PH: T4 Slip 3

Oregon

Theodore Kulongoski, Governor

Department of Environmental Quality
Northwest Region Portland Office
2020 SW 4th Avenue, Suite 400
Portland, OR 97201-4987
(503) 229-5263
FAX (503) 229-6945
TTY (503) 229-5471

April 21, 2003

Ms. Anne Summers
Environmental Program Manager
Port of Portland
Box 3529
Portland, OR 97208

RE: Record of Decision,
Port of Portland, Terminal 4, Slip 3 Upland
ECSI # 272

Dear Ms. Summers:

Attached is a copy of the Record of Decision (ROD) for the Port of Portland Terminal 4, Slip 3 Upland Facility. Comments on the Staff Report provided by the Port and Lower Willamette Group were incorporated into the ROD as indicated in our March 31, 2003 Response to Comments. The ROD was signed by Neil Mullane, the Department of Environmental Quality's (DEQ) Northwest Region Division Administrator, on April 16, 2003.

We are making revisions to the draft Remedial Design/Remedial Action Consent Decree and are preparing a Scope of Work, and will submit those to you in the next few days. We look forward to continuing our successful working relationship with the Port as the site progresses through implementation of the selected remedy.

If you would like to discuss the ROD, please call me at 503-229-5502.

Sincerely,

Thomas E. Roick, Project Manager
Cleanup & Portland Harbor

Enclosure: ROD

cc: Don Pettit / Tom Gainer / Jim Anderson / Fenix Grange/ Mike Rosen, DEQ NWR
Kurt Burkholder, Department of Justice
David Ashton, Port of Portland
Tara Martich, EPA
Chip Humphrey, EPA
Barbara Inyan, Nez Perce Tribe
Helen Hillman, NOAA
Bob Wyatt, Lower Willamette Group
Herb Clough, Hart Crowser

REMEDIAL ACTION

RECORD OF DECISION

For

PORT OF PORTLAND - TERMINAL 4, SLIP 3 UPLAND

MULTNOMAH COUNTY, OREGON

Prepared by

Oregon Department of Environmental Quality

April 2003

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For

PORT OF PORTLAND – TERMINAL 4, SLIP 3 UPLAND

1.0 INTRODUCTION AND PURPOSE

1.1 Introduction

This document presents the selected remedial action for the Port of Portland Terminal 4, Slip 3 Upland Facility (T4/Slip 3). The Terminal 4 Slip 3 Upland Facility occupies approximately 50 acres of the Port of Portland's Terminal 4 in Portland, Oregon, as depicted in Attachment A to the DEQ-Port Voluntary Cleanup Program Agreement for Feasibility Study, DEQ No. LQVC-NWR-02-11. The Terminal 4 Slip 3 Upland Facility is located within the Portland Harbor Superfund Site, but excludes other adjoining property at Terminal 4 owned by the Port or any property at Terminal 4 under investigation or remediation by someone else, such as the Union Pacific Railroad St. Johns Tank Farm facility, Environmental Cleanup Site Information No. 2017.

A Staff Report summarizing the recommended remedial action was finalized on January 27, 2003 and made available for public comment on March 1, 2003. The selected remedial action was chosen in accordance with Oregon Revised Statutes (ORS) 465.200 through 465.325, and Oregon Administrative Rules (OAR) 340-122-0090 through 340-122-0115. The selected remedial action is based on the administrative record for this site. A copy of the administrative record index is attached as Appendix A. This Record of Decision (ROD) summarizes more detailed information provided in the January 21, 2000 *Remedial Investigation Report*, the October 18, 2000 *Human Health and Ecological Baseline Risk Assessment*, and the July 5, 2002 *Feasibility Study Report* prepared by Hart Crowser on behalf of the Port of Portland. The Oregon Department of Environmental Quality (DEQ) provided oversight for this work through Intergovernmental Agreement No. WMCVC-NWR-98-06 and subsequent Voluntary Agreement for Feasibility Study No. LQVC-NWR-02-11.

1.2 Summary of the Selected Remedial Action

The remedial action objectives and selected remedy for each objective are listed below and described in more detail in Section 6 of this ROD.

The remedial action objectives are to: (1) prevent human exposure to surface soil which contains petroleum hydrocarbons above acceptable risk levels in the former Quaker State tank farm area; (2) achieve source control to prevent petroleum hydrocarbon migration from the T4 Slip 3 Upland Facility to the Willamette River at concentrations that could adversely affect beneficial uses; and (3) identify residual petroleum hydrocarbon contaminated areas for tenants, site contractors and others, and ensure proper management of any contaminated soil or groundwater excavated or removed in the future.

The selected remedy consists of: (1) removal and off-site disposal of shallow soil in the former Quaker State tank farm area; (2) groundwater pumping to remove light non-aqueous phase liquid (LNAPL) associated with the diesel fuel pipeline release, evaluation of dual-phase (vacuum enhanced) LNAPL extraction, removal and off-site disposal of contaminated soil at the Slip 3 riverbank, and groundwater monitoring; and (3) an institutional control which identifies residual petroleum hydrocarbon contaminated areas in the T4 Slip 3 Uplands Facility and the need for appropriate contaminated soil or groundwater management.

The selected remedy is intended to be the final action for the T4/Slip 3 Upland, contingent upon these measures being consistent with future criteria that may be approved by the U.S. Environmental Protection Agency (EPA) for sediments and surface water at the Portland Harbor site. The selected remedy does not address existing contamination in sediments of Slip 3, which is part of the EPA Portland Harbor investigation.

1.3 Cultural and Archaeological Resources

During subsurface investigation and remedial activities, the Port is responsible for taking appropriate action to ensure compliance with any applicable state and federal laws regarding the protection of cultural resources. These laws may include:

- National Historic Preservation Act of 1966,16 USC 470 et seq.,
- the Archeological Resources Protection Act, 16 USC 470aa et seq.,
- the Native American Graves Protection and Repatriation Act of 1990, 25 USC 3001 et seq.,
- Oregon Laws Protecting Indian Graves, ORS 97.740 et seq., or
- Archeological Site Permit Requirements, ORS 358.905 et seq.

Cultural resources can include archeological and historical resources such as ceremonial artifacts, traditional cultural properties, objects at burial sites, or human remains. While DEQ does not administer or enforce federal or state laws regarding cultural and archeological resources, the Port has undertaken and proposes to undertake measures to ensure substantive compliance with these laws. The Port's proposed actions include a National Historic Preservation Act cultural resources reconnaissance for an area including the T4/Slip 3 Uplands Facility. Tribes and the State Historic Preservation Office were provided further opportunity to comment on this aspect of the Port's work through DEQ's providing public notice and opportunity to comment on the Staff Report.

2.0 SITE DESCRIPTION AND HISTORY

2.1 Site Setting

The T4/Slip 3 Upland Facility is surrounded by the larger Port of Portland Marine Terminal 4 at 11040 North Lombard Street in Portland, Oregon (Figures 1 and 2). Terminal 4 is located along the east bank of the Willamette River, near river mile 5 in the Portland Harbor area of the Willamette River. Terminal 4 lies within the St. Johns area of North Portland on land zoned for industrial use. The areas surrounding Terminal 4 are occupied by marine, industrial, and commercial operations. A small residential area is located about 200 feet east of the T4/Slip 3 site.

T4/Slip 3 and the associated former petroleum handling facilities (Figures 2 and 3) subject of this Staff Report are bounded by other Terminal 4 facilities: on the north by Slip 3 and Kinder Morgan (formerly Hall-Buck Marine), on the west by the Willamette River, on the south by the Toyota Automobile Receiving Area, and on the east by the former Union Pacific Railroad (UPRR) St. Johns tank farm facility. T4/Slip 3 includes ship-berthing areas 410, 411 and former Berth 412. While the Upland includes the docks and shoreline at the berths, it excludes the in-water portion of Slip 3.

2.2 Site Geology and Hydrogeology

Terminal 4 is generally flat at an average elevation of about 35 feet above mean sea level (MSL). Immediately east of the T4/Slip 3 site, the ground surface rises at about a 15 percent grade to a bluff at an elevation of about 100 feet. At the depths explored during site investigation activities, site geology consists of two primary units beneath the site, a dredge fill unit underlain by recent alluvial deposits.

- The Fill unit is dredge material consisting of brown, medium-grained sand. The fill ranges in thickness from more than 40 feet in the western portion of the site to less than 5 feet thick at the eastern boundary of the site where the site grade rises.

- The Alluvial unit consists primarily of gray to brown, generally well-sorted silts and sandy silts, and fine-grained sands, with discontinuous lenses of clays and pebble-sized gravels. Based on adjacent site data, the Alluvial deposits are locally about 80 feet thick and are underlain by the Troutdale Formation.

Groundwater at the site typically ranges from 12 to 20 feet below ground surface (bgs). Shallow groundwater flow is generally west or northwest, towards Slip 3 and the Willamette River. Monitoring well data suggest an upward vertical groundwater gradient between the shallow and deeper water-bearing zones beneath the site.

2.3 Land and Water Uses

Current site use is marine and heavy industrial. Reasonably likely future land use in the area is similarly industrial, based on zoning, the City of Portland's comprehensive plan, and existing and planned business developments.

Shallow groundwater beneath the site discharges to the adjacent Willamette River. Potential impacts to beneficial uses of the river are the primary concern of the Upland RI/FS. The Port conducted a beneficial water use determination for the facility that indicates future beneficial use of shallow groundwater is limited to surface water recharge. On-site use of shallow groundwater, including drinking water use, is not reasonably likely. Deeper aquifers (beneath the Alluvial Unit in the Troutdale Formation) have been used in the site locality for industrial process water. Although the deeper aquifer is of a quality suitable for drinking water, area properties are connected to the municipal water supply system and rely on this system for drinking water.

2.4 Site History and Releases

2.4.1 Facility Development

UPRR owned and operated the T4/Slip 3 facility as early as 1906. The City of Portland's Commission of Public Docks (Commission) purchased the property from UPRR in 1917 and began the initial development of Terminal 4 with the construction of piers served by Slip 1. Construction of a pier served by Slip 3 followed shortly thereafter. In 1920, the Commission acquired a five-acre parcel adjoining the Slip 3 pier from UPRR. A petroleum pipeline and fuel oil dock were not included in the purchase. The Commission granted to UPRR an easement for the continued use of the pipeline and dock. The Commission merged with the Port of Portland (Port) in 1971.

The site is currently paved with asphalt. Buildings include two warehouses (No. 5 and No. 7); the Hall-Buck Marine facility, which operates bulk handling at Berths 410 and 411; and the former Quaker State tank farm and Gearlocker facility (Figure 3). Berth 412 was removed in 1997. The berthing areas have historically been used for bulk cargo loading and unloading of diesel and oil; pencil pitch; soda ash; talc; iron, lead, zinc and copper ores; bentonite clay; coke; and briquettes. Handling of pencil pitch was discontinued in 1998. Only soda ash is currently loaded at Slip 3.

2.4.2 Quaker State Oil Operations

From 1953 to 1985, Quaker State operated an oil canning facility immediately east of Slip 3. Oil was off-loaded from ships at the Slip through a pipeline to above ground storage tanks (ASTs) within the concrete containment area at the Quaker State facility. Oil was packaged east of the ASTs at the former Quaker State canning facility (Gearlocker). The ASTs were removed in 1985. The abandoned underground oil pipeline was also removed (Figure 3).

2.4.3 Pipeline Operations

A 10-inch diameter steel pipeline was used by UPRR to transfer diesel, No. 6 fuel, and Bunker C oil from marine vessels at Slip 3 to bulk storage tanks located east of the Site at the UPRR St. Johns tank farm (Figure 3). The fuel was then loaded from the bulk storage tanks into railcars at a railcar loading area along the eastern boundary of T4/Slip 3. The facility and associated pipelines were leased and operated by Chevron from 1969 to 1983. Petroleum transfer and storage operations ceased in 1983. In 1997, as part of a wharf removal project at Berth 412, the Port drained and removed the under-dock portions of the pipeline. In June 1998, the Port drained, cleaned and/or removed subsurface portions of the pipeline.

2.5 Previous Environmental Investigations

A seep of petroleum hydrocarbons was first observed at former Berth 412 in 1970. Initial attempts to address the seep consisted primarily of replacing leaking sections of the active pipeline (Figure 3). The northern, oldest section of pipeline was used until about 1971, after which the southern section of pipeline was used. Although no longer in service, the northern section was not formally abandoned at that time. A second seep was observed at the east end of Slip 3 in 1991. Since 1991, site investigations or attempts to control the petroleum seeps have been conducted at different times by Quaker State, Chevron, UPRR and most recently, the Port. These actions included pipeline product removal and decommissioning; trenching, oil and sorbent boom placement along the Slip 3 riverbank; and product recovery from wells within the riverbank. In May and June 1998 the Port removed sections of the northern pipeline to determine the number and location of historical pipeline leaks. Soil samples were collected from along the pipeline (samples S-1 through S-70) and about 1,000 gallons of diesel product were removed from the westernmost portion of the main pipeline. Field observations and analytical data indicated the presence of petroleum hydrocarbons and potential source areas in the pipeline excavation north of Warehouses No. 5 and No. 7 (Figure 4). Despite these efforts, a plume of petroleum light non-aqueous phase liquid (LNAPL) remains in the Upland subsurface, acting as a continuous source of petroleum hydrocarbon contamination to Slip 3.

Previous Upland investigation and remedial activities not associated with the pipeline releases included underground storage tank (UST) decommissioning at the former Quaker State/Gearlocker facility in 1991 and 1996. Three USTs containing waste oil, diesel, and gasoline, respectively, were excavated and removed from the site. During that work about 12 tons of petroleum hydrocarbon-contaminated soil were excavated and transported off-site for disposal.

In January 1998, DEQ issued a draft Preliminary Assessment for Terminal 4. Subsequently, the Port submitted the T4/Slip 3 site for eligibility in DEQs' Voluntary Cleanup Program and agreed to perform a T4/Slip 3 Remedial Investigation and Feasibility Study (RI/FS). The RI was conducted in two phases, one for sediments within Slip 3 and one for the Upland area. This ROD summarizes the Upland RI/FS.

2.6 Recent Interim Action

The Port of Portland began startup of an interim action system in May 1999 at the Slip 3 riverbank. The purpose of the system was to limit the migration of LNAPL to Slip 3. The interim action was a dual-phase extraction system consisting of pumping soil vapor, free-phase liquid petroleum hydrocarbons and groundwater containing dissolved-phase petroleum hydrocarbons from three wells (MW-1, MW-2 and MW-3) located immediately upgradient of the seep at Slip 3. As of July 31, 2001 about 270,000 gallons of water containing petroleum hydrocarbons had been treated and discharged to the Willamette River under a National Pollutant Discharge Elimination System (NPDES) permit. Additional activities included the maintenance of containment and sorbent boom at the seep and the bailing of NAPL from Upland groundwater monitoring wells. The effectiveness of the interim action was limited and the system is not currently operating. Effectiveness of the system was limited by several factors which include the following.

- LNAPL recovery was attempted using existing wells between Slip 3 and the LNAPL plume, and relied primarily on the natural groundwater transport of LNAPL to the vicinity of the wells. Because the remaining petroleum hydrocarbons are relatively immobile, little LNAPL removal could be achieved.
- The shallow depth of the existing wells limited the drawdown (and therefore capture radius) of the wells.
- Residual hydrocarbons within the riverbank between the recovery wells and Slip 3 contribute to sheen on the surface water of the slip, despite the recovery of upgradient LNAPL.

3.0 REMEDIAL INVESTIGATION SUMMARY

3.1 Nature and Extent of Contamination

Investigations were conducted in three general areas: (1) Hall-Buck and Quaker State/Gearlocker facilities, (2) pipelines between the former UPRR facility and the western site boundary, and (3) the former UPRR railcar loading area at the east boundary of the site (Figure 4). Between 1991 and 1998, site work was conducted by Hahn and Associates (Gearlocker waste oil UST decommissioning), Century West Engineering (UPRR pipeline, Slip 3 oil seep, former waste oil UST and groundwater monitoring investigations), GeoEngineers (Gearlocker diesel and gasoline UST decommissioning), Kennedy /Jenks Consultants (Quaker State site investigation), Pacific Environmental Group (UPRR pipeline, Quaker State/Gearlocker and seep area site investigations), and Hart Crowser (northern pipeline investigation, excavation and removal).

In 1998 the Port implemented a comprehensive remedial investigation with DEQ oversight to supplement the existing work noted above and complete the site characterization. Thirty-three Geoprobe borings were completed by Hart Crowser. The borings were completed to depths ranging from 20 feet to 40 feet below ground surface (bgs), sufficient to collect groundwater samples and to assess the vertical extent of soil contamination. Seventeen groundwater monitoring wells (HC-1 through HC-14), including three shallow/deep well clusters (HC-4S/D, HC-6S/D, HC-12S/D), were installed at the Site in 1998. Well depths ranged from 20 feet to 45 feet bgs.

Shallow soil contamination was found only within the former Quaker State facility and at the former UPRR railcar loading area, presumably from surface releases in those areas. The areal extent of surface soil contamination at the former Quaker State tank farm is limited by the concrete containment wall of the former tank farm, which is still present at the site (Figure 4). Contamination at the former UPRR railcar loading area was generally defined on Port property by borings west of the rail lines and will be further defined by UPRR through additional investigation of the associated UPRR St. Johns tank farm site.

Subsurface soil contamination is generally located at two areas along the northern section of pipeline, and at the former railcar loading area (Figure 5). The highest concentration of diesel range petroleum hydrocarbons was 61,000 mg/kg in soil adjacent to the northern pipeline at IB-30, 16.5 feet bgs. The subsurface pipelines from UPRR to Slip 3 were approximately 4 feet bgs, resulting in releases and associated soil contamination starting at a depth of about 4 feet bgs (Figures 5 and 7). An LNAPL plume has been observed along the northern section of pipeline from MW-15, north of Warehouse No. 7, extending to the Slip 3 riverbank (Figures 6 through 9). LNAPL has been measured at up to 13.38 feet thick in the well casing of MW-19 with lesser thicknesses in surrounding wells. LNAPL extends vertically to approximately the top of the alluvial unit (Figure 9).

3.2 Contaminant Fate and Transport

Contaminant transport occurred primarily in the fill materials from depths of approximately 5 to 40 feet, east to west across the site. Silts within the underlying native alluvium and shallow groundwater appear to have inhibited vertical migration. Dissolved-phase groundwater contamination has been detected primarily adjacent to and in association with the LNAPL plume.

Diesel was the primary product released and is made up of predominantly middle-range petroleum hydrocarbons. Attenuation mechanisms, occurring since the original pipeline releases approximately 20 to 30 years ago, favor degradation of the lighter distillates in diesel. Consequently, the remaining hydrocarbons are heavier and less likely to degrade than the original product, and the rate of natural attenuation will slow with time. The heavier fraction hydrocarbons are less soluble, less volatile, and less mobile than the original product. Chemical data and field observations at T4/Slip 3 are consistent with this model. For example, the lack of volatile organic compounds such as benzene in groundwater is indicative of the loss of lighter fractions, and a noted decrease in the seep at Slip 3 is indicative of a reduction in contaminant mobility. Based on the type of release, age, and degradation processes, it is expected that natural attenuation (or movement of the LNAPL plume) has slowed and will not be a significant factor in additional contaminant reduction over a reasonable time period.

3.3 Human Health Risk Assessment

A deterministic human health risk assessment (RA) was performed as part of the RI to evaluate existing and reasonably likely future risks to human health and potential ecological receptors. The baseline human health risk assessment assumes no action to control or mitigate releases.

The contaminants of concern (COCs) are oil range total petroleum hydrocarbons (TPH) at the former Quaker State facility, diesel and heavier fuel oil range TPH from the underground pipeline releases and railcar loading, and associated carcinogenic and non-carcinogenic polynuclear aromatic hydrocarbons (PAHs). TPH was evaluated qualitatively and based on the PAH constituents, for which toxicity can be quantified. Volatile organic compounds (VOCs), including benzene, toluene, ethylbenzene and xylenes, and metals were analyzed and screened out because they were either not detected, or had concentrations below risk-based screening values.

Consistent with the identified current and reasonably likely future land uses, the industrial worker and utility (trench) worker exposure scenarios were used for evaluating risk from current and reasonably likely exposures to soil at the site. No complete shallow groundwater exposure pathways were identified. This is because other than recharge to surface waters no reasonably likely future on-site use of shallow groundwater was identified, the depth to groundwater (12 to 20 feet) is below a typical excavation worker scenario, and the lack of VOCs limits potential risks through inhalation exposure. Therefore, potential groundwater exposure was not carried forward in the detailed risk assessment for the site.

Only one PAH in soil exceeded the acceptable risk levels defined by OAR 340-122-0115. Benzo(a)pyrene had a reasonable maximum exposure (RME) of $2x10^{-5}$ excess cancer risk for an industrial worker (Table 1). Total cancer risk for the sum of PAHs was also $2x10^{-5}$ for an industrial worker. All other COCs and exposure scenarios were below both cancer and non-cancer acceptable risk levels (Tables 1 and 2). The maximum detected PAH concentrations were in sample HC-SS-04, collected from the 0-1 foot depth within the former Quaker State tank farm. Risk estimates calculated without this single sample resulted in a revised risk for benzo(a)pyrene of $9x10^{-7}$ and cumulative carcinogenic risk of $1x10^{-6}$, both within acceptable risk levels (Tables 3 and 4). Although an unacceptable risk was not identified for TPH related to the pipeline releases, high TPH concentrations in soil warrant notice and appropriate management during any future subsurface construction or utility activities.

3.4 Ecological Risk Assessment

As part of the RI, the Port completed a Level I Scoping Ecological Risk Assessment for T4/Slip 3. Terminal 4 is covered by asphalt and buildings, with only small, weedy vegetated areas between buildings and along the former railcar loading area. The terminal provides very poor habitat, limiting exposure for terrestrial ecological receptors. Chemicals of potential concern were screened by comparison to the lowest of DEQ's ecological screening benchmark values from the 1998 Guidance for Ecological Risk Assessment (Table 5). Only naphthalene in one sample (HC-SS-06) at 49 mg/kg exceeded the screening level for plants of 10 mg/kg. Screening levels for invertebrates, birds and mammals were not exceeded. Additionally, no threatened or endangered species are known to inhabit the Upland area.

Site contaminants in groundwater have impacted surface water and sediments in Slip 3 as indicated by petroleum seeps and sheens on surface water within the slip, observed periodically since 1970. Bioassays conducted for the sediment investigation in 1998 showed toxicity to the test species exposed to sediments collected at several locations within Slip 3. Sediment toxicity appears to be correlated at least in part to diesel-range petroleum hydrocarbons from the Upland area. Therefore, Upland contamination poses a risk to ecological receptors through the groundwater to surface water migration pathway.

Based on the results of the risk assessment, DEQ determined that a Feasibility Study should be performed to evaluate remedies for human health risk from soil in the former Quaker State tank farm and ecological risk from groundwater contaminant migration to the Willamette River.

3.5 Hot Spot Evaluation

Hot spots, as defined by OAR 340-122-0115(31), were evaluated in the FS. LNAPL at the site is considered a hot spot because it is reasonably likely to migrate and adversely affect beneficial uses of adjacent surface waters. Groundwater is a hot spot only in the immediate vicinity of the LNAPL plume, where dissolved-phase contamination is present that could migrate to the Willamette River. Both LNAPL and associated groundwater contamination can be treated in a reasonable time to protect beneficial uses of adjacent surface waters.

Contaminant concentrations in soil are below risk levels that would constitute a hot spot and, with the exception of LNAPL, are not likely to migrate. Therefore soil at the site is not considered a hot spot.

4.0 DESCRIPTION OF REMEDIAL ACTION ALTERNATIVES

4.1 Remedial Action Objectives

The remedial action objectives are to:

- Prevent human exposure to soil which contains PAHs above acceptable risk levels in the former Quaker State tank farm area of the T4 Slip 3 Upland Facility;

- Achieve source control to prevent petroleum hydrocarbon migration from the T4 Slip 3 Upland Facility to the Willamette River at concentrations that could adversely affect beneficial uses; and

- Identify residual TPH contaminated areas for tenants, site contractors and others, and ensure proper management of any contaminated soil or groundwater excavated or removed in the future.

The potential for beneficial uses of the Willamette River to be impacted by site contaminants will be gauged by comparison of groundwater concentrations to existing surface water screening levels. The Level II Screening Level Values from DEQ's Guidance for Ecological Risk Assessment (DEQ April 1998/December 2001) or other applicable numeric standards approved by DEQ will be used. Narrative water quality standards, such as objectionable oily sleek (sheen), would also be applied for surface water. The Port anticipates that upon completion of the LNAPL removal, dissolved-phase groundwater contamination will have been reduced to below surface water screening levels.

4.2 Remedial Alternatives Development and Screening

All alternatives, with the exception of no action, include excavation of approximately 120 cubic yards of PAH-contaminated surface soil in the former Quaker State tank farm (a removal action) to address human health risk. The alternatives screening pertains only to the remediation of contaminated media impacting beneficial water uses. Alternative technologies associated with a variety of general response actions were screened in the FS, focusing on LNAPL as the primary media of concern (Table 6). The shaded technologies on Table 6 were eliminated from further consideration based on the rationale noted in the table, and the remaining technologies were carried forward in the evaluation (Table 7). Those technologies that were carried forward were combined into Alternatives A through K.

4.2.1 Alternative A - No Action

The no action alternative is included in the FS for comparison. The no action alternative assumes no action is taken. Petroleum hydrocarbons would remain at the site above acceptable risk levels.

4.2.2 Alternative B – Off-site Landfill Disposal of Soil

This alternative includes demolition of site buildings in the LNAPL contaminated area and the excavation, loading and hauling of contaminated soil to a Subtitle D solid waste landfill. Approximately 55,000 cubic yards (82,500 tons) of material would be excavated including clean overburden soil. Of the 55,000 cubic yards excavated, approximately 30,000 cubic yards (45,000 tons) would be disposed of off-site as contaminated material. The remainder of the soil would be replaced in the excavation as clean fill. Contaminated groundwater would be pumped from the exposed excavation prior to backfilling. Collected LNAPL and groundwater would be separated, the LNAPL taken to a recycling facility, and the groundwater treated and discharged to the Willamette River. Approximately six wells would be installed for compliance monitoring.

4.2.3 Alternative C – Soil Landfarming

This alternative includes all the components of Alternative B above; however, contaminated soil would be biologically treated on-site in lined treatment cells rather than disposed of off-site.

4.2.4 *Alternative D – Soil Treatment by Thermal Desorption*

This alternative includes all the components of Alternatives B and C above; however, contaminated soil would be transported to a permitted thermal desorption facility and returned to the excavation after treatment.

4.2.5 *Alternative E – Well Pumping*

For this alternative, groundwater extraction wells would be installed in the LNAPL source area. Downhole pumps would be used to extract LNAPL and contaminated groundwater for on-site separation and groundwater treatment. Groundwater pumping will create a zone of depression around each well in the source area, inhibiting further migration of petroleum to Slip 3. Soil within the Slip 3 riverbank would contain residual TPH that would act as an ongoing source of contamination to the river, regardless of upgradient source control measures. Therefore, an estimated 2,800 cubic yards (4,200 tons) of soil with residual petroleum hydrocarbons along the riverbank would be excavated for off-site disposal. Some of the limitations of the most recent interim action (pumping of wells within the riverbank) would be addressed by placing extraction wells throughout the LNAPL plume, installing wells at a deeper interval to allow greater drawdown, and removing residual soil adjacent to the ongoing sheen in the slip.

4.2.6 *Alternative F – Dual Phase Extraction*

This alternative would consist of the Alternative E elements above, but would include vacuum extraction at each well to remove soil vapors and enhance the effectiveness of pumping. Applying a vacuum potentially reduces the groundwater pumping zone of depression needed for mobilizing LNAPL to each well. The relative performance of vacuum enhanced pumping versus pumping alone would be evaluated by aquifer and pump testing during remedial design.

4.2.7 *Alternative G – Cut-off Wall*

This alternative would consist of removing approximately 1,500 cubic yards (2,250 tons) of contaminated soil at the riverbank seep, and installing interlocking sheet piles as a physical hydraulic barrier to stop LNAPL migration. Sheet piles would be driven into the Alluvial unit to a depth of about 30 feet bgs. The length of the wall would be about 1,200 feet. Because source area contamination would not be significantly reduced, petroleum in shallow groundwater would pose an ongoing threat to deeper aquifer units that have potential beneficial uses. To address this concern, three monitoring wells would be installed at the site in the deeper aquifer units to monitor potential vertical migration of contamination. Groundwater monitoring would be necessary indefinitely (the FS assumed 30 years).

4.2.8 *Alternative H – Hydraulic Containment*

This alternative includes riverbank soil removal as described in Alternative G above. However, rather than a cut-off wall, groundwater extraction wells would be installed near the downgradient edge of the LNAPL source area to prevent LNAPL from migrating to the slip. Downhole pumps would be used to extract LNAPL and contaminated groundwater for on-site separation and groundwater treatment. Mobile LNAPL would migrate to the extraction wells. Eventually, mobile LNAPL would no longer be present and the system could be shut down (10 to 15 years based on modeling in the FS). Less mobile NAPL would remain and may require long-term monitoring (30 years assumed in the FS).

4.2.9 *Alternative I – Cut-off Wall Combined with Limited Pumping*

This alternative would include soil excavation at the riverbank, cut-off wall installation, and use of three existing wells at the riverbank to extract LNAPL and groundwater. With a cut-off wall, the existing wells would be sufficient to prevent migration of LNAPL to the slip.

4.2.10 *Alternative J – Thermally Enhanced Soil Vapor Extraction*

In addition to soil removal at the riverbank, this alternative would include hot air/steam injection into the LNAPL zone to volatilize contaminants. An estimated 19 vapor extraction wells would be installed above the contaminated zone and a vacuum applied to the extraction wells to remove vapors. Treatment of the vapors would be required before release to the atmosphere. Cleanup is estimated to be achieved in 6 months to 1 year. Post-cleanup groundwater monitoring would be necessary for approximately 2 years.

4.2.11 *Alternative K– In situ Chemical Treatment*

In addition to soil removal at the riverbank, this alternative would include the injection of an oxidizing agent (e.g., hydrogen peroxide) into the contaminated zone. The oxidizing agent would chemically break down LNAPL. Six wells would be installed after treatment to monitor for the presence of LNAPL in the treated area. Additional post-cleanup groundwater monitoring would be conducted for approximately 2 years.

5.0 EVALUATION OF THE REMEDIAL ACTION ALTERNATIVES

OAR 340-122-0090 specifies that the Director shall select or approve a remedial action that:

a) is protective of present and future public health, safety and welfare and of the environment;

b) balances remedy selection factors, specifically effectiveness, long-term reliability, implementability, implementation risk, and reasonableness of cost; and

c) treats hot spots of contamination in water to the extent feasible, or treats or excavates hot spots in media other than water.

The remedial alternatives were evaluated in accordance with these criteria. In order to evaluate the balancing factors, each alternative was scored relative to every other alternative as more favorable (+), equal to (0) or less favorable (-). The scores were summed and the alternatives ranked #1-11 from the highest to the lowest score (Table 9). Although not reflected in the tables, Oregon Revised Statutes [ORS 465.315(1)(d)(E)] state that where two or more remedial alternatives are protective, the least expensive alternative shall be preferred, unless the additional cost of a more expensive remedial action alternative is justified by proportionately greater benefits. The evaluation is subject to a preference for treatment of hot spots of contamination.

5.1 Protectiveness

OAR 340-122-0040 requires that remedial actions be implemented to achieve the acceptable risk levels for human health and ecological receptors. Subject to the preference for treatment of hot spots, a remedial action may achieve protection through treatment, excavation and off-site disposal, engineering controls (e.g., capping), institutional controls (e.g., deed restrictions), and any other methods of protection or combinations of methods. The protective criterion is pass/fail.

All of the alternatives are considered protective except no action and possibly the cut-off wall. No action would not address potential human health or ecological risk, and the cut-off wall may not prevent migration of LNAPL around the wall. In all the alternatives except no action, removal of surface soil (about 120 cubic yards) at the former Quaker State tank farm would be conducted to reduce individual carcinogenic excess cancer risk to less than or equal to 1×10^{-6}, cumulative excess cancer risk to less than or equal to 1×10^{-5}, and a Hazard Index [HI] less than or equal to 1 for non-carcinogenic compounds. In all of the alternatives except no action and possibly the cut-off wall, pipeline area contamination would be treated or contained to prevent further impacts to beneficial uses of the Willamette River.

5.2 Balancing Factors

5.2.1 Effectiveness

OAR 340-122-0090(3)(a) requires that remedial action alternatives be assessed for effectiveness in achieving protection by considering, as appropriate: the magnitude of risk from untreated waste or contaminants; the adequacy of engineering and institutional controls necessary to manage the residual risk; the extent to which the remedial action restores or protects existing and reasonably likely future beneficial uses of water; the adequacy of treatment technologies; the time until remedial action objectives are achieved; and any other relevant information.

Alternatives which remove and treat contaminated material, such as off-site landfill disposal and soil treatment by thermal desorption are generally more effective than in situ treatment or containment, such as soil vapor extraction or a cut-off wall combined with limited pumping. However, the cut-off wall ranked equal to landfill disposal and thermal treatment in the FS because the time required to complete the remedial action (limiting LNAPL migration to the River) would be the shortest. No action is the least effective alternative.

5.2.2 Long-Term Reliability

OAR 340-122-0090(3)(b) specifies that each remedial action alternative be assessed for its long-term reliability by considering, as appropriate: the reliability of the treatment technologies in meeting treatment objectives; the reliability of engineering and institutional controls necessary to manage residual risk, including enforceability over time; the nature, degree, and certainties or uncertainties of any necessary long-term management; and other relevant information.

Alternatives that permanently treat the contamination, such as thermally enhanced soil vapor extraction, rank highest. Groundwater/LNAPL extraction alternatives ranked next because only the mobile fraction can be recovered and long-term operation and maintenance are required.

Containment alternatives are less reliable, with the cut-off wall the lowest ranked. No action is the least reliable of all the alternatives.

5.2.3 *Implementability*

OAR 340-122-0090(3)(c) requires that each remedial action alternative be assessed for the ease or difficulty of implementation by considering, as appropriate: the practical, technical, and legal difficulties and unknowns associated with the construction and implementation of a technology, engineering control, or institutional control including potential schedule delays; the ability to monitor the effectiveness of the remedy; consistency with federal, state, and local requirements; activities needed to coordinate with other agencies; ability and time needed to obtain necessary authorization from other government bodies; availability of necessary services, materials, equipment, disposal facilities; and any other relevant information.

The no action alternative is the easiest to implement, followed by the cut-off wall which uses standard construction techniques. Excavation with off-site treatment or disposal ranked similar to groundwater/LNAPL pumping. Excavation alternatives require some building demolition, while pumping requires pilot testing to verify design criteria. In situ treatment alternatives are less implementable because they require more sophisticated technologies and pilot testing. Soil landfarming was ranked the least implementable because of the logistics of conducting excavation during seasonally low water levels and subsequently treating during warm, summer months. The Port will meet substantive requirements of state and local permits and will obtain federal permits or otherwise comply with applicable federal laws for each component of the remedy. The necessity to meet substantive requirements or obtain permits for in-water (riverbank) work and the time required for compliance with applicable laws might affect the implementation schedule for the in-water portion of the remedy.

5.2.4 *Implementation Risk*

OAR 340-122-0090(3)(d) specifies that each remedial action alternative be assessed for implementation risks by considering as appropriate the potential impacts to the community, workers, and the environment, and the effectiveness and reliability of protective or mitigative measures to reduce these risks; the time until the remedial action is complete; and any other relevant information.

There is no implementation risk for the no action alternative. The cut-off wall ranked next because it is entirely on-site and does not expose workers to contamination. Excavation ranked next. Pumping alternatives include long-term discharge of treated water and carry increased risk of an unacceptable discharge to the river. The highest risk (lowest ranked) alternatives are the in-situ treatment alternatives which have significant risk to workers during implementation.

5.2.5 *Reasonableness of Cost*

OAR 340-122-0090(3)(e) requires that each remedial action alternative be assessed for the reasonableness of the cost of the remedial action by considering, as appropriate: the net present value of the cost of the remedial action; the degree to which the costs of the remedial action are proportionate to the benefits to human health and the environment through risk reduction or risk management; preference for treatment of hot spots of contamination; the degree of sensitivity or uncertainty of the costs; and any other relevant information.

The estimated cost of each alternative is presented in Table 8. There is no cost associated with the no action alternative. Well Pumping is estimated at $1,030,000. In situ chemical treatment is the most costly at an estimated $2,790,000.

5.3 Treatment of Hot Spots

OAR 340-122-0090 requires that remedial actions treat hot spots of contamination in groundwater to the extent feasible. Other than no action, the cut-off wall is the only alternative that does not provide some level of treatment.

6.0 SUMMARY OF THE SELECTED REMEDIAL ACTION

The selected remedial action is Alternative E/F with the addition of an institutional control. The selected remedy includes:

- Excavation of shallow soil in the former Quaker State tank farm and off-site disposal at a landfill or thermal treatment facility (Alternative E or F),
- LNAPL recovery in the pipeline area through pumping wells (Alternative E),
- Dual phase extraction pilot testing and, if effective, implementation (Alternative F),
- Excavation of contaminated riverbank soils and off-site disposal at a landfill or thermal treatment facility (Alternative E or F),
- Groundwater monitoring and compliance evaluation (Alternative E or F), and
- Institutional control (amended Alternatives E or F).

Although there is a broad range of scores, no single alternative scored significantly higher than any other evaluated in the FS (Table 9). Cut-off wall ranked the highest, but does not meet the preference for treatment of hot spots. Soil treatment by thermal desorption and off-site landfill disposal of soil ranked second and third, but are estimated to be over twice the cost of dual-phase extraction or well pumping.

Well pumping is protective, treats hot spots of contamination, and is the least-cost alternative that also has reasonable assurance of both short-term source control and longer-term cleanup through contaminant reduction. Hydraulic containment is less costly, but is not as effective or as reliable as pumping because system operation would be required for a much longer time period. Pumping will treat LNAPL and groundwater hot spots of contamination. Dual-phase extraction has only slightly higher estimated cost than groundwater pumping alone, and the additional cost may be offset by improved efficiency of the pumping system. Other alternatives may be faster (e.g., thermally enhanced soil vapor extraction) and treat a larger volume of contaminated material including vadose zone soil (e.g., excavation and thermal desorption). However, the significant additional costs of these alternatives are not warranted since the remedial objective is not to treat all contamination, but to treat only mobile contaminants which are likely to impact beneficial uses of the river.

6.1 Description of the Selected Remedial Action

6.1.1 Quaker State Tank Farm Excavation

An estimated 120 cubic yards (180 tons) of surface soil located at the former Quaker State tank farm area will be excavated. The excavated soil will be loaded into trucks and hauled to a permitted landfill or thermal treatment facility. Confirmation samples will be collected and analyzed to demonstrate that any residual petroleum hydrocarbon contamination is below acceptable risk levels for human health.

6.1.2 LNAPL Pumping

Groundwater extraction wells will be installed in the LNAPL source area and downhole pumps used to extract LNAPL and contaminated groundwater. The extracted LNAPL/groundwater will be treated via oil/water separator, bag filtration, and carbon adsorption. Effluent from the treatment system will be discharged to the Willamette River at concentrations that meet the compliance criteria listed in Section 6.1.5 of this ROD and substantive requirements of a National Pollutant Discharge Elimination System (NPDES) permit. The collected LNAPL will be routed to a storage container and periodically transported to a licensed recycling facility.

The proposed well layout includes eight wells placed within the LNAPL plume at a typical spacing of about 100 feet (Figure 8). Well screen depths will be approximately 20 to 25 feet. The estimated total flow from each well will be 1 to 6 gallons per minute, depending on the season. The proposed well configuration will be refined through pilot testing and remedial design. Performance measures will be established to assess the need for adjustments to the system.

6.1.3 Dual-Phase Extraction

Pilot testing will be conducted to determine if applying a vacuum to the extraction wells enhances the effectiveness of the LNAPL pumping. Each extraction well will have a down-hole pump to remove liquid phase hydrocarbons and groundwater, and would also be connected to a vacuum extraction system to enhance vapor phase recovery (i.e., dual-phase extraction). The proposed well layout for dual phase extraction includes fifteen wells placed within the LNAPL plume (Figure 9). As above for LNAPL pumping, extracted LNAPL/groundwater will be treated and the groundwater effluent discharged to the Willamette River. The collected LNAPL will be routed to a storage container and periodically transported to a licensed recycling facility. Vapors from the vacuum system will be discharged to the atmosphere. If vapors contain petroleum hydrocarbons at concentrations of concern, treatment will be necessary prior to discharge.

6.1.4 Riverbank Excavation and Backfill

To address residual TPH within the Slip 3 riverbank, soil at the location of the riverbank seep will be excavated. The excavation is estimated at 150 feet wide and will extend from the low water line landward about 55 feet. An estimated 1,300 cubic yards (1,950 tons) of clean overburden soil along the riverbank will be excavated from above the saturated zone. An estimated 2,800 cubic yards (4,200 tons) of soil with residual petroleum hydrocarbons will be excavated from below the saturated zone. The contaminated soil will be loaded into trucks and hauled off-site to a permitted landfill or thermal treatment facility. The riverbank will be restored with imported silty sand fill in the saturated zone and the 1,300 cubic yards of clean overburden soil. Laboratory testing will be completed to evaluate adsorption capacities of potential saturated zone backfill materials. The amount of excavation and type of backfill may be adjusted to provide adsorption capacity as a backup measure in the event residual contamination from the upgradient pipeline area is mobilized in the future.

The work will be conducted in compliance with federal/state removal-fill requirements. The face of the bank will be restored in accordance with the Port's Riverbank Management Plan dated April 2001.

6.1.5 Groundwater Monitoring and Compliance Evaluation

Groundwater monitoring will be necessary to demonstrate that mobile LNAPL has been removed, that dissolved-phase contaminant concentrations have been reduced below risk screening levels, and that the remedy is consistent with criteria applied by EPA to Portland Harbor. A groundwater monitoring plan will be prepared and implemented. Groundwater monitoring will be conducted for a minimum of two years following the removal of mobile LNAPL and shutdown of the treatment system. After two years, the need for additional monitoring will be assessed.

Groundwater monitoring compliance points will be established that reflect groundwater discharging to sediments and surface water. Compliance criteria will be the Level II Screening Level Values from DEQ's Guidance for Ecological Risk Assessment (DEQ April 1998/December 2001) as follows:

Contaminant	Aquatic SLV (mg/L)
Acenaphthene	0.520
Benzo[a]anthracene	0.000027
Benzo[a]pyrene	0.000014
Fluoranthene	0.00616
Fluorene	0.0039
Naphthalene	0.620
Phenanthrene	0.0063

Total petroleum hydrocarbons will be assessed relative to the 1 mg/L discharge limitation for NPDES 1500A Waste Discharge permits. Other applicable numeric standards approved by DEQ may be used. Narrative water quality standards, such as objectionable oily sheen, will also be applied for surface water.

If performance monitoring during treatment or groundwater monitoring following treatment indicates that screening levels for protection of surface waters are unlikely to be achieved or that the remedy is inconsistent with EPA criteria developed for Portland Harbor, the remedial action will be re-evaluated. The Port will consider methods of improving the existing treatment system and may elect to develop site-specific cleanup endpoints based on fate and transport modeling or other site-specific factors. Any revisions to the compliance criteria shall be reviewed and approved by DEQ.

6.1.6 Institutional Control

In addition to those actions evaluated in the FS, an institutional control will be used to identify the location of areas where there is residual TPH contamination. Notification will be provided to Port workers, contractors or tenants of the presence of contamination through a method approved by DEQ, so that management of TPH contaminated soil or groundwater can be incorporated into the planning stages of future site work.

6.2 Applicable Laws

6.2.1 Clean Water Act Section 402 and ORS Chapter 468B

The ORS 465.315 exemption of state and local permits will apply to on-site activities approved in this ROD. Waste water discharges to surface waters of the lower Willamette from the groundwater pump and treat system will be consistent with the compliance criteria listed in Section 6.1.5 of this ROD and will meet applicable substantive water quality criteria, and water quality monitoring and reporting requirements under federal and state law, including pertinent criteria contained in OAR 340-41, Table 20 and adopted in OAR 340-41.

6.2.2 Clean Water Act Section 404, Rivers and Harbors Act Section 10, and ORS Chapter 196

The Port will obtain federal permits or otherwise comply with applicable laws for any excavation and filling and any discharge of dredged or fill material associated with the bank excavation component of the remedy to meet the requirements of sections 10 of the Rivers and Harbors Act of 1899, 33 U.S.C.A. 403, and 404 of the Clean Water Act, 33 U.S.C.A. 1344. Section 10 of the Rivers and Harbors Act regulates construction or modification of structures in a Port and Rivers and Harbors Act regulates construction or modification of structures in a Port and Rivers and Harbors of the United States. Likewise, such bank excavation remedial excavation and filling in waters of the United States. Likewise, such bank excavation remedial activities will comply with the substance of Oregon's Removal-Fill Law, ORS 196.795-990 and the State of Oregon's Lower Willamette River Management Plan. The work will be conducted consistent with the in-water work windows established by the Oregon Department of Fish and Wildlife.

6.2.3 Endangered Species Act Section 7

In connection with Section 404 of the Clean Water Act, the Port will assure that a biological assessment be prepared under the Endangered Species Act for the bank excavation work and, if required, that consultation with National Marine Fisheries Service and U.S. Fish and Wildlife Service occur. Section 7 of the Endangered Species Act requires the federal agencies with jurisdiction over aspects of this cleanup, such as the U.S. Army Corps of Engineers, ensure that any action authorized, funded, or carried out by such agencies are not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of designated critical habitat of such species.

6.2.4 National Historic Preservation Act Section 106, 16 U.S.C. 470(f)

The Port will take steps to protect any historic, archaeological and cultural resources that may be located in the remedial action area by complying with applicable federal and state laws. The Port will perform a cultural resources survey for the facility consistent with Section 106 of the National Historic Preservation Act prior to undertaking any ground-disturbing work and will in addition take any required steps to protect any cultural or archaeological resources that might be discovered in the facility. The Port will coordinate its efforts with interested Indian tribes, in addition to appropriately involving the Advisory Council on Historic Preservation (ACHP) and the State Historic Preservation Office (SHPO).

6.2.5 Portland City Code Chapter 24.50 and Federal Executive Order 11988 (Floodplain Management)

The Port will implement the cleanup remedy on-site consistent with applicable floodplain management requirements under federal and local law. The bank excavation component of the remedy will be designed and implemented after identification of the area floodplain and demonstration that the 100 year flood elevation will not be increased. As with all the City legal requirements discussed below, the Port will coordinate with the City to identify applicable substantive requirements using the mechanism to identify substantive requirements applicable to the selected remedy identified in the DEQ-City 2002 Fact Sheet "Portland's Development Regulations and Hazardous Substance Cleanup Projects."

6.2.6 Portland City Code Chapter 33.440 Greenway Overlay Zones

The Port will implement the cleanup remedy on-site in compliance with the substance of applicable development standards, Willamette Greenway Plan and Willamette Greenway design guidelines triggered by City of Portland Greenway Overlay Zones. The Terminal 4 Slip 3 Facility is located within the Greenway Overlay zone for River Industrial (i).

6.2.7 Portland City Code Chapter 24.70 Grading and Clearing

After coordination with the City, the Port will implement the cleanup remedy on-site in compliance with the substance of City grading and clearing requirements applicable to projects involving excavation or filling of greater than 10 cubic yards of material.

6.2.8 Portland City Code Chapter 17.38 (Stormwater Management) and Title 10 (Erosion Control)

The Port will implement the cleanup remedy in accordance with City best management practices for the control of erosion and stormwater discharges.

6.2.9 Other Legal Requirements

The Port will comply with any other legal requirements determined to be applicable to the selected remedy, including those applicable to the off-site disposal aspects of the remedy. Building, plumbing and electrical permits will be obtained from the City for the groundwater remedial action equipment.

6.3 Residual Risk

In accordance with OAR 340-122-0084 (4), a residual risk assessment was completed to evaluate the risk posed by untreated hazardous substances. Upon completion of the recommended remedial action, residual petroleum hydrocarbon contamination will remain at the site in subsurface soils.

Excavation of soil at the Quaker State tank farm will reduce potential human exposure to acceptable risk levels ($1x10^{-6}$ excess cancer risk for individual substances). Risk estimates were calculated without the soil sample from the tank farm that had the highest PAH concentrations. The revised risk for benzo(a)pyrene was $9x10^{-7}$ and cumulative carcinogenic risk was $1x10^{-6}$, within acceptable risk levels.

Mobile LNAPL will be removed through pumping and dissolved phase concentrations of PAHs in groundwater are expected to be reduced to below surface water screening levels. Either existing screening levels for surface water or site-specific cleanup concentrations for groundwater will be used to demonstrate that contaminant concentrations are below acceptable ecological risk levels.

6.4 Satisfaction of Statutory Requirements

The selected remedial action is protective and was chosen based on a balance of the remedy selection factors: effectiveness, long-term reliability, implementability, implementation risk, and reasonableness of cost. The selected remedy will treat hot spots of contamination and satisfies the requirements of ORS 465.315 and OAR 340-122-0090.

7.0 PEER REVIEW SUMMARY

A project team, consisting of a Project Manager, a Hydrogeologist, an Engineer, a Toxicologist, and the Section Manager was involved at various stages during the course of this project. Team members reviewed project documents such as work plans, the RI and FS reports, and this ROD, and submitted oral and written comments to the Project Manager. Team members also participated in various meetings with representatives of the Port of Portland, and the environmental consulting firm assisting on this project. The project team supports the selected remedial action.

8.0 CONSIDERATION OF EPA AND PUBLIC COMMENTS

Pursuant to DEQ's Memorandum of Understanding (MOU) with EPA for the Portland Harbor Superfund Site, DEQ submitted a draft of the Staff Report as a proposed source control decision to EPA and other MOU parties for their review and comment. Pursuant to DEQ's Voluntary Agreement with the Port of Portland, DEQ submitted a draft of the Staff Report to the Port of Portland for its review and comment. Comments received from EPA, the National Oceanic and Atmospheric Administration (NOAA) and Barbara Inyan of the Nez Perce Tribe were considered by DEQ in preparation of the Staff Report and Recommended Remedial Action. DEQ informed community representatives of the recommended remedial action, including members of the Portland Harbor Citizen Advisory Group, and the community was invited to comment during a 30-day public comment period. DEQ received comments on the Staff Report from the Port of Portland and the Lower Willamette Group during the comment period. DEQ considered all submitted comments prior to selecting the final remedial action for the site.

9.0 DOCUMENTATION OF SIGNIFICANT CHANGE

DEQ did not make significant changes to the recommended remedy as a result of public comments. DEQ revised sections 5.2.3, 6.1.2, 6.1.3, 6.1.4 and 6.2.2 of the Staff Report for the ROD as stated in the attached Appendix B Response to Comments, dated March 31, 2003. DEQ considers these to be minor changes made to clarify when the treatment criteria may be re-evaluated and to recognize the Port's desire for flexibility in meeting federal permit requirements.

10.0 SIGNATURE

Neil Mullane 4/16/03

Neil Mullane, Administrator Date
Northwest Region Department of Environmental Quality

Appendix A

Administrative Record Index

The Administrative Record consists of the documents on which the recommended remedial action for the site is based. The primary documents used in evaluating the remedial action alternatives for the T4/Slip 3 site are listed below. Additional reports, background and supporting information can be found in the project file located at DEQ's Northwest Region office in Portland.

Hart Crowser, 1998. Interim Action Work Plan, Petroleum Hydrocarbon Seep, Port of Portland, Terminal 4 Slip 3, Portland, Oregon, November 20, 1998.

Hart Crowser, 2000a. Remedial Investigation Report, Terminal 4, Slip 3 Upland, Port of Portland, Portland, Oregon, January 21, 2000.

Hart Crowser, 2000b. Remedial Investigation Report, Terminal 4, Slip 3 Sediments, Port of Portland, Portland, Oregon, April 18, 2000.

Hart Crowser, 2000c. Baseline Human Health and Ecological Baseline Risk Assessment, Terminal 4, Slip 3 Upland, Portland, Oregon, October 18, 2000.

Hart Crowser, 2002. Feasibility Study Report, Terminal 4, Slip 3 Upland, Portland, Oregon, July 5, 2002.

Appendix B

Staff Report Response to Comments

Oregon
Theodore Kulongoski, Governor

Department of Environmental Quality
Northwest Region Portland Office
2020 SW 4th Avenue, Suite 400
Portland, OR 97201-4987
(503) 229-5263
FAX (503) 229-6945
TTY (503) 229-5471

March 31, 2003

Mr. David Ashton
Assistant General Counsel
Port of Portland
PO Box 3529
Portland, OR 97208

Mr. Bob Wyatt
Co-Chair
Lower Willamette Group
PO Box 3529
Portland, OR 97209

RE: Staff Report, Response to Comments
Port of Portland, Terminal 4, Slip 3 Upland

Dear Mr. Ashton and Mr. Wyatt:

Thank you for your comments on the Staff Report for the Terminal 4, Slip 3 Upland Facility. The Department of Environmental Quality (DEQ) received comments from David Ashton of the Port of Portland by letter dated March 3, 2002 and from Bob Wyatt and Larry Patterson of the Lower Willamette Group by letter dated March 3, 2003. DEQ has prepared the following response to those comments.

There are two main concerns expressed by both the Port and Lower Willamette Group: 1) that the proposed remedial action should be considered a final remedy by DEQ and formally endorsed as a final action by EPA; and 2) that any requirement to obtain federal permits should be exempted. DEQ's response to these concerns follows:

1) While DEQ intends this to be not only a source control decision but also the final remedy for the T4 Slip 3 Upland Facility, we disagree that the remedy should not be subject to reopening based upon Portland Harbor sediment decisions. Risk assessment of sediment and pore-water contaminant impacts in Slip 3 have not been completed and may affect compliance criteria for groundwater discharging from the upland area to Slip 3. Therefore, while EPA is to provide review of upland source control decisions in accordance with the interagency Memorandum of Understanding (MOU), potential inconsistencies with the harbor-wide cleanup cannot be resolved now because the harbor investigation has not been completed. Despite this uncertainty, the Port and DEQ have discussed on several occasions that petroleum hydrocarbons at the T4 Slip 3 Upland are expected to be amenable to product recovery and thereby achieve the stated compliance criteria for groundwater (DEQ's Level II Screening Level Values).

2) Currently there is no authority for DEQ to apply the CERCLA permit exemption to the T4 Slip 3 Upland cleanup, which is being selected under Oregon Revised Statutes 465. However, in recognition that the Port might pursue the topic with EPA or federal permitting agencies, DEQ will revise the Staff Report language referring to permits. The last sentence of section 5.2.3 will be revised to read: *"The Port will meet substantive requirements of state and local permits and will obtain federal permits or otherwise comply with applicable federal laws for each component of the remedy. The necessity to meet substantive requirements or obtain permits for in-water (riverbank) work and the time required for compliance with applicable laws might affect the implementation schedule for the in-water portion of the remedy."* Sections 6.1.2, 6.1.3, 6.1.4 and 6.2.1 will similarly be revised to indicate that the Port will meet substantive requirements, and obtain permits or otherwise comply with applicable laws.

In addition to these two concerns the Port suggested that section 6.1.5 of the Staff Report be modified to read that "As an alternative *or* in *addition to* evaluating treatment alternatives, the Port may elect to develop site-specific cleanup endpoints based on fate and transport modeling or other site-specific factors." DEQ agrees that the Level II Screening Level Values are conservative and developing site-specific cleanup endpoints is acceptable; however, the Port has not exercised that option to date. The Port should first make reasonable efforts to implement the remedial alternative and associated cleanup endpoints established in the ROD. DEQ envisions two scenarios under which the proposed compliance criteria may need to be re-evaluated: 1) if performance measures indicate that the selected alternative will be unable to achieve the cleanup goals and ways to improve performance of the existing system have been fully considered, or 2) if future Portland Harbor sediment decisions suggest there should be alternative groundwater-surface water compliance criteria. To clarify this point, the last sentence of section 4.1 in the Staff Report will be deleted, and the first and second sentences of the last paragraph, section 6.1.5 will be rewritten as "*......the remedial action will be re-evaluated. The Port will consider methods of improving the existing treatment system and may elect to develop site-specific cleanup endpoints.............*"

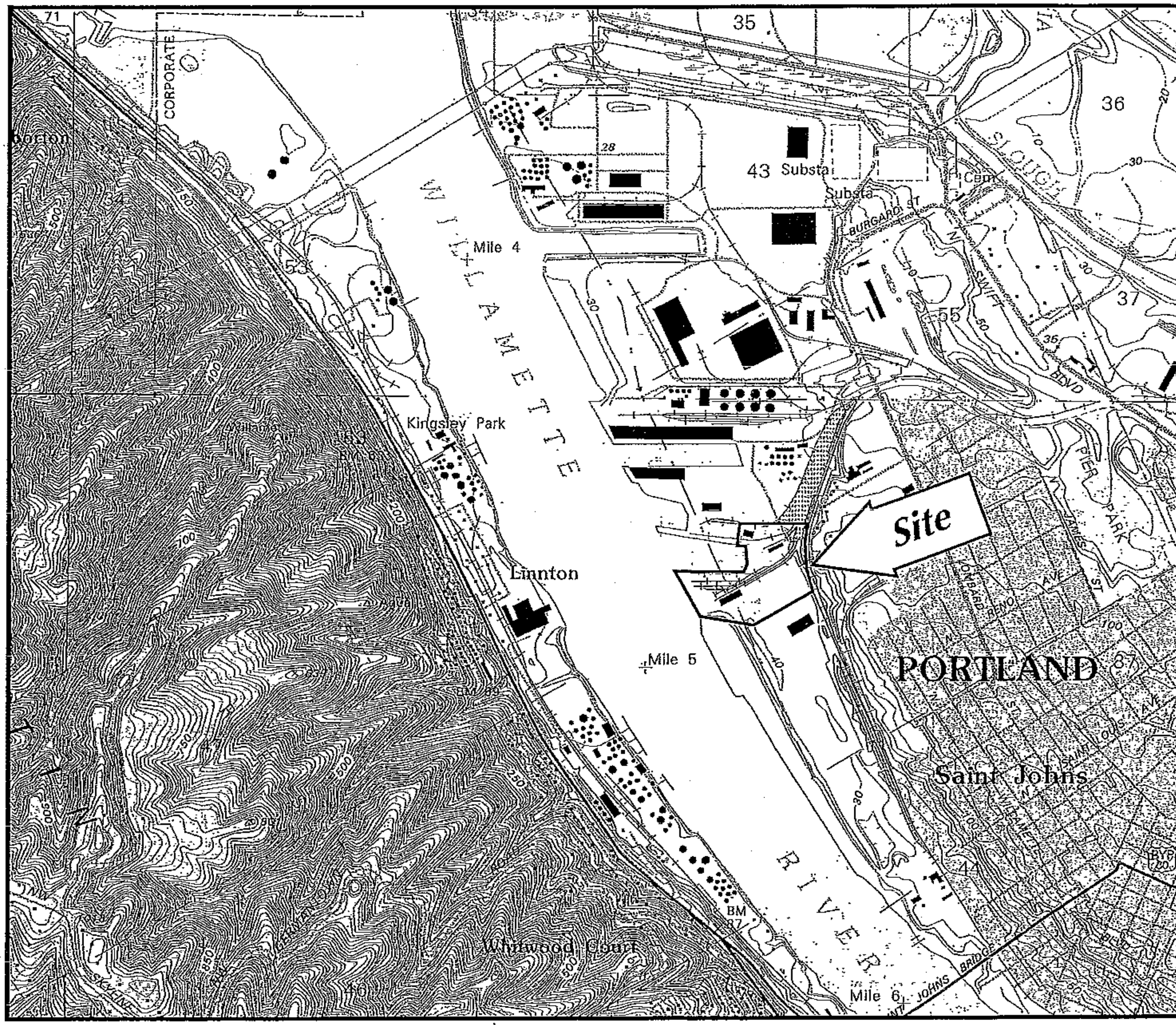
Revisions will be made to the Staff Report as described above. With these revisions, the Staff Report will be finalized as the Record of Decision (ROD) for the site. The ROD will likely be signed by DEQ's Northwest Region Administrator, Neil Mullane, in early April.

Sincerely,

Thomas E. Roick, Project Manager
Cleanup & Portland Harbor

cc: Don Pettit / Tom Gainer / Jim Anderson / Fenix Grange/ Mike Rosen, DEQ NWR
Kurt Burkholder, Department of Justice
Anne Summers, Port of Portland
Tara Martich, EPA
Chip Humphrey, EPA

Site Location Map
Port of Portland, Terminal 4 - Slip 3 Upland



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

SCALE 1 : 24 000

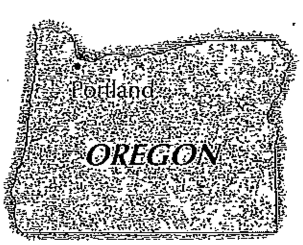
1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

CONTOUR INTERVAL 10 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

N



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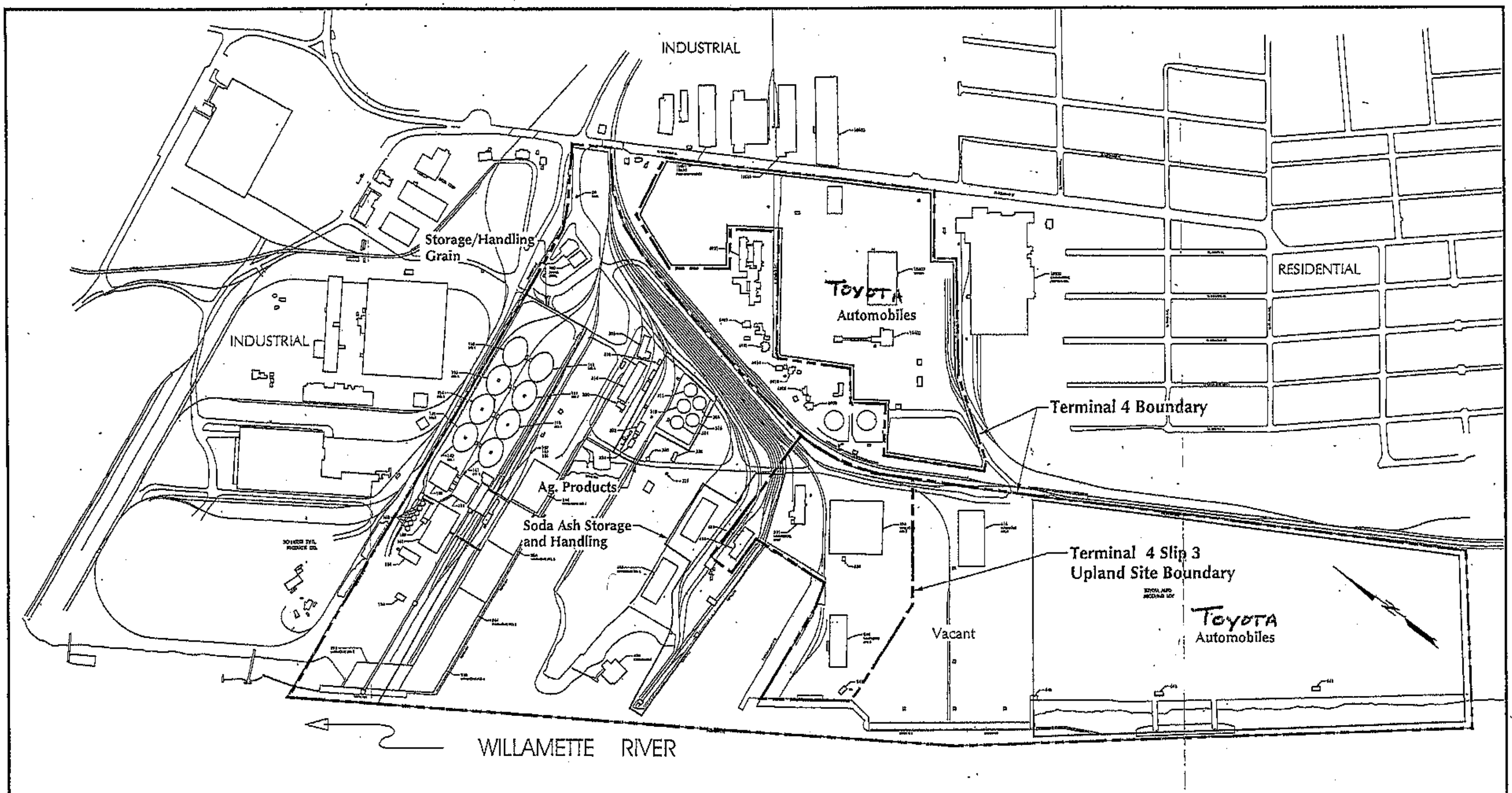
5624-14 7/02

Figure 1

Site and Vicinity Plan
Port of Portland, Terminal 4 - Slip 3 Upland



Note: Base map prepared from a Port of Portland Terminal No. 4 plan, dated 4/96.

0 300 600 1,200

Approximate Scale in Feet

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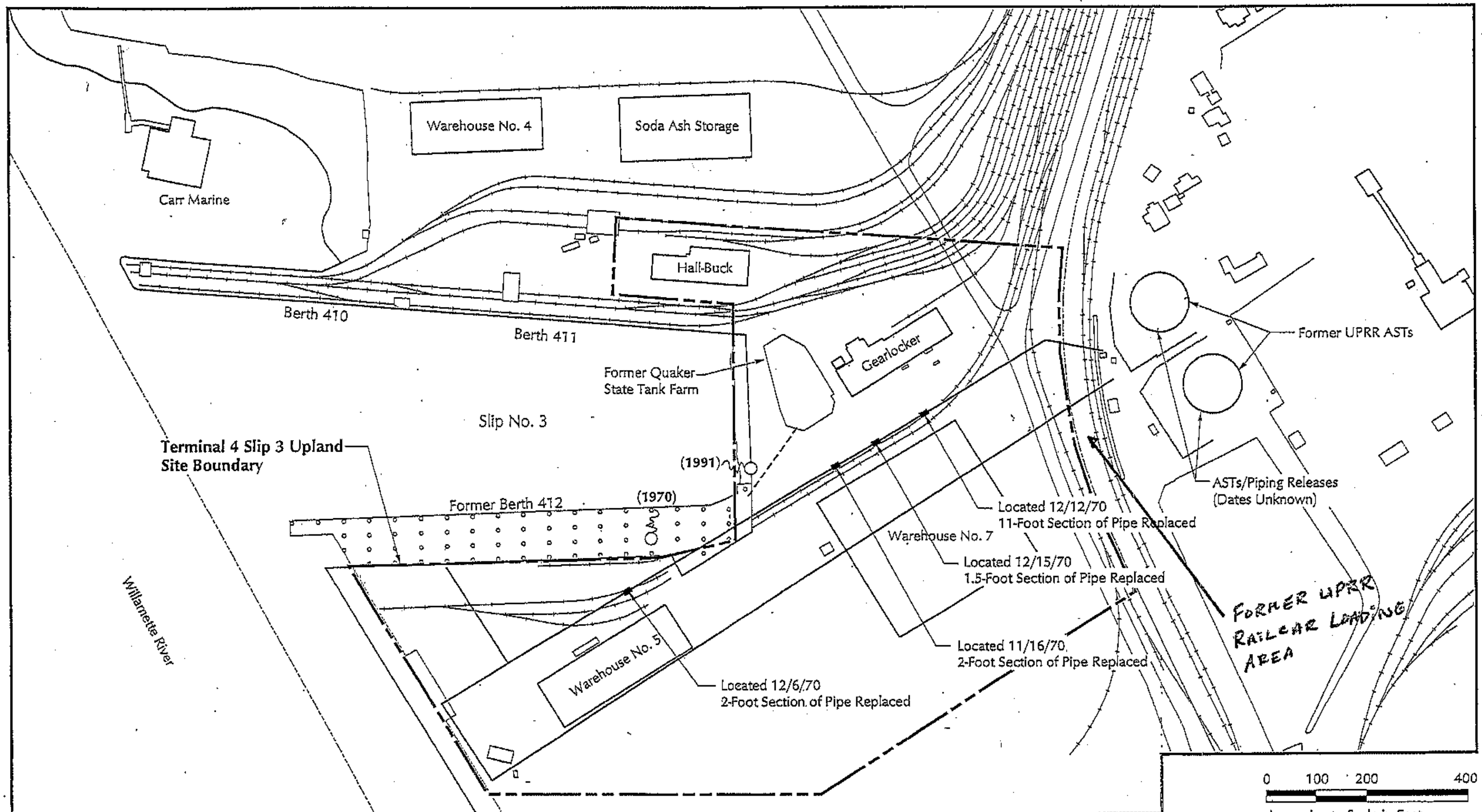
J-5624-09 1/00

Figure 2

Known/Suspected Releases from Pipeline/Bulk Storage Tanks
Port of Portland, Terminal 4 - Slip 3 Upland



Notes: (1) Base map prepared from a Port of Portland Terminal No. 4 plan, dated 4/96. (2) Indications of petroleum leaks were observed along the entire length of the northern pipeline during the 1998 northern pipeline investigation and removal.

Legend:

- Abandoned UP Fuel Line
- Former Quaker State Oil Line
- Documented Pipeline Leak
- (1991) Petroleum Seep (Date First Observed)

RI Report, Rev. 3, 1/21/00

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J-5624-09 1/00

Figure 3

Site Exploration Plan: Detailed View

Port of Portland, Terminal 4 - Slip 3 Upland

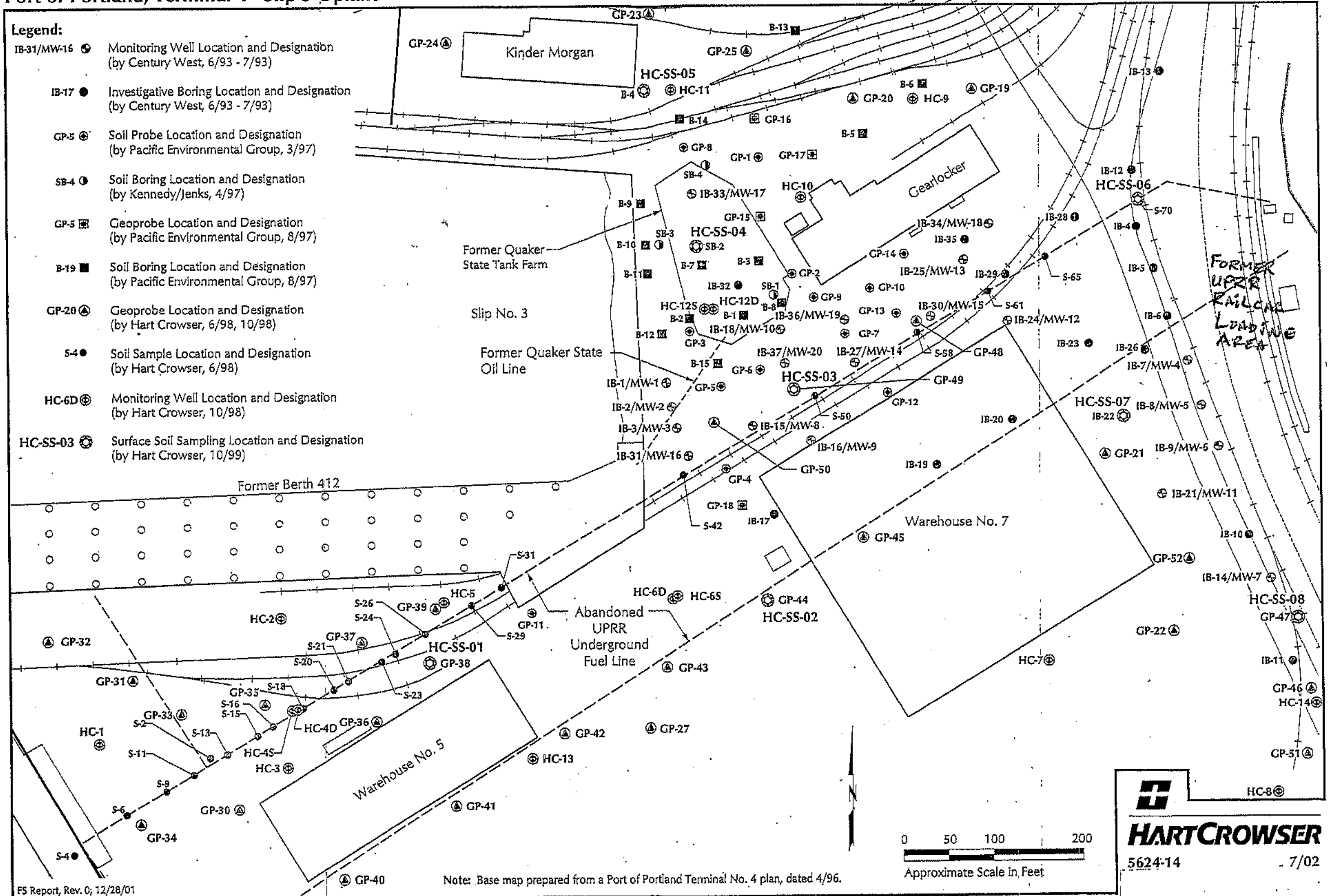

Figure 4

Lateral Extent of Total Petroleum Hydrocarbon in Soil

Port of Portland, Terminal 4 - Slip 3 Upland

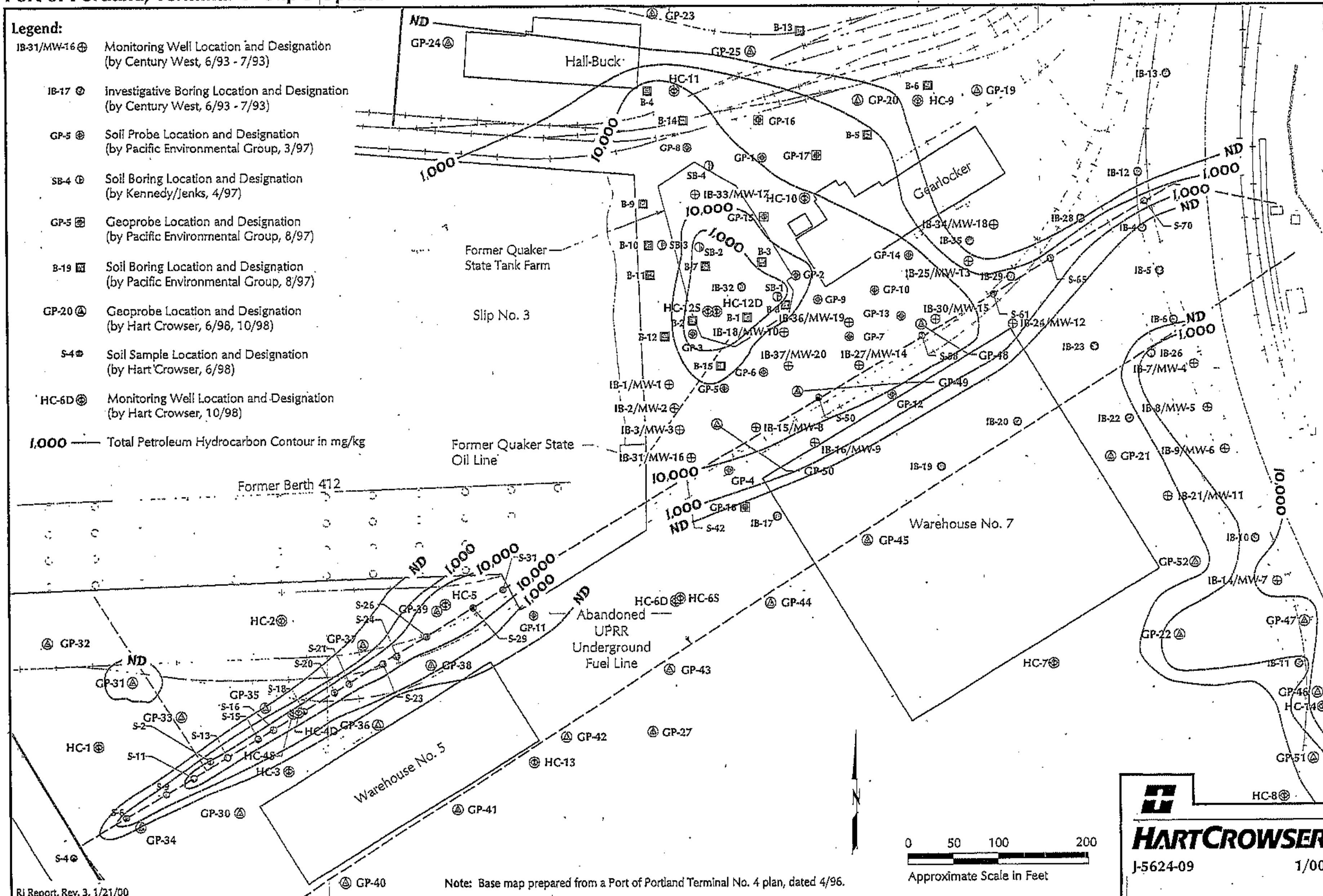

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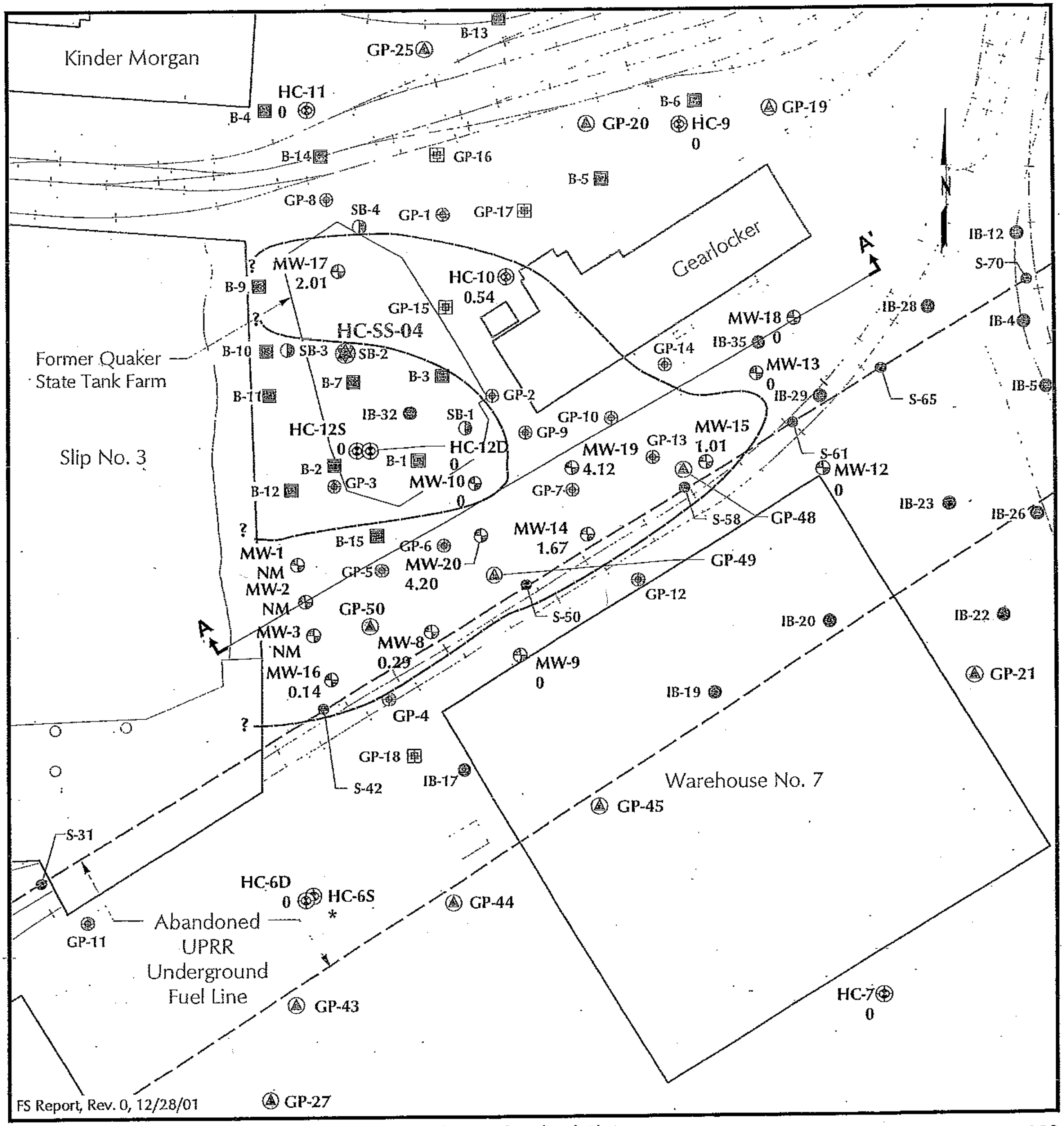
Figure 5

Lateral Extent of Measured LNAPL: November 1999
Port of Portland, Terminal 4 - Slip 3 Upland



Note: Base map prepared from a Port of Portland Terminal No. 4 plan, dated 4/96.

0 50 100 200

Approximate Scale in Feet

Legend:

HC-6D MW-20	Monitoring Well Location and Designation
2.40	LNAPL Thickness in Feet
NM	Not Measured (IA Extraction Well)
*	Not Measured (Well Dry)
	Estimated Lateral Extent of LNAPL in November 1999
A A'	

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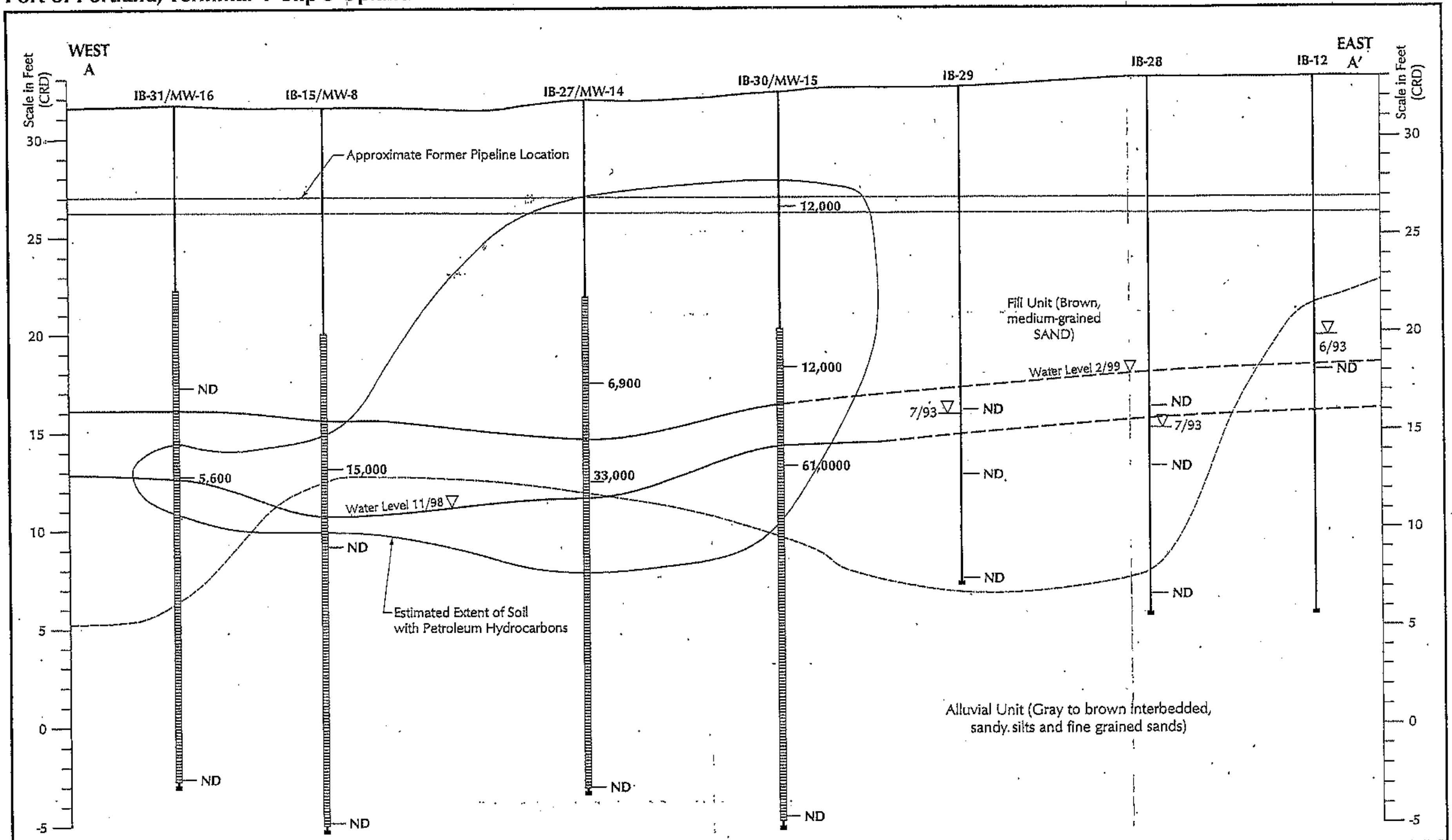
Cross Section A-A′

Port of Portland, Terminal 4 -Slip 3 Upland



Note: Exploration boring and well completion data from Century West (1994).

Legend:

- IB-31/MW-16 — Investigative Boring/Monitoring Well Designation
- Investigative Boring/Monitoring Well Location
- Well Screen
- 5,600 — Total TPH in Soil in mg/kg

RI Report, Rev. 3, 1/21/00

Approximate Horizontal Scale in Feet: 0, 25, 50, 100

Approximate Vertical Scale in Feet: 0, 2.5, 5, 10

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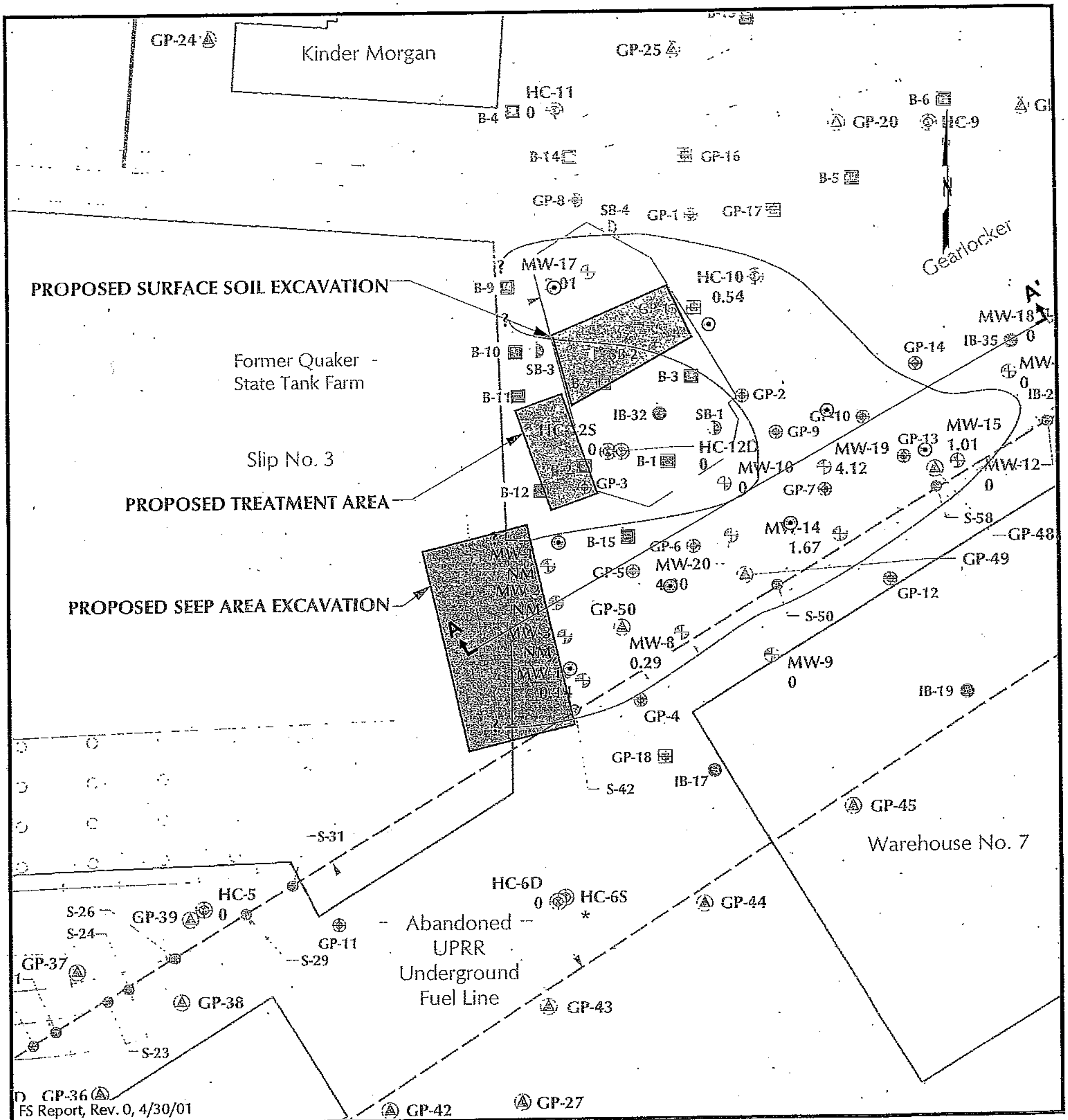
J-5624-09 1/00

Figure 7

Proposed Layout for Alternative E: Well Pumping
Port of Portland, Terminal 4 - Slip 3 Upland



Note: Base map prepared from a Port of Portland Terminal No. 4 plan, dated 4/96.

0 50 100 200

Approximate Scale in Feet

Legend:

Estimated Lateral Extent of LNAPL in November 1999

Proposed Extraction Well

A A'

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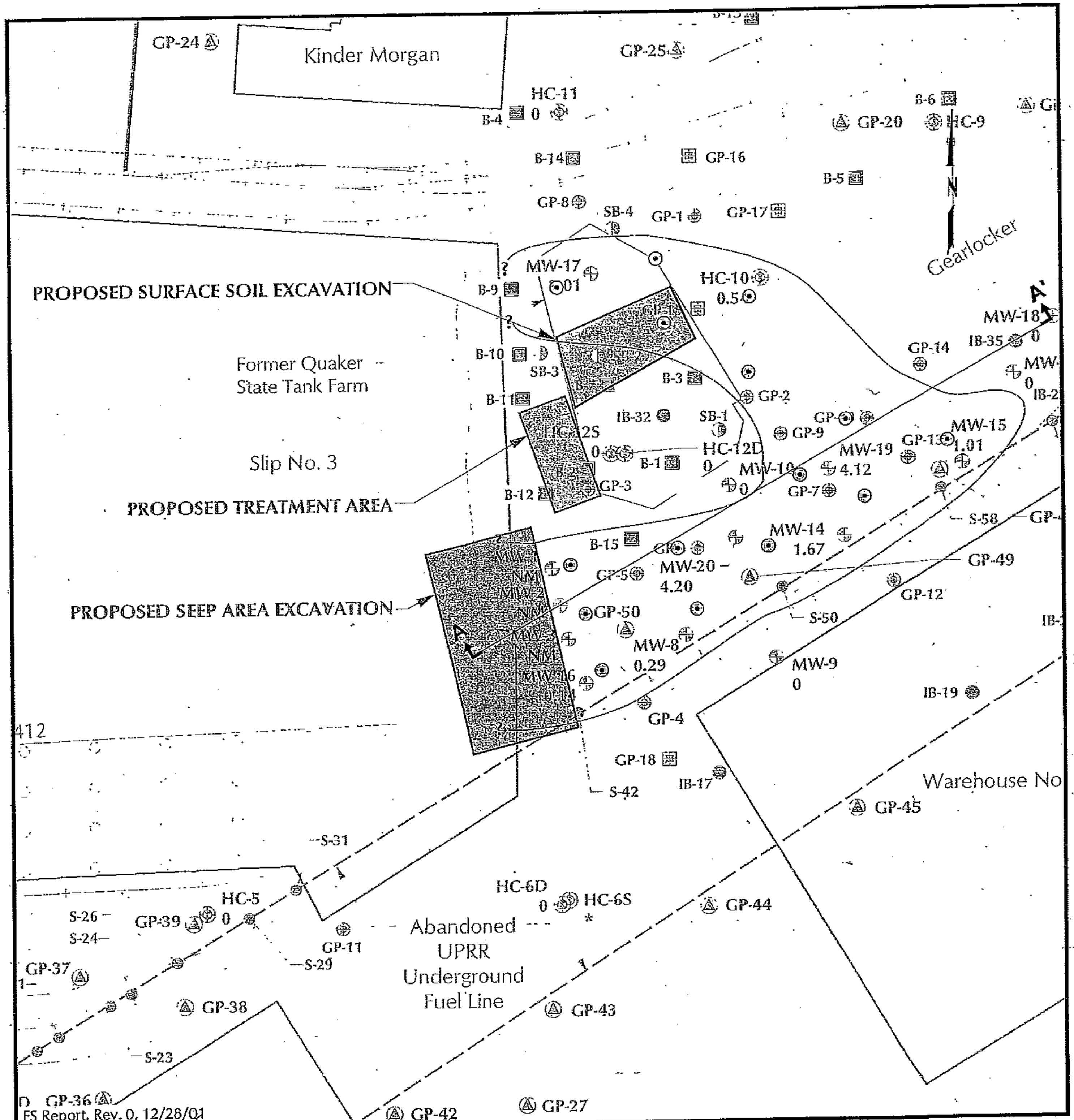
7/02

Proposed Layout for Alternative F: Dual Phase Extraction
Port of Portland, Terminal 4 - Slip 3 Upland



Note: Base map prepared from a Port of Portland Terminal No. 4 plan, dated 4/96.

0 50 100 200

Approximate Scale in Feet

Legend:

Estimated Lateral Extent of LNAPL in November 1999

Proposed Dual Phase Extraction Well

A A' Cross Section Location and Designation

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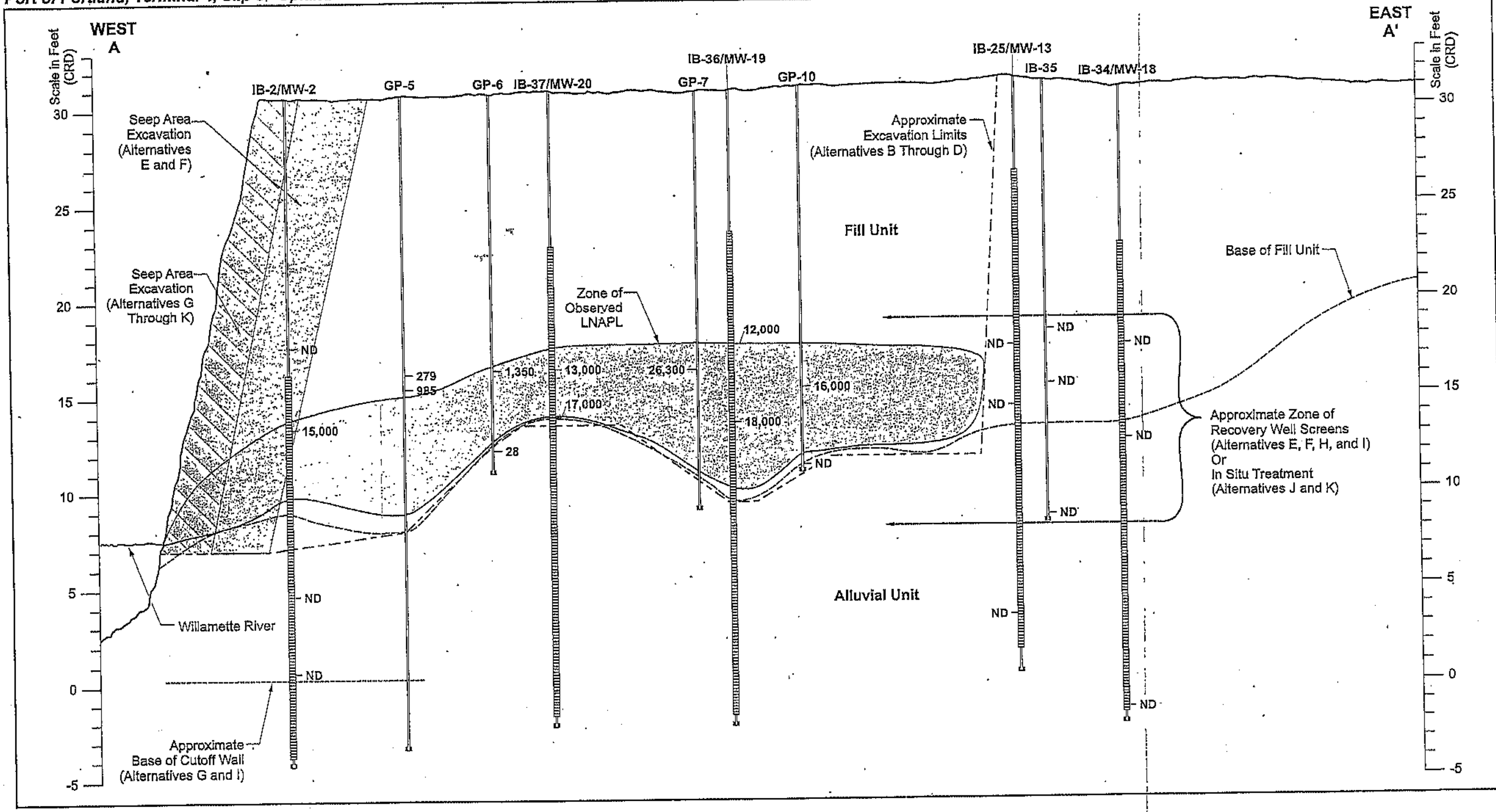
5624-14 7/02

Cross Section A-A' - Remediation Schematic Details
Port of Portland, Terminal 4, Slip 3 - Upland



Legend:

- Investigative Boring/Monitoring Well Number
- Investigative Boring/Monitoring Well Location
- Well Screen
- Total TPH in Soil in mg/kg

Approximate Horizontal Scale in Feet
0 25 50 100

0 2.5 5 10
Approximate Vertical Scale in Feet

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Figure 10

Table 1 - Human Health Risk Characterization - Industrial Worker
Port of Portland, Terminal 4 - Slip 3 Upland
Portland, Oregon

Total Risk for Individual COPCs

COPC	Total Cancer Risk		Hazard Index	
	RME	CT	RME	CT
Semivolatiles				
2-Methylnaphthalene	--	--	4.E-02	3.E-03
Acenaphthene	--	--	5.E-04	4.E-05
Acenaphthylene	--	--	3.E-07	2.E-07
Anthracene	--	--	3.E-05	3.E-06
Benzo(a)anthracene	1.E-06	4.E-08	--	--
Benzo(a)pyrene	2.E-05	4.E-07	--	--
Benzo(b)fluoranthene	2.E-06	4.E-08	--	--
Benzo(g,h,i)perylene	--	--	1.E-04	1.E-05
Benzo(K)fluoranthene	1.E-07	4.E-09	--	--
Chrysene	1.E-08	4.E-10	--	--
Dibenz(a,h)anthracene	2.E-06	6.E-08	--	--
Dibenzofuran	--	--	2.E-03	2.E-04
Fluoranthene	--	--	2.E-04	2.E-05
Fluorene	--	--	1.E-03	9.E-05
Indeno(1,2,3-cd)pyrene	2.E-06	4.E-08	--	--
Naphthalene	--	--	4.E-03	3.E-04
Phenanthrene	--	--	2.E-04	2.E-05
Pyrene	--	--	2.E-04	3.E-05
Total Risk	**2.E-05**	**6.E-07**	**5.E-02**	**3.E-03**

Notes:
COPC = Compound of potential concern.
RME = Reasonable maximum exposure.
CT = Central tendency.

Table 2 - Human Health Risk Characterization - Utility Worker
Port of Portland, Terminal 4, Slip 3 Upland
Portland, Oregon

Total Risk for Individual COPCs

COPC	Total Cancer Risk		Hazard Index	
	RME	CT	RME	CT
Semivolatiles				
2-Methylnaphthalene	--	--	1.E-02	3.E-04
Acenaphthene	--	--	2.E-04	4.E-06
Acenaphthylene	--	--	9.E-08	2.E-08
Anthracene	--	--	1.E-05	5.E-07
Benzo(a)anthracene	2.E-08	5.E-10	--	--
Benzo(a)pyrene	2.E-07	5.E-09	--	--
Benzo(b)fluoranthene	2.E-08	5.E-10	--	--
Benzo(g,h,i)perylene	--	--	4.E-05	3.E-06
Benzo(K)fluoranthene	2.E-09	5.E-11	--	--
Chrysene	2.E-10	6.E-12	--	--
Dibenz(a,h)anthracene	3.E-08	3.E-09	--	--
Dibenzofuran	--	--	6.E-04	2.E-05
Fluoranthene	--	--	8.E-05	4.E-06
Fluorene	--	--	4.E-04	9.E-06
Indeno(1,2,3-cd)pyrene	2.E-08	5.E-10	--	--
Naphthalene	--	--	1.E-03	2.E-05
Phenanthrene	--	--	9.E-05	3.E-06
Pyrene	--	--	8.E-05	5.E-06
Total Risk	**3.E-07**	**1.E-08**	**1.E-02**	**3.E-04**

Notes:
COPC = Compound of potential concern.
RME = Reasonable maximum exposure.
CT = Central tendency.

Table 3 - Human Health Risk Characterization - Industrial Worker
Port of Portland, Terminal 4, Slip 3 Upland
Portland, Oregon

Total Risk for Individual COPCs; No Sample HC-SS-04

COPC	Total Cancer Risk		Hazard Index	
	RME	CT	RME	CT
Semivolatiles				
2-Methylnaphthalene	--	--	4.E-02	3.E-03
Acenaphthene	--	--	5.E-04	4.E-05
Acenaphthylene	--	--	3.E-07	2.E-07
Anthracene	--	--	3.E-05	3.E-06
Benzo(a)anthracene	2.E-07	1.E-08	--	--
Benzo(a)pyrene	9.E-07	7.E-08	--	--
Benzo(b)fluoranthene	6.E-08	7.E-09	--	--
Benzo(g,h,i)perylene	--	--	1.E-05	4.E-06
Benzo(K)fluoranthene	2.E-08	1.E-09	--	--
Chrysene	3.E-09	2.E-10	--	--
Dibenz(a,h)anthracene	1.E-07	1.E-08	--	--
Dibenzofuran	--	--	2.E-03	2.E-04
Fluoranthene	--	--	6.E-05	9.E-06
Fluorene	--	--	1.E-03	1.E-04
Indeno(1,2,3-cd)pyrene	1.E-07	7.E-09	--	--
Naphthalene	--	--	4.E-03	3.E-04
Phenanthrene	--	--	2.E-04	2.E-05
Pyrene	--	--	1.E-04	2.E-05
Total Risk	**1.E-06**	**1.E-07**	**5.E-02**	**4.E-03**

Notes:
COPC = Compounds of potential concern.
RME = Reasonable maximum exposure.
CT = Central tendency.

Table 4 - Human Health Risk and Hazard Summary
Port of Portland, Terminal 4, Slip 3 Upland
Portland, Oregon

Industrial and Utility Worker Scenarios

Carcinogenic Risk				
	Soil Pathways			
Exposure Scenario	Ingestion	Dermal	Inhalation of Dust	Total Risk
Industrial Worker - RME[1]	1.E-05	1.E-05	1.E-09	**2.E-05**
Industrial Worker - CT[1]	2.E-07	4.E-07	4.E-11	**6.E-07**
Utility Worker - RME[2]	7.E-08	3.E-07	2.E-12	**3.E-07**
Utility Worker - CT[2]	2.E-09	8.E-09	2.E-13	**1.E-08**

Hazard Quotient				
	Soil Pathways			
Exposure Scenario	Ingestion	Dermal	Inhalation of Dust	Total Hazard
Industrial Worker - RME[1]	3.E-02	2.E-02	7.E-05	**5.E-02**
Industrial Worker - CT[1]	2.E-03	2.E-03	9.E-06	**3.E-03**
Utility Worker - RME[2]	5.E-03	7.E-03	3.E-06	**1.E-02**
Utility Worker - CT[2]	1.E-04	2.E-04	3.E-07	**3.E-04**

Revised Industrial Risk and Hazard Estimates (no sample HC-SS-04)				
	Soil Pathways			
Exposure Scenario	Ingestion	Dermal	Inhalation of Dust	Total Risk
Carcinogenic - RME[3]	6.E-07	8.E-07	6.E-11	**1.E-06**
Carcinogenic - CT[3]	3.E-08	7.E-08	8.E-12	**1.E-07**
Noncarcinogenic - RME[3]	3.E-02	2.E-02	7.E-05	**0.05**
Noncarcinogenic - CT[3]	2.E-03	2.E-03	1.E-05	**0.00**

Notes:
NE = Not evaluated for this receptor.
-- = No carcinogenic or noncarcinogenic COPCs for this exposure route.
RME = Reasonable maximum exposure.
CT = Central Tendency
1. From Table 12.
2. From Table 13.
3. From Table 14.

Table 5 - Ecological Screening of Surface Soil Results
Port of Portland, Terminal 4, Slip 3 Upland
Portland, Oregon

Level 1 Scoping Ecological Risk Assessment

Analyte	HC-SS-01	HC-SS-02	HC-SS-03	HC-SS-04	HC-SS-05	HC-SS-06	HC-SS-07	HC-SS-08	Screening Level (1)
Semivolatiles (mg/kg)									
2-Methylnaphthalene	0.02	0.005 U	0.021	0.024	0.008	500	2	0.02	NA
Acenaphthene	0.005 U	0.005 U	0.005 U	0.25	0.005 U	12	0.12	0.005	20
Acenaphthylene	0.007	0.005 U	0.005 U	0.006	0.005 U	0.05 U	0.005 U	0.005 U	NA
Anthracene	0.011	0.005 U	0.016	0.31	0.007	4.5	0.04	0.015	NA
Fluorene	0.005 U	0.005 U	0.008	0.1	0.005 U	19	0.15	0.005 U	30
Naphthalene	0.017	0.005 U	0.008	0.033	0.008	49	0.024	0.016	10
Phenanthrene	0.03	0.005 U	0.064	1.3	0.023	29	0.18	0.054	NA
Total LPAHs	0.065	0.005 U	0.096	1.999	0.038	113.5	0.514	0.09	NA
Benzo(a)anthracene	0.099	0.005 U	0.12	2.2	0.048	0.26	0.013	0.052	NA
Benzo(a)pyrene	0.15	0.005 U	0.005 U	2.9	0.07	0.05 U	0.023	0.067	7
Benzo(b)fluoranthene	0.1	0.005 U	0.08	2.5	0.048	0.05 U	0.024	0.064	NA
Benzo(k)fluoranthene	0.14	0.007	0.026	2.4	0.056	0.26	0.023	0.066	NA
Benzo(g,h,i)perylene	0.16	0.007	0.047	1.7	0.069	0.05 U	0.043	0.064	NA
Chrysene	0.14	0.006	0.33	2.3	0.057	0.43	0.028	0.068	NA
Dibenz(a,h)anthracene	0.018	0.005 U	0.014	0.35	0.008	0.05 U	0.005	0.011	NA
Fluoranthene	0.17	0.006	0.052	2.9	0.088	1.1	0.04	0.11	NA
Indeno(1,2,3-cd)pyrene	0.16	0.007	0.021	2.7	0.073	0.05 U	0.041	0.066	NA
Pyrene	0.23	0.008	0.15	2.8	0.11	1.6	0.061	0.1	NA
Total HPAHs	1.367	0.041	0.84	22.75	0.627	3.65	0.301	0.668	NA
Dibenzofuran	0.007	0.005 U	0.005 U	0.048	0.005 U	4.9	0.005 U	0.009	NA

Notes:
NA = Screening Level Not Available
U = Not detected at indicated sample quantitation limit.
Shaded fields denote constituent concentrations which exceed the established screening level.
(1) = Screening Levels are the most conservative of the ecological soil screening benchmarks presented in DEQ, 1998b.

Table 6

Initial Screening and Evaluation of Technologies for Mobile Liquid-Phase Petroleum Hydrocarbons
Feasibility Study - Terminal 4, Slip 3 Upland
Port of Portland - Portland, Oregon

General Response Action	Technology	Description	Effectiveness	Screening Comments
NO ACTION	None	No Action	Not Effective	Retained as a baseline for comparison
INSTITUTIONAL CONTROL	Access Restrictions	Restrict access with physical and/or legal barriers.	Effective at preventing direct contact.	Not acceptable for future site activities and does not address potential biological exposure pathway.
	Monitoring	Laboratory analyses of soil or groundwater samples.	Effective for documenting conditions and concentrations of contaminants.	Applicable to document effectiveness of other treatment technologies.
DISPOSAL	Landfill	Disposal of excavated soils in suitable landfill.	Effective, but does not reduce volume or toxicity of contamination.	Applicable for handling excavated soils. Compatible with on-site space restrictions. May have future liability.
	Discharge	Discharge of water (which may require treatment) into suitable receiver (e.g., sanitary sewer, river, etc.).	Effective for extracted groundwater. Treatment of water may be necessary prior to disposal.	Applicable. Surface water and sanitary sewer are available in the site vicinity.
REMOVAL	Excavation	Removal of contaminated soil (including soil in zone of liquid phase hydrocarbons) using conventional equipment or specialized methods where needed.	Effective to depths of up to 20 to 30 feet, but may require dewatering and/or shoring for depths over a few feet.	Applicable to shallow source soils. Not suitable for remediation of contaminated soil beneath building. Likely need to combine with pumping of liquid phase hydrocarbons and groundwater from open excavation.
	Pumping	Extraction well(s) with submersible pumps to remove contaminated groundwater. May also pump liquid phase hydrocarbons and groundwater from open excavations.	Effective in porous soils typical of much of site. May also be used in conjunction with other technologies.	Applicable.
	Subsurface Drains	Trench or horizontal conduit filled with porous media; gravity drains or sump pump.	Effective for shallow groundwater. May also be used in conjunction with other technologies.	Generally not effective for site conditions (depth to groundwater, proximity of river, coarse soil conditions).
CONTAINMENT/ ENGINEERING CONTROLS	Cover	Cover area of contaminated soil with impermeable (or semi-permeable) cover.	Effective at preventing direct contact. May reduce mobilization of contaminants (reduction of precipitation infiltration).	Not applicable for on-site disposal because not compatible with site use. Does not address potential ecological exposure pathway.
	Barrier	Installation of a barrier (e.g., sheet piling, bentonite, grout, etc.) to prevent migration of free product with groundwater.	Cut off walls effective at preventing migration, but difficult to achieve full containment. Cannot prevent downward migration.	Applicable. Effectiveness at preventing migration dependent upon type of barrier installed. Also dependent on the orientation of barrier.
	Pumping/ Hydraulic Containment	Extraction well(s) with submersible pumps to lower the water table and create hydraulic gradients that direct contaminant migration into the extraction well.	Effective in porous soils. May also be used in conjunction with other technologies. Also removes some of the contamination.	Applicable.
IN-SITU BIOLOGICAL TREATMENT	Bioventing	Delivering oxygen to contaminated (unsaturated) soils by forced air movement to stimulate biodegradation.	Effective for petroleum hydrocarbon contaminated soil, but limited effectiveness for liquid-phase hydrocarbons.	Not applicable for liquid hydrocarbons.
	Enhanced Bioremediation	Adding nutrients, electron donors, or other amendments to enhance bioremediation.	Effective for contaminated soil with addition of suitable amendments, usually in conjunction with source removal. Difficult to ensure adequate coverage. May not be effective on heavier hydrocarbons or for liquid phase.	Suitable additives exist for enhancing bioremediation of petroleum hydrocarbons. However, liquid phase hydrocarbons too concentrated for direct bioremediation. May not be suitable for remediation of source area. May not be necessary to stimulate biological activity.

Table 6

Initial Screening and Evaluation of Technologies for Mobile Liquid-Phase Petroleum Hydrocarbons
Feasibility Study - Terminal 4, Slip 3 Upland
Port of Portland - Portland, Oregon

General Response Action	Technology	Description	Effectiveness	Screening Comments
IN-SITU BIOLOGICAL TREATMENT CON'T	Land Treatment	Combination of aeration (tilling) and amendments to enhance bioremediation in surface soils.	Effective for shallow (surface) contamination with addition of suitable amendments. Requires sufficient access for soil equipment movement.	Not applicable because contamination predominately at depth.
	Natural Attenuation	Using natural processes to reduce contaminant concentrations to acceptable levels.	May be effective, especially in areas of low concentrations (near plume boundaries), but is dependant upon site conditions. Usually in conjunction with source removal. Not effective for liquid phase hydrocarbons.	Not suitable for short-term remediation of source area. Applicable for any remaining soil and groundwater contamination following free product removal. Suitable for use in conjunction with other treatment alternatives.
	Phytoremediation	Using plants to remove, transfer, stabilize, or destroy contaminants in soil.	May be effective for shallow contamination with concentrations below toxicity thresholds for selected plants. Requires surface area suitable for plant growth.	Incompatible with anticipated future site use and not suitable for free product removal.
IN-SITU PHYSICAL/ CHEMICAL/ THERMAL TREATMENT	Electrokinetic Separation	Use of electrochemical/electrokinetic processes to desorb and remove metals and polar organics.	Can be effective in low permeability soils (clays) with highly polar contaminants. Used in conjunction with other removal technologies (such as groundwater pumping) to extract mobilized contaminants.	Ineffective in coarser-grained site soils.
	Fracturing	Development of cracks in low permeability and over-consolidated soils to create passageways that increase the effectiveness of other *in-situ* processes and extraction technologies.	Effective in increasing influence radius of other *in-situ* technologies. May bypass significant contamination between cracks.	Not necessary with site soil conditions.
	Soil Flushing	Circulation of water (or water-additive) through the contaminated soil mass. Recovered water is treated and recycled.	Most effective in treatment of inorganic contaminants. Use of surfactants to increase organic solubility may alter physical/chemical properties of soil system.	Less effective for organic contaminants. Injected surfactants may not be compatible with continued aquifer use (i.e., discharge to aquatic environment). Not applicable to mobile liquid phase.
	Soil Vapor Extraction	Application of a vacuum in extraction wells to induce gas-phase volatiles to be removed from the soil.	Effective for the removal of volatile organics. Less effective in fine-grained soils.	Generally not effective for heavy liquid phase hydrocarbons. Thermally enhanced soil vapor extraction preferred for low volatility contaminants such as diesel.
	Solidification/ Stabilization	Physically binding contaminants within a stabilized mass or inducing chemical reactions that reduce mobility.	Can be effective at reducing migration/toxicity of contaminants. Chemical additives may have long-term leaching issues.	Injected chemicals (or reaction by-products) may not be compatible with continued aquifer use (i.e., discharge to aquatic environment). Difficult to ensure complete coverage. Likely not applicable to liquid phase hydrocarbons.
	Thermally Enhanced Soil Vapor Extraction	Applying heat (steam, hot air, heating units, directed energy) to increase volatilization rate of less volatile chemicals.	Effective for increasing usability of SVE for low-volatility compounds. High moisture content or saturated conditions will decrease effectiveness.	Shown to be effective for diesel contaminants.
	Chemical Reduction/ Oxidation	Chemically converts hazardous contaminants to less toxic compounds.	Effective in destroying organic contaminants (including free product) and oxidizing inorganic contaminants to less toxic/less mobile forms. Can be difficult to provide adequate coverage in subsurface.	Applicable.

Initial Screening and Evaluation of Technologies for Mobile Liquid-Phase Petroleum Hydrocarbons
Feasibility Study - Terminal 4, Slip 3 Upland
Port of Portland - Portland, Oregon

General Response Action	Technology	Description	Effectiveness	Screening Comments
IN-SITU PHYSICAL/ CHEMICAL/ THERMAL TREATMENT CON'T	Aeration/Air Sparging	Increasing the contact between water and air to enhance volatilization and/or bioremediation. Air sparging involves injecting air into saturated matrices.	Effective for volatile contamination and organics susceptible to biological destruction. May require shallow vapor extraction to prevent uncontrolled vapor migration.	Generally not compatible with liquid-phase hydrocarbons.
	Bioslurping/Dual Phase Extraction/ Fluid-Vapor Extraction	Applies vacuum to extract combination of contaminated groundwater, free-phase product, and organic vapors.	Effective at removing mobile and volatile fractions of LNAPL. Also enhances bioremediation and some contaminated groundwater.	Applicable.
	Steam Flushing/ Steam Stripping	Steam is injected into the contaminated aquifer to vaporize less volatile organics.	Used in conjunction with vapor recovery. May be effective for increasing usability of SVE for low volatility compounds.	Should be effective for diesel. Thermally enhanced soil vapor extraction will be retained as representative of in-situ thermal treatment.
	In-Well Air Stripping	Uses a double-screened well and injected air to circulate groundwater in the lower screen and out the upper screen. Vacuum in well collects vapors.	Most effective for treatment of VOCs at sites with deep water tables (no need to bring water to surface). May not be effective with low permeability (< 1E-5) soils in matrix.	Not compatible with site contaminants and liquid-phase hydrocarbons.
	Passive/Reactive Treatment Walls	Barriers placed across groundwater movement that allows passage of water while facilitating degradation or removal of contaminants.	Can be effective in the remediation of VOC and metal contamination. May not be suitable for source area remediation. Location of barriers requires adequate site access.	Generally not applicable to site contaminants and liquid-phase hydrocarbons.
EX-SITU BIOLOGICAL TREATMENT	Biopiles	Mixing soil amendments into excavated soil and placing in aerated piles.	Effective at removing many organic contaminants from excavated soil. Requires excavation of soil and area for both soil piles and pile handling.	Applicable. Landfarming may be more cost-effective if sufficient space is available. Landfarming will be retained as a representative technology.
	Composting	Excavated soil is mixed with bulking agents and organic amendments to promote microbial activity.	Effective at removing many organic contaminants from excavated soil. Requires excavation of soil and area for both soil piles and pile handling.	Amendments generally not required for diesel. Retain landfarming as a representative technology.
	Landfarming	Excavated soil is placed in lined beds and periodically tilled, watered, and fertilized to promote biological reduction.	Effective at removing many organic contaminants from excavated soil. Bioactivity is uncontrolled and may be less effective than other biological approaches.	Applicable. Site space is potentially available.
	Slurry-Phase Biological Treatment	A slurry of soil and water with additives is continuously mixed to keep solids suspended and microorganisms in contact with soil contaminants.	Effective at removing many organic contaminants from excavated soil. Wastewater requires additional treatment.	Handling of slurry and wastewater is complicated and expensive. Slurry-phase treatment generally not required for diesel.
	Bioreactors	Contaminants in extracted groundwater are put into contact with microorganisms in attached or suspended growth biological reactors.	Effective at removing many organic contaminants from extracted groundwater.	Technologies not commonly used for petroleum.
	Constructed Wetlands	Utilizes natural geochemical and biological processes inherent in an artificial wetland ecosystem to remove contaminants from extracted water.	Effective at removing many organic and inorganic contaminants from extracted groundwater. Requires area to construct wetland.	Not compatible with anticipated future site use.

Table 6

Initial Screening and Evaluation of Technologies for Mobile Liquid-Phase Petroleum Hydrocarbons
Feasibility Study - Terminal 4, Slip 3 Upland
Port of Portland - Portland, Oregon

General Response Action	Technology	Description	Effectiveness	Screening Comments
EX-SITU PHYSICAL/ CHEMICAL/ THERMAL TREATMENT	Chemical Extraction	Excavated soil is mixed with an extractant which dissolves the contaminants. The resultant solution is placed in a separator to remove the contaminant/extractant mixture for treatment.	Can be effective in removing most organic contaminants from soil. Difficult to remove all contaminant/extractant mixture from soil; would likely require finish treatment. Contaminant/extractant requires additional treatment.	Generally not cost-effective for diesel.
	Chemical Reduction/ Oxidation	Chemically converts hazardous contaminants to less toxic compounds.	Effective in destroying organic contaminants (including free product) and oxidizing inorganic contaminants to less toxic/less mobile forms.	Applicable. *In situ* chemical reduction/oxidation is more cost-effective.
	Dehalogenation	Reagents are mixed with excavated soils contaminated with halogenated organics.	Most suited to the treatment of halogenated semi-volatile organics and pesticides.	Halogenated chemicals not present.
	Soil Washing	Contaminants are separated from the excavated soil with wash water augmented with additives to help remove organics.	Most suited to the treatment of semi-volatile organics, metals, and fuels. Recovered wash water requires additional treatment.	Handling of slurry and wastewater is complicated and expensive. Slurry phase treatment is generally not required for diesel.
	Soil Vapor Extraction	Application of a vacuum in a network of piping in an above-ground soil pile to induce gas-phase volatiles to be removed from the soil.	Effective for the removal of volatile organics. Less effective in fine-grained soils.	Generally not compatible with site contaminants.
	Solar Detoxification	Contaminants are destroyed by photochemical and thermal reactions using ultraviolet energy in sunlight.	Can be effective for the detoxification of many organic compounds. Requires suitable climate and adequate space.	Less effective for site contaminants. Climate is not suitable for long-term solar exposure.
	Solidification/ Stabilization	Physically binding contaminants within a stabilized mass or inducing chemical reactions that reduce mobility.	Can be effective at reducing migration/toxicity of contaminants.	Not required for disposal.
	Thermal Desorption/ Pyrolysis/ Hot Gas Decontamination	Waste soils are heated to either volatilize (desorption and hot gas) or to anaerobically decompose (pyrolysis) organic contaminants. Off-gas is collected and treated.	Effective in the treatment of soils contaminated with volatile organics and petroleum hydrocarbons.	Applicable.
	Incineration	High temperatures are used to combust organic contaminants.	Effective in the treatment of soils contaminated with organics.	Generally not required for diesel. Not cost-effective.
	Adsorption	Concentrating solutes on the surface of a sorbent material, removing the solute from the bulk liquid.	Effective at removing many organic compounds from extracted water stream.	Applicable for treatment of extracted water, if necessary.
	Air Stripping	Volatile organics are partitioned from extracted groundwater by increasing surface area exposed to air.	Effective at removing many volatile organic compounds from extracted water stream.	Generally not compatible with site contaminants.
	Gravity Separation	Separates contaminants in water based on mass of chemical constituents.	Effective at removing the majority of petroleum hydrocarbons.	Applicable in conjunction with other technologies.

Table 6

Initial Screening and Evaluation of Technologies for Mobile Liquid-Phase Petroleum Hydrocarbons
Feasibility Study - Terminal 4, Slip 3 Upland
Port of Portland - Portland, Oregon

General Response Action	Technology	Description	Effectiveness	Screening Comments
EX-SITU PHYSICAL/ CHEMICAL/ THERMAL TREATMENT CON'T	Separation: Reverse Osmosis	Extracted groundwater is forced through a selectively permeable membrane under pressure. Water is allowed to pass through the membrane while contaminants are trapped.	Effective at removing many contaminants from the extracted water stream.	Technology not used for petroleum [illegible]
	Sprinkler Irrigation	Contaminated water is distributed through a pressurized sprinkler irrigation system, allowing transfer of VOCs from aqueous phase to vapor phase in the atmosphere.	Effective at removing highly volatile organic compounds from the extracted water stream.	Not compatible with anticipated future site use or site contaminants.
	Ultraviolet (UV) Oxidation	Ultraviolet radiation is used to destroy organic contaminants as water flows through treatment cell.	Effective at removing many organic contaminants from the extracted water stream.	Applicable, but other technologies are more cost-effective and will be retained as representative of water treatment.

Notes:
Shading represents technologies that have been eliminated from consideration.

Table 7

Alternatives for Detailed Evaluation
Feasibility Study - Port of Portland, Terminal 4, Slip 3 Upland
Portland, Oregon

Technologies[1]
1) No Action
2) Monitoring
3) Off-Site Landfill Disposal of Soil
4) Groundwater Discharge
5) Soil Excavation
6) Groundwater Well Pumping
7) Pumping from Open Excavation
8) Cut-off Wall
9) Groundwater Well Pumping for Hydraulic Containment
10) Natural Attenuation
11) Thermally Enhanced Soil Vapor Extraction
12) In-Situ Chemical Treatment
13) Dual Phase Extraction
14) Soil Landfarming
15) Soil Treatment by Thermal Desorption
16) Groundwater Treatment by Carbon Adsorption
17) Groundwater Treatment by Gravity Separation

Alternative Combination Identification		
Group #	**Alternative**	**Alternative Identification**
1	A[2]	No Action
2	B[3]	Off-Site Landfill Disposal of Soil
2	C[3]	Soil Landfarming
2	D[3]	Soil Treatment by Thermal Desoption
3	E[4]	Groundwater Well Pumping
3	F[4]	Dual Phase Extraction
4	G[5]	Cut-off Wall
4	H[4]	Hydraulic Containment
4	I[4]	Cut-off Wall Combined with Limited Pumping
5	J[5]	Thermally Enhanced Soil Vapor Extraction
5	K[5]	In-Situ Chemical Treatment

Data\Jobs\Port of Portland\5624-14 T-4 Slip 3 FS\FS Document 5624-14\Tables (Tab 2 Init Screening)

NOTES:

1. Technologies remaining after screening in Table 1.
2. Stand-alone alternative.
3. Additional included technologies: soil excavation, groundwater pumping from excavation, groundwater treatment by gravity separation and carbon adsorption, groundwater discharge, natural attenuation, and monitoring.
4. Additional included technologies: limited surface soil excavation and disposal, groundwater treatment by gravity separation and carbon adsorption, groundwater discharge, natural attenuation, and monitoring.
5. Additional included technologies: limited surface soil excavation and disposal, natural attenuation, and monitoring.

Table 8

Remedial Action Alternative Cost Estimates
Feasibility Study - Terminal 4 Slip 3 Upland
Port of Portland

Alternative / Category / Item	Quantity Unit	Unit Cost	Extended Cost	
A No Action				
Total Present Worth Cost				$0
B Off-site Landfill Disposal of Soil				
Capital Cost				
Demolition/Disposal Concrete Wall	120 cy	$30	$ 3,600	
Demolition of the Gearlocker	1 ls	$20,000	$ 20,000	
Abandonment of Wells	13 well	$1,000	$ 13,000	
Move/Upgrade Groundwater Treatment System	1 ls	$20,000	$ 20,000	
Surface Soil Sampling/Removal/Disposal	120 cy	$50	$ 6,000	
Clean Overburden Excavate and Replace	25,000 cy	$8	$ 200,000	
Excavation/Transport/Disposal Contaminated Soil	30,000 cy	$50	$ 1,500,000	
Import Backfill/Compaction	20,000 cy	$11	$ 220,000	
Pea Gravel	10,000 cy	$20	$ 200,000	
Groundwater/LNAPL Extraction O&M	2 month	$4,000	$ 8,000	
Install Monitoring Wells	6 well	$4,000	$ 24,000	
Engineering/Oversight	8 week	$5,000	$ 40,000	
Design/Work Plan/Procurement	1 ls	$20,000	$ 20,000	
Report	1 ls	$6,000	$ 6,000	
Contingency on Capital Cost (15%)			$ 342,090	
Total Capital Cost				$ 2,622,690
Operation, Maintenance, Monitoring, and Review*				
Monitoring (TPH Qtly)	2 yrs	$14,000	$25,138	
Abandon Monitoring Wells	30 ea	$1,000	$ 25,960	
Contingency on Long-Term Cost (5%)			$ 2,555	
Total Present Worth Long-Term Cost				$ 53,653
Total Present Worth Cost				$ 2,676,343
C Soil Landfarming				
Capital Cost				
Demolition/Disposal Concrete Wall	120 cy	$30	$ 3,600	
Demolition of the Gearlocker	1 ls	$20,000	$ 20,000	
Abandonment of Wells	13 well	$1,000	$ 13,000	
Move/Upgrade Groundwater Treatment System	1 ls	$20,000	$ 20,000	
Surface Soil Sampling/Removal/Disposal	120 cy	$50	$ 6,000	
Clean Overburden Excavate	25,000 cy	$4	$ 100,000	
Fill Clean Overburden/Compaction	15,000 cy	$4	$ 60,000	
Disposal of Remaining Clean Overburden	10,000 cy	$2	$ 20,000	
Excavate/Landfarming/Lining	30,000 cy	$35	$ 1,050,000	
Place Landfarm Soil/Compaction	30,000 cy	$6	$ 180,000	
Pea Gravel	10,000 cy	$20	$ 200,000	
Groundwater/LNAPL Extraction O&M	2 month	$4,000	$ 8,000	
Install Monitoring Wells	6 well	$4,000	$ 24,000	
Engineering/Oversight (Excavate & Construct)	8 week	$5,000	$ 40,000	
Engineering/Oversight (Landfill operation)	5 month	$5,000	$ 25,000	
Design/Work Plan/Procurement	1 ls	$20,000	$ 20,000	
Report	1 ls	$6,000	$ 6,000	
Contingency on Capital Cost (15%)			$ 269,340	
Total Capital Cost				$ 2,064,940
Operation, Maintenance, Monitoring, and Review*				
Monitoring (TPH Qtly)	2 yrs	$14,000	$25,138	
Abandon Monitoring Wells	30 ea	$1,000	$ 25,960	
Contingency on Long-Term Cost (5%)			$ 2,555	
Total Present Worth Long-Term Cost				$ 53,653
Total Present Worth Cost				$ 2,118,593

Table 8

Remedial Action Alternative Cost Estimates
Feasibility Study - Terminal 4 Slip 3 Upland
Port of Portland

Alternative / Category / Item	Quantity Unit	Unit Cost	Extended Cost	
D Soil Treatment by Thermal Desorption				
Capital Cost				
Demolition/Disposal Concrete Wall	120 cy	$30	$ 3,600	
Demolition of the Gearlocker	1 ls	$20,000	$ 20,000	
Abandonment of Wells	13 well	$1,000	$ 13,000	
Move/Upgrade Groundwater Treatment System	1 ls	$20,000	$ 20,000	
Surface Soil Sampling/Removal/Disposal	120 cy	$50	$ 6,000	
Clean Overburden Excavate and Replace	25,000 cy	$8	$ 200,000	
Excavate/Transport/Thermal Desorption	30,000 cy	$50	$ 1,500,000	
Treated Soil Return/Fill/Compaction	20,000 cy	$4	$ 80,000	
Pea Gravel	10,000 cy	$20	$ 200,000	
Groundwater/LNAPL Extraction O&M	2 month	$4,000	$ 8,000	
Install Monitoring Wells	6 well	$4,000	$ 24,000	
Engineering/Oversight	8 week	$5,000	$ 40,000	
Design/Work Plan/Procurement	1 ls	$20,000	$ 20,000	
Report	1 ls	$6,000	$ 6,000	
Contingency on Capital Cost (15%)			$ 321,090	
Total Capital Cost				$ 2,461,690
Operation, Maintenance, Monitoring, and Review*				
Monitoring (TPH Qtly)	2 yrs	$14,000	$25,138	
Abandon Monitoring Wells	30 ea	$1,000	$ 25,960	
Contingency on Long-Term Cost (5%)			$ 2,555	
Total Present Worth Long-Term Cost				$ 53,653
Total Present Worth Cost				$ 2,515,343
E Well Pumping				
Capital Cost				
Surface Soil Sampling/Removal/Disposal	120 cy	$50	$ 6,000	
Seep Area Clean Soil Excavate and Replace	1,300 cy	$10	$ 13,000	
Seep Area Soil Excavate/Transport/Landfill	2,800 cy	$60	$ 168,000	
Seep Area Silty Sand Backfill	2,000 cy	$20	$ 40,000	
Seep Area Sand/Gravel and Rip Rap Backfill	800 cy	$25	$ 20,000	
Seep Area Excavation Dewatering	1 ls	$15,000	$ 15,000	
Well Installation	8 well	$4,000	$ 32,000	
Product/Water Pumps	8 each	$1,500	$ 12,000	
Piping, Fittings, and Valves	8 well	$2,000	$ 16,000	
Trenching/Fill	1200 lf	$4	$ 4,800	
Treatment System Upgrade	1 ls	$40,000	$ 40,000	
Engineering/Oversight	7 week	$5,000	$ 35,000	
Aquifer Test	1 ls	$15,000	$ 15,000	
Design/Work Plan/Procurement	1 ls	$20,000	$ 20,000	
Report	1 ls	$6,000	$ 6,000	
Contingency on Capital Cost (15%)			$ 66,420	
Total Capital Cost				$ 509,220
Operation, Maintenance, Monitoring, and Review*				
System O&M/discharge sampling	8 yrs	$60,000	$ 351,438	
Engineering/Oversight	8 yrs	$3,000	$ 17,572	
Monitoring (LNAPL and TPH Qtly for 10 yrs)	10 yrs	$14,000	$ 96,097	
5-year Review	2 ea	$5,000	$ 5,909	
Abandon Monitoring/Recovery Wells	45 ea	$1,000	$ 25,232	
Contingency on Long-Term Cost (5%)			$ 24,812	
Total Present Worth Long-Term Cost				$ 521,060
Total Present Worth Cost				$ 1,030,280

Table 8

Remedial Action Alternative Cost Estimates
Feasibility Study - Terminal 4 Slip 3 Upland
Port of Portland

Alternative / Category / Item	Quantity Unit	Unit Cost	Extended Cost	
F Dual Phase Extraction				
Capital Cost				
Surface Soil Sampling/Removal/Disposal	120 cy	$50	$ 6,000	
Seep Area Clean Soil Excavate and Replace	1,300 cy	$10	$ 13,000	
Seep Area Soil Excavate/Transport/Landfill	2,800 cy	$60	$ 168,000	
Seep Area Silty Sand Backfill	2,000 cy	$20	$ 40,000	
Seep Area Sand/Gravel and Rip Rap Backfill	800 cy	$25	$ 20,000	
Seep Area Excavation Dewatering	1 ls	$15,000	$ 15,000	
Well Installation	15 well	$4,000	$ 60,000	
Blower (150 cfm)	3 ea	$5,000	$ 15,000	
Product/water pumps	15 ea	$1,500	$ 22,500	
Piping, Fittings, and Valves (air)	15 well	$2,000	$ 30,000	
Piping, Fittings, and Valves (water)	15 well	$2,000	$ 30,000	
Trenching/Fill	2250 lf	$4	$ 9,000	
Upgrade Treatment System	1 ls	$40,000	$ 40,000	
Engineering/Oversight	7 week	$5,000	$ 35,000	
Pilot Test	1 ls	$15,000	$ 15,000	
Design/Work Plan/Procurement	1 ls	$20,000	$ 20,000	
Report	1 ls	$6,000	$ 6,000	
Contingency on Capital Cost (15%)			$ 81,675	
Total Capital Cost				$ 626,175
Operation, Maintenance, Monitoring, and Review*				
System O&M/discharge sampling	6 yrs	$60,000	$281,631	
Engineering/Oversight	6 yrs	$3,000	$14,082	
Monitoring (LNAPL and TPH Qtly for 8 yrs)	8 yrs	$14,000	$82,002	
5-year Review	2 ea	$5,000	$ 6,286	
Abandon Monitoring/Recovery Wells	52 ea	$1,000	$ 33,694	
Contingency on Long-Term Cost (5%)			$ 20,885	
Total Present Worth Long-Term Cost				$438,580
Total Present Worth Cost				$ 1,064,755
G Cut-off Wall				
Capital Cost				
Surface Soil Sampling/Removal/Disposal	120 cy	$50	$ 6,000	
Seep Area Clean Soil Excavate and Replace	800 cy	$10	$ 8,000	
Seep Area Soil Excavate/Transport/Landfill	1,500 cy	$60	$ 90,000	
Seep Area Silty Sand Backfill	700 cy	$20	$ 14,000	
Seep Area Sand/Gravel and Rip Rap Backfill	800 cy	$25	$ 20,000	
Seep Area Excavation Dewatering	1 ls	$10,000	$ 10,000	
Deep Aquifer Investigation	1 ls	$50,000	$ 50,000	
Cutoff Wall	36,000 sf	$25	$ 900,000	
Engineering/Oversight	6 week	$5,000	$ 30,000	
Design/Work Plan/Procurement	1 ls	$15,000	$ 15,000	
Report	1 ls	$6,000	$ 6,000	
Contingency on Capital Cost (15%)			$ 172,350	
Total Capital Cost				$ 1,321,350
Operation, Maintenance, Monitoring, and Review*				
Monitoring (Water/LNAPL Levels Semi-Annually)	30 yrs	$2,000	$23,621	
Monitoring (TPH Qtly)	2 yrs	$14,000	$25,138	
5-year Review	6 ea	$5,000	$ 10,167	
Abandon Monitoring Wells	37 ea	$1,000	$ 4,226	
Contingency on Long-Term Cost (5%)			$ 3,158	
Total Present Worth Monitoring Cost				$66,309
Total Present Worth Cost				$ 1,387,659

Table 8
Remedial Action Alternative Cost Estimates
Feasibility Study - Terminal 4 Slip 3 Upland
Port of Portland

Alternative / Category / Item	Quantity Unit	Unit Cost	Extended Cost	
H Hydraulic Containment				
Capital Cost				
Surface Soil Sampling/Removal/Disposal	120 cy	$50	$ 6,000	
Seep Area Clean Soil Excavate and Replace	800 cy	$10	$ 8,000	
Seep Area Soil Excavate/Transport/Landfill	1,500 cy	$60	$ 90,000	
Seep Area Silty Sand Backfill	700 cy	$20	$ 14,000	
Seep Area Sand/Gravel and Rip Rap Backfill	800 cy	$25	$ 20,000	
Seep Area Excavation Dewatering	1 ls	$10,000	$ 10,000	
Deep Aquifer Investigation	1 ls	$50,000	$ 50,000	
Well Installation	4 well	$4,000	$ 16,000	
Pumps	4 each	$1,500	$ 6,000	
Piping, Fittings, and Valves	4 well	$2,000	$ 8,000	
Trenching/Fill	400 lf	$4	$ 1,600	
Treatment System Upgrade	1 ls	$10,000	$ 10,000	
Engineering/Oversight	4 week	$4,000	$ 16,000	
Aquifer Test	1 ls	$15,000	$ 15,000	
Design/Work Plan/Procurement	1 ls	$20,000	$ 20,000	
Report	1 ls	$6,000	$ 6,000	
Contingency on Capital Cost (15%)			$ 44,490	
Total Capital Cost				$ 341,090
Operation, Maintenance, Monitoring, and Review*				
System O&M/discharge sampling	15 yrs	$50,000	$441,356	
Engineering/Oversight	15 yrs	$3,000	$26,481	
Monitoring (Water/LNAPL Levels Semi-annually)	30 yrs	$2,000	$23,621	
Monitoring (TPH Qtly)	2 yrs	$14,000	$25,138	
5-year Review	6 ea	$5,000	$ 10,167	
Abandon Monitoring/Recovery Wells	41 ea	$1,000	$ 13,857	
Contingency on Long-Term Cost (15%)			$ 81,093	
Total Present Worth Long-Term Cost				$621,712
Total Present Worth Cost				$ 962,802
I Cut-off Wall Combined with Limited Pumping				
Initial Cost				
Surface Soil Sampling/Removal/Disposal	120 cy	$50	$ 6,000	
Seep Area Clean Soil Excavate and Replace	800 cy	$10	$ 8,000	
Seep Area Soil Excavate/Transport/Landfill	1,500 cy	$60	$ 90,000	
Seep Area Silty Sand Backfill	700 cy	$20	$ 14,000	
Seep Area Sand/Gravel and Rip Rap Backfill	800 cy	$25	$ 20,000	
Seep Area Excavation Dewatering	1 ls	$10,000	$ 10,000	
Deep Aquifer Investigation	1 ls	$50,000	$ 50,000	
Cutoff Wall	10,500 sf	$25	$ 262,500	
Well Installation	3 well	$4,000	$ 12,000	
Pumps	3 each	$1,500	$ 4,500	
Piping, Fittings, and Valves	3 well	$2,000	$ 6,000	
Trenching/Fill	600 lf.	$4	$ 2,400	
Treatment System Upgrade	1 ls	$10,000	$ 10,000	
Engineering/Oversight	4 week	$5,000	$ 20,000	
Aquifer Test	1 ls	$15,000	$ 15,000	
Design/Work Plan/Procurement	1 ls	$20,000	$ 20,000	
Report	1 ls	$6,000	$ 6,000	
Contingency on Capital Cost (15%)			$ 83,460	
Total Capital Cost				$ 639,860
Operation, Maintenance, Monitoring, and Review*				
System O&M/discharge sampling	10 yrs	$45,000	$308,884	
Engineering/Oversight	10 yrs	$3,000	$20,592	
Monitoring (Water/LNAPL Levels Semi-annually)	30 yrs	$2,000	$23,621	
Monitoring (TPH Qtly)	2 yrs	$14,000	$25,138	
5-year Review	6 ea	$5,000	$ 10,167	
Abandon Monitoring/Recovery Wells	40 ea	$1,000	$ 19,408	
Contingency on Long-Term Cost (15%)			$ 61,171	
Total Present Worth Long-Term Cost				$468,980
Total Present Worth Cost				$ 1,108,840

Table 8

Remedial Action Alternative Cost Estimates
Feasibility Study - Terminal 4 Slip 3 Upland
Port of Portland

Alternative / Category / Item	Quantity Unit	Unit Cost	Extended Cost	
J Thermally Enhanced Soil Vapor Extraction				
Capital Cost				
Surface Soil Sampling/Removal/Disposal	120 cy	$50	$ 6,000	
Seep Area Clean Soil Excavate and Replace	800 cy	$10	$ 8,000	
Seep Area Soil Excavate/Transport/Landfill	1,500 cy	$60	$ 90,000	
Seep Area Silty Sand Backfill	700 cy	$20	$ 14,000	
Seep Area Sand/Gravel and Rip Rap Backfill	800 cy	$25	$ 20,000	
Seep Area Excavation Dewatering	1 ls	$10,000	$ 10,000	
Themally Enhanced Soil Vapor Extraction	10,000 cy	$120	$ 1,200,000	
Engineering/Oversight	8 week	$2,000	$ 16,000	
Pilot Study	1 ls	$40,000	$ 40,000	
Design/Work Plan/Procurement	1 ls	$20,000	$ 20,000	
Well Abandonment	30 ea	$1,000	$ 30,000	
Report	1 ls	$6,000	$ 6,000	
Contingency on Capital Cost (15%)			$ 219,000	
Total Capital Cost				$ 1,679,000
Operation, Maintenance, Monitoring, and Review*				
Monitoring (TPH Qtly)	2 yrs	$14,000	$25,138	
Abandon Monitoring Wells	37 ea	$1,000	$ 32,017	
Contingency on Long-Term Cost (5%)			$ 2,858	
Total Present Worth Long-Term Cost				$ 60,013
Total Present Worth Cost				$ 1,739,013
K In-situ Chemical Treatment				
Capital Cost				
Surface Soil Sampling/Removal/Disposal	120 cy	$50	$ 6,000	
Seep Area Clean Soil Excavate and Replace	800 cy	$10	$ 8,000	
Seep Area Soil Excavate/Transport/Landfill	1,500 cy	$60	$ 90,000	
Seep Area Silty Sand Backfill	700 cy	$20	$ 14,000	
Seep Area Sand/Gravel and Rip Rap Backfill	800 cy	$25	$ 20,000	
Seep Area Excavation Dewatering	1 ls	$10,000	$ 10,000	
Well Abandonment	13 ea	$1,000	$ 13,000	
Chemical Treatment (vendor estimate)	1 ls	$1,980,000	$ 1,980,000	
Install Monitoring Wells	6 well	$4,000	$ 24,000	
Engineering/Oversight	45 week	$4,000	$ 180,000	
Design/Work Plan/Procurement	1 ls	$30,000	$ 30,000	
Report	1 ls	$6,000	$ 6,000	
Contingency on Capital Cost (15%)			$ 357,150	
Total Capital Cost				$ 2,738,150
Operation, Maintenance, Monitoring, and Review*				
Monitoring (TPH Qtly)	2 yrs	$14,000	$25,138	
Abandon Monitoring Wells	30 ea	$1,000	$ 25,960	
Contingency on Long-Term Cost (5%)			$ 2,555	
Total Present Worth Long-Term Cost				$ 53,653
Total Present Worth Cost				$ 2,791,803

Data\Jobs\Port of Portland\5624-14 T-4 Slip 3 FS\FS Document 5624-14\Tables (Tab 3 Cost - Revised)

* Present value costs calculated with an annual discount rate of: 7.5%

Table 9

Comparison of Remedial Action Alternatives
Feasibility Study - Terminal 4, Slip 3 Upland
Portland, Oregon

Balancing Remedy Selection Factors[5]

Effectiveness

Alternative	A	B	C	D	E	F	G	H	I	J	K
A[1] No Action		-	-	-	-	-	-	-	-	-	-
B[2] Off-Site Landfill Disposal of Soil	+		+	0	+	+	0	+	+	+	+
C[2] Soil Landfarming	+	-		-	+	+	-	+	+	0	0
D[2] Soil Treatment by Thermal Desorption	+	0	+		+	+	0	+	+	+	+
E[3] Well Pumping	+	-	-	-		-	-	+	+	-	-
F[3] Dual Phase Extraction	+	-	-	-	+		-	+	+	-	-
G[4] Cut-off Wall	+	0	+	0	+	+		+	+	+	+
H[3] Hydraulic Containment	+	-	-	-	-	-	-		-	-	-
I[3] Cut-off Wall Combined with Limited Pumping	+	-	-	-	-	-	-	+		-	-
J[4] Thermally Enhanced Soil Vapor Extraction	+	-	0	-	+	+	-	+	+		0
K[4] In-Situ Chemical Treatment	+	-	0	-	+	+	-	+	+	0	

Long-Term Reliability

Alternative	A	B	C	D	E	F	G	H	I	J	K
A[1] No Action		-	-	-	-	-	-	-	-	-	-
B[2] Off-Site Landfill Disposal of Soil	+		-	-	+	+	+	+	+	-	-
C[2] Soil Landfarming	+	+		0	+	+	+	+	+	0	0
D[2] Soil Treatment by Thermal Desorption	+	+	0		+	+	+	+	+	0	0
E[3] Well Pumping	+	-	-	-		-	+	+	+	-	-
F[3] Dual Phase Extraction	+	-	-	-	+		+	+	+	-	-
G[4] Cut-off Wall	+	-	-	-	-	-		-	-	-	-
H[3] Hydraulic Containment	+	-	-	-	-	-	+		-	-	-
I[3] Cut-off Wall Combined with Limited Pumping	+	-	-	-	-	-	+	+		-	-
J[4] Thermally Enhanced Soil Vapor Extraction	+	+	0	0	+	+	+	+	+		0
K[4] In-Situ Chemical Treatment	+	+	0	0	+	+	+	+	+	0	

Implementability

Alternative	A	B	C	D	E	F	G	H	I	J	K
A[1] No Action		+	+	+	+	+	+	+	+	+	+
B[2] Off-Site Landfill Disposal of Soil	-		+	0	0	0	-	0	0	+	+
C[2] Soil Landfarming	-	-		-	-	-	-	-	-	-	-
D[2] Soil Treatment by Thermal Desorption	-	0	+		0	0	-	0	0	+	+
E[3] Well Pumping	-	0	+	0		0	-	0	0	+	+
F[3] Dual Phase Extraction	-	0	+	0	0		-	0	0	+	+
G[4] Cut-off Wall	-	+	+	+	+	+		+	+	+	+
H[3] Hydraulic Containment	-	0	+	0	0	0	-		0	+	+
I[3] Cut-off Wall Combined with Limited Pumping	-	0	+	0	0	0	-	0		+	+
J[4] Thermally Enhanced Soil Vapor Extraction	-	-	+	-	-	-	-	-	-		0
K[4] In-Situ Chemical Treatment	-	-	+	-	-	-	-	-	-	0	

Implementation Risk

Alternative	A	B	C	D	E	F	G	H	I	J	K
A[1] No Action		+	+	+	+	+	+	+	+	+	+
B[2] Off-Site Landfill Disposal of Soil	-		-	0	+	+	-	+	+	+	+
C[2] Soil Landfarming	-	+		+	+	+	-	+	+	+	+
D[2] Soil Treatment by Thermal Desorption	-	0	-		+	+	-	+	+	+	+
E[3] Well Pumping	-	-	-	-		0	-	+	+	+	+
F[3] Dual Phase Extraction	-	-	-	-	0		-	+	+	+	+
G[4] Cut-off Wall	-	+	+	+	+	+		+	+	+	+
H[3] Hydraulic Containment	-	-	-	-	-	-	-		-	+	+
I[3] Cut-off Wall Combined with Limited Pumping	-	-	-	-	-	-	-	+		+	+
J[4] Thermally Enhanced Soil Vapor Extraction	-	-	-	-	-	-	-	-	-		-
K[4] In-Situ Chemical Treatment	-	-	-	-	-	-	-	-	-	+	

Reasonableness of Cost

Alternative	A	B	C	D	E	F	G	H	I	J	K	Score	Rank[6]
A[1] No Action		+	+	+	+	+	+	+	+	+	+	10	11
B[2] Off-Site Landfill Disposal of Soil	-		-	-	-	-	-	-	-	-	+	6	3
C[2] Soil Landfarming	-	+		+	-	-	-	-	-	-	+	1	5
D[2] Soil Treatment by Thermal Desorption	-	+	-		-	-	-	-	-	-	+	13	2
E[3] Well Pumping	-	+	+	+		+	+	+	-	+	+	0	6
F[3] Dual Phase Extraction	-	+	+	+	-		+	-	+	+	+	2	4
G[4] Cut-off Wall	-	+	+	+	-	-		-	-	+	+	16	1
H[3] Hydraulic Containment	-	+	+	+	+	+	+		+	+	+	-11	8
I[3] Cut-off Wall Combined with Limited Pumping	-	+	+	+	-	-	+	-		+	+	-11	8
J[4] Thermally Enhanced Soil Vapor Extraction	-	+	+	+	-	-	-	-	-		+	-10	7
K[4] In-Situ Chemical Treatment	-	-	-	-	-	-	-	-	-	-		-16	10

Data\Jobs\Port of Portland\5624-14 T-4 Slip 3 FS\FS Document 5624-14\Tables (Tab 4 Comp Anal)

NOTES:

1. Stand-alone alternative.
2. Includes technologies: soil excavation, groundwater pumping from excavation, groundwater treatment by gravity separation and carbon adsorption, groundwater discharge, natural attenuation, and monitoring.
3. Includes technologies: limited surface soil excavation and disposal, groundwater treatment by gravity separation and carbon adsorption, groundwater discharge, natural attenuation, and monitoring.
4. Includes technologies: limited surface soil excavation and disposal, natural attenuation, and monitoring.
5. The comparative analysis was completed by comparing each alternative to every other alternative within each criterion
   + = The alternative is favored over the compared alternative (score=1)
   0 = The alternative is equal with the compared alternative (score=0)
   - = The alternative is less favorable than the compared alternative (score=-1)

   The example comparison to the right illustrates the comparison of effectiveness between alternative D and B. For this example, alternative D is more effective than alternative B, and therefore, alternative D scores more favorably (shown as a "+" at the intersection of row "D" and column "B."

Effectiveness	A	B	C	D
A		-	-	-
B	+		0	-
C	+	0		-
D	+	+	+	

6. Ranking based on both score and whether alternative meets the protectiveness requirements of OAR 340-122-040.