Staff Report
Zidell Waterfront Property
ECSI No. 689
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DEQ Northwest Region
Voluntary Cleanup Program
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1 Introduction and Purpose

This Staff Report presents a summary of the remedial investigation and feasibility study (RI/FS) of the waterfront property owned by ZRZ Realty Company (Zidell) in Portland, Oregon (ECSl No. 689). The RI and FS were conducted pursuant to a voluntary agreement between Zidell and the Oregon Department of Environmental Quality (DEQ), effective April 14, 1995 (WMCVC-NWR-94-23).

The RI/FS was performed pursuant to DEQ approved work plans consistent with U.S. Environmental Protection Agency (USEPA) guidance for conducting remedial investigation and feasibility studies (RI/FSs) under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (USEPA, 1988) and Oregon Administrative Rule (OAR) 340-122-0080.

1.1 Scope and Role of the Recommended Remedial Action

The recommended remedial action addresses the presence of metals, petroleum hydrocarbons and associated polycyclic aromatic hydrocarbons (PAHs), polychlorinated-biphenyls (PCBs), and tributyl tin (TBT) and its degradation products in contaminated soil and/or sediment at the Zidell site.

The recommended remedial action for contaminated soil is Soil Alternative 6, which generally consists of the following elements:

- Excavation and off-site disposal of up to 8,000 cubic yards of contaminated soil exceeding hot spot concentrations, and asbestos containing material;
- On-site consolidation of soil exceeding cleanup levels from Greenway Area or future public right-of-ways to non-Greenway area of the site prior to capping;
- Re-grading the Greenway shoreline to facilitate placement of a soil cap above an elevation of 13 feet, and upgrading existing armoring of the riverbank from 13 feet to the Willamette River sediment surface to minimize future releases of hazardous substances in soil to the Willamette River;
- Engineering controls involving placement of a cap over residual soil contamination exceeding risk based concentrations;
- Institutional controls involving inspection and maintenance of the soil cap and protocols for future sub-surface maintenance activities; and
- Contingencies to facilitate future pre-treatment of stormwater prior to discharge to the Willamette River.
The recommended remedial action for contaminated sediments is Sediment Alternative 3, which consists of the following elements:

- Engineering controls to include placement of a clean sand/rock cap over approximately 8 acres of contaminated sediment along the Zidell shoreline;
- Institutional controls involving inspection and maintenance of the cap;
- Periodic reviews by DEQ; and
- Contingency plan to selectively dredge the barge launchway to facilitate continued site operations or future use of the area for public access for river-related activities.

1.2 Report Organization

This staff report is organized as follows:

- **Section 2: Site Background.** This section provides a description of the facility and overview of the history of plant operations and environmental investigations performed for the RI/FS.

- **Section 3: Remedial Investigation Summary.** This section summarizes the nature and extent of contamination, contaminant fate and transport, human health and ecological baseline risk assessments, and identification of potential hot spots of contamination.

- **Section 4: Remedial Action Objectives & Cleanup Levels.** This section identifies the remedial action objectives (RAOs) and associated risk-based concentrations (RBCs) for affected media. The information presented in this section provides the key information for development of remedial action alternatives in Section 5, and evaluation of the alternatives in Section 6 of the report.

- **Section 5: Description of Remedial Action Alternatives.** This section provides a description of the remedial alternatives identified in the FS.

- **Section 6: Evaluation of Remedial Action Alternatives.** This section summarizes DEQ’s evaluation of the remedial action alternatives against the remedial action selection criteria under Oregon Environmental Cleanup Rules.
• **Section 7: Recommended Remedial Alternative for Soil and Sediment.** This section recommends a single alternative and explains the basis for its selection; and provides information required in the Oregon Administrative Rules.
2 Site Background

The Zidell waterfront property consists of 32.17 acres in Section 10, Township 1 South, Range 1 East of the Willamette Meridian (Figure 2-1). The site is located at 3121 SW Moody Avenue in Portland, Multnomah County, Oregon (Figure 2-2). The property is bordered by SW Moody Avenue on the west, by property zoned for commercial use on the north (currently vacant property owned by the Oregon Health Sciences University [OHSU]), and by the former Pacific Metals facility on the south currently under redevelopment. The site is bordered to the east by the Willamette River between river miles 13 and 15. Zidell Marine Corporation and Zidell both operate on the site, which varies from 70 feet to 850 feet wide (east to west), and is 3,300 feet long (north to south).

Historically, the site was used for building, dismantling, converting, repairing, and salvaging ships and barges. It was also used for scrap metal operations, wire burning and aluminum smelting, and housing construction. The south part of the site is currently used for barge construction, and the north part is vacant or used to store salvage materials.

Zidell also owns two lots west of SW Moody Avenue, on either side of Grover Street (Caruthers Addition tax lot 1 of lots 1-4 of block 101 and Caruthers Addition lots 1 and 2 and lots 3 and 4 of block 119) (Figure 2-3). These parcels were not used for Zidell’s operations but were reportedly used for vehicle parking.

2.1 Site Description

2.1.1 Topography and Drainage

The site is generally flat, with elevations ranging from 28 feet to 35 feet relative to the City of Portland (COP) datum (COP benchmark 1514) (Figure 2-4). Elevations in the north part of the site are generally higher than those in the south part (35 feet versus 30 feet). The 100-year floodplain elevation is approximately 30.4 feet along this reach of the Willamette River. The elevation of the top of the bank ranges from approximately 25.5 feet to 30.0 feet.

The topography of the site has been modified over the years by fill placement. Based on a review of aerial photographs taken between 1936 and 1984, the youngest fill was placed between 1963 and 1966 along the bank immediately north and south of the Ross Island Bridge. Initial fill placement at the site likely occurred in the early 1900s when heavy industrial activity began in the area. The fill generally consists of gravel with
brick, asphalt, wood, metal, plastic, asbestos, and glass, and it may extend to 40 feet below ground surface (bgs).

The site has approximately 3,000 lineal feet of frontage on the west bank of the river. Shoreline features include steeply sloped banks covered with construction debris, ballast rock, paving stones, and other material. A dock extends along the shore and out into the water in Area 2. A dock formerly occupied approximately 1,430 lineal feet of the site in Area 2; the dock was built in 1942 and destroyed by fires in 1957 and 1983.

Stormwater outfalls (OFs) are present along the river at the site. Two City of Portland (COP) OFs (OFs 6 and 7) for combined sewer overflows (CSOs) are present along the river at the site. In addition, an Oregon Department of Transportation (ODOT) stormwater outfall (OF 42) is in the north part of the site, near COP OF 7 (Figure 2-2). Two OFs that drain the Zidell waterfront property are also present at the site, including two 18-inch lines (OFs 1 and 2) draining Area 1 (the barge-building yard south of the Ross Island Bridge). Two OFs that drain the Zidell or Westwood Development Corporation properties are also present at the site, including two 10-inch lines north of the Ross Island Bridge.

2.1.2 Surface Water Hydrology & Fluvial Setting

The site is located between river miles 13 and 15 of the Willamette River, between the Marquam Bridge and Ross Island. Along this reach, the river flows northwest and is 1,400 to 1,500 feet wide. The main channel is bifurcated by Ross Island along this reach of the river. During periods of low and medium flows, tidal effects are evident to river mile 26.5 (Willamette Falls); reverse flow has been measured as far upstream as Ross Island (river mile 15) during low-flow periods.

Figure 2-4 shows the bathymetry for the Willamette River near the site, based on soundings measured in fall 2000. Near shore river currents appear to support deposition of fine-grained sediment resulting in the creation of a lateral bar or sill, and the development of shallow water habitat. Sediment is generally being deposited near the former dock area next to the north-central part of the site. At the site, shallow water habitat includes the riverbank from an elevation of 18 feet above the Columbia River datum (CR) to a depth of -20 feet CR in the river.

Deep water habitat is found below -20 feet CR. On the basis of the bathymetry, shallow water habitat extends up to 350 feet from the riverbank in the north part of the site and extends to less than 60 feet from the riverbank in the south part of the site. Deeper water in the nearshore area in the south part of the site is attributed to historical dredging. Zidell personnel have indicated that parts of the river next to the dock were dredged to
maximum depths of -32 feet CR in 1955, -30 ft CR in 1961 (500 feet along the south part of the dock), and -32 ft CR in 1978 (585 feet along the south part of the dock) to accommodate passage and moORAGE of vessels.

2.1.3 Geology and Hydrogeology
The geology of the Portland area is characterized by a broad structural depression or basin filled with sedimentary rocks and bordered by the Cascade Mountains on the east and the Coast Range on the west. Geologic formations in the basin are also folded and cut by a number of northwest-trending faults. The Portland Hills (Tualatin Mountains) form a northwest-trending anticlinal ridge that is faulted along its eastern flank by the Portland Hills fault. The Willamette River flows along the base of the eastern side of the Portland Hills; the Zidell site is located on the southwest bank of the river. A number of additional faults are located approximately parallel or perpendicular to the Portland Hills Fault and are mapped along or near the Portland Hills, with an inferred fault projected immediately west of the site. Upland areas along the margin of the basin are commonly capped by flows of the Columbia River Basalt Group (CRBG), localized flows of Boring lava, and occasionally by sediments of the Troutdale Formation.

The CRBG underlies the entire basin and is overlain by up to 1,300 feet of sediments, deposited primarily by the Columbia and Willamette rivers. From the ground surface to depth, the sediments are composed of up to 200 feet of younger alluvium and up to 1,100 feet of older alluvium, including the Troutdale and Sandy River Mudstone formations.

The site is underlain by up to 35 feet of fill material consisting of construction debris, scrap metal, and material dredged from the Willamette River, and by 25 feet of overbank deposits (from periodic flooding of the river) consisting of clay and fine-grained sandy silt. A sand unit that apparently underlies the overbank deposits near the site is approximately 75 feet thick.

The younger alluvium is underlain by the Pliocene Troutdale Formation. This formation consists of a thick sequence of gravel and sandstone conglomerate with minor beds of clay and sand. The Pliocene-age Sandy River Mudstone (or fine-grained equivalent) underlies and interfingers with the Troutdale Formation. It is composed of mudstone and claystone with scattered lenses of sandstone and conglomerate. The Miocene-age CRBG underlies the Sandy River Mudstone.

The geologic units have been divided into eight major hydrogeologic units in the Portland Basin (Hartford and McFarland, 1989; Swanson et al., 1993; McFarland and Morgan, 1996). From youngest to oldest, they include: (1) the unconsolidated sedimentary aquifer (USA); (2) the Troutdale gravel aquifer (TGA) in the Troutdale
Formation; (3) confining unit 1 (CU1); (4) the Troutdale sandstone aquifer (TSA) in the Troutdale Formation; (5) confining unit 2 (CU2); (6) the sand and gravel aquifer (SGA); and (7) Columbia River Basalt Group (CRBG) flows and interflow zones. The eighth unit consists of undifferentiated fine-grained sediments (UF) and occurs in areas of the basin where the TSA and SGA are absent or where there is insufficient information to characterize the aquifer units in the fine-grained Sandy River Mudstone.

The following aquifers are interpreted to be present at or near the site: the unconsolidated sediments of the USA (generally underlying fill material from 34 feet to 100 feet bgs), the cemented sand and gravel deposits of the TGA (generally below 100 feet bgs), the UF (generally below 200 feet bgs), and the CRBG aquifer (generally below 200 feet bgs). The clayey silt and sand of the USA near the Willamette and Columbia rivers yield from 5 to 40 gallons per minute (gpm), depending on a well’s location (McFarland and Morgan, 1996). The poorly to moderately cemented conglomerate and sandy conglomerate of the TGA is an important and productive aquifer in the Portland Basin, in which many public-supply, industrial, and domestic wells are completed. Most wells will yield a minimum of 50 gpm (McFarland and Morgan, 1996). Several engineering and industrial wells located near the site are completed in this aquifer. The UF is generally a poor water-bearing formation. The CRBG is also used as an aquifer near the site and is capable of producing more than 1,000 gpm.

Groundwater is present in the fill material at depths ranging from about 5 feet and 30 feet depending on a well’s location and the season. The depth to water varies seasonally, with the greatest fluctuations observed near the Willamette River. Groundwater flows toward and discharges into the Willamette River. The shallow groundwater flow direction, however, may be locally modified by seasonal fluctuations in the river and by permeability differences associated with underground utility piping and different types of fill. Horizontal gradients range from 0.02 ft/ft to 0.05 ft/ft. Estimates of horizontal hydraulic conductivity \( (K_h) \) range from 0.00075 feet per minute (ft/min) in MW-11 to 0.102 ft/min. Estimates of horizontal groundwater velocity for the shallow fill aquifer range from 0.06 ft/day to 17.28 ft/day.

### 2.1.4 Climate and Meteorology

The climate in Portland is west coast marine, characterized by moderate rainfall. About 80 percent of the rainfall occurs from October to May, 9 percent in June and September, and 3 percent in July and August. The average rainfall in Portland is 36.3 inches, according to records from 1961 to 1990. December is the wettest month, with rainfall averaging 6.1 inches. July is the driest month, averaging 0.63 inches of rainfall.
Wind direction is usually northwesterly in spring and summer and southeasterly in fall and winter. Average wind speed in Portland ranges from 6.5 miles per hour (mph) in early autumn to 10 mph in winter. The annual mean wind speed is 7.9 mph (Oregon Climate Service, 2001). The highest summer temperatures generally occur when hot, dry continental air masses move west through the Columbia River Gorge. Cold continental air moving through the gorge in the winter brings the coolest weather. In general, temperatures in the winter range from 32°F to 52°F. Temperatures in the summer range from 54°F to 80°F.

2.1.5 Current and Reasonably Likely Future Land Use
The 32.17-acre Zidell waterfront property has been a heavy industrial site since the turn of the last century, and adjacent properties have been industrialized since before World War II. The Zidell property and adjacent properties are currently zoned for central commercial use (CXdg). The CX zone is intended to provide for commercial development within Portland’s most urban and intensely developed areas. A broad range of uses is allowed to reflect Portland’s role as a commercial, cultural, and governmental center.

Future development of the site is expected to emphasize commercial, retail, and high-density residential development, similar to other proposed or completed development projects near the site and immediately north of the Marquam Bridge. The site is subject to the Central City and North Macadam design guidelines. Figure 2-5 shows the anticipated future site infrastructure layout. The Willamette River Greenway overlay provides for a greenway setback that extends 100 feet landward from the existing top of the bank.

2.1.6 Current and Reasonably Likely Future Beneficial Water Use
Groundwater. The Zidell property and the region are supplied with potable water by the COP municipal water supply. Groundwater in the general vicinity of the site is not now used or anticipated to be used as a source of drinking water at or near the site. The site and the North Macadam District will be redeveloped in the future and will be supplied with water by the COP municipal water supply.

Shallow groundwater discharges to or is recharged by the Willamette River (depending on the season). Groundwater is currently not used or anticipated to be used for beneficial purposes in the future in the region except as recharge for the Willamette River. Beneficial uses of shallow groundwater include discharge to the Willamette River. Beneficial uses of surface water include aesthetic quality, recreation, transportation,
wetland areas, fishing and hunting, anadromous fish passage, and fish and wildlife habitat. Deeper groundwater from Troutdale and deeper aquifers in the region is currently used and is reasonably anticipated to be used for industrial and engineering purposes in the future. The Zidell waterfront property has not adversely affected these beneficial uses of deep groundwater within the region.

**Surface Water.** The Willamette River is the sole surface water body within the locality of the facility. Beneficial uses of Willamette River water include aesthetic quality, recreation, transportation, wetland areas, fishing and hunting, anadromous fish passage, and fish and wildlife habitat.

Future water supply sources may include the Willamette River upstream of the site. Currently, the cities of Tigard, Wilsonville, Tualatin, and Sherwood are evaluating the use of Willamette River water and the construction of a water treatment plant on the Willamette River. Plant intakes would be at least 24 miles upstream of the site and above Willamette Falls and the quality of surface water would not be affected by COIs detected in soil, groundwater, or sediment at the Zidell site. Other current uses of the Willamette River are unlikely to change in the future.

### 2.2 Site History

In 1926, Coast Steel and Machinery occupied the north part of the site. By 1930, Zidell Machinery and Supply Company and Zidell-Steinberg Company occupied a warehouse and sold steel plates from a small area east of and next to SW Moody Avenue, north of the Ross Island Bridge. From 1920 to 1942, numerous businesses occupied the rest of the present site. In 1942, Commercial Iron Works was constructed. From 1942 to 1947, Commercial Iron Works built and repaired ships during World War II. Ships were built south of the Ross Island Bridge, where a large dock was constructed to support such operations.

In 1947, the Zidell Ship Dismantling Company leased the Commercial Iron Works dock from the Portland War Assets Administration. The Zidell Company dismantled surplus World War II ships on the river beside the docks until cranes could move sections to the shore north of the Ross Island Bridge for final dismantling and storage. Electrical wire was burned to recover copper in an open pit and later in two incinerators north of the Ross Island Bridge. Various Zidell companies, a steel-tube-forging business, and a plumbing supply company occupied the site during the 1950s and 1960s.

In 1965, a fire destroyed five Commercial Iron Works buildings south of the Ross Island Bridge. A Zidell company began building barges in a new metal building constructed on the south part of the site in 1968. In 1973, a second fire destroyed another Commercial
Iron Works building immediately south of the Ross Island Bridge. The docks caught fire in 1957 and in 1983.

Ship dismantling, wire burning, and secondary aluminum smelting ceased by approximately the mid-1970s. Since that time, most site activity has been in buildings south of the Ross Island Bridge, where Zidell companies maintain offices and Zidell Marine Corporation has barge-building facilities. From about 1983 to 1986, Jones Construction Company leased the site north of the bridge to manufacture prefabricated modular housing.

Most of the current site activity is on Tax Lot 42, where the Zidell companies maintain offices. Zidell Marine Corporation builds and sells or leases steel barges, and Zidell manages the Zidell companies’ real estate holdings. Current manufacturing activities are essentially limited to barge fabrication by Zidell Marine Corporation, in the large building on the south part of Tax Lot 42 (see Figure 2-3).

2.3 Regulatory History

On December 13, 1968, the first waste discharge permit was issued to Zidell Explorations, Inc., to control oil discharges to the river during ship dismantling. Oil recovered from ships was transferred to a bottomless oil/water separator, floating on the Willamette River, from which oil was pumped as it accumulated.

In 1969, the DEQ disapproved the continued use of the floating separator and, as part of a July 1, 1970 wastewater discharge permit, required Zidell to construct an on-shore oil/water separator system that controlled ship ballast water, yard runoff, and other oily water. The permit expired on December 31, 1979 and was not renewed because ship dismantling had ceased.

DEQ files for Zidell Explorations, Inc. records oil spills into the Willamette River on July 5, 1972 and September 6, 1973. In addition, on September 24, 1986 the DEQ recorded an oil spill into the Willamette River from a floating crane.

On May 12, 1975, an air contaminant discharge permit (ACDP 26-2071) was issued for secondary smelting. On June 1, 1980, the ACDP expired and was not renewed because smelting had ceased.

In April 1988, Zidell removed four USTs, including one 5,000-gallon heating oil UST, two 1,000-gallon gasoline USTs, and one 10,000-gallon UST, as recorded in the DEQ UST files under the Resource Conservation and Recovery Act (RCRA). Zidell personnel reportedly observed no releases from the USTs when they were removed.
Since September 1989, Zidell Explorations, Inc., has been registered as a RCRA hazardous-waste generator of F001, F005, D001, D003, and D008 hazardous wastes (USEPA generator identification No. ORD 0277165650), which are shipped off-site for treatment and/or disposal.

Zidell was issued a National Pollutant Discharge Elimination System (NPDES) 1200-Z general stormwater discharge permit in June 1999.

2.4 Previous Investigations

2.4.1 Federal Preliminary Assessment
In September 1987, the DEQ completed a federal preliminary assessment (PA) of the site with oversight from the USEPA, and concluded that the site should be investigated further because of past industrial land use (DEQ, 1987).

In 1988, EPA’s Contractor, Ecology and Environment Inc. (E&E) prepared a site investigation report. E&E’s site inspection concluded in July 1988 that although on-site hazardous waste disposal was not confirmed, past on-site land use suggested the potential for past releases of hazardous substances (E&E, 1988). Because of the limited use of surface water and groundwater, E&E concluded that the risk to human health and the environment did not merit further assessment by the USEPA. Further investigation was left to the property owner, under DEQ oversight.

In November 1990, a strategy recommendation was prepared by the DEQ Site Assessment Section. The recommendation was to perform an expanded preliminary assessment (XPA) to collect representative soil and groundwater samples and determine whether remedial action was necessary at the site.

2.4.2 OMNI Environmental Evaluation
The earliest environmental sampling at the site was conducted by OMNI in 1988 (OMNI, 1989). The sampling results indicated the presence of arsenic, lead, chromium, PCBs, PAHs and petroleum hydrocarbons in soil. Volatile organic compounds (VOCs) and metals were detected in groundwater samples.

2.4.3 EMCON Preliminary Assessment & Site Investigation
EMCON performed a PA in 1994 to identify potential threats to human health and the environment (EMCON, 1994). The PA completed by EMCON concluded that potential
releases of asbestos, metals, oils, PAHs, and solvents may have occurred. Site features or areas of concern (AOCs) included former wire-burning incinerators, transformers, open-pit wire-burning area, gasoline and fuel oil USTs, oil/water separator near the river, steam-cleaning area and crane pit sump, electrical/maintenance/carpentry shop, oil-storage area, and the steam-cleaning area, and nonpoint source releases generated during historical ship dismantling, salvaging, and processing operations or from materials in the fill. The identification of these features is provided in Table 2-1 and the locations illustrated in Figure 2-6.

From April 1995 to February 1996, EMCON performed an expanded preliminary assessment (XPA) to characterize the distribution of hazardous substances at the site to evaluate possible threats to human health and the environment, and determine what areas of the site required additional assessment. A total of 130 soil samples, 24 groundwater samples, and 18 sediment samples were analyzed primarily for metals, PCBs, PAHs, VOCs, and chlorinated herbicides in selected areas. The presence of asbestos was noted during subsurface exploration. The results from the XPA were incorporated into the RI, and are discussed in Section 3 of this report.
3 Remedial Investigation Summary

A general description of the RI is summarized below. Specific procedures and methods for conducting the investigation activities are presented in the RI Report. The RI was completed by Maul Foster and Alongi, Inc. (MFA) between 1997 and 2004. Plans and reports prepared by MFA on behalf of Zidell are summarized in the Administrative Record Index.

3.1 Remedial Investigation Elements

A number of areas of concern identified in pre-RI investigations were further characterized during the RI. The characterization of site soils included collection of additional samples to determine background concentrations for metals, and determinate the horizontal and vertical extent of soil contamination. A total of 32 Geoprobe™ borings were installed and 15 test pits excavated to characterize the horizontal and vertical extent of soil contamination.

The groundwater investigation included installation of seven additional groundwater monitoring wells to improve the coverage of the groundwater monitoring network. The groundwater monitoring wells were located to assess previously identified groundwater contamination and potential groundwater impacts downgradient of areas with elevated concentrations of metals in subsurface soil to assess potential leaching of contaminants from soil to groundwater and migration to the Willamette River. Subsurface soil samples were also collected and analyzed during the installation of new groundwater monitoring wells to further assess the vertical distribution of hazardous substances. Groundwater monitoring was conducted during completion of the RI from wells where COIs were detected above screening criteria (e.g. drinking water maximum contaminant levels [MCLs], ambient water quality criteria [AWQC], or ecological screening level values [SLVs]). Measurements were also collected to assess aquifer properties to evaluate transport and fate of chemicals of interest (COIs) migrating in groundwater.

The Willamette River sediment investigation, which was completed in several phases, included sampling and analysis of 72 bulk sediment and 21 pore water samples collected at and near the Zidell waterfront property to evaluate sediment physical properties, the distribution of COIs in sediment, toxicity and the potential for impact to surface water quality. The COIs included in the analytical testing included PCBs, PAHs, metals, butyltins, and TPH. In addition seven bulk sediment samples were tested for toxicity using acute 10-day amphipod (*Hyalella azteca*) survival test and acute/chronic 10-day midge (*Chironomus tentans*) survival and growth tests.
COIs that affect all media at the site (soil, groundwater, and river sediment) are as follows: PCBs, metals (antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc), PAHs, and petroleum hydrocarbons (primarily in the heavy-oil and diesel ranges). The RI also evaluated VOCs in soil and groundwater, chlorinated herbicides and organophosphorous pesticides near an area on the neighboring Schnitzer property where pesticides were formulated, dioxins and furans in soil in wire burning areas, and butyltins in sediment. Asbestos-like material has been observed in soil near the riverbank. Impacts in the upland area extend from the ground surface to depths up to 34 feet in localized areas. Willamette River sediments are impacted in some areas from the riverbank to 500 feet into the river and to at least 10 feet below the sediment/water interface.

In September 2004, additional investigation was conducted to characterize the contaminant distribution in the riverbank to support development of remedial alternatives for the FS (MFA 2004b). As part of this investigation, surveys were conducted to assess the bank dimensions, evaluate habitat characteristics, and bank stability. A total of 28 transects were surveyed along the bank and soil samples were collected at elevations of approximately 13 feet and 24 feet COP datum and analyzed for metals, PAHs, PCBs, and organotins. Samples of insulation debris were also collected to verify the presence of asbestos.

### 3.2 Nature and Extent of Contamination

The following subsections summarize the nature and extent of contamination in soil, groundwater, sediment, and sediment pore water at the Zidell site.

#### 3.2.1 Soil

The following COIs were detected above the screening values protective of human and ecological receptors (see Section 3.4) in soil: PCBs (primarily Aroclor 1254, Aroclor 1260, and total PCBs); antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc; PAHs; VOCs (benzene); and petroleum hydrocarbons (diesel, gasoline, oil, grease, and other petroleum hydrocarbons). Table 3-1 summarizes the range of concentrations of COIs detected in soil in the site upland areas, and Table 3-2 summarizes COIs detected in surface soils along the bank of the Willamette River.

Soil contamination in Areas 2 and 3 were more widespread than in Area 1, presumably because Area 1 has been paved during much of the operational history of the site and much of the salvaging operations occurred in Areas 2 and 3. For the most part, significant contamination is limited to less than 5 feet below ground surface (bgs), except
in a limited area in Area 2 and near the shoreline where contaminant distribution is more complex as a result of historical fill activities.

**Asbestos Materials.** Asbestos containing material (ACM) has been confirmed in landfilled insulation materials in several locations along the riverbank in the area where ship salvaging activities historically occurred. The landfilled material containing ACM is several feet thick in these areas.

**VOCs & TPH.** A number of chlorinated and fuel related VOCs were detected in soil in the former locations of USTs in Area 1. Detected concentrations were below their respective USEPA Region 9 preliminary remediation goals (PRGs) and hot spot concentrations, except for benzene in one sample. VOCs were generally not detected in soil in Areas 2 and 3. Detected concentrations did not exceed their respective PRGs. Heavy weight petroleum hydrocarbons products were detected in at concentrations ranging from 20 mg/kg to 80,000 mg/kg.

**Metals.** Of the nine metals that were evaluated in the RI, antimony, arsenic, and lead exceeded background concentrations or PRGs with the highest frequency. Lead is widespread at the site and concentrations exceeding background levels in approximately half of the samples tested for lead. The highest lead concentrations were detected in Area 3, with a maximum detected concentration of 58,000 mg/kg. Other metals detected at concentrations significantly above background levels include antimony, cadmium, chromium copper, mercury and zinc.

**Polycyclic Aromatic Hydrocarbons.** Carcinogenic PAHs were detected more frequently in Area 2 than in Areas 1 and 3. Benz(a)anthracene and benzo(a)pyrene were detected above their respective PRGs and hot spot concentrations at only one location in Area 1, the former steam cleaning area next to the maintenance building. Carcinogenic PAHs were detected in approximately one-half the samples collected from Area 1, with most of the detected concentration exceeding PRGs. Only one of eighteen samples collected from Area 3 exceeded PRGs.

**Polychlorinated Biphenyls.** PCB Aroclors detected in Area 1 at levels exceeding PRGs but below hot spot concentrations were limited to the transformer locations. Total PCB Aroclors exceeded hot spot concentrations in Area 2 at nine sampling points, and in Area 3 at six sampling locations.

**Dioxins and Furans.** Soil samples collected near former wire-burning areas were analyzed for dioxins and dibenzofurans. Analytical results for dioxins and furans are reported in terms of a number of chlorinated dibenzo-\(p\)-dioxin and dibenzofuran congeners, which have similar molecular structures but differ in number and position of chlorine atoms on the molecule, which results in varying degrees of congener toxicity. The congener 2,3,7,8-tetrachlorodibenzo-\(p\)-dioxin (TCDD) is the most toxic of the
congeners, and so is commonly used to represent the entire group of dioxins and furans. The less-toxic congeners are usually referred to in terms of “TCDD equivalents” and thus are each assigned a specific toxic equivalency factor (TEF) by which the detected concentrations of each congener are multiplied to obtain TCDD-equivalent concentrations. Transformed concentrations can then be compared to the PRG for TCDD, which is the only congener assigned a USEPA Region 9 PRG. Dibenzofuran congeners were the only compounds detected above the equivalent 2,3,7,8-TCDD PRG.

3.2.2 Groundwater

Groundwater monitoring has been performed since 1995 from 15 monitoring wells completed prior to and as part of the RI. Groundwater monitoring was also conducted using push-probe sampling methodology in discrete areas to assess the nature and extent of petroleum contamination associated with USTs or sumps.

As noted above, shallow groundwater is not currently used for drinking water purposes and is not expected to be used for drinking water in the future. Therefore, the only potential receptors for shallow groundwater are aquatic organisms in the surface water and sediments of the Willamette River. The groundwater monitoring results are therefore compared with AWQC for the protection of ecological receptors in freshwater established by the USEPA and the DEQ’s Level II ecological screening level values (SLVs) for freshwater.

Antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, PCB Aroclors 1254 and 1260, ethylbenzene, xylenes, toluene, and carbon disulfide have been detected in at least one location at levels exceeding DEQ’s SLVs or the AWQC. Table 3-3 summarizes the groundwater data for metals, PAHs and PCBs.

VOCs and TPH. A number of VOCs were detected in one or more samples in groundwater samples collected from MW-5, which is located approximately 500 feet from the Willamette River shoreline. Detected concentrations did not exceed the AWQC or DEQ SLVs, except for ethylbenzene (up to 12.6 µg/L) and xylenes (up to 32 µg/L for m,p-xylenes and up to 75 µg/L for total xylenes). Occasional detections of VOCs have been reported in other on-site monitoring wells at levels below the AWQC or SLVs.

Detected concentrations of diesel in wells near UST areas have periodically exceeded 1 mg/L. TPH concentrations in downgradient monitoring points located near the shoreline occasionally exceeded 1 mg/L of diesel or heavy oil. As discussed in Section 3.5.3, contaminant transport modeling indicates VOCs and TPH in groundwater are not predicted to reach the Willamette River at significant concentrations.
Polychlorinated Biphenyls. Aroclors 1254 and 1260 was the only PCB congener detected in groundwater at the site. All of the detected concentrations exceeded AWQC of 0.014 µg/L, but did not exceed the DEQ SLV for aquatic receptors of 94 µg/L. The concentrations of Aroclors detected in these wells have decreased since 1997 coincident with modified sampling procedures that reduced the suspended solids in samples. The detections of PCBs in groundwater, therefore, are suspected to be associated with PCBs sorbed to fine soil particles and not dissolved in groundwater.

Total and Dissolved Metals. Groundwater samples were analyzed for antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. Compared with dissolved metal concentrations, total metal concentrations were consistently higher. The elevated total metals concentrations are believed to be attributable to the mobilization of fine grained soil particles caused by the purging and sampling methodology. Turbid groundwater samples typically result metal concentrations that are not indicative of the concentrations actually moving in the aquifer.

Detected concentrations of total and dissolved metals varied during monitoring from 1997 through 1999. In general total concentrations declined during this period after low-flow sampling techniques were implemented. Antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc have been detected at concentrations exceeding DEQ fresh water SLV for aquatic receptors from MW-5 and/or MW-9. Groundwater modeling results indicate metals will not reach the Willamette River at levels exceeding ambient water quality criteria (AWQC).

Polycyclic Aromatic Hydrocarbons. Detected concentrations of PAHs did not exceed their respective AWQC or DEQ SLVs for aquatic receptors, except for benz(a)anthracene and benzo(a)pyrene in samples from MW-5 and MW-8 that were collected in 1995. These detections are likely due to suspended sediments in the water samples as discussed for PCBs.

Chlorinated Herbicides and Organophosphorous Pesticides. Groundwater samples from MW-6 and MW-11 were analyzed for chlorinated herbicides and organophosphorous pesticides because the wells are near a former pesticide and herbicide manufacturing company northwest of this part of the site (Unit A of the former Schnitzer property). Pesticides were not detected at or above the MRLs in groundwater samples collected from the wells. Generally herbicides were not detected at or above the MRLs, except for 2,4,5-T, 2,4,5-TP (silvex), 2,4-D, and dicamba in samples collected in 1994 and 1995. Herbicide concentrations were detected at low part per billion (ppb) levels. There are no AWQC or DEQ SLVs available for these compounds.
3.2.3 Sediment

Sediment samples were collected from the Willamette River adjacent to the facility during 4 rounds of sampling. Figure 3-1 shows the facility storm drainage system and associated outfalls and the location of the sediment sampling locations. The following summarizes the nature and extent of COIs in surface and subsurface sediment and pore water and the results of the toxicity testing. Detected concentrations are compared with the DEQ SLVs used in the Level II Screening Ecological Risk Assessment (ERA). Significant levels of contamination are located within 200 feet of the shoreline, although concentrations of metals above background levels were measured up to 500 feet from the shoreline. Background levels were estimated by DEQ based on upstream monitoring in the proximity of Ross Island. The estimated area of significant sediment impacts is discussed in Section 4. Table 3-4 summarizes the results of the sediment testing for COIs for the site.

3.2.3.1 Surface Sediment

Surface sediment is defined as sediment collected from the biologically active zone (depth of 30 centimeters or about 10 inches).

Polychlorinated Biphenyls. PCBs were generally detected only in surface sediment samples. Aroclor 1254 was detected in nine samples at concentrations ranging from 0.12 mg/kg to 5 mg/kg. The detected concentrations exceeded the toxicity SLV of 0.007 mg/kg. Aroclor 1260 was detected in 19 samples at concentrations ranging from 0.0051 mg/kg to 2.6 mg/kg. Fourteen of the detected concentrations exceeded the toxicity SLV of 0.034 mg/kg. Total PCBs were detected in 20 samples at concentrations ranging from 0.0255 mg/kg to 8.45 mg/kg. Sixteen of the detected concentrations exceeded the toxicity SLV of 0.034 mg/kg.

Metals. The distribution of metals contamination is similar to PCBs and other COIs, with metals concentrations exceeding DEQ SLVs in samples located adjacent to the shoreline. Metals concentrations exceeding SLVs include antimony, arsenic, cadmium, chromium, copper, lead, mercury nickel and zinc:

- Antimony was detected at concentrations exceeding the SLV of 3 mg/kg in three sediment samples;
- Arsenic was detected at concentrations exceeded the SLV of 6 mg/kg in seven of 29 surface sediment samples;
- Cadmium was detected at concentrations ranging from 0.12 mg/kg to 6.5 mg/kg, all of which exceed the toxicity SLV of 0.6 mg/kg;
• Chromium was detected in all surface sediment samples at concentrations ranging from 11.2 mg/kg to 143 mg/kg. The toxicity SLV for chromium is 37 mg/kg;
• Copper was detected in all surface sediment samples at concentrations ranging from 1.6 mg/kg to 1,210 mg/kg. The toxicity SLV of 36 mg/kg was exceeded in samples collected from along the entire shoreline of the site. The highest concentrations were detected near stormwater outfalls and the barge launchway;
• Lead was detected at concentrations ranging from 2 mg/kg to 2,290 mg/kg. The toxicity SLV of 35 mg/kg was exceeded in samples collected from along the entire shoreline. The highest concentrations were detected near stormwater outfalls and the barge launchway and under parts of the former dock;
• Mercury was detected at concentrations ranging from 0.016 mg/kg to 1.4 mg/kg. The toxicity SLV of 0.2 mg/kg was exceeded in samples collected from samples located along the shoreline, with highest concentrations detected near outfalls immediately north of the Ross Island Bridge;
• Nickel was detected in all surface sediment samples at concentrations ranging from 12 mg/kg to 108 mg/kg. The toxicity SLV of 18 mg/kg was exceeded in most of the samples;
• Zinc was detected in all surface sediment samples at concentrations ranging from 35 mg/kg to 2,270 mg/kg. The toxicity SLV of 123 mg/kg was exceeded in samples collected from along the shoreline.

Polycyclic Aromatic Hydrocarbons. PAHs were detected in surface sediment samples at most of the sampling locations. The highest concentrations of low-molecular-weight PAHs (LPAHs) in surface sediment were detected near the south part of the former dock and a former oil/water separator at a concentration of 4,330 micrograms per kilogram (µg/kg). Detected concentrations decreased with depth. PAHs included in the calculation of total LPAHs were 2-methyl naphthalene, naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. The highest concentrations of high-molecular-weight PAHs (HPAHs) were also detected near the south part of the former dock and a former oil/water separator at levels up to 22,460 µg/kg. Detected concentrations decreased with depth and with increased distance from the shoreline. Total HPAHs were calculated from fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, dibenzofuran, and benzo(g,h,i)-perylene.
Petroleum Hydrocarbons. Hydrocarbon scans generally detected only diesel and heavier petroleum hydrocarbons. Diesel was detected in surface sediment samples collected from upstream of the site at levels up to 74 mg/kg in WRS-22. Diesel was also detected upstream of the site, offshore of the barge launchway, and offshore of COP OF 6.

Lube oil was detected at concentrations ranging from 78 mg/kg to 8,600 mg/kg. Motor oil was detected at concentrations that ranged from 0.17 mg/kg to 890 mg/kg in WRS-46.

Butyltins. Tributyl tin (TBT) is the active ingredient in marine antifoulant paints that may have been present on ships that were salvaged and scrapped at the site. Zidell has reported that they have not used TBT-containing antifoulant paints on barges. TBT degrades to dibutyltin and monobutyltin by photolysis in surface water and by biological degradation in sediment.

The highest concentrations of dibutyltin and monobutyltin were detected in subsurface sediment samples collected near the south part of the former dock. TBT was detected in surface sediment samples at concentrations ranging from 2 µg/kg to 1,990 µg/kg. TBT concentrations exceeded the toxicity SLV of 3 µg/kg at all locations. Dibutyltin (DBT) was detected in surface sediment samples at concentrations ranging from 2 µg/kg to 368 µg/kg. DBT concentrations exceeded the toxicity SLV of 3 µg/kg in all but four sampling locations. Monobutyltin (MBT) was detected in surface sediment at concentrations ranging from 0.85 µg/kg to 1,140 µg/kg. MBT concentrations exceeded the toxicity SLV of 3 µg/kg at all but four locations sampled.

Bioassay Toxicity Testing. Field activity included collecting sediment samples for bioassays (10-day Chironomid and Hyalella tests). The samples submitted for Chironomid tests indicated no statistically significant mortality. Only one sample elicited adverse effects related to Chironomid growth. Three samples elicited statistically significant mortality in Hyalella. A relatively high incidence of mortality (28.8 percent) was seen in one sample collected about 150 feet offshore. A moderate incidence of mortality (17.5 percent) was seen in one sample located downriver and about 500 feet offshore of the north part of the site.

3.2.3.2 Subsurface Sediment
Depth-discrete sediment samples were collected at depths ranging from 1 to 10 feet. PCBs were generally detected in deeper sediments near the shoreline but not in samples collected beyond 100 feet from the shoreline. Detected concentrations of Aroclor 1260 decreased with depth, except in WRS-37.
Metals concentrations generally decreased with depth except along the shoreline in the former dock location at 8 sampling locations where significant levels of barium, chromium copper, lead and zinc were detected in subsurface sediments.

PAHs were detected in sediment samples collected from all borings except at two locations. Detected concentrations generally decreased with depth. The highest concentrations of LPAHs (2,500 ug/kg) and HPAHs (3,600 ug/kg) in subsurface sediment were detected at a depth of 7 feet bgs. The toxicity SLVs for the following PAHs were exceeded in one or more locations: 2-Methylnaphthalene, benzo(b)fluoranthene, benzo(k)fluoranthene, fluoranthene, phenanthrene, and pyrene.

Hydrocarbon scans generally detected only diesel and heavier petroleum hydrocarbons. Diesel was detected in two subsurface sediment samples collected at a depth of 5 feet bgs at concentrations of 98 mg/kg and 160 mg/kg. Motor oil was detected at concentrations that ranged from 42 mg/kg at 10 feet bgs to 900 mg/kg at 5 feet bgs. Detected concentrations of motor oil decreased with depth in several locations, but increased with depth at several others.

TBT concentrations in subsurface sediments ranged from 1 µg/kg to 14,000 µg/kg at 7 feet bgs. TBT concentrations exceeded the toxicity SLV of 3 µg/kg in all but one sample. DBT concentrations ranged from 16 µg/kg to 360 µg/kg, which exceed the toxicity SLV of 3 µg/kg. MBT concentrations ranged from 0.72 µg/kg to 58 µg/kg, with only one sample exceeding the toxicity SLV of 3 µg/kg.

### 3.2.4 Sediment Pore Water
Sediment pore water analyses were performed on samples collected from the biologically active zone at 21 locations and analyzed for butyltins, metals, and ammonia.

TBT and DBT were detected in only one pore water sample at a concentration of 0.6 µg/L, which exceeded the toxicity SLV of 0.063 µg/L. MBT was detected at three locations at concentrations ranging from 0.22 ug/L to 5.3 ug/L and above the SLV of 0.063 ug/L.

Antimony, cadmium, and mercury were not detected in sediment pore water samples. Arsenic was detected at concentrations ranging from 0.0012 mg/L to 0.0042 mg/L, below the toxicity SLV of 0.150 mg/L. Chromium was detected in all samples at concentrations ranging from 0.0014 mg/L to 0.008 mg/L, below the SLV for hexavalent chromium of 0.011 mg/L. Copper concentrations ranged from 0.0011 mg/L to 0.012 mg/L, with one sample exceeding the toxicity SLV of 0.009 mg/L. Lead was detected in two samples with one sample exceeding the toxicity SLV of 0.0025 mg/L. Nickel was detected at...
concentrations ranging from 0.0019 mg/L to 0.0063 mg/L, which are below the toxicity SLV of 0.052 mg/L. Zinc was detected at concentrations ranging from 0.0043 mg/L to 0.026 mg/L and below the toxicity SLV of 0.120 mg/L.

Ammonia was detected at concentrations ranging from 1.4 mg/L to 60 mg/L. The detected concentrations exceeded the toxicity SLV of 0.017 mg/L.

### 3.3 Contaminant Fate and Transport

This section discusses the processes that control the fate and transport of the COIs detected in soil, groundwater and sediment at the Zidell site. COIs in this evaluation include organic compounds: PCBs, PAHs, and TPH constituents; and metals.

#### 3.3.1 Soil

The COIs in soil are adsorbed to soil particles. Adsorption is expected to be the primary mechanism affecting contaminant fate in the subsurface at the site. Fate and transport mechanisms for COIs adsorbed to soil particles are discussed below.

**Polychlorinated Biphenyls.** PCBs have low aqueous solubility, relatively low vapor pressure, and extreme resistance to chemical reaction. PCBs tend to adsorb strongly to soils and to resist dissolution. The low solubility of PCB mixtures inhibits the migration of PCBs from soil to groundwater. PCBs have a high vapor pressure and volatilization is not a major factor in the environmental fate and transport of PCBs. PCBs are very stable compounds that resist both oxidation and hydrolysis, undergo very limited photolysis, and are resistant to biodegradation. Because of the persistence and low mobility of PCBs, most PCB contamination is persistent in the environment and tends to be confined to soils close to the point of release, except in circumstances where contaminated soil is transported via erosion cause by significant rainfall events.

**Polycyclic Aromatic Hydrocarbons.** The breakdown of PAHs in soil is accomplished largely by biodegradation, although biodegradation potential of PAHs decreases as the number of aromatic rings increases. Typically, PAHs with five aromatic rings are relatively resistant to biodegradation. PAHs are similar to PCBs in that they tend to adsorb to soils, particularly soils that are high in organic content, and that volatilization is not typically an important transport process.

**Diesel- and Heavy-Oil-Range Petroleum Hydrocarbons.** The principal fate of diesel- and heavy oil-range TPH is biodegradation. Petroleum products released into the environment undergo weathering as a result of both volatilization and leaching. Evaporative processes are important in the weathering of petroleum products that contain a large proportion of volatile components. Given that the fraction of volatile components
is low for diesel- and heavy-oil-range TPH, volatilization is not an important transport process for the TPH constituents released at the site.

Leaching introduces the soluble components of petroleum hydrocarbon into the water phase. Aromatics, especially BTEX, tend to be the most water-soluble components. Given that diesel- and heavy oil-range petroleum products tend to have a low aromatic content, leaching tends not to be an important process for those petroleum products. Groundwater monitoring at the site has detected TPH contamination generally less than 1 mg/L, and VOCs including BTEX in the low part per billion ranges. Elevated TPH concentrations may be associated with suspended sediments in the groundwater samples. Groundwater modeling was performed to assess horizontal transport of TPH to the Willamette River. Significant levels of TPH in groundwater were not predicted to reach the Willamette River from inland on-site source areas.

**Metals.** The fate and transport of a metal in soil and groundwater depends significantly on its chemical form and speciation. The presence of inorganic anions (carbonate, phosphate, sulfide) in the pore water of soil influences the soil’s ability to sorb metals chemically. The anions can form relatively insoluble complexes with metal ions and cause metals to desorb or precipitate in their presence, thus reducing their ability to migrate. Soil pH largely influences the mobility of metals in soil. Metal cations are most mobile under acidic conditions, while anions tend to sorb to oxide minerals in that low pH range. Organic matter, particularly humic materials, can cause metals to complex and affect their removal from solution.

Groundwater monitoring at the site identified elevated metals concentrations exceeding AWQC or DEQ SLVs for surface water in unfiltered samples. Groundwater samples that were field filtered to remove suspended solids in the collected samples generally did not show significant levels of metals above SLVs. The groundwater monitoring results support a conceptual fate and transport model for metals in soil that indicates metals are strongly sorbed to soil and not subject to transport via leaching from soil to groundwater, and subsequent migration of groundwater to surface waters.

### 3.3.2 Willamette River Sediment

The primary source of sediment contamination appears to be related to past ship-dismantling activities and fires along the dock. Organotin contamination is most likely associated with paint chips produced by sand blasting. The source of metals is most likely sand-blasting grit, paint chips (chromium, copper, and lead), and other parts of the ships. PCBs may have been contained in cables, gaskets, paint, and elsewhere in older ships, as well as in transformers dismantled at the site. The PAHs and petroleum hydrocarbons may have been generated during ship and tank dismantling as well as during dock fires. The source of COIs may also be particulates suspended in stormwater...
discharged to the Willamette River through stormwater outfalls, surface soils eroded from the upland portion or bank of the site, historical groundwater discharges to the Willamette River, and suspended sediment transported from upriver sources.

Many factors influence the transport, fate, and bioavailability of chemicals in sediments and their partitioning into pore water, including the type of chemical (nonpolar hydrophobic organic compounds and metals), the chemistry of the environment (oxic versus anoxic, marine versus freshwater), physical conditions (grain size, disturbance, and stability of the sediments), the amount and source of organic carbon in sediments (humic material, coal, soot, oil), the pH and concentration of ammonia in pore water, and the presence of metal sulfides in sediment.

**Organic Compounds.** The fate of PCBs and PAHs in sediment is similar to that in soil. Adsorption to sediment and suspended material is an important fate process. PCB and PAH tendency to adsorb to sediment particles increases with decreasing solubility (which corresponds to the degree of chlorination).

PCBs are highly lipophilic and bioconcentrate in the tissue of aquatic organisms. PAHs tend to concentrate lower in the food chain (i.e. phytoplankton, certain zooplankton, snails etc), and thus species that feed at the lower end of the food chain are at a higher risk of bioaccumulation than species that feed higher on the chain. The human health and ecological risks posed by this process were evaluated in the risk assessment discussed in Section 3.4.

**Metals.** Most metals entering surface water are rapidly adsorbed to particulate matter, which settles out as sediment. The presence of metal sulfides in sediment, as well as the type and amount of organic carbon and the presence of colloids, appears to control the partitioning of metals between sediment and pore water. The extent to which metals bind to marine and freshwater sediments are likely related to acid volatile sulfide (AVS) concentrations within sediment pore water.

**Butyltins.** TBT detected in sediment was apparently released to the environment as paint chips or larger fragments containing marine antifouling paint during historical scrapping and dismantling of ships at the site. TBT is expected to be strongly sorbed to sediment. The tendency for adsorption to humic material and suspended particulates is thought to be much weaker. TBT cations may react with sulfides in sediment to form TBT sulfide.

Once TBT is adsorbed, the decrease in concentration takes place mainly by degradation. The degradation of TBT oxide occurs by the breaking of the carbon-tin bond by means of physicochemical processes (primarily, direct photolysis in surface water) and biological mechanisms (degradation by microorganisms and metabolism by higher organisms).
Sediment data indicates degradation of TBT is occurring in sediment based on the detection of mono- and di-butyl tin compounds.

The lipophilic properties of TBT, its moderately high octanol-water partition coefficient ($\log K_{ow} > 3$), and a measured BCF of greater than 6,000 indicate that TBT will strongly bioconcentrate in various aquatic organisms.

### 3.4 Human Health and Ecological Risk Assessments

This section summarizes the findings of the baseline human health risk assessment (HHRA) and the ecological risk assessment (ERA) that were completed as part of the RI. This section also identifies potential hot spots of contamination based on the results of the HHRA and ERA.

#### 3.4.1 Human Health Risk Assessment

The HHRA evaluated potential impacts to human health associated with site-related constituents detected in on-site soil in the upland part of the site. A reasonable maximum exposure (RME) scenario and a central tendency exposure (CTE) scenario were used to evaluate risk to three types of potential receptors: (1) future residents, (2) excavation workers, and (3) construction workers. An addendum to the HHRA assessed potential human health risks to recreational anglers and tribal fishers to sediment by transfer of contaminants through ingested fish.

COIs were screened to identify contaminants of potential concern (COPCs) for human receptors, as described in DEQ guidance. COPCs are COIs that exceed screening criteria, specifically USEPA Region 9 preliminary remediation goals (PRGs), as described in DEQ guidance. Those COPCs for human receptors that screened in the HHRA and found to occur at risk levels that exceed the DEQ-acceptable potential excess cancer risk (PECR) level of $1 \times 10^{-6}$ for an individual carcinogen, or a HQ of 1.0 for an individual noncarcinogen, are referred to as COCs for human receptors.

The site was divided into four areas of concern for the baseline HHRA. For each of the four soil exposure areas, three soil depth intervals were assessed: 0 to 0.5 feet bgs, 0 to 3 feet bgs, and 0 to 15 feet bgs. Potential future exposure of construction workers to soil considered only the 0-to-15-feet interval in each exposure area. The DEQ-acceptable level for potential excess carcinogenic risk (PECR) related to an individual carcinogen is $1 \times 10^{-6}$; the DEQ-acceptable level for cumulative PECR is $1 \times 10^{-5}$; and the DEQ-acceptable level for noncarcinogenic risk for both an individual chemical hazard quotient (HQ) and a multiple-chemical cumulative hazard index (HI) is 1.0. In all cases, potential
residential exposure produced the highest risk numbers. Table 3-6 summarizes the estimated future risks for the exposure scenarios evaluated in the HHRA.

Potential risk associated with site groundwater was assessed for residents exposed to chemicals that could volatilize from groundwater into indoor and outdoor air, and for excavation workers and construction workers directly contacting groundwater in trenches. Residential exposure to chemicals in indoor and outdoor air was assessed using a fate-and-transport model, in addition to comparing detected concentrations with DEQ risk-based concentrations.

Reasonable maximum exposure (RME) and central tendency exposure (CTE) human health risks were calculated for both carcinogenic and noncarcinogenic risk (referred to in terms of PECR and HI, respectively) based on incidental ingestion of, dermal contact with, and (particulate) inhalation of soil. Results are presented below.

- Potential carcinogenic and non-carcinogenic risk associated with residential RME to multiple chemicals detected in soil significantly exceeds DEQ-established acceptable levels based on risks associated with ingestion of and dermal contact with soil. In the greenway area, the cumulative RME PECR for potential contact of residents with upland soil is $6 \times 10^{-4}$, while the cumulative RME HI is 262. The cumulative CTE PECR and HI are $1 \times 10^{-5}$ and 5, respectively. In the non-greenway area, the cumulative RME PECR for potential contact of residents with upland soil is $2 \times 10^{-3}$, while the cumulative RME HI is 381. The cumulative CTE PECR and HI for the non-greenway area are $1 \times 10^{-5}$ and 2, respectively.

- Potential volatilization of COPCs in soil to indoor and outdoor air would not pose an unacceptable risk to future residents. Low levels of some VOCs were detected in groundwater, but do not pose unacceptable risk to human receptors inhaling indoor or outdoor air.

- Potential risks related to beneficial use of groundwater is not a concern, because deeper aquifers are not impacted and there is no use of shallow groundwater beyond recharge to the river. The area is served by a municipal supply and is reasonably expected to be served by a municipal supply in the foreseeable future.

- Potential risks associated with direct contact of excavation workers and construction workers to groundwater do not exceed DEQ-acceptable levels.

Lead does not have assigned toxicity values, so human health risk cannot be quantified for this chemical. However, exceedances of the site-specific, human health-related lead cleanup level of 400 mg/kg and hot spot level of 4,000 mg/kg were evaluated. In the
Greenway and Non-Greenway areas, the RME and CTE concentrations of lead exceed the cleanup level of 400 mg/kg but not the hot spot level.

For recreational fishers, cumulative RME PECR ($1 \times 10^{-3}$) and the highest RME cumulative noncarcinogenic risk (HI = 53) exceed DEQ-acceptable levels in regard to recreational angler exposure to sediment through fish ingestion. Individual carcinogens with RME PECRs that exceed the DEQ-acceptable level of $1 \times 10^{-6}$ include Aroclor 1254, Aroclor 1260, arsenic, benzo(a)pyrene, benz(a)anthracene, dibenz(a,h)anthracene, and benzo(b)fluoranthene. Individual noncarcinogens with RME HQs that exceed the DEQ-acceptable level of 1.0 include Aroclor 1254, copper, and cadmium.

The conclusions of the HHRA are that the upland portions of the site pose an unacceptable risk to future residents, and current and future excavation and construction workers. In addition, the existing sediment contamination within 200 feet of the shoreline poses an unacceptable risk to recreational anglers through the fish ingestion pathway. Section 4 of this report describes the remedial action objectives developed for the site in the FS to address these unacceptable risks and associated exposure pathways.

### 3.4.2 Ecological Risk Assessment

The Ecological Risk Assessment (ERA) involved two assessment levels: scoping (level I) and screening (level II). The level I study identified potentially complete exposure pathways, potential ecological receptors, and the following COIs at the Zidell property: VOCs, semivolatile organic compounds, PCBs, metals, petroleum hydrocarbons, butyltins (in sediment); and dioxins, asbestos, chlorinated pesticides, and organophosphorous herbicides (in soil). Potential terrestrial receptors included plants, birds, small mammals, and soil invertebrates. Potential aquatic receptors included invertebrates, mammals, piscivorous birds and ESA-listed salmonids.

The purpose of the Level II Assessment was to ascertain whether potentially unacceptable ecological risks existed in soil and in Willamette River sediment at the site. The following contaminants of potential ecological concern (CPECs) were identified in shallow soil (0 to 2.5 feet bgs): metals, PAHs, and PCBs. The following CPECs were identified in sediment in the biologically active zone: metals, PAHs, PCBs, and butyltins.

Bioassays (10-day midge [Chironomus tentans] and amphipod [Hyalella azteca] tests were performed on sediment samples to assess potential toxicity to aquatic organisms. The Chironomid samples showed no statistically significant mortality, but the Hyalella samples did elicit significant mortality.
The conclusions of the ERA were that the upland portions of the site posed an unacceptable risk to ecological receptors including terrestrial species, birds, plants and invertebrates. Existing sediment contamination within the Willamette River and along the shoreline of the site poses an unacceptable risk to sediment dwelling organisms and other ecological receptors (e.g. birds and mammals) through food web exposures. Section 4 of this report describes the remedial action objectives developed for the site in the FS to address these unacceptable risks and associated exposure pathways.

### 3.5 Identification of Hot Spots

OAR 340-122-0115(31)(b) defines hot spots in media other than water as hazardous substances that present a risk to human health or the environment exceeding the acceptable risk level and any of the following criteria:

(a) Are present in concentrations exceeding risk-based concentrations corresponding to:

1. 100 times the acceptable risk level for human exposure to each individual carcinogen
2. 10 times the acceptable risk level for human exposure to each individual non-carcinogen
3. 10 times the acceptable risk level for individual ecological receptors or populations of ecological receptors to each individual hazardous substance

(b) Are reasonably likely to migrate to such an extent that [a significant adverse effect on beneficial use(s) of water] or the conditions specified (a) or (c) would be created or

(c) Are not reliably containable, as determined in the feasibility study.

#### 3.5.1 Soil

Hot spots in soil were calculated separately for the greenway and non-greenway areas. In the greenway setback, hot spot concentrations were calculated for both human and ecological receptors. In the non-greenway area, hot spot concentrations were based solely on human health risk levels. Terrestrial ecological receptors are not a concern in the non-greenway area because of the absence of ecologically important habitats. Table
4-1 summarizes the hot spot concentrations for soil. The calculation of hot spot concentrations is discussed below.

**Human Receptors.** Hot spot concentrations for human receptors were calculated in the FS for COCs detected in upland soil based on residential, industrial, recreational and construction worker exposure scenarios. For most COCs, PRGs for soil at residential sites were used as the acceptable risk levels for the hot spot calculations. For COCs that had assigned cleanup levels based on background concentrations (arsenic and chromium), the hot spot concentrations for human receptors also were calculated by using the PRGs as the acceptable risk level, except for zinc. A ceiling value of 100,000 mg/kg was used as the hot spot concentration for zinc.

**Ecological Receptors.** Hot spot concentrations for ecological receptors were calculated by multiplying the ecological cleanup levels by 10. For chromium, a background concentration of 27 mg/kg was used as the site-specific soil cleanup level; multiplying this cleanup level by 10 results in a site-specific hot spot concentration of 270 mg/kg for chromium. Hot spot concentrations for ecological receptors are provided in Table 4-1.

**Hot Spots Based on Likelihood of Migration.** Based on the data collected during the RI, hazardous substances in the soil do not have a high degree of mobility to a degree that it has created a potential hot spot in water. No hot spot areas were identified based on the criteria of not likely to migrate. As discussed in Section 6 of this report, soil contamination can be reliably contained.

### 3.5.2 Sediment

Hot spots in sediment were calculated for both human and ecological receptors. Table 4-2 summarizes the hot spot concentrations. The calculation of hot spot concentrations is discussed below.

**Human Receptors.** Hot spot concentrations for human receptors were calculated for human health through recreational fisherman exposure scenario.

**Ecological Receptors.** Hot spot concentrations for ecological receptors were calculated by multiplying the ecological cleanup levels by 10. Hot spot concentrations for ecological receptors are provided in Table 4-2.

**Hot Spots Based on Likelihood of Migration.** Based on the sediment pore water monitoring data collected during the RI, hazardous substances in sediment do not have a high degree of mobility to a degree that it has created a potential hot spot in water. No hot spot areas were identified based on the criteria of not likely to migrate. As discussed in Section 6 of this report, soil contamination can be reliably contained.
3.5.3 Groundwater

OAR 340-122-0115(31)(a) defines a hot spot in groundwater as a hazardous substance having a significant adverse effect on the beneficial water use. OAR 340-122-0115(5) defines significant adverse effect as current or reasonably likely future exceedance of the following:

(a) Applicable or relevant federal, state or local water quality standards, criteria, or guidance.

(b) In the absence of applicable or relevant water quality standards, criteria, or guidance, the acceptable risk level.

(c) If subsections (a) and (b) of this section do not apply, the concentration of a hazardous substance indicated by available published peer-reviewed scientific information to have a significant adverse effect on a current or reasonably likely future beneficial use of water.

For groundwater in which a significant adverse effect on the beneficial use(s) is identified, the FS must evaluate whether treatment is reasonably likely to restore or protect the beneficial use(s) of water within a reasonable time. If treatment is determined to be able to restore or protect the beneficial use(s) within a reasonable time, the groundwater contamination must be identified as a hot spot.

Calculated risk levels associated with potential human exposure to groundwater (volatilization, direct contact) did not exceed DEQ-established acceptable risk levels.

Beneficial uses of shallow groundwater include discharge to the Willamette River. Beneficial uses of Willamette River water include aesthetic quality, recreation, transportation, wetland areas, fishing and hunting, anadromous fish passage, and fish and wildlife habitat. Total copper and lead concentrations in only one well near the river have intermittently exceeded the AWQC. Petroleum hydrocarbons have also been detected in groundwater in wells along the riverbank.

Transport of selected metals and TPH in groundwater to surface water was modeled using a two-dimensional groundwater flow model. The objective of the modeling was to estimate the concentrations of dissolved TPH and metals entering the river. Dissolved TPH and metals in groundwater were not predicted to reach the river above AWQC or other screening criteria. The modeling results indicate that COIs in groundwater would not adversely impact surface water in the Willamette River. Therefore, there are no hot spots of contamination in groundwater at the site.
4 Remedial Action Objectives and Cleanup Levels

The overall goal of the remedial action for the site is to protect human health and the environment from exposure to COCs and CECs identified in the baseline HHRA and ERA. This section summarizes the site specific remedial action objectives (RAOs) and cleanup levels for the site that will achieve the overall goal and eliminate or manage the potential risks to human health and the environment. Section 5 provides a description of the remedial alternatives and Section 6 provides an evaluation of the ability of each of the remedial alternatives to satisfy the RAOs.

4.1 Remedial Action Objectives

The following site specific RAOs were developed to describe how protection of human health and the environment would be achieved through the cleanup. The COCs and the media affected, for which the RAOs apply, are included in Tables 4-1 and 4-2.

<table>
<thead>
<tr>
<th>Medium</th>
<th>Remedial Action Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>Prevent future residents and worker exposure to soil containing constituents exceeding acceptable risk-based concentration (RBC) values. Prevent ecological receptors from exposure to soil containing CPECs exceeding DEQ SLVs. Prevent transport of COCs/CECs in soil to the Willamette River through stabilization of shoreline and storm water runoff controls. RemEDIATE soil hot spots to the extent feasible.</td>
</tr>
<tr>
<td>Sediments</td>
<td>Protect humans against exposure to site-related COCs above protective levels. Minimize transport of sediment containing COCs and CECs above cleanup levels to downstream areas of the river. Ensure sediments contaminated with CECs above protective levels do not become accessible to benthic organisms, or aquatic and terrestrial organisms through food chain exposure. RemEDIATE hot spots of contamination in sediment by reducing their concentration, volume, or mobility to the extent feasible and practical.</td>
</tr>
<tr>
<td>Surface Water</td>
<td>Protect ecological habitat and beneficial uses of surface water adjacent to the facility.</td>
</tr>
</tbody>
</table>
4.2 Cleanup Levels and Hot Spot Concentrations

This section summarizes the development of cleanup levels for soil and sediment. Table 4-1 summarizes the cleanup levels and hot spot concentrations for soil, and Table 4-2 summarizes the cleanup levels and hot spot concentrations for sediment.

4.2.1 Soil

**Human Receptors.** EPA Region 9 preliminary remediation goals (PRGs) were selected as cleanup levels for soil due to the planned re-development of the property that would include high-density residential use. For arsenic, the background concentration was used as the cleanup level in accordance with the cleanup rules because the PRG is below background. Hot spot concentrations were set at 100 times the cleanup level for carcincogens and 10 times the cleanup level for non-carcinogens, as specified in Oregon Cleanup Rules.

**Ecological Receptors.** The greenway area will be redeveloped and may support native plant and invertebrate communities that may be used by terrestrial birds and mammals. No threatened or endangered species are expected to have significant exposure to site-related chemicals in soil at the site. Consistent with DEQ guidance, chemical-specific cleanup levels for ecological receptors were set at a population level SLVs except for chromium (see Table 4-1). The site-specific cleanup level used for each CPEC is based on the most stringent (lowest) SLV for plants, invertebrates, birds, or mammals. For chromium, the value of five times the most stringent SLV was lower than the background concentration, so the background concentration was used as the cleanup level. Hot spot concentrations for ecological receptors were set at ten times the cleanup level consistent with DEQ guidance.

4.2.2 Sediment

**Human Receptors.** Cleanup levels for sediment were derived based on a recreational fisherman indirect exposure to COCs through fish ingestion as a result of bioaccumulation of contaminants present in sediment. COCs that pose an unacceptable risk from the fish ingestion pathway are limited to PCBs and PAHs. Hot spot concentrations were set at 100 times the cleanup level for carcincogens and 10 times the cleanup level for non-carcinogens, as specified in Oregon Cleanup Rules.

**Ecological Receptors.** Cleanup levels for sediment were based on the prediction of sediment toxicity using consensus-based freshwater sediment quality guidelines developed by Ingersoll (Ingersoll 2000), and site-specific probable effects quotient (PECQ) of 0.26 using the methodology defined by McDonald (McDonald 2000). DEQ...
proposes to use 10 times the PECQ as the hot spot criteria for ecological receptors rather than 10 times the cleanup level for each CPEC in sediment. Table 4-2 also identifies petroleum hydrocarbons as CECs based on bioassay toxicity testing that suggests that there may be an association of toxicity with elevated petroleum hydrocarbons in sediment. No cleanup levels are available for petroleum hydrocarbons, however.

### 4.2.3 Water
Cleanup levels were not developed for COPCs in groundwater because risk levels associated with potential exposure of human receptors to groundwater did not exceed DEQ-established acceptable risk levels. Oregon Water Quality Criteria under OAR Chapter 340, Division 41 are applicable standards for protection of surface water beneficial uses within the locality of the facility.

### 4.3 Cleanup and Hot Spot Areas and Volumes
This section summarizes the volume of soil and sediment exceeding the cleanup levels or hot spot concentrations for human health or ecological receptors. Volume estimates were developed separately for the greenway and non-greenway areas.

#### 4.3.1 Soil
For the purposes of the FS, the entire upland property area was assumed to contain one or more COC/CEC at levels exceeding cleanup levels. The estimated volume of soil that exceeded the site-specific cleanup level in the greenway and non-greenway is approximately 682,000 cubic yards. The volume of soil that exceeded the human health hot spot concentrations to a depth of 15 feet below ground surface is 6,600 cubic yards. Table 4-3 summarizes the estimated volume of soil exceeding human health or ecological cleanup levels or hot spot concentrations. Figure 4-1 illustrates the soil that exceeds cleanup levels and hot spot concentrations.

#### 4.3.2 Sediment
Figure 4-2 illustrates the areas of sediment where one or more COCs/CECs exceed the cleanup levels presented in Table 4-2. The volume of sediment exceeding either human health or ecological based cleanup levels is approximately 150,000 cubic yards. The volume of hot spot sediments is approximately 44,000 cubic yards. Table 4-4 summarizes the estimated volume of sediment exceeding human health or ecological cleanup levels or hot spot concentrations.
4.4 Regulatory Requirements

The feasibility study identified several federal, state, and local laws, rules, and requirements that may be applicable to remedial actions at the Zidell site. These are summarized below:

**Oregon Hazardous Waste Management Act (ORS 466).** This act and the implementing administrative regulations (OAR 340-100-0001 et seq.) govern the generation, transportation, treatment, storage, and disposal of hazardous wastes and may have applicability at the Zidell site if remedial actions generate characteristic or listed hazardous wastes. This act incorporates requirements of the federal Resource Conservation and Recovery Act (RCRA) program.

Excavated soils at the site could potentially be classified as RCRA hazardous wastes if they exhibit the characteristic of toxicity as established by the Toxicity Characteristic Leaching Procedure (TCLP) test. Soils exceeding the TCLP criterion for metals would be classified as characteristic hazardous wastes and should be appropriately managed in accordance with all applicable state requirements of OAR 340, Divisions 100 through 120 and federal RCRA requirements of 40 CFR Parts 260, 261, 262, 263, 264, 265, and 268.

**Oregon Solid Waste Management (ORS 459 and OAR 340-093 and 340-095).** This statute and implementing rules govern the management of solid wastes, including the permitting of disposal sites, and are applicable to the off-site management of contaminated soils.

**Oregon Water Quality Standards (ORS 468B and OAR 340-041).** These standards protect aquatic life and public health, and are applicable to the Zidell site for any discharges to the Willamette River from shallow groundwater or overland flow of stormwater.

**Oregon Water Pollution Control (ORS 468B and OAR 340-045).** These laws and the implementing administrative regulations govern discharge of pollutants to surface waters. The act incorporates the state’s delegated program under federal Clean Water Act (CWA), including the NPDES permitting system.

**Oregon Groundwater Quality Protection (ORS 468B and OAR 340-040).** These laws and the implementing administrative regulations constitute Oregon's groundwater protection program. The program incorporates federal Safe Drinking Water Act requirements and maximum contaminant level (MCL) standards. The groundwater protection program policy states that the rules are not to be used as cleanup standards, but they may be used to evaluate non-degradation of existing
groundwater resources and may be considered for remedial actions that include the use of underground injection control (UIC) systems for stormwater disposal.

**Oregon Air Pollution Control Law (ORS 468A).** This law and its implementing administrative rules (OAR 340-200 through -208) specify permitting procedures, emission limits, and operating and reporting requirements for stationary air pollution sources (e.g., emissions from the air stripper and dust from construction activities). This law incorporates aspects of the federal Clean Air Act, NESHAPS, and new source performance standards. Airborne discharges resulting from future remedial actions may be subject to these requirements.

**Oregon Occupational Safety and Health Code (OAR 347).** These codes, analogous to the federal Occupational Safety and Health Administration codes, contain health and safety requirements that must be met during implementation of any remedial actions. These standards are intended to protect construction and utility workers at the site.

**Fill or Removal Permits for Work in Willamette River.** Section 404 of the CWA prohibits any person from discharging dredged or fill material into the waters of the United States (in this case, the Willamette River) without first obtaining a permit from the Corps of Engineers (COE). A similar permit requirement exists under the Oregon fill and removal law, ORS Chapter 196, which is enforced by the Department of State Lands. A permit may be issued by the COE only after the proposed discharge is reviewed and measured against the requirements of the CWA, including the Section 404(B)(1) guidelines implemented by the USEPA (40 CFR § 230). ORS 465.315(3) authorizes the DEQ to exempt remedial actions from the requirement to obtain a State removal fill permit, but does not authorize an exemption from the Federal permit requirement or from underlying substantive requirements of either the CWA or the Oregon fill and removal law applicable to remedial alternatives for sediment at the Zidell site.

**Section 10 Permit for Work in Willamette River.** The COE administers a regulatory program under Section 10 of the Rivers and Harbors Act of 1899 that requires its approval of any work in navigable waters. The Willamette River is a navigable waterway, so Section 10 would most likely apply to any dredging or capping conducted during remedial activities, and a Section 10 permit will be required. Section 10 of the Rivers and Harbors Act may be an action-specific regulatory requirement for the Zidell site.

**Endangered Species Act.** The Endangered Species Act (ESA) of 1973 protects plant and animal species that are listed by the federal government as “endangered” or “threatened” and protects critical habitat necessary for the protection of these species.
(16 USC 1531-1543 and 50 CFR § 10, 13, 17, 222, 226, 402, 424, 450-453). In addition to federally listed threatened and endangered species, there are state-listed sensitive species. The Oregon Department of Fish and Wildlife (ODFW) is tasked with protecting threatened and endangered species for the state of Oregon (ORS 655-100-00). The Oregon Natural Heritage Program (ONHP) maintains a database of the locations of threatened and endangered species.

ESA requirements are applicable to the Zidell site if threatened or endangered species are determined to be present or would be affected adversely by site remediation. Two sections of the ESA are of primary importance for site remediation. Section 7 discusses the requirements of consultation with the U.S. Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration (NOAA) (formerly National Marine Fisheries Service) in regard to the presence of listed species in a project area. Section 9 stipulates the prohibitions against the “taking” of a listed species. Taking of a listed species is broadly defined to include “harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect,” which also prohibits the significant modification of habitat considered critical to the protection of the listed species.

Generally, an ESA consultation is required for projects that are undertaken, funded or authorized by a federal agency, including the issuance of permits. The results of the ERA for the site should fulfill the substantive requirements of Section 7 of the ESA.

The ONHP search and subsequent discussions with the ODFW (2000) identified the following protected species of anadromous fish, which are or may be present intermittently in waterways in the project area:

- Coho salmon—lower Columbia River (*Oncorhynchus kisutch*): Candidate for listing as a federally designated threatened species, state-designated as endangered since July 1999.
- Steelhead trout—lower Columbia River (*Oncorhynchus mykiss*): Federally designated threatened species.
- Chinook salmon—lower Columbia River (*Oncorhynchus tshawytscha*): Federally designated threatened species.
- Chum salmon—lower Columbia River (*Oncorhynchus keta*): Listed threatened species.
In terms of fulfilling the substantive requirements of Section 9 of the ESA, which prohibits the taking of listed species, preventive measures may be needed during the remedial actions at the site. NOAA has identified factors that cause decline in salmonid populations: erosion and sedimentation, contaminants that make their way into streams, dam operations, changes in water temperature, disturbance of material in stream or river channels, ocean and inland fisheries, inadequate water diversion screens, loss of habitat, changes in natural hydrographs, channelization of streams and rivers, and barriers to fish passage (e.g., culverts). Note that the COE obtained a large-scale Section 7 consultation in 2001 for its operation of the Willamette basin reservoir system. This multispecies consultation is intended to address the likely effects on listed species of continued operation of the Willamette River Basin Project, which includes dredging.

**City of Portland.** Plumbing, construction, and building permits may be required for the construction phase of remedial actions. Excavation of more than 50 cubic yards of soil may require a grading and excavation permit from the county. In addition, local zoning ordinance governs the current and future land use of the site and site vicinity, which is an important consideration in the evaluation of current and reasonably likely future land uses and associated environmental protection zones (e.g. greenways adjacent to the Willamette River), and storm water management options.
5 Description of Remedial Action Alternatives

This section summarizes the remedial action alternatives for soil and sediment for the site. The alternatives presented in the FS Report satisfy the requirements for feasibility studies under OAR 340-122-0085. The evaluation of the alternatives against the protectiveness and feasibility criterion specified in OAR 340-122-0090 is described in Section 6.

5.1 Remedial Alternatives for Soil
Seven remedial alternatives were developed for upland soil including no action. The developed alternatives provide a range of removal and containment options for the significant volume of soil contaminated at levels exceeding the human health or ecological based cleanup levels or hot spot concentrations. Each of the soil alternatives, with the exception of the no action alternative includes the following common elements:

Deed Notifications and/or Deed Restrictions: Each of the alternatives includes deed notifications and restrictions to reduce or prevent future exposure of receptors to soil containing residual hazardous substances at concentrations above relevant cleanup levels (CULs). Deed notifications notify potential purchasers of the property of the presence of COCs/CECs in soil. Deed restrictions limit activities or land use at the site and define requirements for future site redevelopment activities. Deed restrictions require that future redevelopment activities at the site comply with a Soil Management Plan.

Soil Management Plan: A Soil Management Plan (SMP) would be developed to guide future excavation activities that could potentially encounter impacted soil. The SMP would outline specific requirements for managing soil on site as part of future redevelopment. Waste disposal requirements and sampling and analysis requirements would also be addressed in the plan.

For the site, in addition to excavation performed as part of remediation, some soil may be excavated from areas such as building footings, underground parking structures, and public right-of-ways (ROWS) for site redevelopment. Soil excavated for redevelopment purposes would be used as backfill on site to the extent feasible, and managed in a way that is protective of human health and the environment. The proper placement of impacted soil will be directly incorporated into redevelopment plans. Also, the plan will specify that public streets and utility corridors will contain a minimum of 5 feet of clean fill, as required by the COP’s Soil Reuse Policy (COP, 1999).
The SMP would also specify that if potential ACM is found during excavation, it would be segregated and characterized by a certified asbestos contractor and managed following applicable asbestos and solid waste regulations. The plan would require that areas filled with excavated soil be surveyed and included in deed notifications and deed restrictions.

**Access Restrictions/Fencing:** Access restrictions, such as fencing, would be constructed to restrict public access to the site to prevent contact with soil through completion of site capping. In addition, existing asphalt-concrete pavement that covers much of Operational Area 1 and the concrete floor slabs of the existing buildings will be retained until remedy construction activities are implemented to further reduce the potential for exposure to contaminated soil.

**Engineered Cap:** An engineered cap would be used to prevent contact with impacted soil and thus minimize exposure to COCs/CECs and prevent erosion of impacted soil to surface water and sediment. The engineered cap would consist of a demarcation material to identify the top of the impacted soil, and a 2-foot vegetated clean soil cap. Alternatively, the cap may consist of asphalt concrete or other suitable barriers (e.g., pavers) that will be components of site redevelopment. For that portion of the cap on the river bank below the 10-year flood elevation (or a similar elevation established during design), the demarcation layer would also act as an erosion control layer. A monitoring and maintenance program would be implemented to insure that the integrity of the engineered cap is maintained over time.

Based on the bank evaluation (MFA, 2004), existing bank armoring comprised of concrete, rock, and ballast stone would serve as the cap between an elevation of approximately 3 feet and 13 feet COP datum. Deleterious material (e.g., rebar, wood scrap, wire, rubber etc.) would be removed. Additional armoring may be necessary (e.g., near outfalls) to ensure long-term reliability of the armored cap. The areas for armor improvements will be identified during remedial design.

**Drainage Controls:** A stormwater collection and conveyance system would be designed and constructed as part of the engineered cap to manage stormwater during and after implementation of the final remedy.

**Soil Screening:** Fill material historically placed on the site, especially along the bank, consists of large amounts (75%) of oversize, primarily inert, material (e.g., concrete). Soil screening would be used to isolate the impacted soil from the inert material. The separated rock and concrete may be stored on site for recycling as aggregate (following crushing) during the site redevelopment. Other oversized material (e.g., wood, solid waste) would be transported off site for disposal.
Consolidation: Significant excavation of existing fill material within the future greenway area of the site will be necessary to re-contour the existing bank for placement of a stable soil cap, and additional contaminated soil excavation will be necessary in ROWs. The soil would be temporarily placed in a lined and covered staging area, either before or after screening as described above. Following screening, the reduced volume of excavated soil would be incorporated into the redevelopment design in a manner that ensures protection of human health and the environment.

The site redevelopment may require an overall site elevation increase of approximately 3 to 6 feet. Clean fill will be imported to meet this requirement. Through proper design, impacted soil that requires excavation will be placed below this clean fill, or below other site appurtenances or structures. Parameters for soil placement to ensure long-term protection of human health and the environment will be established in the SMP, and incorporated into redevelopment designs. These include, but are not limited to, requiring that impacted soil be placed outside the public ROWs and utility corridors, within existing impacted areas, and above the water table.

Excavation and Off-Site Disposal: Excavation would remove all or some of the soil exceeding the cleanup levels for the site. The soil would be transported to permitted off-site treatment and/or disposal facilities. The excavated soil from this site is not expected to require pre-treatment before disposal. Figure 5-1 illustrates areas where soil contamination exceeding cleanup levels or hot spot concentrations would be excavated for either on-site consolidated containment or off-site disposal.

Assumptions were made in the FS regarding the location, size, and configuration of the Willamette River greenway and non-greenway areas, and public ROWs. The assumptions are based on 2002 redevelopment plans, including the River Parkway Staff Amendment figure prepared by the COP Bureau of Planning, dated October 30, 2002, and considers the 2004 draft Greenway plan, which is not binding on the property owner. Because redevelopment plans for the site have not been finalized, the locations, sizes, and configuration of the greenway and non-greenway areas may change between now and redevelopment. The remedy that is selected for each type of area (greenway, non-greenway, and public ROWs) will be implemented regardless of its location in the final redevelopment plans. Changes in the configuration of each type of area will therefore affect the cost estimates developed for the FS.

5.1.1 Soil Alternative 1: No Action
Under Alternative 1, no additional action would be taken to address the impacted soil present at the site. Alternative 1 assumes that the existing structures are not in place and
that no redevelopment will occur. Because no remedial activities would be implemented under Alternative 1, long-term human health and environmental risks for the site would essentially be the same as those identified in the baseline HHRA and Level II ERA. Alternative 1 evaluates whether leaving the site “as-is” meets the RAOs and serves as a baseline against which the other alternatives are compared.

### 5.1.2 Soil Alternative 2: Engineered Cap

Alternative 2 includes the common elements as described above and would include the following elements:

- Excavation of approximately 33,000 cubic yards of soil and debris fill during regarding of the greenway for cap construction for on-site consolidation and capping outside of the greenway;
- Characterization and off-site disposal of ACM encountered during excavations completed for redevelopment;
- Decommissioning of the oily water vault, dry well/stormwater lines, and other historical operational features;
- Decommissioning of monitoring wells installed for the RI;
- Placement of a cap over both the greenway and non-greenway areas of the site.

Alternative 2 relies on engineering and institutional controls to prevent migration and exposure to soil containing COCs/CECs at concentrations exceeding the site-specific CULs. Alternative 2 includes a phased approach to remediation to accommodate future redevelopment of the site. The first phase includes fencing the perimeter of the site to preclude public contact with soil and maintaining existing engineering controls. Existing building foundations or pavement would be used as a temporary barrier against direct contact with soil until site redevelopment occurs. Deed notifications and deed restrictions, including a SMP, would be placed on the property.

The last phase of remediation would be implemented as part of the redevelopment of the site and would include the placement of an engineered cap. The materials used in the engineered cap may vary throughout the site, depending on the differing land uses (e.g., greenway, non-greenway, future public ROWs, buildings, parking lots, open spaces). The material used for the cap will be dictated by redevelopment. The engineered cap may consist of asphalt pavement, a concrete building foundation, clean sand or gravel fill, or any other barrier that precludes direct contact with the soil. Appropriate options for the capping material would be developed in detail during the remedial design, and incorporated into the redevelopment design.
Cap integrity will be ensured through an Operations, Maintenance, and Monitoring Plan (OMMP), which will outline routine cap performance monitoring and schedule and reporting requirements. It will also include contingencies to be taken if the cap fails to meet the performance criteria.

Cap placement above the bank armor requires reducing the bank slope to 3:1 H:V along most of the bank. The estimated volume of fill material to be removed from the future greenway area of the site for consolidation in the non-greenway area is 33,000 cubic yards. As noted above, this material may be screened, along with the ROW soil, to remove oversize inert materials (e.g., concrete). The oversize material, if clean, could be recycled (crushed for aggregate) for use during redevelopment. If the recycling option is not employed, all excavated materials will be placed in non-ROW areas and capped, as described above. Bank stabilization will also involve erosion control (e.g., silt fence) at the lower edge of the soil cap until the vegetative layer is established.

Standard facility decommissioning techniques will be employed for the oily water vault, dry well/stormwater, and the other historical operational features, concurrent with operational changes or redevelopment. This will involve breaking, cutting, and dismantling of the structures for removal and off-site disposal. Inert material may be left on site for use as fill during redevelopment provided such material is not significantly contaminated with COCs that pose an unacceptable risk to human health or the environment. Monitoring wells will be decommissioned following applicable state law.

The estimated cost for implementation of Alternative 2 is $3.75 million, which includes $213,000 for remedial design, $2.48 million for remedial action construction, $123,000 for long-term monitoring and maintenance, and contingencies of $562,000.

5.1.3 Soil Alternative 3: Engineered Cap with Excavation of Hot Spots in the Greenway—On-Site Management

Alternative 3 contains all the elements described for Alternative 2 and incorporates excavation of additional 4,000 cubic yards of human health and ecological hot spot soil and debris fill from the greenway area to a depth of 3 feet below final grade. The estimated volume of fill material to be removed from the future greenway area of the site for consolidation in the non-greenway area is 37,000 cubic yards.

The estimated cost for implementation of Alternative 3 is $3.91 million, which includes $270,000 for remedial design, $2.77 million for remedial action construction, $123,000 for long-term monitoring and maintenance, and $651,000 in contingencies.
5.1.4 Soil Alternative 4: Engineered Cap with Excavation of Hot Spots in the Greenway – Off-Site Management

Alternative 4 is the same as Alternative 3, except the estimated 2,100 cubic yards of soil exceeding residential hot spot concentrations excavated from the greenway and non-greenway areas of the site would be transported off-site for disposal instead of consolidated on-site in the non-greenway area. This soil will be sampled and analyzed post-excavation/post-screening to evaluate off-site disposal options. Screened soil would likely be staged in uniform stockpiles (e.g., 100 cubic yards). Each stockpile will be sampled to verify presumed waste profile characteristics and to confirm that residential hot spot concentrations are exceeded. If concentrations do not exceed the hot spot concentrations, the soil would be managed on site in the temporary cell.

The estimated cost for implementation of Alternative 4 is $4.05 million, which includes $270,000 for remedial design, $2.98 million for remedial action construction, $123,000 for long-term monitoring and maintenance, and $675,000 in contingencies.

5.1.5 Soil Alternative 5: Engineered Cap with Excavation of Hot Spots in Greenway and Non-Greenway—On-Site Management

Alternative 5 is the same as Alternative 3, except an additional 4,400 cubic yards of hot spot soils would be excavated from the non-greenway area for on-site consolidation prior to capping the site. Hot spot soil would be excavated to a depth of 15 feet below final grade.

The estimated cost for implementation of Alternative 5 is $4.25 million, which includes $270,000 for remedial design, $3.15 million for remedial action construction, $123,000 for long-term monitoring and maintenance, and $651,000 in contingencies.

5.1.6 Soil Alternative 6: Engineered Cap with Excavation of Hot Spots in Greenway and Non-Greenway—Off-Site Management

Alternative 6 is the same as Alternative 5, except for off-site disposal of approximately 6,500 cubic yards of soil exceeding human health hot spot concentrations based on residential exposures. Under this alternative, an additional 4,000 cubic yards of hot spot soil in the non-greenway would be excavated and disposed of off-site.

The estimated cost for implementation of Alternative 6 is $4.44 million, which includes $270,000 for remedial design, $3.3 million for remedial action construction, $123,000 for long-term monitoring and maintenance, and $740,000 in contingencies.
5.1.7 Alternative 7: Excavate Soil to Cleanup Levels
Under Alternative 7, all soil with COC/CEC at concentrations exceeding CULs would be excavated and disposed off-site for landfill disposal in accordance with applicable regulations, and excavated areas backfilled with clean fill. The estimated volume of soil for off-site disposal is 330,000 cubic yards. Excavation of soil would follow the procedures described in the design documents, including the SMP, and would be completed either before or as part of redevelopment.

The estimated cost for implementation of Alternative 7 is $30.24 million, which includes $224,000 for remedial design, $24.86 million for remedial action construction, and $5.0 million in contingencies.

5.2 Remedial Alternatives for Willamette River Sediments
Five remedial alternatives were developed for Willamette River sediments including no action. The developed alternatives provide a range of removal and containment options for the significant volume of sediment contaminated at levels exceeding the human health or ecological based cleanup levels or hot spot concentrations. Each of the sediment alternatives, with the exception of the no action alternative includes the following common elements:

Institutional Controls and Monitoring: Institutional controls would involve use restrictions, marking of boundaries, and monitoring and maintenance programs designed to confirm the long-term effectiveness of the remedial action. The United States Coast Guard Notice to Mariners system will be used to limit the size of ships and activities near the cap area. This system uses radio broadcasts to inform watercraft in the area as well as postings in all marinas. In addition, the perimeter may be marked with buoys and signs to minimize recreational boaters traversing the area.

To ensure cap preservation, legal restrictions would need to be placed to limit in-water development within the sediment management area. Implementing these restrictions would require approval from the Oregon Department of State Lands (DSL) who owns the river bottom below the OHW elevation. The implementability of this provision is discussed in Section 6 of this report.

An Operations, Maintenance and Monitoring Plan (OMMP) would be developed for routine cap performance monitoring, including the schedule and reporting requirements, an emergency response plan should an environmental upset occur (e.g., vessel grounding or a flood in exceedances of design criteria), and a contingency plan that will identify actions to be taken if the cap fails to meet the performance criteria.
**Engineered Cap:** Remedial alternatives that involve long-term management of contaminated sediment (Alternatives 2 through 4, and Alternative 5 as a possible contingency) include capping sediment to isolate it from aquatic species (i.e. benthic organisms, fish, and wildlife) to minimize or prevent bioaccumulation of contaminants in the food chain, and physical transport downstream. Several cap configurations are possible: conventional sand, armored, and composite.

Conventional capping consists of placing sand or other appropriate material over the top of contaminated sediments. Material selection and cap thickness design are based on consideration of contaminant properties and local hydraulic conditions. Sand-size material or larger is typically preferred as cap material over fine-grained material. The latter are more difficult to place evenly, cause a great deal of turbidity during placement, and are more susceptible to erosion.

With armored caps, a conventional cap is protected from erosive forces through placement of rock. An alternative to conventional armor is the use of interlocking concrete blocks which typically have a lower profile in comparison to conventional armor and may offer some advantages for habitat creation.

Composite capping involves placement of a geotextile or flexible membrane liner directly over the contaminated sediment which is then held down with a conventional capping or armoring material. The geotextile or flexible member liner must be selected for strength, workability and resistance to contaminants of concern.

The western edge of the Sediment Management Area (SMA) is the bottom of the existing armor, which ranges from approximately 3 feet COP in the south SMA to 13 feet COP in the north (including at the barge launch) as well as where the sand beach forms near the bank at the midway point of the SMA.

Based on the bank evaluation (MFA, 2004), bank armor will remain unaltered, except for removal of deleterious material (e.g., rebar, wood scrap, wire, rubber [excludes concrete, rock, and ballast stone]). Exceptions include areas found during design that need additional armoring to ensure long-term reliability (e.g., near COP outfalls).

**5.2.1 Sediment Alternative 1: No Action**
Under Alternative 1, no additional action would be taken to address the contaminated sediments. The No Action alternative is the basis for comparison of the other alternatives.
5.2.2 Sediment Alternative 2: Partial Cap

Alternative 2 relies on engineering controls to prevent exposure to and migration of sediments in the SMA where the cap is placed. Under Alternative 2, discrete areas of the SMA would be capped based on engineering considerations. Specifically, those areas within the northern two thirds of the SMA that have existing slopes of 3:1 or less would be capped. Areas internal to the SMA boundaries that have slopes greater than 3:1 would also be capped if the resultant extent of the cap remains within the SMA. Large, excessively steep areas would require excessive cap thickness to reach a stable slope of 3:1 and extend the cap toe beyond the SMA boundary would be excluded under Alternative 2.

Use of these criteria would eliminate capping where the river bank has a slope greater than 3:1 that continues into the river. In these areas, if a cap was constructed, it would require placement of at least 5 to 9 feet of sand to achieve the 3:1 slope, extending up to 40 feet beyond the SMA boundary. Application of this criterion results in a cap that covers approximately 70 percent of the SMA, using a little more than half the volume of cap material needed for Alternative 3 (full cap). Figure 5-2 shows the approximate cap limits for Alternative 2.

Alternative 2 would include the following components:

- Refinement of the SMA boundary through further sediment sampling and analysis, and a preconstruction bathymetric survey.
- Characterization of sediment engineering properties.
- Remove in-water objects and debris.
- Monitoring before, during, and after construction.
- Capping parts of the SMA with a minimum 2-foot-thick engineered sand cap.
- Placement of 1 foot of 2- to 6-inch, rounded, river rock armor on cap to minimize erosion.

Any in-water work to be performed on the Willamette River must be done within the allowable work windows of July 1 through October 31 and December 1 through January 31. During the work windows, the river elevation and flow varies widely, with high flow conditions common. Access from land will be limited and the use of land-based equipment is infeasible, so virtually all construction work performed would use river-based equipment.

Capping would also require removal of most in-water obstructions. The requirement to remove existing pilings from the dock area will be determined during permitting. A survey would be required to identify the location of the obstructions requiring removal and a plan would need to be prepared with removal procedures.
Cap configuration would depend on the results of the design process. Hydraulic and geotechnical calculations are required, with consideration given to sediment and backfill or armoring material composition in order to determine the most feasible option for some of the steep bathymetry. As part of the cap design process, sediment in the river bank would be analyzed for strength and slope stability. The geotechnical analysis will also include sediment bearing capacity assessment and a seismic evaluation.

The area and thickness of the cap would be determined by considering sediment sample data and physical isolation requirements, edge stability, and chemical diffusion and permeation. Analysis of physical stability will be necessary, with consideration given to slopes, currents, waves, seismicity, and constructability. Navigational and floodway encroachment issues would also be assessed during design.

Floodway encroachment issues will be evaluated as part of design because the cap will be located in the Willamette River floodway. Generally, hydrologic modeling must show that there is no surface water elevation rise in the floodway during a 100-year flood event resulting from the cap installation.

The primary physical forces that can affect the cap include high-velocity currents, wind-driven wave action, and vessel-induced waves and propeller wash. Each force is negated through the use of rock armoring over the cap. For this analysis it was assumed that all areas of the cap would be armored with 12 inches of 2 to 6-inch rounded river rock, which is generally considered “fish friendly.”

No known utilities run through the SMA. However, a gas line and water line cross the river north of the SMA near the Marquam Bridge. As part of the design process, all utilities will be precisely located and the owners contacted to coordinate construction work. Given the distance from the SMA, the known utilities are not expected to complicate the installation of the cap.

The estimated cost for implementation of Alternative 2 is $1.51 million, which includes $270 thousand for remedial design, $813 thousand for remedial action construction, $77 thousand for periodic maintenance and monitoring, and $348 thousand for contingencies.

5.2.3 Sediment Alternative 3: Full Cap
Alternative 3 is the same as Alternative 2, except that the full SMA would be capped, as shown on Figure 5-3.

The estimated cost for implementation of Alternative 3 is $2.02 million, which includes $316 thousand for remedial design, $1.15 million for remedial action construction, $92 thousand for periodic maintenance and monitoring, and $467 thousand for contingencies.
5.2.4 Sediment Alternative 4: Hot Spot Dredging with Capping

Under Alternative 4, hot spots in the SMA would be dredged. For the FS, the lateral extent of the hot spots was delineated by establishing the midpoint between sampling locations where hot spot concentrations were exceeded and locations where they were not exceeded. Figure 5-4 shows the estimated extent of hot spots. As with Alternative 5, the assumed depth requiring dredging is 13 feet below the current river bottom. This assumption would be confirmed through further sediment characterization during design.

For long-term stability, over-excavation will be required to reach a 3:1 final hot spot area side slope. Capping of the remaining SMA would be implemented as described in Alternative 2. Alternative 4 would include all of the components listed in Alternatives 2 and 5, adjusted for the revised dredging and cap limits as described above. Under Alternative 4, estimated volumes and areas are as follows:

- Approximately 3,200 linear feet of temporary sheet piling would be installed to a depth of 25 feet below current grade (128,000 square feet) around hot spot areas to control sediment resuspension and to maintain river bank stability.
- Approximately 44,000 cubic yards of sediment would be dredged, dewatered and transported to a solid waste landfill for disposal.
- Approximately 46,000 cubic yards of sand or sediment backfill would be placed to restore bank stability, minimize erosion potential and safeguard against potential contaminant exposure.
- A 2-foot-thick engineered sand cap would be placed covering non-hot spot areas that exceed the CULs in the SMA (23,500 cubic yards).
- One foot of 2- to 6-inch rounded river rock armor would be placed on the cap to minimize erosion (13,000 cubic yards).

Design for Alternative 4 design would be very similar to Alternatives 2 and 5 because similar calculations and modeling would be performed to determine the exact boundaries of dredging and specific configuration of the cap.

The estimated cost for implementation of Alternative 4 is $10 million, which includes $415 thousand for remedial design, $7 million for remedial action construction, $60 thousand for periodic maintenance and monitoring, and $2.5 thousand for contingencies.
5.2.5 Sediment Alternative 5: Dredging

Alternative 5 would involve removal of all contaminated sediments in the SMA. Alternative 5 would include the components described for Alternative 2 and the following additional components:

- Installation of approximately 5,600 linear feet of vinyl sheet piling to a depth of 25 feet below current grade (224,000 square feet) around entire dredging area to control sediment re-suspension and to maintain river bank stability during dredging.
- Performance of clamshell or hydraulic dredging from a barge to remove sediment exceeding CULs throughout the SMA. The FS assumed dredging to a depth of 13 feet below the current sediment surface resulting in approximately 151,500 cubic yards of sediment removed. Removal of other obstructions, such as pilings in the north part of the SMA.
- Placing backfill of 102,000 cubic yards of sand or sediment (from off-site sources).
- Dewatering of dredge spoils on-site (upland).
- Performing three-stage treatment for water generated from sediment dewatering and for a portion of surface water within sheet pile containment (settling, filtration, and carbon treatment), followed by discharge to the Willamette River.
- Transporting dewatered sediment to RCRA Subtitle D landfill.
- Implementing institutional controls to ensure backfill and bank integrity (e.g., deed restrictions).
- Performing long-term inspections, maintenance, and reporting.

In areas close to the shore, dredging would undermine the bank without the use of sheet piling. Steel sheet piling would need to be installed and the dredging completed using water-based equipment. Sheet pile may also be necessary around the remainder of the SMA to limit suspended solid transport downstream. An entrance for working vessels would be maintained using sediment curtains. Water within the dredging zone may require three-stage treatment for suspended sediment and dissolved constituents. Monitoring would be required, with dredging methods adjusted based on turbidity measurements and compliance levels.

All dredging would take place in the SMA—there would be no over-excavation into areas outside of the SMA. After dredging, backfill would be placed to stabilize slopes nearest the shoreline prior to removal of sheet piling. Some natural slope-stabilizing movement along the north, south, and east periphery of the SMA is likely to occur during removal of sheet piling in these areas.
Material removed through dredging would be transported via barge to an upland portion of the site for dewatering, where water would be treated and solids transported to a RCRA Subtitle D landfill. If dewatered sediment contains excess water (i.e., it fails the “paint filter test”), fly ash or wood byproducts would likely be added to further reduce the moisture content and avoid disposal surcharge fees. This would result in a greater volume of material requiring disposal.

Upon completion of the dredging and backfill, an OMMP would be implemented to assure that area integrity is maintained, that contaminants have been effectively removed, and that any lower-level contamination beneath the dredging area is contained. Maintenance would be conducted as necessary following reporting or inspections. With careful design, major maintenance would not be expected. However, if needed, it is likely to be related to erosion or a maritime related incident, or enhancement of fish and benthic habitat.

The estimated cost for implementation of Alternative 5 is $20.15 million, which includes $415 thousand for remedial design, $15 million for remedial action construction, $60 thousand for periodic maintenance and monitoring, and $4.5 thousand for contingencies.
6 Evaluation of Remedial Action Alternatives

This section presents the evaluation of the remedial action alternatives with respect to the remedy selection criteria in OAR 340-122-0090. Section 6.1 provides an overview of the evaluation criteria in the cleanup rules. Section 6.2 provides an evaluation of the remedial alternatives against the remedy selection criteria. The results of the evaluation provide the basis for the recommended remedial action alternative described in Section 7.

6.1 Overview of Evaluation Criteria

The evaluation of remedial action alternatives involves three main criteria:

- The protectiveness of the alternative, based upon the standards set forth in OAR 340-122-0040;
- The feasibility of the alternative, based upon a balancing of the remedy selection factors set forth in OAR 340-122-0090(3) and (4); and
- The extent to which the remedial action alternative remediates hot spots of contamination.

The protectiveness of the alternatives is evaluated relative to the site-specific RAOs and cleanup goals described in Section 4. The feasibility of a remedial action alternative is based on evaluation of the following factors:

6.1.1 Protectiveness

Any removal or remedial action shall address a release or threat of release of hazardous substances in a manner that assures protection of present and future public health, safety, and welfare, and the environment. In the event of a release of a hazardous substance, remedial actions shall be implemented to achieve:

- Acceptable risk levels defined in OAR 340-122-0115, as demonstrated by a residual risk assessment; or
- Numeric soil cleanup levels specified in OAR 340-122-0045, if applicable; or
- Numeric cleanup standards developed as part of an approved generic remedy identified or developed by the Department under OAR 340-122-0047, if applicable; or
• For areas where hazardous substances occur naturally, the background level of the hazardous substances, if higher than those levels specified in subsections (2)(a) through (2)(c) of this rule.

In the event of a release of hazardous substances to groundwater or surface water constituting a hot spot of contamination, treatment shall be required in accordance with OAR 340-122-0085(5) and (7), and OAR 340-122-0090.

A removal or remedial action shall prevent or minimize future releases and migration of hazardous substances in the environment. A removal or remedial action and related activities shall not result in greater environmental degradation than that existing when the removal or remedial action commenced, unless short-term degradation is approved by the Director under OAR 340-122-0050(4).

A removal or remedial action shall provide long-term care or management, as necessary and appropriate, including but not limited to monitoring, operation, maintenance, and periodic review.

6.1.2 Effectiveness

• The magnitude of risk from untreated waste or treatment residuals remaining at the facility absent any risk reduction achieved through onsite management of exposure pathways;
• The adequacy of any engineering and institutional controls necessary to manage the risk from treatment residuals and untreated hazardous substances remaining at the facility;
• The extent to which the remedial action restores or protects existing and reasonably likely future beneficial uses of water;
• The adequacy of treatment technologies in meeting treatment objectives; and
• The time until the remedial action objectives would be achieved.

6.1.3 Long-Term Reliability

• The reliability of treatment technologies in meeting treatment objectives;
• The reliability of engineering and institutional controls necessary to manage the risk from treatment residuals and untreated hazardous substances, taking into consideration the characteristics of the hazardous substances to be managed and the effectiveness and enforceability over time of engineering and institutional
controls in preventing migration of contaminants and in managing risks associated with potential exposure; and

- The nature, degree, and certainties or uncertainties of any necessary long-term management (e.g., operation, maintenance, and monitoring).

### 6.1.4 Implementability

- The practical, technical, and legal difficulties and unknowns associated with the construction and implementation of a technology, engineering control, or institutional control, including potential scheduling delays;
- The ability to monitor the effectiveness of the remedy;
- Consistency with federal, state and local requirements; activities needed to coordinate with other agencies; and the ability and time required to obtain any necessary authorization from other governmental bodies; and
- The availability of necessary services, materials, equipment, and specialists, including the availability of adequate off-site treatment, storage, and disposal capacity and services, and availability of prospective technologies;

### 6.1.5 Implementation Risk

- The potential impacts on the community during implementation of the remedial action and the effectiveness and reliability of protective or mitigative measures;
- The potential impacts on workers during implementation of the remedial action and the effectiveness and reliability of protective or mitigative measures;
- The potential impacts on the environment during implementation of the remedial action and the effectiveness and reliability of protective or mitigative measures; and
- The time until the remedial action is complete.

### 6.1.6 Reasonableness of Cost

The cost of the remedial action including:

- Capital costs, including both direct and indirect costs;
- The net present worth of the annual operation and maintenance costs, including costs for any periodic review requirements;
• The degree to which the costs of the remedial action are proportionate to the benefits to human health and the environment created through risk reduction or risk management;
• The degree to which the costs of the remedial action are proportionate to the benefits created through restoration or protection of existing and reasonably likely future beneficial uses of water; and
• The degree of sensitivity and uncertainty of the costs.

6.2 Evaluation of Soil Alternatives

6.2.1 Protectiveness
Alternatives 2 through 7 were found to be protective. Alternative 7 would be the most protective because all soil above human health and ecological CULs would be removed. Under Alternatives 2 through 6, an engineered cap would be placed over soil containing COC/CEC concentrations that exceed relevant cleanup levels. With an engineered cap in place, no complete exposure pathways to COCs/CECs in soil beneath the cap would exist for potential receptors. Implementation of SMP for re-development, institutional controls in the form of deed notifications and deed restrictions, and a cap monitoring and maintenance program to detect and repair any breaches would provide necessary assurances that the cap would be maintained to prevent future exposures.

Alternatives 3 through 6 are considered more protective than Alternative 2 because soil that contains COC/CEC concentrations exceeding human health and ecological hot spot concentrations in the Greenway within the expected potential exposure zone (3 feet below final grade) would be excavated from the Greenway zone. Alternatives 4 and 6 are considered slightly more protective than Alternatives 3 and 5 because the hot spots would be transported off-site for disposal.

Alternative 1 is not protective because it does not address current unacceptable risks to human health and the environment.

6.2.2 Effectiveness
The evaluation of effectiveness in this section is based on the remedial action alternative’s ability to achieve the desired level of protection, and the magnitude of untreated wastes remaining at the site that would be managed by engineering and institutional controls. Since Alternatives 2 through 6 have common engineering and
in institutional controls, this criterion was considered neutral in the comparative evaluation of effectiveness between these alternatives.

Alternative 7 was ranked as the most effective alternative because soil above human health and ecological CULs would be removed from the site for off-site disposal, effectively eliminating risk. Alternative 7, however, would take longer to achieve than Alternatives 2 through 6 due to the extensive soil removal that would be conducted.

Alternative 6 was ranked second in effectiveness because it would remove shallow human health hot spots from the site for off-site disposal. Alternative 4 was rated slightly lower than Alternative 6 because hot spot soils between a depth of 3 feet and 15 feet would remain in place in the non-greenway portion of the site. Alternatives 3 and 5 were ranked lower than Alternative 4 because hot spot soils from the greenway area would remain on-site resulting in no substantive reduction in toxicity, mobility or volume. Alternative 2 ranked lower than Alternatives 3 and 5 due to the presence of hot spot soils remaining in the greenway at relatively shallow depth below the soil cap, which increases the potential for significant exposure to COCs in the future.

Alternative 1 is the least effective alternative because no actions are taken to reduce the volume, toxicity, or mobility of the contaminants and does not include engineering or institutional controls to manage the unacceptable risk.

### 6.2.3 Long-Term Reliability

In general, long-term reliability provides an assessment of the remedial action alternative’s ability to maintain the required level of protection over the long term after it is implemented.

Alternative 7 was given the highest rating because all soil above human health and ecological CULs would be removed, with no residual materials requiring long-term management.

Alternative 6 was rated second in long-term reliability because both Greenway and Non-Greenway soil exceeding human health hot spot concentrations would be managed in an off-site disposal facility, which reduces the uncertainty of potential failure of engineering and institutional controls that could result in a significant risk to human health or the environment.

Alternative 4 was rated third due to some increased uncertainty in long-term reliability of on-site management of hot spot soils in non-greenway areas of the site. Alternatives 3 and 5 were ranked slightly lower than Alternative 4 due to the increased uncertainty.
involved in management of hot spot soils on-site rather than at an off-site engineered landfill.

Alternative 2 was ranked lower than Alternatives 3 and 5 due to the increased uncertainty in long-term management of hot spot soils within the unpaved greenway portion of the site. Alternative 1 is not reliable because it does not include treatment, engineering or institutional controls, and does not adequately address unacceptable risks posed by the site.

6.2.4 Implementability
The assessment of implementability is intended to determine whether, or with how much difficulty, the remedial action alternative can be implemented, the availability of various remediation elements or equipment, consistency or authorization from federal, state or local governmental bodies, and whether the alternative’s continued effectiveness can be assessed and verified.

Alternative 2 was rated highest for implementability. Construction of the engineered cap would present few practical, technical, or legal difficulties, and because the effectiveness of the cap is easily monitored. Deed notifications and restrictions and the SMP would require legal assistance, but would not be difficult to implement since the soil remedies do not involve any off-site properties. Minimal time would be required to obtain authorization for placing the cap. The local approvals required by the COP to implement Alternative 2 would be the same as those required for any other development project and would include a grading plan, land use review, and Greenway review. A Greenway Goal exception is not expected to be applicable to the site because activities in the Greenway will not preclude river-dependent uses. In addition, construction of the cap could be completed using readily available services, materials, and equipment. Because excavation and fill along the river bank above the armor would occur at elevations below the ordinary high water line of the Willamette River (approximately 18 feet COP), a COE permit would be required.

Alternatives 4 and 6 were given the second highest rating for implementability. These alternatives would require transporting impacted soil over public roadways, and disposal in permitted facilities, but do not pose significant implementation issues based on the availability of qualified and licensed service providers, and disposal facilities.

Alternatives 3 and 5 were given the next highest rating for implementability. Implementation problems that might be posed by this approach are the potential design requirements that might be required by DEQ to relocate hot spot materials from the greenway area to the non-greenway areas of the site (i.e. liners comparable to solid waste
landfill requirements). The necessary services, materials, equipment, and specialist required to implement the alternative are readily available.

Alternative 7 would require excavation of the large volume of soil requiring transport over public roadways as compared to all other alternatives, and the associated transport and disposal issues identified above.

DEQ does not consider Alternative 1 as implementable because it would pose an unacceptable risk to human health and the environment.

### 6.2.5 Implementation Risk

The evaluation of implementation risk criterion addresses the effects of each alternative during the construction and implementation phase (i.e., up to the point that RAOs are met). Under this criterion, alternatives are evaluated with respect to their effects on human health and the environment during implementation of the remedial action.

Alternative 2 has a low implementation risk, which is primarily associated with potential worker exposure to impacted soil and standard construction safety hazards. As shown in Table 3-6, the estimated risk to site workers exceeds regulatory thresholds by a factor of 4 to 10 for carcinogenic and non-carcinogenic effects, respectively. Potential impacts to the community are associated primarily with fugitive dust emissions associated with excavation. Environmental impacts are primarily associated with potential short-term releases of soil during bank excavation. All of the potential issues are readily manageable through proper design, planning, and implementation. Standard procedures used in the construction and environmental remediation industries can be employed to minimize implementation risk.

Alternatives 3 and 5 have a slightly greater implementation risk as compared to Alternative 2 due to the increased volume of soil managed. As with Alternative 2, these issues are well understood and readily manageable through proper design, planning, and implementation, and the use of standard construction and environmental remediation industry procedures.

Alternatives 4 and 6 have a greater degree of implementation risk than Alternatives 3 and 5, which are associated with transporting impacted soil over public roadways for disposal in permitted facilities. These are considered minor factors that are readily managed using qualified and licensed service providers.

Alternative 7 was given a lower rating than Alternatives 4 and 6 due to large volume of soil requiring transport over public roadways. Although manageable, implementation
risk is expected to be a function of vehicle-miles traveled, which is significantly greater for this scenario as compared to all others.

Alternative 1 has the greatest implementation risk because RAOs would not be achieved resulting in significant risk to onsite workers or future residents at levels higher than construction workers.

6.2.6 Preference to Remediate Hot Spots
This section lists whether or not each alternative treats hot spots and the extent of the treatment, which is a preference under Oregon’s environmental cleanup law.

Alternative 7 remediates all soil exceeding human health and ecological hot spot concentrations through off-site disposal at a licensed disposal facility. Therefore, it meets the Oregon environmental cleanup law’s preference to remediate hot spots.

Alternative 6 substantially meets the Oregon environmental cleanup law’s preference to remediate hot spots through off-site disposal of approximately 6,500 cubic yards of hot spot soil. Alternative 4 provides a lesser degree of remediation of hot spots than Alternative 6, with an incremental volume of 5,700 cubic yards of hot spot material remaining on-site.

Alternatives 3 and 5 do not remediate hot spot soil through treatment or off-site disposal, but does provide containment outside of the Greenway area. Placement of hot spot soils in an engineered containment cell would substantially satisfy this requirement, however.

Alternative 2 provides containment only and does not actively remediate hot spots within the meaning of the Oregon environmental cleanup law. Likewise, Alternative 1 does not meet the Oregon environmental cleanup law’s preference to remediate hot spots.

6.2.7 Cost Reasonableness
The cost of each remedial action alternative was estimated using standard engineering procedures. The estimated cost includes all elements of the remedial action alternative, including the cost of mobilization, treatment, disposal, site restoration, monitoring, and operation and maintenance (O&M). The estimated cost of a reduced property value was not considered in the evaluation (e.g., estimated losses in property value due to reliance on engineering or institutional controls). Per standard FS protocols, the estimated costs should be within the range of +50 percent to -30 percent of actual costs if the alternative were implemented. The cost estimates for each alternative were noted in Section 5.2. The total cost for each alternative is summarized in Table 6-1.
The evaluation of reasonableness of cost is typically completed in two parts. The first part is an estimate of cost for each alternative and a comparison of costs between alternatives. The second part involves evaluating the degree to which the costs are proportional to the benefits. The second part is a qualitative evaluation. In general, those alternatives that are considered protective (effective and reliable); can be readily implemented with minimal impacts to the community, workers, and the environment; and have a lower cost will be regarded as having a greater level of cost reasonableness. In assessing cost reasonableness of those alternatives that meet the threshold requirement of protectiveness, the relative ability of each alternative to address the four other evaluation criteria (as reflected in the ratings described above) were reviewed together with the relative costs. That is, a relative benefit-to-cost analysis was completed.

For the Greenway, the volume of soil exceeding hot spot concentrations associated with the recreational use scenario is included in the volume exceeding ecological hot spot concentrations. In addition residential hot spot soil would be removed during bank stabilization. Therefore, the volume of soil exceeding ecological and residential hot spot concentrations was used, and is estimated to be 1350 cubic yards. This was compared to the volume corresponding to residential CULs, which is estimated to be 132,000 cubic yards. The analysis shows a significant increase in soil volume (and cost) which is disproportionate with contaminant concentration reductions associated with off-site treatment and/or disposal of soil above cleanup levels but below hot spot concentrations. A similar conclusion was reached for the Non-Greenway. For this area of the site, the estimated volumes of soil above residential hot spot concentrations and residential CULs were 330,000 cubic yards.

Alternative 6 had the highest non-economic factor rating in the FS. The cost differential for Alternative 6 as compared to Alternatives 3 through 5 was not considered excessive. The non-economic rating of Alternative 5 is incrementally higher than that of Alternative 4, and the cost differential as compared to Alternative 6 was lower than the Alternative 4 differential. Combining these benefit and cost factors resulted in a rating slightly lower than Alternative 6 and slightly greater than that assigned to Alternative 4, which was rated third in the FS. The benefit and cost factors rating for Alternative 3 were above that assigned to Alternative 2, but below those for Alternatives 4 through 6.

Alternative 7 had a low non-economic factor rating, and an estimated cost greatly in excess of all other alternatives, and therefore received a cost reasonableness rating well below the ratings for Alternatives 2 through 6. Alternative 1 does not meet the threshold criterion of protectiveness, and therefore received the lowest cost reasonableness rating.
6.3 Evaluation of Sediment Alternatives

6.3.1 Protectiveness
Ambient levels of PCB Aroclors 1254 and 1260 have been estimated to be in the range of 10 to 12 ppb, which exceed the cleanup level of 2 ppb for each Aroclor. None of the remedial alternatives for sediment would restore the site to human health cleanup levels for PCBs and PAHs due to ambient levels exceeding the cleanup levels.

Alternative 5 was rated the highest in protectiveness, as all sediments exceeding the cleanup levels in Table 4-2 for ecological receptors would be removed, and the excavation areas backfilled with clean sand. Alternative 4 was rated second in protectiveness because hot spot sediments would be removed and residual sediment contamination exceeding cleanup levels would be capped with up to 10 feet of clean sand.

Alternative 3 was found to be protective. Under this alternative, sediment in the SMA would be capped. With an engineered cap in place, no complete exposure pathways to chemicals in sediment beneath the cap would exist for potential receptors. Therefore, no unacceptable levels of risk would exist for human or ecological receptors within the capped SMA. Institutional controls in the form of deed notifications and deed restrictions should be reliable in managing COCs/CECs remaining in sediment at the site, because removal of cap material would not be allowed, and periodic monitoring would be conducted to identify any unanticipated breaches in the cap due to physical transport during major flooding events. The residual risk to ecological receptors from residual contamination outside of the SMA would not exceed the regulatory threshold criteria. The residual risk to human receptors would exceed the regulatory threshold criteria for carcinogenic risk to PCBs due to ambient concentrations within the river.

Alternative 2 is less protective than Alternative 3 as a portion of the SMA would not be capped resulting in unacceptable risk for a portion of the site. Also, residual contamination within the SMA that is not capped could migrate during high flow periods within the Willamette, which could result in re-contaminating the capped portion of the SMA and adjacent areas.

Alternative 1 would leave contaminated sediment that poses and unacceptable risk in place without treatment or controls, and therefore is not be protective of human health or the environment.

6.3.2 Effectiveness
Alternative 5 was rated highest in effectiveness by reducing risk through the removal of impacted sediment from the in-water environment and placing it in a permitted landfill.
Alternative 4 was rated lower than Alternative 5 because residual contamination below hot spot levels and cleanup levels would remain. Alternative 3 was rated lower than Alternative 4 because sediment hot spots would not be removed. The hot spots should be effectively managed through capping, however. Alternative 2 is only partially effective because some SMA areas, including hot spots, remain unaddressed. Additionally, recontamination of the capped area is a potential concern. Alternative 1 is not effective at decreasing the risk on site because no actions are taken to control impacted sediment or reduce the volume, toxicity, or mobility of the contaminants. In addition, no engineering or institutional controls are used to manage the risk.

6.3.3 Long-Term Reliability
Alternative 5 is rated as most reliable in the long term, since the sediment is removed and placed in a permitted landfill. Because the sediment is no longer in the in-water environment, this alternative was rated higher than Alternatives 3 and 4. Long-term reliability of Alternative 4 is slightly greater than full containment (Alternative 3), since hot spot sediments are no longer located in the SMA, and therefore cannot be released to the in-water environment. However, because the cap is a reliable long-term remedy, the increase in reliability was not considered significant.

Capping is reliable if properly designed to prevent failure during high-flow conditions in the river. Alternative 3 is considered reliable in the long term provided monitoring and maintenance of the cap is implemented in the long-term to ensure reliability. Alternative 2 is reliable for a portion of the SMA but not in the remaining uncapped areas. Alternative 1 is not reliable in the long term because it does not manage risk from impacted sediments.

6.3.4 Implementability
Cap construction activities under Alternatives 2 through 4 are implementable, as they would be based on proven materials management and placement technologies. Materials and equipment are standard, and are readily available in the Northwest. These alternatives would require an agreement with DSL that facilitates long-term access to and use of state lands, and require compliance with permitting requirements specified by the COE, DSL, DEQ, and other requirements identified by NOAA related to protection of habitat for T&E fish species. Completing the access/use and permitting requirements will increase the complexity of implementation of these alternatives. DSL has provided comments to DEQ on other sediment remedies involving capping that opposed the placement of a cap and expressed a preference for removal of contaminated sediments from State lands. DSL is also evaluating land sales, easements, and leases to facilitate use of state lands where the selected remedy involves leaving contamination in place,
such as with capping. Negotiations related to access and use may delay implementation of any alternative that involves capping of contaminated sediments in place. Because this implementation issue is common to each alternative (including Alternative 5 where complete removal may be infeasible because of technical reasons), the implementability comparison of alternatives focused on the constructability of the remedial components.

Alternative 3 was rated highest in implementability by DEQ. Alternative 4 was rated lower than Alternative 3, due to the increased complexity associated with large volume hot spot dredging, dewatering, transport, and disposal. The permitting and environmental protection measures required for the dredging component of the alternative are significant. The sediment and impacted water volumes to be managed are smaller than for full SMA dredging (Alternative 5).

Alternative 5 is not easily implementable. Standard and specialized equipment, materials, and technologies would need to be applied. The large volumes of sediment to be dredged, dewatered, transported, and disposed of, as well as the large volume of water requiring treatment and discharge make this alternative challenging. Permitting complexity and the necessary environmental protections also add to the difficulty in implementing this option.

DEQ rated Alternative 2 lower in implementability because it does not adequately address risks throughout the site, and could be deemed unacceptable by DSL, who owns submerged portions of the river. As noted in the evaluation of soil alternatives, DEQ does not consider Alternative 1 as implementable because it would pose an unacceptable risk to human health and the environment. DEQ therefore, considers both sediment Alternatives 1 and 2 as not implementable.

### 6.3.5 Implementation Risk

Alternative 3 has minimal implementation risk. Standard construction safety practices could be employed per state and federal regulations. The risk of negative impacts to the environment during implementation is low due to the fact that impacted sediments are not removed from the site and no water treatment is required. The time required for completion is relatively short. For these reasons, Alternative 3 was rated best for implementation risk.

The implementation risk of Alternative 4 is comparable but lower than full SMA dredging (Alternative 5), because the volumes involved are significantly smaller, the implementation risk is correspondingly reduced.

Alternative 5 has considerable implementation risk, resulting primarily from the potential for system upsets and impacted material releases during dredging, transport to the dewatering facility, dewatering, off-site transport, and disposal. System failures during
sheet pile installation and removal, and failure of the temporary water treatment system also increase the implementation risk.

While the implementation risk for Alternative 2 is comparable to Alternative 3, it was rated lower than Alternatives 3 through 5 because RAOs would not be satisfied for much of the SMA. Alternative 1 has the greatest implementation risk because RAOs would not be achieved resulting in significant risk to ecological receptors and recreational fishermen that consume fish caught in the area.

6.3.6 Preference to Remediate Hot Spots
Alternatives 4 and 5 remediate all sediment exceeding human health and ecological hot spot concentrations through dredging. Therefore, these alternatives meet the Oregon environmental cleanup law’s preference of remediation. Alternative 3 does not actively remediate hot spots through treatment or off-site disposal, but provides containment of most of the sediments with COC/CPEC above cleanup levels. Alternative 2 provides containment for only a portion of the hot spot sediments. Alternative 1 does not treat hot spots.

6.3.7 Cost Reasonableness
Details and primary assumptions used in development of the cost estimates are provided in Appendix E of the FS. The cost estimates for each alternative were noted in Sections 5.3. The total cost for each alternative is summarized in Table 6-2.

When comparing the expected performance of Alternatives 2 and 3, Alternative 3 higher than Alternative 2 because the increased cost is warranted to fully achieve the RAOs. The costs for both Alternatives 4 and 5 involving sediment removal are much higher than Alternative 3, which are significantly disproportionate to the decrease in residual risk potentially achievable through removal. Although Alternative 4 meets the preference for hot spot remediation, the costs outweigh the benefits realized.

Alternative 1 does not meet the threshold criterion of protectiveness, and therefore received the lowest cost reasonableness rating.

6.4 Evaluation Summary

Based on the evaluation of soil and sediment alternatives presented in the FS Report, Zidell selected Alternative 6 for soil and Alternative 3 for sediment. DEQ generally concurs with the alternatives selected by Zidell. Section 7 provides a description of the DEQ recommended alternatives that include modifications of the alternatives as
described in the FS, a description of other laws that are applicable or relevant to the recommended alternatives, and an evaluation of residual risks.
7 Recommended Alternatives for Soil and Sediment

DEQ has selected Soil Alternative 6 and Sediment Alternative 3, modified as discussed below, as the recommended remedial action alternatives for the site. The estimated cost for implementation of Soil Alternative 6 is $4.44 million, which includes $270 thousand for remedial design, $3.3 million for remedial action construction, $123 thousand for long-term monitoring and maintenance, and $740 thousand in contingencies. The estimated cost for implementation of Sediment Alternative 3 is $2.0 to $2.5 million, which includes $316 thousand for remedial design, $1.15 to $1.65 million for remedial action construction, $92 thousand for periodic maintenance and monitoring, and $467 thousand for contingencies. The total cost of the soil and sediment remedial alternatives is $6.46 to 7 million. Figures 7-1 and 7-2 show the recommended, integrated upland and in-water remedial alternatives in plan and cross-sectional view, respectively.

7.1 Recommended Alternative for Soil

Alternative 6 is the recommended soil alternative, as modified and described below. This remedial action provides a cost-effective, protective approach to remediating impacted soil while allowing for high-density residential, commercial, and recreational redevelopment of the site. Protectiveness is achieved by: 1) excavation and off-site disposal of human health hot spot soils and other hazardous materials containing asbestos from the greenway portion of the site; (2) excavation and on-site consolidation of ecological-based hot spot soils on the non-greenway portion of the site; 3) engineering controls involving capping the site to reduce potential exposure to residual contamination; and 4) placement of institutional controls to ensure long-term effectiveness of engineering controls.

Recommended Alternative 6 would include the following modifications from the alternative described in the FS:

- Treatment of soil as necessary to remove hazardous waste leaching characteristics prior to off-site landfill disposal of soil exceeding hot spot concentrations based on future residential use of the property;

- Excavation of hot spot soils to a depth of 5 feet below final grade in both the greenway and non-greenway areas of the site (instead of 3 feet in the greenway and 15 feet in the non-greenway areas as proposed); and

- Contingencies to install stormwater treatment ponds within the greenway for pre-treatment of stormwater from re-developed portions of the site prior to discharge to the Willamette River.

The recommended soil remedy would be implemented in a phased approach. The first phase would address the greenway portion of the site to include hot spot and ACM removal, re-grading and placement of an engineered cap in the greenway area including...
upgrading existing armoring in the bank line as necessary, and placement of non hot-spot soils outside of the greenway in an engineered containment cell. Removal and off-site disposal of limited hot spot soil from the non-greenway would also be completed during the first phase. Existing infrastructure such as pavement, building foundations or importing clean fill would be used in the non-greenway areas as a temporary barrier against direct contact with soil until site redevelopment occurs. Deed notifications and deed restrictions, including a SMP, would be placed on the property.

The second phase of remediation would be implemented as part of the redevelopment of the non-greenway portion of the site and would include additional earth work related to building and associated infrastructure construction prior to the placement of an engineered cap. The materials used in the engineered cap may consist of asphalt pavement, concrete building foundations, clean sand or gravel fill, or any other barrier that precludes direct contact with the soil. A demarcation layer, such as a geomembrane, would be placed underneath the cap for the purposes of separating residual contaminants from the clean cap materials. Appropriate options for the capping material would be developed in detail during the remedial design, and incorporated into the redevelopment design.

### 7.1.1 Excavation, Screening, Consolidation and Disposal of Soil

Placement of a stable cap within the greenway that addresses hot spot soils within the existing bank would require reducing the bank slope to 3:1 horizontal to vertical along the bank, which would involve excavation of approximately 40,000 cubic yards of material from the greenway area. Areas containing hot spot materials or asbestos containing material would be over-excavated to a depth of 5 feet below final grade. Hot spot soils in the non-greenway would also be excavated to a depth of 5 feet below current grade for off-site disposal. The FS Report estimated the volume of hot spot soils for off-site disposal at 6,500 cubic yards. In an effort to maintain cost-reasonableness of the recommended alternative, DEQ proposes to limit the volume of hot spot soil for off-site disposal at 8,000 cubic yards using a worst-first approach. Any hot spot soils above this volume would be managed on-site in an engineered containment cell constructed to hold non-hot spot soil from the greenway area.

Fill material historically placed on the site, especially along the bank, consists of large amounts of oversize, primarily inert, material (e.g., concrete). With the exception of ACM, soil screening may be used to isolate the impacted soil from the inert material. The separated rock and concrete may be stored on site for recycling as aggregate (following crushing) during the site redevelopment. Other oversized material (e.g., wood, solid waste) would be transported off site for disposal.

Screened soil that exceeds the hot spot concentrations in Table 4-1 and ACM will be transported off-site for disposal in accordance with applicable state and federal regulations. Soil that exceeds TCLP regulatory thresholds will be disposed as a RCRA
hazardous waste. Alternatively, these soils may be stabilized on-site and disposed at a municipal landfill, provided the stabilized soil do not exceed TCLP leaching criteria and meet RCRA land disposal restriction requirements. The on-site stabilization process is subject to applicable substantive state and federal hazardous waste management requirements, including 40 CFR 262, 265, and 268.

The non-hot spot soil for on-site consolidation would be placed in a lined and covered staging area, either before or after screening as described above. Following screening, the reduced volume of excavated soil would be incorporated into the redevelopment design in a manner that ensures protection of human health and the environment.

Contaminated soils in the utility corridors exceeding the RBCs for the construction worker will be excavated to a depth of up to 5 feet below final street grade as required by the COP’s Soil Reuse Policy (COP, 1999), and appropriately managed in the non-greenway areas outside of utility corridors within the area of contamination (AOC) defined as existing soil contamination areas above the cleanup levels specified in Table 4-1.

The site redevelopment may require an overall site elevation increase of approximately 3 to 6 feet, which may require importing additional clean fill. Alternatively, dredged, dewatered sediment from the site with COCs below human hot-spot concentrations may be used as fill prior to placement of the final site cap. Additional non-hot spot soils may be excavated as needed for site redevelopment (e.g., below ground parking for new buildings etc.), although the excavation of these soils is not a requirement of DEQ’s recommended remedial action. Impacted soil that requires excavation will be placed below clean fill or other site appurtenances or structures. Parameters for soil placement to ensure long-term protection of human health and the environment will be established in the soil management plan (SMP), and incorporated into redevelopment designs. These include, but are not limited to, requiring that impacted soil be placed outside the public ROWs and utility corridors and above the water table. For all redevelopment activities that involve potential exposure to soils exceeding RBCs for the construction worker scenario, the health and safety protocols would be implemented.

### 7.1.2 Capping

An engineered cap would be used to prevent contact with impacted soil and thus minimize exposure to COCs/CECs and prevent erosion of impacted soil to surface water and sediment. A cap will be placed in those areas where residual contaminants remain above the residential RBCs identified in Table 4-1. Within the greenway area, the engineered cap would consist of a demarcation material to identify the top of the impacted soil, and a 2-foot vegetated clean soil cap. Existing bank armoring comprised of concrete, rock, and ballast stone may serve as the cap between an elevation of approximately 3 feet and 13 feet COP datum. Additional armoring would be installed in
the bank areas where existing armoring is discontinuous or of questionable structural integrity. The areas for armor improvements will be identified during remedial design.

For the non-greenway area, the engineered cap may incorporate proposed buildings, pavement, or other improvements constructed as part of the site redevelopment could be substituted for, or used to augment, parts of the soil cap, with DEQ review and approval. The cap will be installed during, and coordinated with, site redevelopment. If no redevelopment occurs for portions of the site within 5 years from the date of the final DEQ Record of Decision, these areas would be capped as described for the greenway area of the site.

A stormwater collection and conveyance system would be designed and constructed as part of the engineered cap to manage stormwater during and after implementation of the final remedy.

7.1.3 Engineering and Institutional Controls

Access restrictions, such as fencing, would be constructed to restrict public access to the site to prevent contact with soil through completion of site capping. In addition, existing asphalt-concrete pavement that covers much of Operational Area 1 and the concrete floor slabs of the existing buildings will be retained until remedy construction activities are implemented to further reduce the potential for exposure to contaminated soil.

Institutional controls would include deed restrictions to prevent disturbance of the cap, address notification of site hazards, and ensure proper controls are implemented during future site activities. Deed restrictions would restrict activities, operations, or uses that would damage or interfere with the integrity of the cap, or disturb residual soil contamination. Deed restrictions would also require the long-term maintenance of the cap and other engineering controls, and provide notification of site hazards. Removal or destruction of the cap or disruption of the residual soil contamination would be cause for initiating additional remedial actions to achieve protective levels. The deed restrictions would also require prior notification to DEQ of any significant changes in site redevelopment plans or changes in site ownership or land use, and if such events occurred, may require an evaluation of the need for further remedial action of all contaminated media to achieve appropriate health-based protective levels. The deed restrictions would run with the land and will be enforceable to all current and future owners of the site.

An Inspection and Maintenance Plan specifying the long-term inspection and maintenance requirements for the cap and other engineering controls would be prepared for DEQ review and approval as part of the remedial design phase of work.
A Soil Management Plan (SMP) would be developed to guide future excavation activities that could potentially encounter impacted soil. The SMP would outline specific requirements for managing soil on site as part of future redevelopment. Oversight of excavation activities would be conducted by an environmental professional to identify ACM or unexpected contaminated soil requiring management. Waste disposal requirements and sampling and analysis requirements would also be addressed in the plan. The SMP will also specify that if potential ACM is found during excavation, it will be segregated and characterized by a certified asbestos contractor and managed following applicable asbestos and solid waste regulations. The plan will require that areas filled with excavated soil be surveyed and included in deed notifications and deed restrictions.

7.2 Recommended Alternative for Sediment
Alternative 3 is the recommended sediment alternative, as modified and described below. Alternative 3 would include engineering controls involving placement of a sediment cap over the impacted sediments within the SMA, and institutional controls to ensure long-term effectiveness of the cap. Alternative 3 would include the following DEQ modifications to the proposed remedial action alternative presented in the FS Report:

- Extending the SMA to include the zone where WRS-12 and WRS-13 were located and extending the SMA an additional 50 to 100 feet from the shoreline;
- Performing periodic monitoring of sediment conditions outside of the final cap area to assess capping reliability and natural restoration of marginally impacted sediments that exceed cleanup levels specified in Table 4-2; and
- Contingencies to perform selective dredging of hot spot sediments in the barge launch area as shown on Figure 7-1.

7.2.1 Selective Dredging
Selective dredging of the barge launchway sediments would be conducted as an alternative to capping in the event Zidell’s barge construction operations are not relocated within 2 years of issuance of the final remedy for the site. Remediation of the hot spot sediments is a high priority to minimize any further transport of contaminated sediments outside of the SMA area and downstream. Placement of the sediment cap in this area, as described for Alternative 3, would obstruct existing operations (prevent barge launching) in the event that Zidell is unable to relocate its facility in the near term.

The dredging area is approximately 300 feet lengthwise extending 100 to 150 feet from the shoreline. Sediment would be dredged to a depth of 5 feet below the current sediment surface and dredged area backfilled with clean sand to restore current elevations. An estimated 8,000 cubic yards of sediment would be removed and replaced with clean fill. The dredged sediment would either be managed on-site as described for the soil alternative or transported off-site for disposal. Based on on-site placement, the estimated cost of this contingency is $500,000.
7.2.2 Engineered Cap
Alternative 3 would include installation of a cap over the modified SMA to isolate contaminated sediment from aquatic species (i.e. benthic organisms, fish, and wildlife) and to minimize or prevent bioaccumulation of contaminants in the food chain, and physical transport downstream. The sediment cap would tie into the armored bank to provide a continuous cap between upland soil and in water sediments. For the proposed alternative it was assumed that the cap would be comprised of a two foot layer of sand that would be armored with 12 inches of 2 to 6-inch rounded river rock.

In-water work performed on the Willamette River would be done within the allowable work windows of July 1 through October 31 and December 1 through January 31. Prior to capping, most in-water obstructions would be removed. Some of the existing pilings within the dock area may remain if they provide cap stability and habitat-enhancement, and are approved for retention during the permitting process with DSL and COE/NOAA.

The SMA area based on the boundary adjustments made by DEQ is approximately 8-9 acres in size. The final cap configuration and design specifications would be finalized during remedial design and permitting based on the additional sediment testing to refine the cap boundaries and hydraulic and geotechnical analyses. The area and thickness of the cap would be determined by considering sediment sample data and physical isolation requirements, edge stability, chemical diffusion and permeation, and physical stability. Navigational and floodway encroachment issues would also be assessed during design.

Floodway encroachment would also be evaluated as part of design because the cap will be located in the Willamette River floodway. If a measurable elevation rise is predicted during a 100-year flood event, then a balanced cut to off-set the flood rise would be required.

No known utilities run through the SMA. However, a gas line and water line cross the river north of the SMA near the Marquam Bridge. As part of the design process, all utilities would be precisely located and the owners contacted to coordinate construction work. Given the distance from the SMA, the known utilities are not expected to complicate the installation of the cap.

7.2.3 Institutional Controls and Monitoring
Institutional controls would involve use restrictions, marking of boundaries, and monitoring and maintenance programs designed to confirm the long-term effectiveness of the remedial action. The United States Coast Guard Notice to Mariners system would be used to limit the size of ships and activities near the cap area. This system uses radio broadcasts to inform watercraft in the area as well as postings in all marinas. In addition, the perimeter may be marked with buoys and signs to minimize recreational boaters traversing the area, and subject to other site restrictions imposed by DSL and the Oregon Marine Board.

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January 20, 2005
Legal restrictions would probably be put in place to limit in-water development. The state of Oregon owns the river bottom where the sediment cap would be placed. Placement of the cap, use restrictions, and other institutional controls will require DSL approval. These potential restrictions will be assessed further during remedial design when cap specifics are determined, with the goal of maximizing cap preservation.

An Operations, Maintenance and Monitoring Plan (OMMP) would be developed for routine cap performance monitoring, including the schedule and reporting requirements, an emergency response plan should an environmental upset occur (e.g., vessel grounding or a flood in exceedances of design criteria), and a contingency plan that will identify actions to be taken if the cap fails to meet the performance criteria. The OMMP would include sediment testing on a five year schedule for at least 10 years to monitor the natural recovery of low-level sediment contamination outside of the cap boundary, and assess potential releases associated with breaches in the sediment cap discovered during physical inspection. The monitoring program for recovery assessment would be discontinued when residual contaminant levels outside the cap area meet the cleanup levels specified in Table 4-2.

### 7.3 Satisfaction of Protection and Balancing Factors

#### 7.3.1 Protectiveness

OAR 340-122-0040 requires that all remedies be protective of human health and the environment, as demonstrated through a residual risk assessment (RRA). A RRA was included in the FS Report to support the selection or approval of the remedial action alternatives for soil and sediment that would meet the acceptable levels of risk in the locality of the facility, as defined in OAR 340-122-0115. The RRA included the following:

- A quantitative assessment of the potential risk resulting from concentrations of untreated waste or treatment residuals remaining at the facility at the end of any treatment, excavation, and off-site disposal activities, taking into consideration current and reasonably likely future land- and water-use scenarios and the exposure assumptions; and
- A qualitative or quantitative assessment of the adequacy and reliability of any institutional or engineering controls used for managing treatment residuals and untreated hazardous substances remaining at the facility.

The recommended remedial action for soil is protective of human health and the environment. The selected remedial action achieves acceptable levels of risk, as defined by OAR-340-122-0115, as demonstrated by a residual risk assessment conducted as part of the FS. The recommended remedy for soil achieves protection through a combination
of excavation, treatment and/or off-site disposal of contaminated soils, engineering controls, and institutional controls.

The recommended remedial action for sediment is protective of the environment including ecological receptors (benthic organisms, mammals, birds and fish). The residual risk assessment for human health was limited to a qualitative evaluation due to detection limits for PCBs in most of the sediment samples exceeding the cleanup level of 2 ug/kg, and the presumed ambient levels being comparable to the “baseline” concentrations (~150 ug/kg) estimated by DEQ for the Portland Harbor Superfund site. PCB levels in the proximity of Ross Island located upstream of the site were estimated at approximately 10 to 12 ug/kg. PCB concentrations outside of the SMA exceed upstream ambient levels to a limited extent resulting in a residual risk in the range of $10^{-5}$ for total PCBs via indirect exposure through fish ingestion.

Capping all sediment contamination with PCBs above apparent ambient levels in this stretch of the Willamette River is impractical. Residual PCB concentrations outside of the capped area are expected to attenuate with time to ambient levels through depositional/erosional processes. Fish advisories have been issued for the lower Willamette River by Oregon Department of Human Services (DHS) related to elevated contaminants including PCBs measured in fish harvested from the river. As part of the 5-year review of remedy protectiveness, DEQ would coordinate with DHS on the continued use of institutional controls in the form of fish advisories for the lower Willamette River. The use of these controls should be effective in reducing fish consumption of resident fish species (e.g. bass, crappie, etc.) by recreational anglers in the general locality of the facility to achieve the acceptable risk level.

Fish bioaccumulation studies PCBs and other contaminants in sediment will be evaluated in Portland Harbor to develop more reliable sediment cleanup levels for the fish ingestion exposure pathway. Potential modification of sediment cleanup levels for fish ingestion will be re-evaluated during the DEQ 5-year remedy review cycle discussed below in Section 7.3.4.

### 7.3.2 Balancing Factors

The recommended remedial actions for soil and sediment are based on a balance of effectiveness, long-term reliability, implementability, implementation risk, and reasonableness of cost, as described in Sections 6.2 and 6.3. Soil Alternative 6 provided the best balance of these factors. For the sediment remedy, Alternative 3 provided the best balance with respect to these factors. Selective dredging of hot spot sediments in the barge launch way is feasible and cost-reasonable based on historical dredging at the site (see Section 2.1.1) for site operations.
7.3.3 Remediation of Hot Spots
The recommended remedial action for soil remediates hot spots of contamination to the extent feasible. Soil human-health hot spots to a depth of 5 feet below final grade are excavated, treated at an off-site facility, and then appropriately disposed, consistent with ORS 465.315(1)(e) and OAR 340-122-0070 through -0090.

The recommended remedial action for sediment would not actively remediate human health or ecological-based hot spots due primarily to implementability and to a lesser degree the costs associated with hot spot sediment removal. DEQ has included a contingency to dredge approximately 8000 cubic yards of hot spot sediment, which would satisfy the preference to remediate hot spots of contamination to the extent practical. Implementation of this contingency would also eliminate the need to restrict future river use in this limited area for a boat taxi service. A partial dredging of hot spots alternative may be considered based on public comments on the recommended alternative.

7.3.4 Periodic Reviews and Contingency Measures
DEQ would conduct periodic reviews of the remedy to ensure that the remedial action remains protective of present and future public health, safety, and welfare, and the environment. Periodic reviews would be conducted at least every 5 years and will include the evaluation of inspection and maintenance reports for the soil and sediment caps, sediment quality monitoring outside of the capped area, land and beneficial water uses for the site and site vicinity, compliance with institutional controls, and any other relevant information.

Contingency measures may be required in the event that any component of the soil or sediment remedy is compromised such that the remedy no longer meets the protection standard, or that RAOs are not otherwise being satisfied. Contingency measures for contaminated soil or sediment would prevent exposure to soils exceeding acceptable risk levels and may include one or a combination of the following: (1) excavation, treatment and/or disposal; (2) in-situ treatment, (3) engineering controls; (4) institutional controls.
ATTACHMENT A
ZIDELL WATERFRONT PROPERTY
ADMINISTRATIVE RECORD INDEX


### Table 3-1
Contaminant Concentrations in On-Site Soil – Non-Greenway Area
Zidell Waterfront Property

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<tr>
<th>Compound</th>
<th>Number of Samples</th>
<th>Concentration¹</th>
<th>Location of Maximum Concentration</th>
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Notes: ¹ Concentrations reported in micrograms per kilogram (ug/kg)
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<th>Concentration</th>
<th>Location of Maximum Concentration</th>
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<tr>
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<td>Chrysene</td>
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Notes: ¹ Concentrations reported in micrograms per kilogram (ug/kg)
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<th>Concentration Range (ug/L)</th>
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<td>Aroclor 1260</td>
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<td>0.08</td>
<td>2.3</td>
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Notes: ^ Concentrations reported in micrograms per liter (ug/L)
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<th>Concentration</th>
<th>Location of Maximum Concentration</th>
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<tbody>
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<td></td>
<td>Min.</td>
<td>Max.</td>
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<td>Metals</td>
<td></td>
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<td>Cadmium</td>
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</tr>
<tr>
<td>Chromium</td>
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<td>143</td>
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<tr>
<td>Copper</td>
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<td>1.6</td>
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<td>Lead</td>
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<td>3,000</td>
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<td>Benzo(a)pyrene</td>
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<td>0.0055</td>
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<td>1,700</td>
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<tr>
<td>Benzo(k)floranthene</td>
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<td>0.0055</td>
<td>1,500</td>
</tr>
<tr>
<td>Chrysene</td>
<td>79</td>
<td>0.0055</td>
<td>3,300</td>
</tr>
<tr>
<td>Dibenz(a,h)anthracene</td>
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<td>0.0044</td>
<td>190</td>
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<tr>
<td>Indeno(1,2,3-c,d)pyrene</td>
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<td>0.0044</td>
<td>630</td>
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<td>PCBs</td>
<td></td>
<td></td>
<td></td>
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<td>Aroclor 1254</td>
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<td>Aroclor 1260</td>
<td>79</td>
<td>0.12</td>
<td>2600</td>
</tr>
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Notes: 1 Concentrations reported in micrograms per kilogram (ug/kg)
<table>
<thead>
<tr>
<th>Compound</th>
<th>Number of Samples</th>
<th>Range</th>
<th>Location of Maximum Concentration</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min.</td>
<td>Max.</td>
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<td></td>
<td></td>
<td>Average</td>
<td></td>
</tr>
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<td><strong>Metals</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Arsenic</td>
<td>9</td>
<td>0.5</td>
<td>4.2</td>
</tr>
<tr>
<td>Cadmium</td>
<td>9</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Chromium</td>
<td>9</td>
<td>1.4</td>
<td>8</td>
</tr>
<tr>
<td>Copper</td>
<td>9</td>
<td>0.5</td>
<td>12</td>
</tr>
<tr>
<td>Lead</td>
<td>9</td>
<td>0.25</td>
<td>3.2</td>
</tr>
<tr>
<td>Mercury</td>
<td>9</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Nickel</td>
<td>9</td>
<td>1.9</td>
<td>6.3</td>
</tr>
<tr>
<td>Tributyltin</td>
<td>19</td>
<td>0.03</td>
<td>0.6</td>
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<tr>
<td>Zinc</td>
<td>9</td>
<td>2</td>
<td>26</td>
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</table>

Notes:  
^1 Concentrations reported in micrograms per liter (ug/L).  
^2 Not applicable – compound not detected in sediment pore water samples.
<table>
<thead>
<tr>
<th>Exposure Scenario</th>
<th>Cumulative Excess Cancer Risk&lt;sup&gt;(2)&lt;/sup&gt;</th>
<th>Adverse Health Effects&lt;sup&gt;(2)&lt;/sup&gt;</th>
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</thead>
<tbody>
<tr>
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<td>Central Tendency</td>
<td>Reasonable Maximum</td>
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<td><strong>Exposure to Soil</strong>&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future Resident</td>
<td>1x10&lt;sup&gt;-5&lt;/sup&gt;</td>
<td>5x10&lt;sup&gt;-5&lt;/sup&gt;</td>
</tr>
<tr>
<td>Excavation Worker</td>
<td>5x10&lt;sup&gt;-8&lt;/sup&gt;</td>
<td>4x10&lt;sup&gt;-6&lt;/sup&gt;</td>
</tr>
<tr>
<td>Construction Worker</td>
<td>2x10&lt;sup&gt;-6&lt;/sup&gt;</td>
<td>3x10&lt;sup&gt;-5&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Exposure to Groundwater</strong>&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future Resident</td>
<td>-----</td>
<td>6x10&lt;sup&gt;-7&lt;/sup&gt;</td>
</tr>
<tr>
<td>Excavation Worker</td>
<td>9x10&lt;sup&gt;-9&lt;/sup&gt;</td>
<td>7x10&lt;sup&gt;-7&lt;/sup&gt;</td>
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<tr>
<td>Construction Worker</td>
<td>-----</td>
<td>4x10&lt;sup&gt;-7&lt;/sup&gt;</td>
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<tr>
<td><strong>Off-Site Media</strong>&lt;sup&gt;(4)&lt;/sup&gt;</td>
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<td></td>
</tr>
<tr>
<td>Recreational Fisherman</td>
<td>1x10&lt;sup&gt;-5&lt;/sup&gt;</td>
<td>1x10&lt;sup&gt;-5&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Notes:

(1) Based on incidental ingestion and dermal exposure to soil 0-3 feet for future residents and 0-15 feet for workers; the highest risk estimates from Areas 1, 2, and 3 reported here, see Tables 8-1 through 8-4 in RI Report.

(2) Regulatory threshold for cumulative carcinogenic risk is 1x10<sup>-5</sup> and a hazard quotient of one (1) for systemic effects.

(3) Based on incidental ingestion and dermal contact exposure to groundwater for workers, and inhalation of vapors intruding into buildings for future residents.

(4) Based on indirect exposure of recreational anglers to bioaccumulative compounds in Willamette River sediments through fish ingestion.
### Table 4-1

**Soil Cleanup Levels and Hot Spot Concentrations (mg/kg)**

**Zidell Waterfront Property**

<table>
<thead>
<tr>
<th>COC/CEC</th>
<th>Future Residents&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Construction Workers&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Ecological Receptors&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soil</strong></td>
<td>Cleanup Levels</td>
<td>Hot Spot Concentrations&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Cleanup Levels</td>
</tr>
<tr>
<td>Metals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antimony</td>
<td>31</td>
<td>310</td>
<td>124</td>
</tr>
<tr>
<td>Arsenic&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7</td>
<td>39</td>
<td>13</td>
</tr>
<tr>
<td>Barium</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Beryllium</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Cadmium</td>
<td>37</td>
<td>370</td>
<td>154</td>
</tr>
<tr>
<td>Chromium</td>
<td>210</td>
<td>21,000</td>
<td>32,000</td>
</tr>
<tr>
<td>Copper</td>
<td>3,100</td>
<td>31,000</td>
<td>12,000</td>
</tr>
<tr>
<td>Lead</td>
<td>400</td>
<td>4,000</td>
<td>800</td>
</tr>
<tr>
<td>Mercury</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Nickel</td>
<td>1,600</td>
<td>16,000</td>
<td>6,200</td>
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<td>Silver</td>
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<td>NA</td>
<td>NA</td>
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<tr>
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<td>100,000</td>
<td>93,000</td>
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<td></td>
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<tr>
<td>Benz(a)anthracene</td>
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<td>62</td>
<td>21</td>
</tr>
<tr>
<td>Benzo(a)pyrene</td>
<td>0.062</td>
<td>6.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Benzo(b)fluoranthene</td>
<td>0.62</td>
<td>62</td>
<td>21</td>
</tr>
<tr>
<td>Benzo(k)fluoranthene</td>
<td>6.2</td>
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<td>6,200</td>
<td>2,100</td>
</tr>
<tr>
<td>Dibenzo(a,h)anthracene</td>
<td>0.062</td>
<td>6.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Indeno(1,2,3-c,d,pyrene</td>
<td>0.62</td>
<td>62</td>
<td>21</td>
</tr>
<tr>
<td>PCBs&lt;sup&gt;e&lt;/sup&gt;</td>
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<td>Aroclor 1242</td>
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<td>7.6</td>
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<td>Aroclor 1254</td>
<td>0.22</td>
<td>22</td>
<td>7.6</td>
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<tr>
<td>Aroclor 1260</td>
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<td>22</td>
<td>7.6</td>
</tr>
</tbody>
</table>

NA – Not applicable because baseline conditions for this chemical result in an acceptable risk, or no cleanup criteria exists.

a With the exception of arsenic, cleanup levels for future residents were set at the USEPA Region 9 residential soil PRG (USEPA, 2004). The cleanup level for arsenic was set at the natural background concentrations based on the state-wide 90th percentile value for Washington (WDOE, 1994)

b Cleanup levels for construction workers were set at the DEQ construction worker RBCs using exposure factors defined in DEQ guidance (DEQ, 2003). The USEPA Region 9 industrial soil PRG was used as the cleanup level for lead (USEPA, 2004).

c Cleanup levels for terrestrial ecological receptors were set at DEQ SLVs protective of populations except for chromium which was set at background (DEQ, 2001)

d Human health hot spot concentrations were set at 100 times the cleanup level for carcinogens, and 10 times the cleanup level for noncarcinogens. Ecological hot spot concentrations were set at 10 times the cleanup level.

e DEQ DRAFT update guidance (May 2003) SLV protective of bioaccumulation to bird and mammalian receptors at the population level. Value is a LOAEL based value calculated using methodology presented in Sutter et al., 2000.

f Arsenic hot spot value set at 100 times the health based cleanup value of 0.39 mg/kg


## Table 4-2
Sediment Cleanup Levels and Hot Spot Concentrations (ug/kg)
Zidell Waterfront Property

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Recreational Fisher Cleanup Level</th>
<th>Benthic Biota Cleanup Level</th>
<th>Hot Spot Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aroclor 1254</td>
<td>2</td>
<td>NA</td>
<td>200</td>
</tr>
<tr>
<td>Aroclor 1260</td>
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<td>200</td>
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<tr>
<td>Benz(a)anthracene</td>
<td>211</td>
<td>NA</td>
<td>21,100</td>
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<tr>
<td>Benzo(b)fluoranthene</td>
<td>211</td>
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<td>21,100</td>
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<td>2,106,200</td>
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<td>Dibenz(a,h)anthracene</td>
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<td>NA</td>
<td>2,100</td>
</tr>
<tr>
<td>Indeno(1,2,3-c,d)pyrene</td>
<td>211</td>
<td>NA</td>
<td>21,100</td>
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<td>Antimony</td>
<td>NA</td>
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<td>1,280,000</td>
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<td>2,000</td>
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<td>486,000</td>
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<td>4,590,000</td>
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<td>6,760</td>
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<tr>
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<td>30</td>
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<td>Petroleum Hydrocarbons</td>
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<td>PECQ</td>
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<td>0.26</td>
<td>2.6</td>
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</tbody>
</table>

**NOTES:**

1. COCs and CECs for sediment (MFA, 2003a; MFA and EMS, 2003a).
2. Recreational fisher risk-based concentration (MFA and EMS, 2003a).
3. Reliable probable effect concentrations (MacDonald et al., 2000) were used as cleanup levels for all chemicals except antimony, mercury, and tributyltin. Mercury cleanup levels set at a threshold effects concentration (TEC) (Smith et al., 1996). Antimony cleanup levels were set at a upper effects threshold (UET, SquiRTs), and tributyltin cleanup levels were set at using a marine apparent effects threshold (AET) as a surrogate (SquiRTs) according to DEQ guidance.
4. Hot spot concentration set at 100 times the recreational fisher cleanup levels based on cancer effects, and 10 times the benthic biota cleanup levels.


**MFA and EMS. 2003a.** Memorandum (re: Establishment of Sediment Management Area, Zidell waterfront property, Portland, Oregon – Proposed Approach) to J. Anderson; Oregon Department of Environmental Quality, from A. St. John, Maul Foster & Alongi, Inc. and J. Peterson, Environmental Management Services, Inc. April 11.
# Table 4-3
## Estimated Soil Volumes Exceeding Cleanup Levels and Hot Spot Concentrations

**ZRZ Realty Company**  
**Zidell Waterfront Property**

<table>
<thead>
<tr>
<th></th>
<th>Cleanup Level Volume Summary in Cubic yards</th>
<th>Hot Spot Volume Summary in Cubic yards</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Greenway</td>
<td>Non-Greenway</td>
</tr>
<tr>
<td>Future Resident</td>
<td>132,000</td>
<td>550,000</td>
</tr>
<tr>
<td>Construction Worker</td>
<td>54,000*</td>
<td>96,800</td>
</tr>
<tr>
<td>Industrial Worker</td>
<td>--</td>
<td>276,000*</td>
</tr>
<tr>
<td>Recreationists</td>
<td>110,000*</td>
<td>--</td>
</tr>
<tr>
<td>Ecological Receptors</td>
<td>120,000</td>
<td>--</td>
</tr>
</tbody>
</table>

**NOTE:**  
*based on EVS calculation.  
**based on EVS visualization for lead.  
-- = not calculated.
### Table 4-4
Estimated Sediment Volumes Exceeding Cleanup Levels and Hot Spot Concentrations
ZRZ Realty Company
Zidell Waterfront Property

<table>
<thead>
<tr>
<th>Estimated Volume of Sediment at Cleanup Levels in Cubic Yards</th>
<th>Estimated Volume of Sediment at Hot Spot Levels in Cubic Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td>151,000</td>
<td>44,000</td>
</tr>
</tbody>
</table>
## Table 6-1
### Soil Alternatives Cost Summary
#### ZRZ Realty Company
#### Zidell Waterfront Property

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Description</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No Action</td>
<td>$0</td>
</tr>
<tr>
<td>2</td>
<td>Engineered Cap</td>
<td>$3,374,545</td>
</tr>
<tr>
<td>3</td>
<td>Engineered Cap with Greenway Hot Spot Excavation – On-Site Management</td>
<td>$3,906,474</td>
</tr>
<tr>
<td>4</td>
<td>Engineered Cap with Greenway Hot Spot Excavation – Off-Site Management</td>
<td>$4,105,918</td>
</tr>
<tr>
<td>5</td>
<td>Engineered Cap with Greenway and NonGreenway Hot Spot Excavation – On-Site Management</td>
<td>$4,049,408</td>
</tr>
<tr>
<td>6</td>
<td>Engineered Cap with Greenway and NonGreenway Hot Spot Excavation – Off-Site Management</td>
<td>$4,438,968</td>
</tr>
<tr>
<td>7</td>
<td>Excavate Soil to Cleanup Levels</td>
<td>$30,097,733</td>
</tr>
</tbody>
</table>
Table 6-2
Sediment Alternatives Cost Summary
ZRZ Realty Company
Zidell Waterfront Property

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Description</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No Action</td>
<td>$0</td>
</tr>
<tr>
<td>2</td>
<td>Partial Cap</td>
<td>$1,507,743</td>
</tr>
<tr>
<td>3</td>
<td>Full Cap</td>
<td>$2,024,519</td>
</tr>
<tr>
<td>4</td>
<td>Hotspot Dredging and Full Cap</td>
<td>$9,781,176</td>
</tr>
<tr>
<td>5</td>
<td>Full Dredging</td>
<td>$20,148,338</td>
</tr>
</tbody>
</table>
Base map prepared from DeLorme 3-D TopoQuads (1999). Site Location: 3121 SW Moody Avenue, Portland, Multnomah County, Oregon, Section 10, Township 1 South, Range 1 East of the Willamette Meridian.
Figure 3-1

SOIL, GROUNDWATER, AND SEDIMENT SAMPLE LOCATIONS

Vancouver: (360) 694-2691
Portland: (971) 544-2139

11/22/04
AJY
11/29/04
AREAS OF SOIL EXCEEDING CLEANUP LEVELS AND HOT SPOT CONCENTRATIONS

**NOTES:**
1) BASE MAP FROM EMCON, 1994 (DRAWING 3-1)
2) THESE AREAS ALSO EXCEED CONSTRUCTION WORKER CLEANUP LEVELS

**LEGEND:**
- SOIL BORING (EMCON)
- SOIL BORING (AGI TECHNOLOGIES)
- SURFACE SEGMNT SAMPLE (MAUL FOSTER & ALONGI, INC.)
- GEOPROBE (MAUL FOSTER & ALONGI, INC.)
- TEST PIT (EMCON)
- TEST PIT (AGI TECHNOLOGIES)
- TEST PIT (MAUL FOSTER & ALONGI, INC.)
- MONITORING WELL (AGI TECHNOLOGIES)
- MONITORING WELL (MAUL FOSTER & ALONGI, INC.)

**FUTURE PUBLIC RIGHT-OF-WAYS AND UTILITY CORRIDORS**

**Vancouver:** (360) 694-2691
**Portland:** (971) 544-2139

**Figure 4-1**

**ZRZ REALTY COMPANY**
**SW MOODY AVENUE**
**PORTLAND, OREGON**
AREAS OF SEDIMENT EXCEEDING CLEANUP LEVELS AND HOT SPOT CONCENTRATIONS

Figure 4-2

ZRZ REALTY COMPANY
SW MOODY AVENUE
PORTLAND, OREGON

LEGEND

- - - - - APPROXIMATE SITE BOUNDARY

Sediment Management Area

Estimated Extent of Sediment Exceeding Hot Spot Concentrations

NOTES
1. CONTROL ON GROUND BY CHACE, JONES & ASSOC., INC.
2. AERIAL MAPPING BY SPEICHER GROSS (FLIGHT DATE: 06/29/95)
3. DETAILED CITY OF PORTLAND BENCH MARK NO. 1514. ELEV. = 3618
4. STUDIED IN THE N.W. 1/4 SECTION 10, T 11 S, R 7 E, W.
5. BASE MAP FROM EMCON, 1985, DRAWING 3-7

Vancouver: (360) 694-2691
Portland: (971) 544-2139

MAUL FOSTER ALONGI INC.

DATE 11/22/04
DWN. 601
APPR. 11/22/04
REV.
PROJECT NO. 8014.01.11

Areas of Sediment Exceeding Cleanup Levels and Hot Spot Concentrations
NOTES:
1) CONTROL ON GROUND BY CHASE, JONES & ASSOC., INC.
2) AERIAL MAPPING BY SPENCER CROUS (FLIGHT DATE: 08/29/95)
3) DATUM: CITY OF PORTLAND BENCH MARK NO. 1514, ELEV. = 58.18
4) SITUATED IN THE N.W. 1/4 SECTION 10, T 15 S, R 7 E, W.M.
5) BASE MAP FROM DEQD, 1998, DRAWING 3-2
6) BATHOMETRY FROM CHASE, JONES AND ASSOCIATES, INC. HYDROGRAPHIC SURVEYS IN DECEMBER 1999 AND APRIL 2001, CITY OF PORTLAND DATUM

LEGEND:
- APPROXIMATE SITE BOUNDARY
- SEDIMENT MANAGEMENT AREA
- ROCK ARMORING
- EXTENT OF CAP

Vancouver: (360) 694-2691
Portland: (971) 544-2139

Figure 5-2
ZRZ REALTY COMPANY
SW MOODY AVENUE
PORTLAND, OREGON

SEEDMENT ALTERNATIVE 2

MAUL FOSTER ALONGI INC.

DATE: 11/01/04
DWN: 11/29/04
APPR: 11/01/04
REV: 11/29/04
PROJECT NO: 8014.01.11
NOTES:

1) CONTROL ON GROUND BY CHASE, JONES & ASSOC., INC.
2) AERIAL MAPPING BY SPENCER CROSS (FLIGHT DATE: 06/29/95)
3) DATUM: CITY OF PORTLAND BENCH MARK NO. 1514, ELAV. = 36.18
4) SITE LOCATED IN THE N.W. 1/4 SECTION 16, T 31 S, R 11 E, W.M.
5) BASE MAP FROM ENCIN, 1994, (DRAWING 3-3)
6) BATHYMETRY FROM CHASE, JONES AND ASSOCIATES, INC. HYDROGRAPHIC SURVEYS IN DECEMBER 1999 AND APRIL 2001, CITY OF PORTLAND DATUM

Figure 5-3
SZR REALTY COMPANY
SW MOODY AVENUE
PORTLAND, OREGON

SEDIMENT ALTERNATIVE 3