its relevance to the recontamination assessment. Additional sediment traps will be deployed immediately upstream of the RAA to assess overall influences from upstream sources, including COP-53 and if that information indicates a potential recontamination source, additional outfall sampling would likely occur.

Data collected through direct sampling will be used in conjunction with estimated annual stormwater runoff volumes to calculate COPC mass loadings associated with each respective outfall. The mass loading associated with outfalls that are not directly sampled will be estimated through the extrapolation of sampling data collected from outfalls with similar catchment basin characteristics (e.g., Basins A, B, and C, which both consist primarily of paved automobile receiving yards) or through the use of published loading factors based on land use. Mass loadings for a range of total suspended solids and contaminant concentrations will be estimated for outfalls that are not directly sampled.

The annual stormwater runoff rate will be estimated for each area using the USEPA SWMM. SWMM is a dynamic rainfall-runoff simulation model that can be used to estimate runoff quantity and quality from primarily urban areas. SWMM transforms user defined rainfall amounts into runoff, then routes the runoff volume through a user defined drainage system (e.g., surface channels, pipes, flow control structures, etc.) to estimate flow rates and water depths throughout the system. SWMM has been updated numerous times since its introduction in 1971, and provides the basis for thousands of stormwater studies throughout the world (www.epa.gov/ednnrmrl/swmm/#A).

For purposes of the recontamination assessment, future trends related to the estimated annual mass loading rates from stormwater outfalls will be evaluated based on available information regarding planned future land uses. In general, it is anticipated that mass loading rates will gradually decline into the future. This assumption is based on upland source control activities currently being investigated by the Port and continuing improvements in the use of best management practices for stormwater runoff by the Port and Port tenants.

Methodology for Evaluating Groundwater Discharge

The recontamination potential associated with groundwater discharges will be evaluated by calculating COPC migration into and through the top 1 foot of sediment, similar to the approach used when designing a sediment cap. The potential migration of COPCs through the top 1 foot of sediment can be modeled through a series of equations that simulate two general types of mass transport. In the absence of groundwater discharge through the underlying sediment, the chemical concentration gradient between the porewater and overlying water will control diffusion of the chemical upward through the surface sediment. If hydraulic conditions in the area indicate the active discharge of groundwater into the water body, the movement of the chemical in porewater from the underlying sediments to the surface sediment and overlying water column

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will most likely be driven by advective transport. This is likely the case for sediment within the Removal Action Area.

A simple, one-dimensional advection-dispersion model that incorporates retardation and has an option for facilitated transport due to the presence of dissolved organic carbon will be used to estimate COPC flux through the top 1 foot of sediment. Existing Terminal 4 data will be used for this analysis. A range of values will be used for those parameters that are estimated. The modeling will follow the procedures presented in current USEPA/USACE capping guidance.

For purposes of the recontamination assessment, the estimated annual mass loading rates from groundwater will be assumed to gradually decline into the future. The rate of decline may vary from area to area depending on the anticipated schedule for upland source control actions.

Methodology for Evaluating Direct Runoff and Bank Erosion

Direct runoff has not been retained as a potential source. The potential for localized recontamination due to bank erosion in Slip 1 and Wheeler Bay will be evaluated by developing bounding estimates of bank erosion rates and concentrations of COPCs associated with the material that would potentially be transported to the surrounding sediment. This approach will require the collection of additional soil samples near the banks where erosion has occurred for chemical analysis. Soil sampling in these areas is being conducted as part of upland source control activities and the additional data will be included into this analysis when available. The rate of erosion will be expressed as a loss (e.g., inches per year) over the area where bank erosion has been observed.

The estimated localized mass loading rates attributable to bank erosion will be assumed to decline into the future as a result of the implementation of source control actions and improvement projects, such as bank stabilization or soil removal.

Methodology for Evaluating Atmospheric Deposition

A literature search will be performed for published studies that evaluate measured or estimated regional atmospheric fallout for the identified COPCs. If regional data are not available, published data from other, similar regions will be evaluated, and the calculations will be performed over a range of values. These data will provide an estimate of seasonal mass loadings of constituents over the Removal Action Area.

Atmospheric deposition is not anticipated to be a significant source of COPC loading to the Removal Action area based on the relatively small air catchment associated with Terminal 4. Atmospheric deposition within the watershed and direct deposition onto the surface of the Removal Action Area would be manifested in sediment trap samples and may be incorporated into the assessment of upstream sources.

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Methodology for Evaluating Existing and Future Structures

A literature search will be performed for published studies that evaluate the release of PAHs from creosote-treated timber structures in freshwater environments. These data will be used in conjunction with conservative estimates of the total exposed surface area of potentially treated wood to calculate a mass flux of dissolved PAHs into surface water within the Removal Action Area.

Methodology for Estimating Sediment Deposition Rates

The primary purpose of the sedimentation analysis will be to estimate the long-term average sediment burial rates and approximate spatial variation in the Removal Action Area. Spatial variations in the sediment burial rate will reflect patterns of near-bottom currents as affected by the river and ship activity, as well as proximity to sediment sources. The estimated burial rate is a necessary input for computing recontamination trends in the top 1 foot of sediment.

The sedimentation analysis will be conducted using a combination of empirical information and model predictions. Empirical information on sedimentation rates and patterns is available through comparison of bathymetric data sets for the Removal Action Area, including bathymetric data previously obtained by the Port of Portland and the LWG. This information will provide an estimate of sediment mass accumulation rates and burial rates and information on the spatial variation in those rates. Preliminary inspection of bathymetric charts indicates higher rates of sediment accumulation in areas (1) less affected by ship scour; (2) toward the back of the slips, where circulation currents are lowest; and (3) in localized sediment depositional deltas near stormwater outfalls and areas of bank erosion. The sediment trap data collected during the 2004 field program and additional sediment trap data to be collected will also provide an estimate of sediment depositional fluxes during normal flow conditions in areas relatively unaffected by prop scour during the deployment period (e.g., Slip 1).

Sedimentation rates and patterns will also be estimated through application of a two-dimensional hydrodynamic model coupled with a sediment transport model. The sediment transport model will be run in deposition-only mode for several representative grain sizes to estimate the relative spatial variation in sedimentation patterns, ignoring redistribution by ships. The sediment transport model will provide a means for estimating sedimentation patterns throughout the Removal Action Area. In addition, areas of higher velocity will be mapped to investigate the potential for scour from fluvial forces within the Removal Action Area. Available empirical information on sedimentation rates from certain areas (for example, areas most frequently surveyed and the sediment trap sampling locations) will be used to estimate sedimentation rates at point locations, and the model results will be used to extrapolate this information to the whole Removal Action Area.

The sedimentation analysis will provide an estimate of the long-term net sediment burial rate for each subarea within the Removal Action Area based on the procedure described above. More detailed modeling of sediment redistribution caused by propeller scour is possible, but the

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approach outlined here is expected to adequately resolve the recontamination question without that additional effort.

Methodology for Evaluating COPC Depositional Fluxes and Surface Sediment Concentrations

The depositional flux of COPCs to each subarea will be estimated based on the estimated COPC loading contributions from each potential source and the results of the sedimentation analysis described above. The potential for scour will also be investigated to estimate potential export of particulate matter from the Removal Action Area.

Long-term future COPC concentrations in the top one foot of sediment will then be estimated based on the estimated COPC depositional fluxes and by using the predictive Officer and Lynch Model (Officer and Lynch, 1988) or equivalent approach. The Officer and Lynch model is a theoretical solution of sediment contaminant concentrations over time in the sediment column. The sediment column is represented as a system undergoing physical and chemical processes to some depth below the sediment-water interface (in this case, one foot). Beneath the mixed layer, sediment concentrations are considered fixed. Sediment below the mixed layer is not considered in this model. The following physical/chemical processes will be considered in the model:

- mixing rates in the mixed layer (bioturbation),
- accumulation rates,
- non-advective exchange rates (resuspension),
- chemical degradation (through biological or chemical processes).

Contaminants associated with particulate matter are deposited to the sediment surface by sedimentation processes. The non-advective concentrate exchange rate at the sediment-water interface is dependent on the fraction of particles which have been lifted and then returned back to the sediment column and the horizontal water column exchange rate out of the computational region. Because the model does not address spatial variability, the amount of resuspended particulate that is advected out of the waterway is determined as the ratio of the water column residence time and water column particulate residence time. For areas that are identified as predominately depositional, this variable would be set to zero.

Areas of potential impact associated with each source will be evaluated in concert to identify those portions of the Removal Action Area that may be most subject to recontamination. The analysis will include figures showing the approximate zones of impact and spatial variations in recontamination potential on the basis of source proximity, sedimentation rates, and sediment fate and transport.

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Identification of Data Needs

Specific data needs and proposed data collection activities are identified in the preceding discussions of evaluation methodologies. Data collection proposed for the recontamination assessment is summarized as follows:

- Collect sediment trap samples under wet-weather conditions in January and February 2005 at the locations shown on Figure 3.
- Collect stormwater and sediment samples from selected stormwater outfalls in January and February 2005.
- Collect soil samples near the banks where erosion has occurred to determine COPC concentrations in eroding bank soils.
- Conduct a literature search for published studies that evaluate measured or estimated regional atmospheric fallout for the COPCs.
- Conduct a literature search for published studies that evaluate the release of PAHs from creosote-treated timber structures in freshwater environments.

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Attachments

Table 1 – Source Screening Summary
Table 2 – Stormwater Outfall Summary
Table 3 – Stormwater Outfall Selection Summary
Figure 1 – Removal Action Area Plan
Figure 2 – Geochemical Conceptual Model
Figure 3 – April/May 2004 Sediment Trap Deployment Locations and Proposed Re-deployment Locations
Figure 4 – Stormwater Drainage Basins
Figure 5 – Surface Sediment Lead and Zinc Concentrations
Figure 6 – Surface Sediment Total PAH Concentrations
Figure 7 – Surface Sediment Σ DDT Concentrations
Figure 8 – Surface Sediment Total PCB Concentrations
Figure 9 – Photographs of Observed Bank Erosion
Figure 10 – Recontamination Analysis Methodology Conceptual Diagram

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Table 1
Source Screening Summary

Source	Available Information	Potential Importance	Screening Result
Upstream Sources	• Sediment trap data for low-flow conditions • Upstream sediment data (assumed)	High	Retained for further evaluation.
Stormwater Outfalls	• Catchment sizes and land use • Sediment chemistry data in vicinity of select outfalls • Outfall pipe size and accessibility for sampling select outfalls • City of Portland (COP) data summary for COP 52-A, 52-C, and 53	High	Retained for further evaluation.
Groundwater Discharges	• Hydrogeologic data, including groundwater flow direction and subsurface physical characteristics • Subsurface sediment chemistry data • Groundwater chemistry data	Moderate	Retained for further evaluation.
Direct Runoff and Bank Erosion	• Bank erosion observations in Slip 1 and Wheeler Bay • Sediment chemistry data in vicinity of eroded banks • Significant direct runoff was not observed	High but localized	Retained for further evaluation.
Removal Action Area Sediment	• Sediment trap data for low-flow conditions • Bathymetric data • Subsurface sediment chemistry data • ADCM and ADCP data	Low	Not retained. Although sediment resuspension in Slip 3 resulting from vessel activity appears to be significant, the potential for future recontamination due to sediment resuspension will be addressed through the removal or capping of impacted sediments and the use of containment measures, as needed, during implementation of the Removal Action.
Atmospheric Deposition	• Literature sources related to regional fallout needed	Low	Retained for further evaluation.
Existing and Future Structures	• Locations of structures likely constructed of creosote-treated timber • Limited sediment chemistry data in vicinity of the structures	Low	Retained for further evaluation.
Operations, Material Handling, and Spills	• Cargo type and frequency of handling at Terminal 4 • Operations and maintenance information for Terminal 4 • Spill response provisions in place	Low	Not retained. No current or planned bulk handling of materials containing COPCs is planned. The likelihood of upland spills affecting Removal Action Area sediment is low and not predictable.

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Table 2. Stormwater Outfall Summary

Catchment Area ID [3]	Approximate Catchment Area[4] (Acres)	General Catchment Area Description [4][6]	Historic Land Uses[4][6]	Current Land Uses[6]	Outfall ID[1]	Outfall Pipe Size [2] (Inches)	Accessibility of Outfall/Associated Manholes[6]
S	1	Paved and gravel area; includes road and roof runoff in southern and eastern portions.	Port of Portland former Cargill facility adjacent to Ceral Foods leasehold. Historic Cargill operations include grain storage and transfer. Storage of materials and maintenance activities could have resulted in historic surface spills. USTs were likely present. Adjacent to Schnitzer Steel and auto fluff material storage.	Provides access to Berth 401.	S-SJ13PP	10	Outfall is visible and accessible from land. No manholes associated with this outfall were observed.
R	15	Mostly asphalt with some gravel areas; a large elevated foundation rail tracks; catchbasins are concentrated in the southern portion of the area. A portion of the northwestern section infiltrates and drains directly to river.	City CPD former cold storage and ventilated warehouse, former Cargill leasehold, and Cereal Foods leasehold. Historic Cargill operations included grain transfer via conveyor. Historic Cereal Foods activities included milling grain products, storage and transfer. Storage of materials and maintenance activities, including transformer handling, could have resulted in historic surface spills. USTs were likely present. Adjacent to Schnitzer Steel and auto fluff material storage.	Cereal Foods leasehold. Operations include milling grain products, and storage and transfer. Provides access to Berth 401. Appears that rail lines have been removed.	R-SJ14PP	21	Outfall not visible or readily accessible from land. Manholes accessible; located in roadway.
Q	18	Paved and gravel areas associated with former grain elevators and rail tracks. Paved road exists along the north side of the basin. Includes roof runoff from the grain elevators.	Port of Portland former Cargill facility. Includes former blacksmith shop, former transformer house and grain storage and conveyors. Historic operations included grain storage and transfer. Storage of materials and maintenance activities could have resulted in historic surface spills. USTs were likely present.	No current use. Provides access to Berth 405. Appears that rail lines have been removed.	Q-SJ15PP	15	Outfall not visible or readily accessible from land. Manhole cover accessible that captures drainage from entry roads and two of the silos.
O	5.5	Paved road, paved parking areas, unpaved roads, gravel surface, and large soil stockpile.	Port of Portland former Cargill facility. Storage of materials and maintenance activities could have resulted in historic surface spills. USTs were likely present.	Rogers Terminal leasehold. Operations include warehouse storage space and administrative activities. Provides access to Berths 405 and 409. Appears that rail lines have been removed.	P	?	Outfall not visible or readily accessible from land. One catchbasin and no manholes observed.
					O-SJ17PP	21	Outfall visible, but not readily accessible, from land. Accessible manhole located near the head of Slip 1.
City of Portland (T)	21.5	City of Portland stormwater outfall that primarily drains Basin T. Discharge is located in Basin O. Includes paved parking lots, roof drainage, Lombard Street, and N. Roberts Street.	Outfall 52-C was constructed in 1986. Former Toyota Motor Sales vehicle processing located within the basin. Borden Chemical Company (portions of the site drains to Outfall 52-C) has manufactured resin and glue products since 1963; Flint Ink Corporation has manufactured industrial inks since 1971; a portion of the Klix Corp. property drains to Outfall 52-C; LUST identified in 1985 and tank cleanup has not been completed. Formerly operated by Layton Drum Company.	Land use in the storm basin is zoned industrial; includes approximately 80% 528 Investors, LLC (pallet company) and 5% roof and paved area drainage from several industrial facilities. Approximately 15% of the basin is rights-of-way.	COP 52-C	36	Manhole cover accessible near the head of Slip 1.
N	3.5	Includes partially paved road/ parking areas, gravel areas, and rail tracks.	This area has been used for liquid bulk storage since 1929 and as a former gearlocker. Liquid bulk storage has included liquid fertilizer, food products, tallow, urea, caustic soda and fats. Historic operations included railcar cleaning, auto repair, blacksmithing, painting, and electrical work. USTs for diesel and heating oil formerly existed in this location.	Port of Portland IRM facility. Operations include liquid bulk storage and transfer activities.	N	6	Outfall visible, but not readily accessible, from land. One accessible manhole exists in the vicinity of the outfall.
M	13.5	Mostly paved parking areas, roads, roofdrains and rail tracks. Trench drains in the temporary Toyota parking area and storm drains at the IRM facility. The western portion of Basin M appears to drain directly to the river, and is not captured in M-SJ18PP system.	Liquid bulk storage. Storage has included liquid fertilizer, food products, tallow, urea, caustic soda and fats. UST for diesel existed in this location. The Leckenby fumigation plant operated within this basin from 1923 until 1955. Ore and concentrate handling occurred along the southern bank of Slip 1. Matson trade (foodstuffs) occurred along the southern bank of Slip 1. USTs were present.	Port of Portland IRM facility and temporary Toyota parking area. Operations include liquid bulk storage and transfer activities. Area will likely be modified as part of Berth 408 Modernization which may include upgrades to stormwater system.	M-SJ18PP	18	Outfall not visible or readily accessible from land. Manholes accessible; located in parking area.
L	30	Includes paved parking areas, roof runoff, paved roads, unpaved gravel areas, rail tracks, and active loading dock. The upstream (eastern) extent of Basin L storm system is approximately Lombard St.	Railroad operations; former utility storage building; ore and concentrate handling; pencil pitch from 1978 to 1998; former ATS salvage yard and gas fueling station.	Port of Portland Kinder Morgan Bulk Terminals facility. Design is in progress to modernize the rail lines and stormwater system for this area.	L-SJ19PP	18	Outfall visible, but not readily accessible, from land. Manholes, located within the Kinder Morgan facility are accessible.
K	1.5	Mostly rail tracks, with some paved roadways and paved parking areas. High traffic area with rail and primary access to Berth 411.	Railyard operations; ore and concentrate handling; pencil pitch from 1978 to 1998; ATS salvage yard. USTs were likely present.	Port of Portland Kinder Morgan Bulk Terminals facility. Design is in progress to modernize the rail lines and stormwater system for this area.	K-SJ20PP	?	Outfall is visible and potentially accessible by stairway under Berth 411. Manholes were not observed.
J	2.6	Mostly gravel area, with gravel storage, newly graded planted and hydroseeded portion at the head of Slip 3, roof runoff from the Turner Construction building.	Former Quaker State/Oregon Terminal Gearlocker location. Historic uses included blending and bottling different grades of motor oil into 1 quart bottles. Historic operations included material transfer from vessels via underground pipeline and material storage in ASTs. USTs were present.	Port of Portland former Turner Construction facility. This area is part of an ongoing remediation project. Unknown if outfalls are still functional or if future modifications are planned.	J - 2	8	Outfall is visible, but not readily accessible, from land. Manhole may exist under laydown materials near Turner building that drains two catchbasins.
					J-SJ21PP	6	Outfall is visible and accessible from land. Catchbasins drain directly to slip without manhole access.
D	17	Primarily paved automobile receiving yard. Also includes paved roadways, former tank foundation/footings, rail tracks, and gravel area located at the southwestern end of Slip 3.	UPRR St. Johns Tank Farm, Pipeline, and Oil Dock included two 55,000-barrel ASTs for oil, pumping facilities, heating facilities, fuel pipeline, Bunker C oil pipeline. Former ATS auxiliary pipeline. General Petroleum Corporation operated a facility near Slip 3 for delivery of bunker fuel and unloading of fuel oil with associated AST; Oregon Sulphur Company imported bulk sulfur starting in at least 1920; ore and concentrate handling; coal storage. USTs were likely present.	Port of Portland facility being converted to a Toyota facility. Unclear at this time if these outfalls are still functional or if future modifications are planned.	I	8	Outfall visible but not active. Catch basin drains covered with filter fabric.
					H	8	Outfall visible but not active. Catch basin drains covered with filter fabric.
					G	8	Outfall visible but not active. Catch basin drains covered with filter fabric.
					F-SJ23PP	Abandoned	
					E-SJ23PP	Abandoned	
					D-SJ224PP	34	Outfall visible, and is accessible from land. Accessible manholes observed within the Toyota Facility. Several manhole accesses exist to allow for the installation of the Downstream Defender unit. Manhole invert elevations may be low enough to be innundated by the river.
C	74	Eastern end is primarily paved parking lots and roads, western end is primarily paved automobile receiving yard. Also includes paved roadways, rail tracks, and gravel area located at the southwestern end of Slip 3. Receives runoff from Lombard Street.	Southern extent of the UPRR Pipeline and Oil Dock.	Port of Portland Toyota facility with ongoing maintenance and construction. Status of stormwater basins and outfalls in this area is uncertain at this time.	C-SJ25PP	54	Outfall visible, but is difficult to access from land. Accessible manholes observed within the Toyota Facility. Several manhole accesses exist to allow for the installation of the Downstream Defender unit.
B	21	Primarily paved auto receiving yard and rail tracks. Upgradient (eastern) extent of Basin B is unknown at this time.	No known historical operations.	Port of Portland Toyota facility with ongoing maintenance and construction. Status of stormwater basins and outfalls in this area is uncertain at this time.	B	36	Outfall is visible but difficult to access. Accessible manholes observed in vicinity of the outfalls.
City of Portland	39/102[5]	Greater than 90% developed. Residential housing with paved streets. The roof drains from some residents have been disconnected from the storm system as part of the downspout disconnection program.	Constructed in 1970 as a CSO-only outfall but was mostly separated in 1995 as part of the St. John's Basin Separation Project and is now primarily a stormwater outfall. There is a potential for CSO discharges during large storm events.	Land use in the storm basin is primarily residential, with approximately 57.8% zoned low-density residential, 4.7% high-density residential and 0.6% commercial land use. Rights-of-way are approximately 36.9% of the basin.	COP 53	48	Outfall is visible and accessible. An accessible manhole, likely associated with this outfall, was observed; would need to be field verified.
A	18	Greater than 95% developed. Primarily paved auto receiving yard with paved roads	No known historical operations.	Port of Portland Toyota facility with ongoing maintenance and construction. Status of stormwater basins and outfalls in this area is uncertain at this time.	A	36	Outfall is visible but difficult to access. Accessible manholes observed in vicinity of the outfalls.
City of Portland	24	Mix of industrial, residential and commercial. The roof drains from some residents have been disconnected from the storm system as part of the downspout disconnection program.	The City of Portland outfall was constructed in 1972. Portion of former Mar Com shipbuilding and repair facility is located within the basin. Mar Com property identified as a high priority site based on DEQ's review of site information, history, and activities. DEQ issued a Record of Decision for the Mar Com North Parcel in May 2004.	Land use within the basin is a mix of industrial, commercial, and residential, with approximately 50% of the basin zoned for industrial use, 14.8% as an employment district, 0.4% high-density residential, and 5.1% low-density residential. Rights-of-way are approximately 29.7% of the basin.	COP 52-A	36	----

---- Information not available to BBL at time of data compilation.

1. Identification numbers provided by Port of Portland
2. Port of Portland Terminal 4 Storm Sewer System Drawings dated June 2004 and *Terminal 4 Early Action Engineering Evaluation/Cost Analysis Work Plan (BBL, 2004a).*
3. *Terminal 4 Early Action Engineering Evaluation/Cost Analysis Work Plan* (BBL, 2004a).
4. The approximate catchment areas associated with the City of Portland outfalls is based on the *Programmatic Source Control Remedial Investigation Work Plan for the City of Portland Outfalls Project* (CH2MHILL 2004) and will be further evaluated in the recontamination assessment.
5. The CSO basin is approximately 102 acres including the stormwater drainage basin.
6. Based on field observations made by BBL personnel in the summer and fall of 2004 and January 2005; descriptions provided in the *Terminal 4 Early Action Engineering Evaluation/Cost Analysis Work Plan* (BBL, 2004a), City of Portland Information, review of 2002 air photo, and *Preliminary Evaluation of City Outfalls - Portland Harbor Study Area* (City of Portland, 2000).

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Table 3
Stormwater Outfall Selection Summary

Basin ID	Approximate Basin Area (acres)	Basin Description/Land Use	Selected for Sampling?	Rationale
S	1	Paved parking lot and office buildings. Low traffic area.	No	Not selected due to small catchment area and no manhole access. Land use is similar to Basins O and Q.
R	15	Paved road, gravel area, grain elevators. Inactive use.	No	Not selected because approximately half of catchment area is gravel, resulting in an increased rate of infiltration versus runoff. Land use is similar to Basins O and Q.
Q	18	Grain silos, entry roads to Terminal 4, and gravel ballast for rail tracks.	Yes	Relatively large catchment area. Possible point source of lead from silos and active traffic area at entrance gate.
O	5.5	Entry roads to Terminal 4, laydown/turn around areas, and soil stockpile.	Yes	Although relatively small catchment area, this basin was selected in order to capture a known source of TSS loading (soil stockpile).
T	21.5	City of Portland outfall 52-C. Primarily paved parking lots and Lombard Street.	Yes	Relatively large catchment area (largest basin draining into Slip 1). Sampling would capture loading from a portion of the former Toyota lease area and Lombard Street. Current traffic levels on this street are anticipated to be sustained into the future, following implementation of the removal action.
N	3.5	Inactive buildings, paved laydown areas, and parking.	No	Not selected because the relatively small catchment area is not anticipated to generate significant flows or sediment contributions. Land use is similar to Basin O and Q which are being sampled.
M	13.5	Primarily paved parking lots and roads.	No	Not selected because significant portion of the western side of the Basin infiltrates or runs directly into the river, resulting in a much smaller catchment area. Land use is similar to Basin L which is being sampled.
L	30	Railroad tracks and ballast, and higher traffic roads.	Yes	Relatively large catchment size should provide sufficient flows to sample effectively. Only catchment area with significant drainage into Wheeler Bay. Good manhole access. Land use is similar to Basins M, K, and J.
K	1.5	Active Kinder Morgan facility, railroad tracks and ballast.	No	Not selected due to relatively small catchment size and no accessible manholes. Land use is similar to Basin L which is being sampled.
J	2.6	Construction laydown area,	No	Not selected due to relatively small catchment size with a

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Table 3
Stormwater Outfall Selection Summary

		newly graded and planted area at the head of Slip 3.		significant portion infiltrating and draining directly to Slip 3. Land use is similar to Basins L and D which are being sampled.
D	17	Old tank footings to the east, rail and vehicle roads, gravel pads, and parking for Toyota vehicle storage.	Yes	Relatively large catchment area which drains into the area north of Berth 414. Drainage system includes new BMPs installed as part of the recent storm system upgrade which will allow for evaluation of BMP effectiveness through time.
C	74	Primarily paved parking lots both at the Lombard Street level, and on the Terminal 4 level.	Yes	Largest Terminal 4 basin. Basin drains into the Willamette directly upstream of the Removal Action Area.
B	21	Recently repaved parking lots within the Toyota Facility.	No	Not selected because the entire basin was recently repaved and drainage can be effectively modeled using published factors. Land use is similar to Basin C which is being sampled.
A	18	Recently repaved parking lots within the Toyota Facility.	No	Not selected because the entire basin recently repaved and can be effectively modeled using published factors. Land use is similar to Basin C which is being sampled.
City of Portland 53	39/102	Residential and commercial development.	Dependent on results of additional sediment trap sampling	Relatively large catchment area located immediately upstream of the Removal Action Area. Land use differs from other northern Terminal 4 basins. Combined sewer overflow.
City of Portland 52-A	24	Residential and commercial development.	No	Not selected because land use is similar to COP-53. The outfall is far enough upstream to be considered part of the overall Willamette River loading to the Remedial Action Area.

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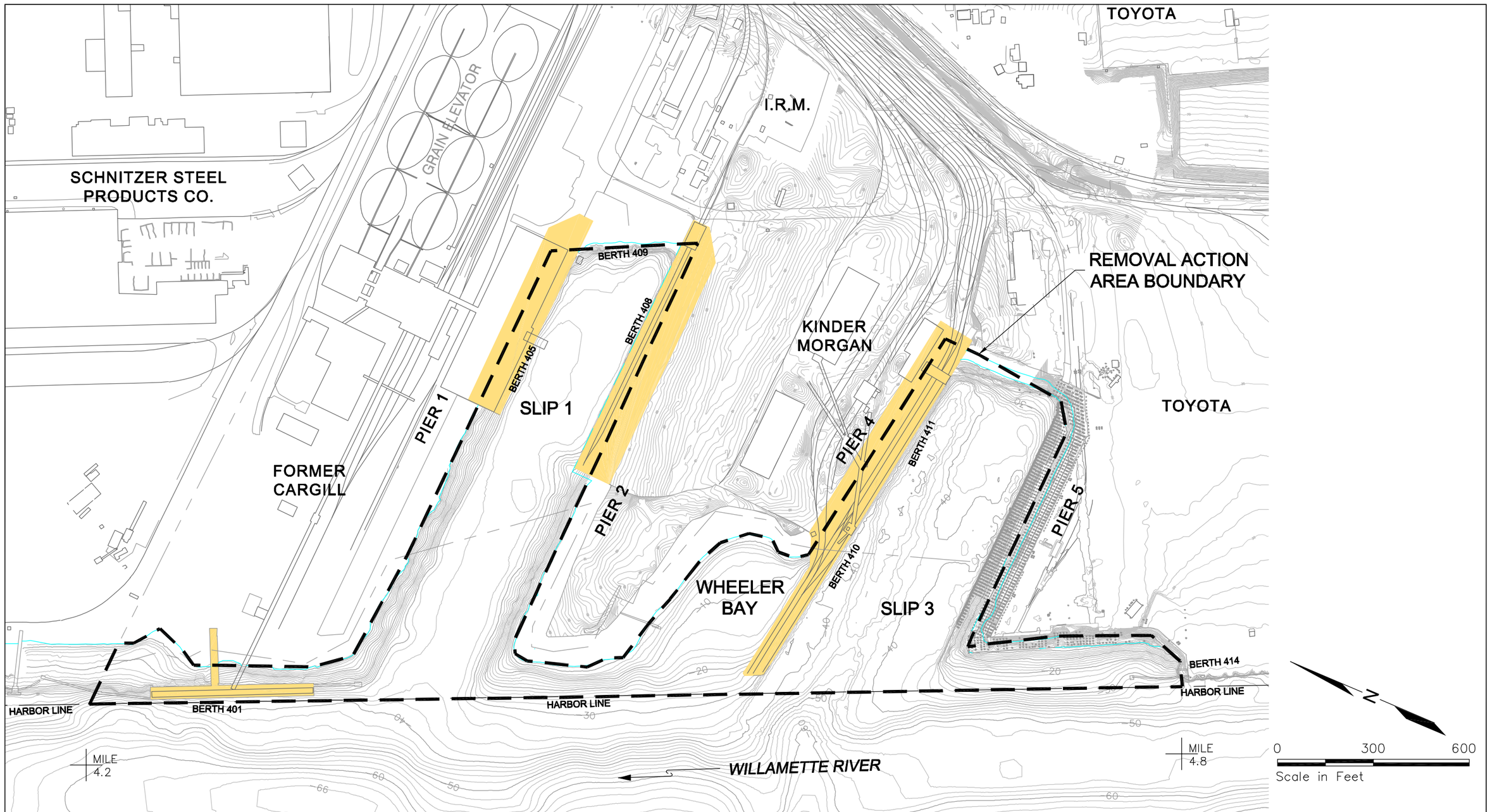

Notes:

1. Upland topographic vertical datum is NGVD; 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. Ordinary Low Water elevation provided by USACE.
8. Ordinary High Water elevation provided by Port of Portland.

Existing Piers

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METHODOLOGY MEMO

REMOVAL ACTION AREA PLAN

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

FIGURE 1

DWG NAME: G:\project\Clients\BBL\Terminal 4\t4_040(Recon_AsFig1).dwg
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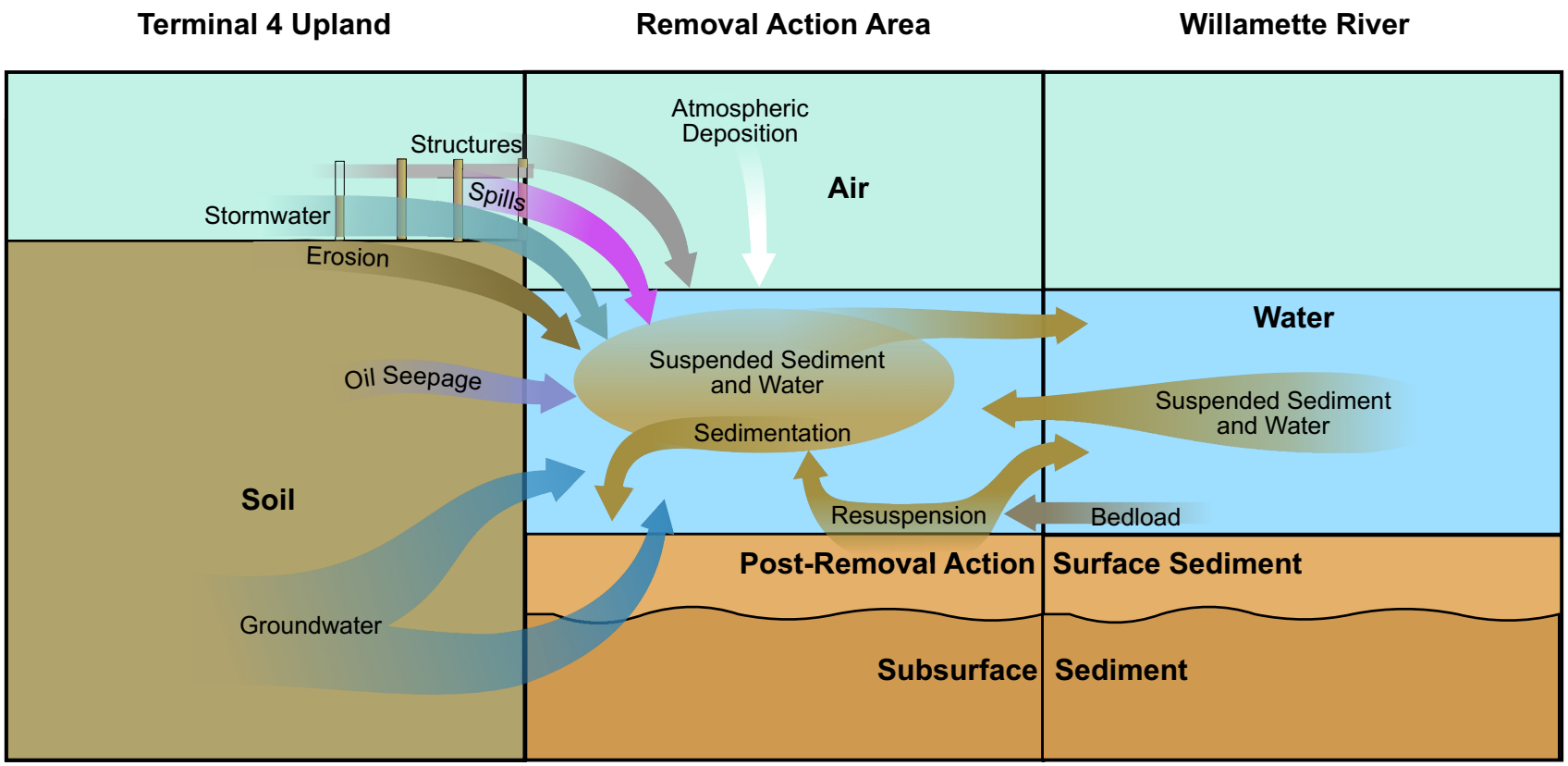

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GEOCHEMICAL CONCEPTUAL MODEL

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FIGURE
2

2004 Sediment Trap Deployment Location (April/May 2004)
2005 Sediment Trap Re-deployment Location (January 2005)

N

0 600 1200

Approximate Scale in Feet

Note: Date of Photo: July 9, 2002

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2004 AND 2005 SEDIMENT TRAP DEPLOYMENT LOCATIONS

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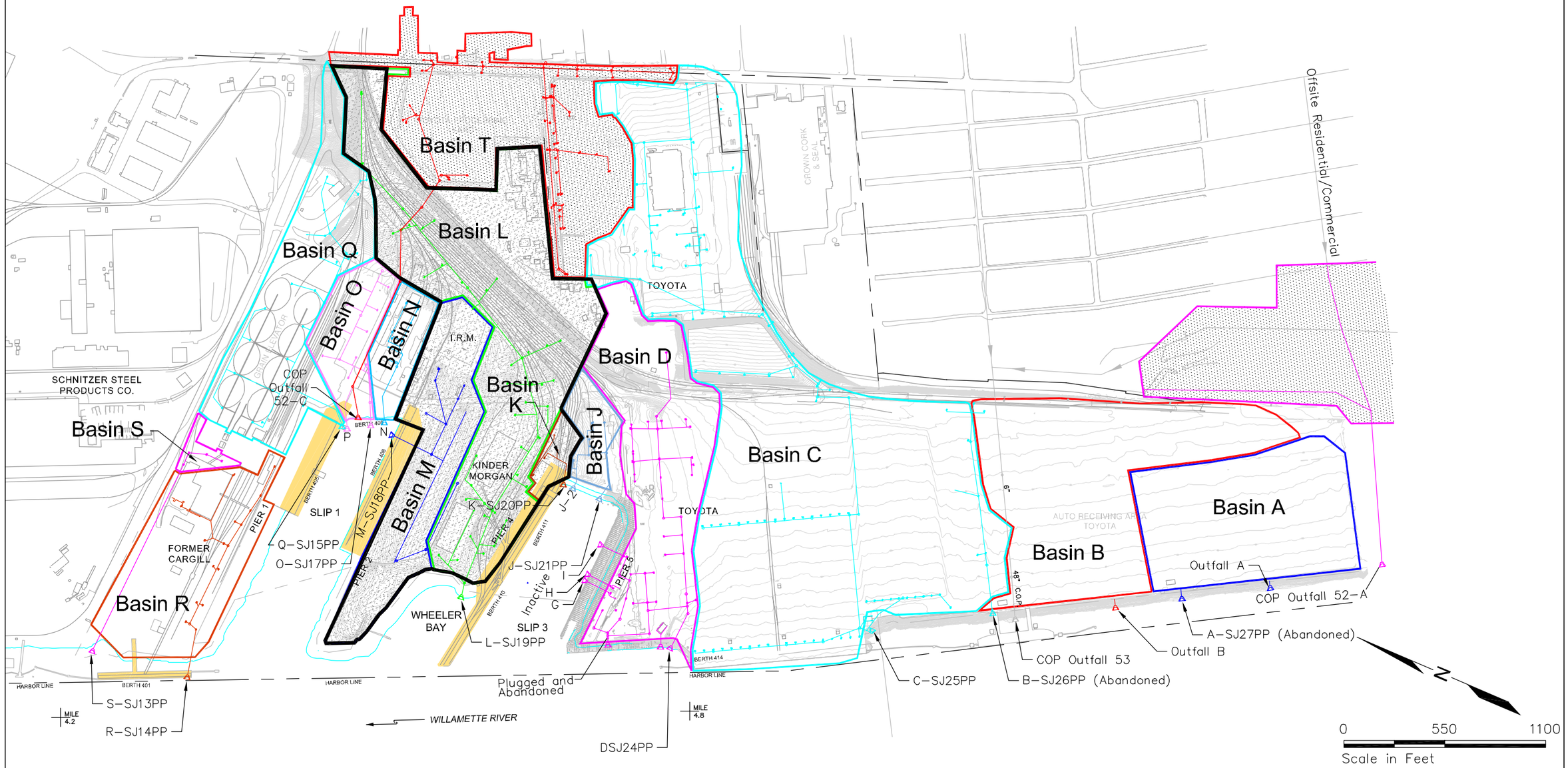
FIGURE 3



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).
8. Stormwater drainage information based on Port of Portland "Drawing No. T4 2000-3027" from June 2000, HDR drawings "Utility Plan Area 4" from July 1, 2004, and Port of Portland "Overall Drainage Plan" drawing from 2004.

Area to be modified for Berth 408 Rail Yard Modernization Project.

Existing Piers

Approximate Drainage Basin Incorporating City of Portland Stormwater Subbasin

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STORMWATER DRAINAGE BASINS

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engineers & scientists

FIGURE
4

DWG NAME: G:\project\clients\BBL\Terminal 4\t4_051(ReconFig4).dwg
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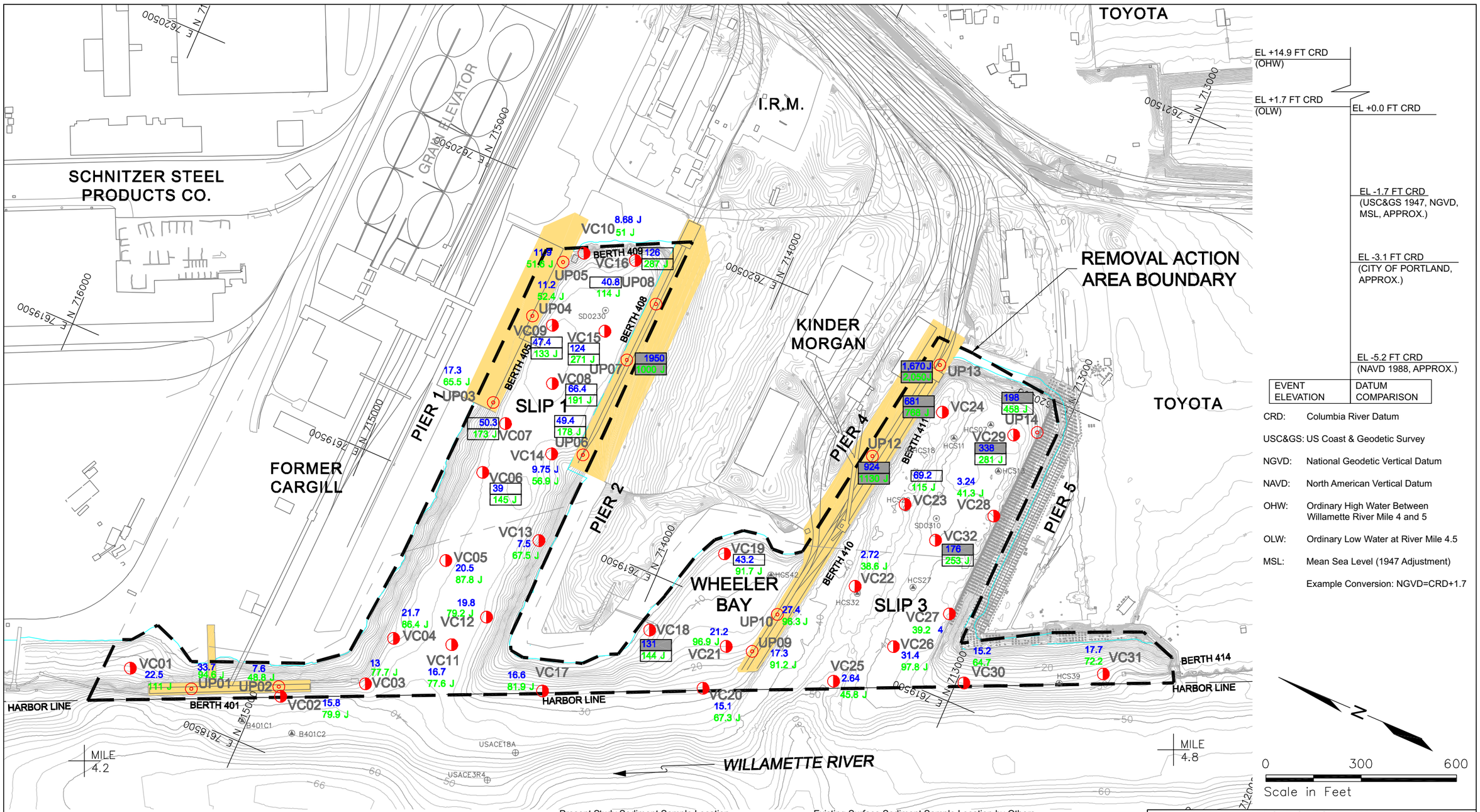

Notes:

1. Upland topographic vertical datum is NGVD; 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. Ordinary Low Water elevation provided by USACE.
8. Ordinary High Water elevation provided by Port of Portland.
9. Datum conversion tables to CRD provided by Port of Portland.

Existing Piers

Present Study Sediment Sample Location

- Field-verified Surface Sediment Sample Location
- Field-verified Under-Pier Surface Sediment Sample Location
- 22.5 Total Lead Concentrations in mg/kg
- 111 Total Zinc Concentrations in mg/kg
- U = compound not detected
- J = estimated value
- = concentration is greater than TEC
- = concentration is greater than PEC

Existing Surface 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)

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SURFACE SEDIMENT LEAD AND ZINC CONCENTRATIONS

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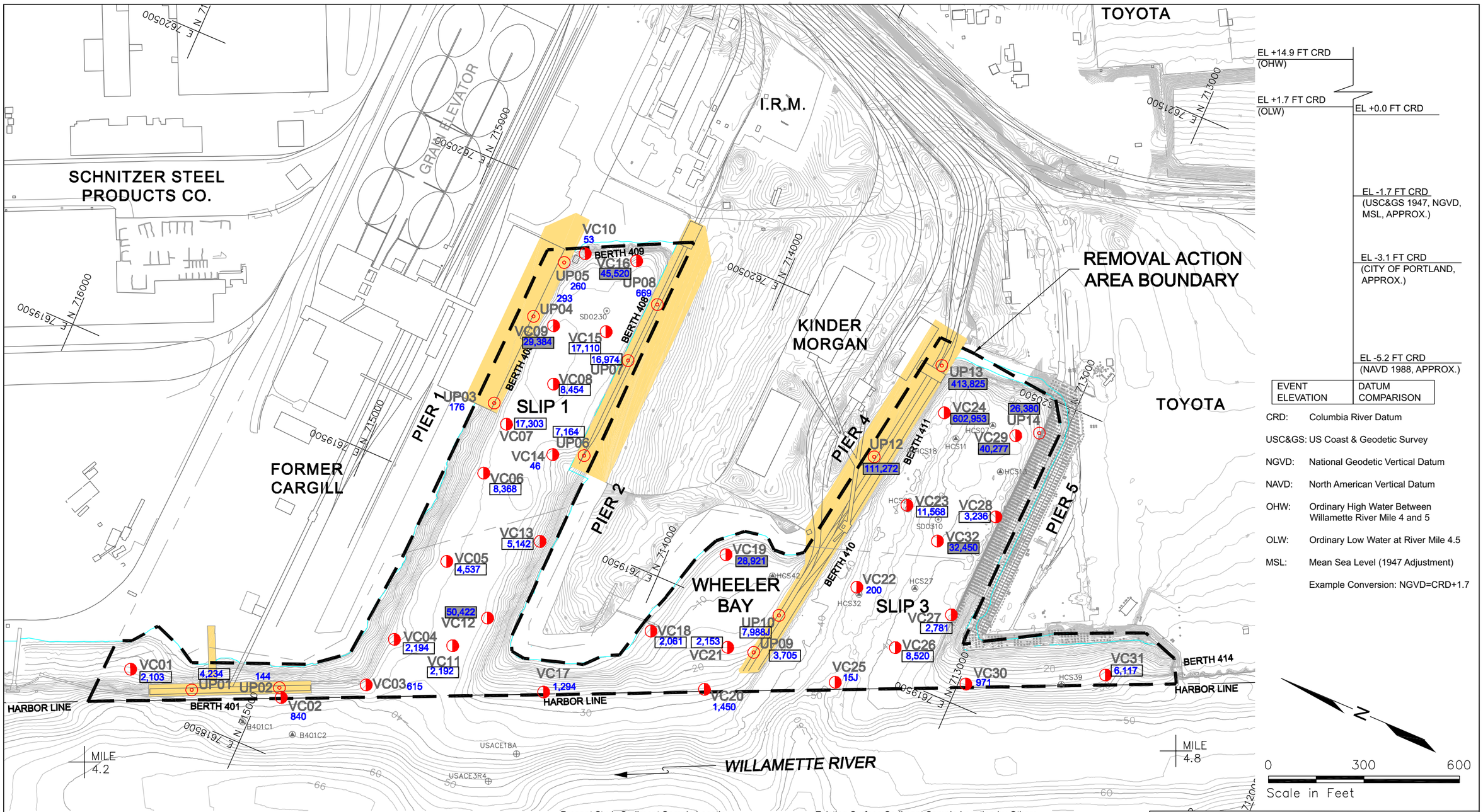
FIGURE 5



Notes:

1. Upland topographic vertical datum is NGVD; 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. Ordinary Low Water elevation provided by USACE.
8. Ordinary High Water elevation provided by Port of Portland.
9. Total PAH is the sum of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, and benzo(a)pyrene. Non-detects were treated as zero. If all results were non-detect, the total represents the highest detection limit.

Existing Piers

Present Study Sediment Sample Location

Field-verified Surface Sediment Sample Location

Field-verified Under-Pier Surface Sediment Sample Location

2103 Total PAH Concentrations in ug/kg
U = compound not detected
J = estimated value
= concentration is greater than TEC
= concentration is greater than PEC

Existing Surface 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)

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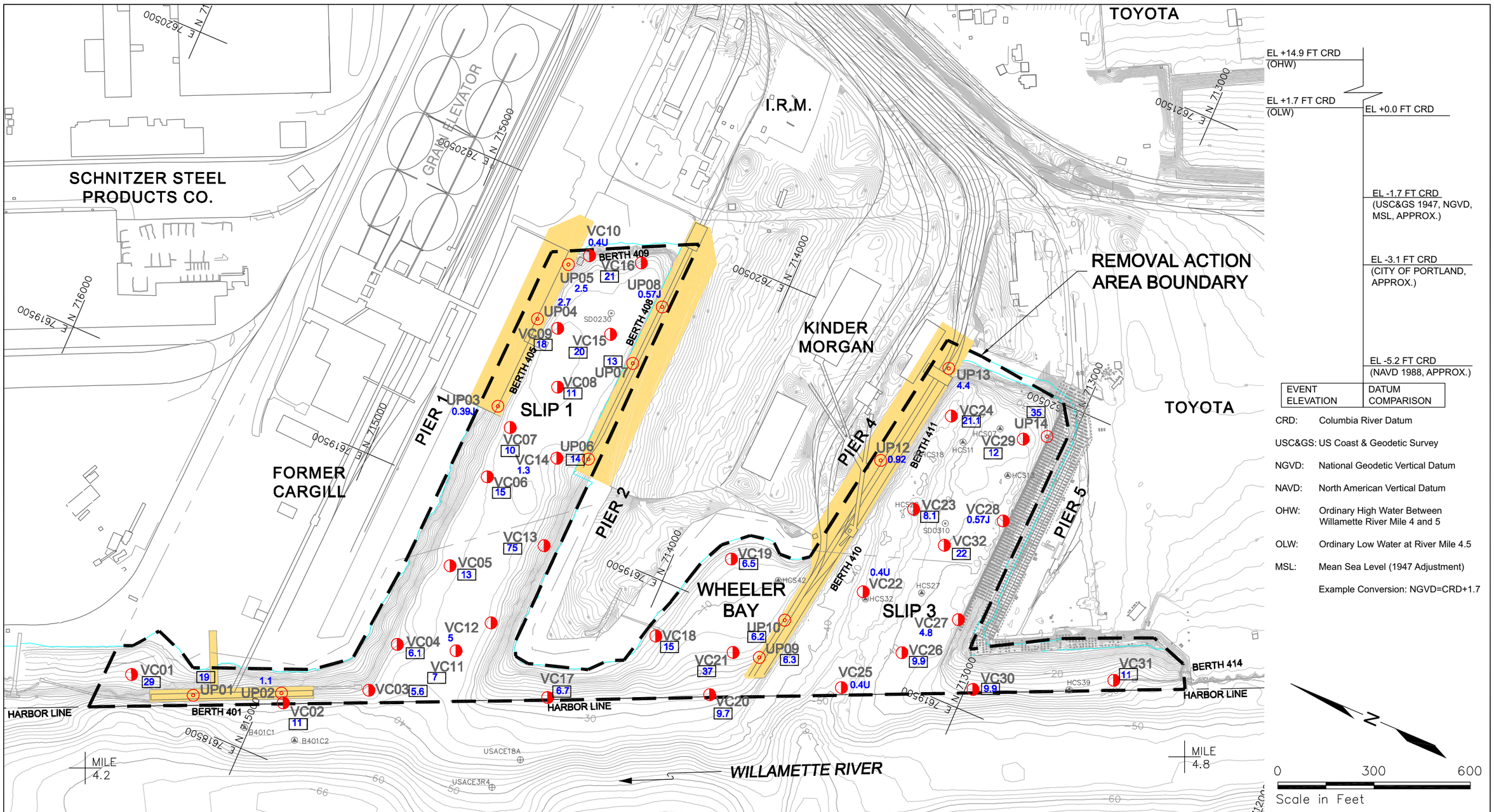
SURFACE SEDIMENT TOTAL PAH CONCENTRATIONS

BLASLAND, BOUCK & LEE, INC. engineers & scientists

FIGURE 6



Notes:

1. Upland topographic vertical datum is NGVD; 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. Ordinary Low Water elevation provided by USACE.
8. Ordinary High Water elevation provided by Port of Portland.
9. ΣDDTs is the sum of the 2,4'-DDD, 2,4'-DDE, 2,4'-DDT, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT results. Non-detects were treated as zero. If all results were non-detect, the total represents the highest detection limit.

Existing Piers

Present Study Sediment Sample Location

Field-verified Surface Sediment Sample Location

Field-verified Under-Pier Surface Sediment Sample Location

6.1 ΣDDTs Concentrations in ug/kg
U = compound not detected
J = estimated value
= concentration is greater than TEC

Existing Surface 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)

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SURFACE SEDIMENT
Σ DDT CONCENTRATIONS

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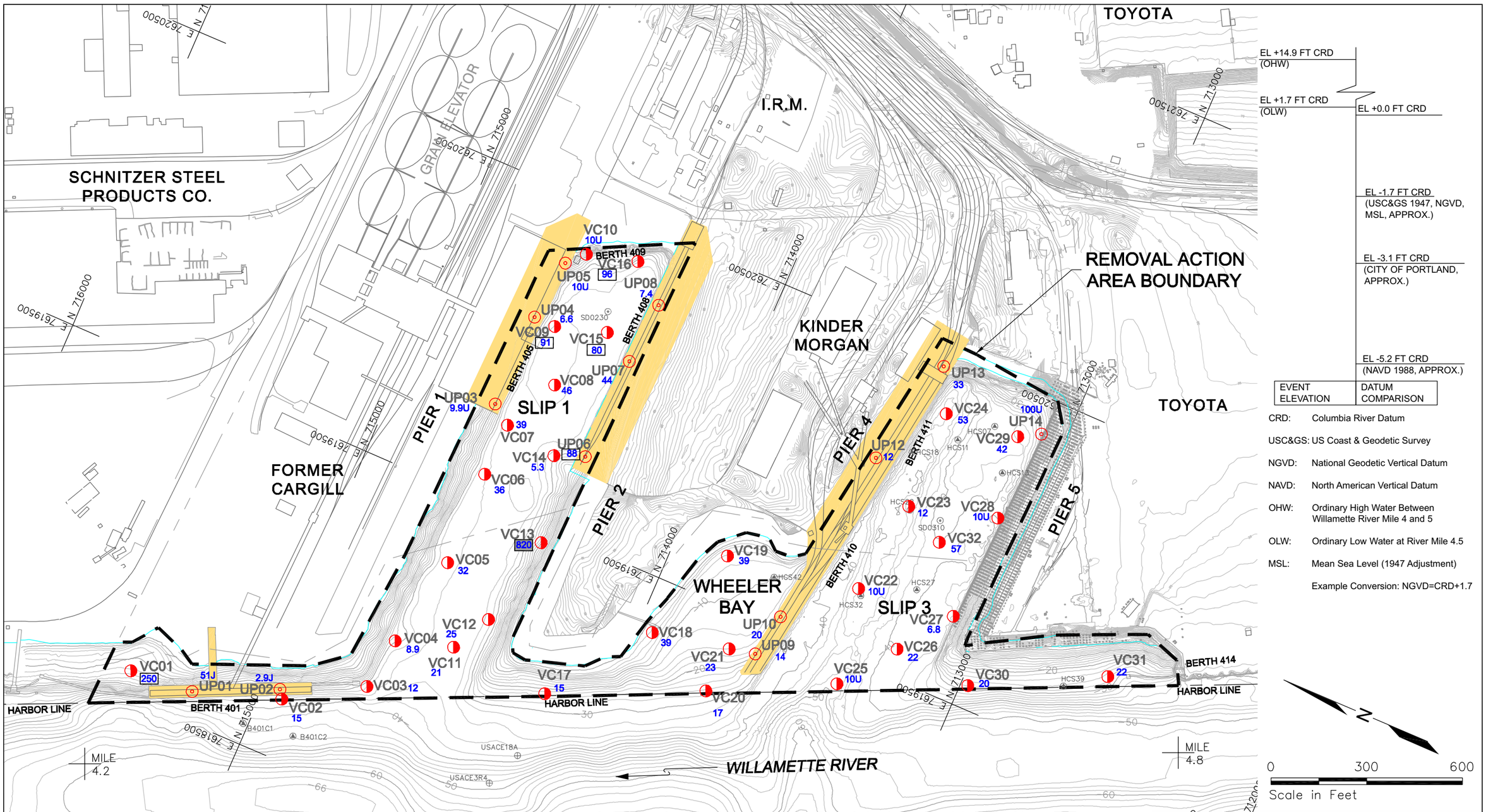
FIGURE 7



Notes:

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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. Ordinary Low Water elevation provided by USACE.
8. Ordinary High Water elevation provided by Port of Portland.
9. Total PCBs is the sum of Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268. Non-detects were treated as zero. If all results were non-detect, the total represents the highest detection limit.

Existing Piers

Present Study Sediment Sample Location

- Field-verified Surface Sediment Sample Location
- Field-verified Under-Pier Surface Sediment Sample Location
- 14.7 Total PCB Concentrations in ug/kg
  U = compound not detected
  J = estimated value
  = concentration is greater than TEC
  = concentration is greater than PEC

Existing Surface 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)

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SURFACE SEDIMENT TOTAL PCB CONCENTRATIONS

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FIGURE 8

Bank Located at Southwest Corner of Slip 1

Wheeler Bay

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PHOTOGRAPHS OF
OBSERVED BANK EROSION

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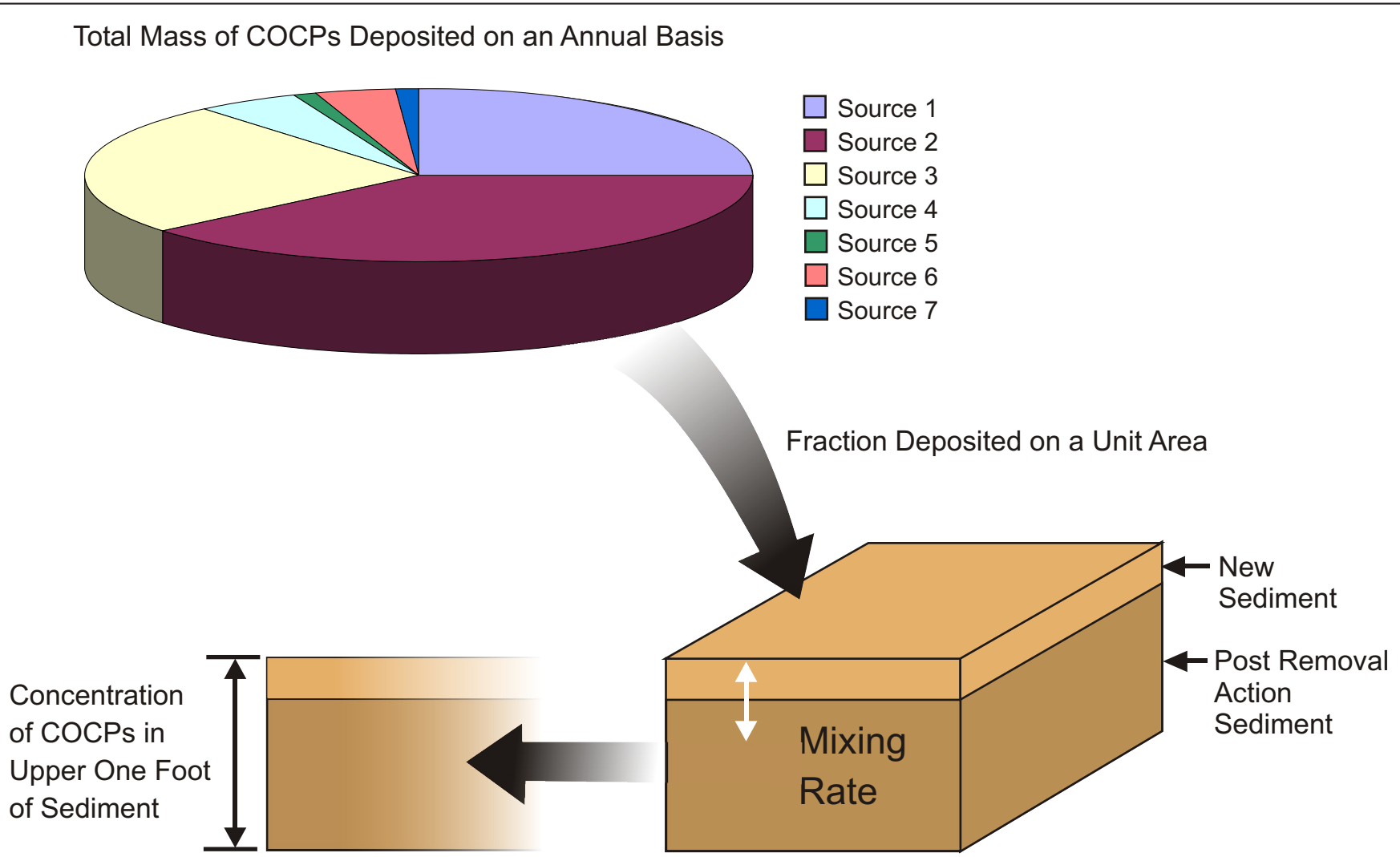
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
9



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RECONTAMINATION ANALYSIS
METHODOLOGY CONCEPTUAL DIAGRAM

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FIGURE
10