ENGINEERING DESIGN REPORT

KINDER MORGAN ENERGY PARTNERS
HARBOR ISLAND TERMINAL
SEATTLE, WASHINGTON

PREPARED BY:

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PROJECT NO. A30-01D

KHM ENVIRONMENTAL MANAGEMENT, INC.

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1.0 INTRODUCTION

KHM Environmental Management, Inc. (KHM) was retained by Kinder Morgan Energy Partners (Kinder Morgan) to prepare this Draft Engineering Design Report for the Harbor Island Terminal in Seattle, Washington. The Engineering Design Report contains detailed information needed to install the selected remedial technologies. The Engineering Design Report is prepared in accordance with the specifications in Section 173-340-410(4)(a) of the Washington Administrative Code (WAC).

1.1 INTRODUCTION

In November 1999, Ecology finalized a Cleanup Action Plan (CAP) for the Kinder Morgan Harbor Island Terminal, Seattle, Washington. The CAP was prepared to satisfy the requirements of the Model Toxics Control Act (MTCA) Agreed Order No. DE 92 TC-N159. The purposes of the CAP were to: 1) describe the site, including a summary of its history and extent of contamination; 2) identify the site specific cleanup standards, 3) summarize the remedial cleanup action alternatives presented in the Focused Feasibility Studies (FFS), 4) identify and describe the selected remedial action alternatives for the site, and 5) discuss the implementation schedule. Detailed information regarding the site history, characterization, and evaluation of alternative cleanup actions is contained in the final Remedial Investigation (RI) and final FSS reports [Pacific Environmental Group, Inc., 1994, 1997].

The Engineering Design Report summarizes site information and presents a brief description of the selected remedial technologies. The report also presents detailed information regarding the design, construction, and operation of the selected cleanup activities.

1.2 SITE LOCATION AND DESCRIPTION

The Kinder Morgan Harbor Island Terminal is located at 2720 13th Avenue Southwest in Seattle, Washington (Figure 1). The facility, approximately 14 acres in size, is located in the highly industrialized north-central section of Harbor Island. The Terminal is situated on relatively level property, with surface elevations ranging between 6 to 11 feet above mean sea level. There are no surface water bodies on or immediately adjacent to the facility. The site is zoned industrial and meets the industrial criteria established under WAC 173-340-745. The site is also part of a U.S. EPA Harbor Island Superfund Site known as the Terminal Operable Unit.

Groundwater is encountered at 3 to 8 feet below ground surface. Groundwater flows in a radial pattern outward from the center of Harbor Island and enters the marine surface water at the island's edge. The Washington State Department of Ecology (Ecology) and the United States Environmental Protection Agency (EPA) have determined that there is no current or planned future use of groundwater beneath Harbor Island for drinking water purposes.

The Terminal is presently divided into five distinct areas (Figure 2). These areas include the A, B, C, D, and E Yards. The A Yard contains two fuel tanker truck-loading racks. The administrative office and maintenance building is also situated in the A Yard. The A Yard is entirely paved with asphalt or concrete. The A Yard is bounded by a containment dike for the B Yard on the north and by chain-link fencing on the south, east, and west.

The B and C Yards are used as bulk fuel storage areas. Fifteen above ground storage tanks are located within the B Yard and six are situated within the C Yard. Both yards are mostly unpaved and are surrounded by concrete containment dikes.

The D Yard is situated between the B and C Yards and has been used to route product and utility lines. Several maintenance buildings and material handling areas are also situated within the D Yard. The partially paved yard is enclosed to the north and south by concrete dikes from the B and C Yards and is fenced on the east and west sides.

The E Yard once served as a fuel loading rack facility. This yard is currently leased to Chevron Oil Company and is partially paved. Terminal operations commenced in 1944 when tanks in the B Yard were installed. Tanks in the C Yard were subsequently constructed in 1951. A loading rack was once situated in the E Yard. This rack and associated piping were removed in 1992. Shell leased the A Yard from the Port of Seattle (Port) in 1979 and constructed two fuel tanker truck loading racks. The loading racks remain in use by Kinder Morgan today.

1.3 REPORT ORGANIZATION

The Engineering Design Report provides information requested in WAC Section 173-340-410(a). A correlation of requested items and report section is presented below.

(i)	Goals of cleanup action	Section 1.4
(ii)	Identification of site owner	Section 1.5
(iii)	General information	Section 2.0
(iv)	Characteristics, quantity, location of materials to be treated	Section 3.2
(v)	Schedule for final design and construction	Section 10.0

(vi)	Description of Cleanup Actions Conceptual plans	Section 3.6
(vii)	Engineering Justification Design criteria and operational parameters.	Section 4.0
(viii)	Design features for control of accidental spills and discharges	Section 7.0
(ix)	Long term safety of workers and local residences	Section 5.0
(x)	Disposal of treatment residuals	Section 8.0
(xi)	Specific characteristics which may affect design, construction, or operation of cleanup actions	Section 4.1
(xii)	Construction Testing	Section 6.0
(xiii)	Compliance Monitoring	Section 9.0
(xiv)	Construction procedures to assure health and safety	Sections 5.0 & 7.0
(xv)	Any information not provided in the RI/FSS reports	Section 2.2
(xvi)	Property access issues	Not Applicable
(xvii)	Other information	Not Required

1.4 GOAL OF CLEANUP ACTION

The goal of the selected remedial action is the protection of human health and the environment. Soil and groundwater cleanup levels were developed based on the industrial zoning of the site and the determination that there is no current or planned future use of the groundwater for drinking water purposes. The purposes of remediation of soil and shallow groundwater beneath the site are the protection of surface waters and associated ecosystems and to prevent dissolved petroleum hydrocarbons from migrating off site and adversely impacting adjacent properties.

Specific cleanup goals for site soil and groundwater are as follows:

- Surface soils (0 – 6-inch depth interval)
  Cap, fixate, or excavate soils with:
  - arsenic at concentrations that exceed 32.6 milligrams per kilogram (mg/kg)
  - lead at concentrations that exceed 1,000 mg/kg.

- C Yard Subsurface soils (6-inch to 10-foot depth interval)
  - Excavate soil hot-spots with total petroleum hydrocarbons (TPH) at concentrations over 10,000 mg/kg.

- Subsurface soils over the remainder of site
  -Excavate soils with TPH hot-spots at concentrations over 20,000 mg/kg.

- Groundwater
  - Remove recoverable separate-phase hydrocarbons, limited to product sheen

1.5 OPERATION AND MAINTENANCE OF THE CLEANUP ACTION

Kinder Morgan will own, operate, and maintain any cleanup action during and following remedial action.

2.0 SITE INFORMATION

The following sections present background site information. Data is presented that formed the basis for selection of site remediation alternatives. A scope of work for Supplemental Studies to be performed is also summarized. The following sections present information requested in WAC Section 173-340-410(a) (i) through (iv).

2.1 SUMMARY OF REMEDIAL INVESTIGATION AND FEASIBILITY STUDIES

The following section summarizes the nature and extent of contamination at the site based on the results of the RI and FFS.

2.1.1 FLOATING PRODUCT

Floating product (separate phase hydrocarbons) is present in several locations in the A Yard and in the B Yard. In January 1997, the thickness of floating product (as measured in monitoring wells) in the A yard, ranged from 0.01 to 0.48 feet. Product observed in wells in the B Yard ranged in thickness from 0.14 to 1.60 feet (Wells 12 and 15) on the same date.

The thickness of measurable product in the C Yard ranged from 0.11 to 1.20 feet in December 1996. In February 1997, measurable amounts of product in the C Yard had decreased in thickness (0.01 to 0.23 feet) as the result of implementation of the interim action. The interim action was discontinued in April 1997. In October 2000, no free product was observed in the C Yard.

2.1.2 ARSENIC AND LEAD

Arsenic and Lead are found at concentrations above cleanup goals in surface soil (0 to 6 inches below grade) in the B and C Yards. The lateral distribution of lead appears to be relatively uniform across the B and C Yards (Figure 4). Lead concentrations decrease rapidly at depth to less than 100 parts per million (ppm) at 1.5 feet below grade. At depths below 1.5 feet, total lead concentrations in soil were below 51 ppm.

2.1.3 TPH AND BTEX COMPOUNDS

SOIL. RI data indicate that elevated concentrations of TPH are present in the subsurface soils over of much of the site. The primary constituents of concern encountered in the subsurface soil beneath the Terminal are TPH-G, TPH-D, and TPH-O. Elevated TPH concentrations exist in four general areas: (1) the south portion of the B Yard, (2) the northern portion of the A Yard, (3) the area adjacent to Tank 44 situated in the southeast portion of the C Yard, and (4) the area between Tank 39 and 42 in the C Yard (Figure 3)

The vertical migration of TPH and BTEX in soil is limited because of the shallow depth to groundwater. In most cases, TPH concentrations are highest at the groundwater table interface. The Supplemental RI data show that a resulting "smear" zone of product in soil beneath the product plume has been detected up to 4 feet below the water table (approximately 9-feet below ground surface). This smear zone is attributed to natural fluctuations in groundwater levels.

GROUNDWATER. The primary dissolved contaminants observed in groundwater include TPH-G, TPH-D, TPH-O, and benzene. The extent of dissolved TPH-G in groundwater is generally limited to the northern, western and southern portions of the A Yard, the southwest portion of the B Yard, and the southern and southeastern portions of the C Yard (Figure 5). Relatively uniform concentrations of TPH-D were observed in groundwater from wells in the C, D, and E Yards . This observation concurs with past gasoline usage and storage practices at the Terminal.

Fate and transport groundwater modeling conducted by Ecology for the tank farms show that constituents of the dissolved petroleum hydrocarbons (e.g., benzene) do not pose a threat at the shorelines of the East and West Waterways of the Duwamish River. Offsite migration of these contaminants in the subsurface (infiltration and groundwater transport) is a secondary concern at the site.

2.1.4 MARINE SEDIMENTS

The Kinder Morgan site is situated in the middle of Harbor Island and has no direct marine sediment contact or shorelines next to its property boundaries.

2.2 SUPPLEMENTAL STUDIES

A series of tasks were identified to provide data needed to complete the design of remediation components. Tasks that were performed include:

- Soil leachability testing for metals, and
- Air-sparge testing.

Data derived from these tasks was used to finalize the remediation designs described in this report. A detailed description of these task and the results of the supplemental studies were included in a separate report.

2.2.1 Lead and Arsenic Shallow Soil Assessment

Additional soil sampling was performed to refine the boundaries between soils which are above and below action levels for lead and arsenic. A total of 28 soil samples were analyzed for lead and 14 samples were analyzed for arsenic (EPA Method 7420).

Arsenic was detected in 9 of the 14 samples analyzed and concentrations ranged from 15.3 ppm to 86.4 ppm. Lead was detected in all 28 samples analyzed and concentrations ranged from 46 ppm to 2250 ppm. Sample locations and metal concentrations are shown on Figure 4.

2.2.2 Soil Fixation Testing

Fixation testing involved testing of lead- and arsenic-affected soil and evaluating the leachability of lead and arsenic in the native material. The purpose of fixation testing was to further evaluate on-site and off-site cleanup alternatives for surface soil.

Soil samples were collected and analyzed for total lead and arsenic using EPA Method 6010. The same samples were also analyzed for TCLP lead and arsenic using EPA Method 1311/6010. The use of these analytical methods allowed the evaluation of the leaching potential of lead and arsenic from the native soil. Data derived from testing indicated that TCLP concentrations were 100 to 1000 times lower than total metal concentrations.

The TCLP data indicates that metal-impacted soil that is excavated could be transported off-site to an appropriate disposal facility more effectively than processing and fixating the soil on-site. The small volume of soil expected to be generated, along with operational constraints of the Terminal, make on-site soil fixation impractical and less feasible than off-site disposal. In addition, since impacted soil will be removed from the site, there will be no need to maintain fixated soil which would be necessary to prevent the future release of lead and arsenic through physical degradation of the fixated soil.

Based upon leachability analysis of the native impacted material and upon discussions with several contractors and disposal facilities, on-site soil fixation is not the most effective alternative to mitigate the metal impacted soil. TCLP testing of surface soil samples indicate that the soil can be excavated and transported to an acceptable disposal facility without fixation. Excavated soil will be stockpiled at tested before being transported to the appropriate disposal facility to document these conclusions.

2.2.3 AIR-SPARGE TESTING

Well Installation

KHM directed drilling and installation of two air sparge wells (AS-1 and AS-2) at the site. All drilling was performed using hollow-stem auger drilling equipment.

The air sparge well Borings AS-1 and AS-2 were advanced to a depth of 20 and 11.5 feet below ground surface, respectively. AS wells were constructed using 2-inch factory-slotted PVC well screen and riser pipe. A 1.5-foot screened interval was placed at the depth interval of 10 to 11.5 feet below grade. Each well was completed at ground surface with a flush-mount lockable security vault placed over the well head.

Feasibility Testing

Air sparge testing was performed on November 9, 2000 to determine the effective radius of influence. KHM performed testing on Wells AS-1 and AS-2 using existing monitoring wells as monitoring points. KHM used helium as a tracer gas to indicate influence. Logs of the test and observation wells were maintained throughout the test.

Two monitoring wells MW-3 and T-7,were used to evaluate the radius of influence of AS-1: located at distances of 29.0 and 16.5 feet, respectively, from the test well. Three monitoring wells were used to evaluate the radius of influence of AS-2: T-3, T-X, and T-2, located at distances of 44.5, 20.8, and 47.5 feet, respectively, from the test well.

A second phase of testing was performed on November 13, 2000. During this testing air injection was applied to Wells AS-1 and AS-2 over a period of 21.5 hours. The expected long-term air-sparging flowrate of approximately 3 to 5 cfm per well and expected pressure of approximately 5 psig, determined through the first phase of testing, was maintained. Prior to initiating the test, background air monitoring was performed using a photoionization detector (PID), and potential vapor pathways, such as utility conduits/vaults and catch basins, were identified. Throughout the test, PID monitoring was performed to monitor for possible fugitive vapors generated by air sparging.

Test Results

The first phase of the air sparging pilot study indicate a minimum effective sparge radius of approximately 40 feet. The second phase of the air sparging pilot study indicated no accumulation of fugitive emissions in subsurface vaults or within other locations within or adjacent to the C Yard.

2.3. INTERIM REMEDIATION

Interim actions (December 1996 through April 1997), were implemented at the site due to the estimated 48,000 spill of gasoline in the C Yard. The result of the Supplemental Investigation of the C Yard Fuel Spill indicate that approximately 7,200 gallons of gasoline were initially recovered from the ground surface and about 4,900 gallons was recovered from the water table. The remainder of the spill probably volatilized directly into the atmosphere or is adsorbed in soil. Three groundwater sampling events were completed during the interim actions. Detected concentrations of TPH-gasoline dissolved in the groundwater ranged from non-detect to 79,600 ppb (79.6 mg/l), while benzene ranged from non-detect to 11,800 ppb (11.8 mg/l). Cut-off trenches and dual phase extraction wells for remote and active extraction of product and groundwater were used on site to contain the spill to manageable conditions pending final remedies in the CAP.

3.0 PROPOSED CLEANUP ACTIONS

The following sections provide a description of the cleanup actions selected in the CAP. A description of interim remediation is also provided.

3.1 OVERVIEW OF CLEANUP ACTIONS

This group of proven technologies will be implemented at the Kinder Morgan site in accordance with the CAP. A brief description of each element and how it will be implemented at the site is presented below:

Surface Soil

- 3 inches Asphalt Capping or its Equivalent of Portland Cement Soil Fixation followed with TCLP testing to ensure that fixation is complete, or

- Soil excavation and disposal.

Subsurface Soil

- Excavation of Accessible TPH hot spots to the extent practicable and disposal/treatment,

- Natural/Intrinsic Biodegradation of residual contaminated soils, and/or

- Soil vapor extraction.

Excavated TPH subsurface soil hot spots will be treated on/off site, and/or disposed at an approved disposal facility. Backfilling of subsurface soils will comprise of clean fill material or treated material which will be tested before reuse on the site to ensure that it meets minimum requirements under the regulation for TPH. Excavation, disposal and back filling would be accomplished through the legal framework of the Consent Decree.

To document that the primary and the secondary concerns for the site are met (continued protection of the surface water and its ecosystem, and containment of plumes within property boundaries), groundwater monitoring will be implemented to monitor the ongoing intrinsic degradation/natural attenuation of TPH in soils as part of the selected cleanup action.

Soil vapor extraction is conceptually designed to remove volatile hydrocarbons from the vadose zone beneath the site to prevent vapor migrations to offices and secondary structures. This technology will be used as needed when appropriate so that the soil vapor to air pathway is interrupted in areas where a hazard exits. The SVE system will also maintain elevated oxygen concentrations within the vadose zone. Operation of the SVE and other technology based applications and systems will be discontinued through performance, cleanup and technology standards evaluations as part of the Compliance Monitoring Program to be developed for the site.

Groundwater

- Dual-phase extraction of groundwater and product, and/or
- Air Sparging.

Floating Product

- Active and passive point-source extraction,
- Partially-penetrating down-gradient vertical barrier to stop product migration, and
- Combinations of the above options.

The selected remedial alternative for addressing separate-phase hydrocarbons identified in selected areas of the A Yard is the use of partially penetrating down-gradient migration barriers coupled with extraction of the product as it collects against the barrier. This alternative provides positive control and capture of product, yet does not create new problems in dealing with the extraction, treatment, and disposal of groundwater. The partially penetrating barrier will be used to intercept product along dominant groundwater flow paths of the property boundary. By partially penetrating the upper aquifer on the down-gradient side of the free-product plume, the migration of free product will be stopped at the barrier.

In areas of the A, B, C and D Yards where product is localized, it will be removed through point-source extraction. An active product recovery technique will be selected for each particular location. Passive product recovery will also be performed at selected locations of the A, B, C, and D Yards where necessary until there is no evidence of measurable petroleum hydrocarbon sheen. Passive product recovery is intended to supplement the active product recovery system as needed.

3.2 OVERVIEW OF CONTAMINANT NATURE AND LOCATION

The primary constituents of concern encountered in the subsurface soil beneath the Terminal are TPH-G, TPH-D, and TPH-O. Elevated TPH concentrations exist in four general areas: (1) the southern portion of the B Yard, (2) the northern portion of the A Yard, (3) the southern half of the C Yard, and (4) the area between Tanks 39 and 42 in the C Yard.

The inorganic metals, arsenic and lead, are present throughout the C and B Yards on the surface soils and in the groundwater. The presence of these metals are likely due to historical air stack emissions from an offsite smelter.

Within the C Yard, TPH-gasoline and benzene are also primary contaminants of concern in the surface soil. GATX conducted an aggressive interim action in 1996 and early 1997 to contain and remove the floating product and dissolved petroleum hydrocarbons from beneath the site resulting from the December 1996 release. Approximately, 7,200 gallons of product, and 142,497 gallons of contaminated groundwater were recovered from the subsurface, recycled (for the product), and treated (the dissolved petroleum hydrocarbons), before disposal.

Floating Product. The presence of floating product is limited to seven areas in the A Yard, one area in the B Yard. In January 1997, the thickness of floating product present in the A yard, ranged from 0.01 to 0.48 feet. Product observed in the B Yard ranged in thickness from 0.14 to 1.60 feet (Wells 12 and 15) during this period. The thickness of measurable product in the C Yard ranged from 0.11 to 1.20 feet in December 1996. In February 1997, measurable amounts of product in the C Yard had decreased since the implementation of the interim action and it ranged, in thickness from 0.01 to 0.23 feet. The interim action was discontinued in April 1997. In May 1998, no free product was observed in the C Yard.

Arsenic and Lead. Arsenic and Lead were found in surface soils throughout B and C Yards, and portions of D, and E, Yards of the tank farms above Harbor Island action levels (lead 1000- mg/kg, arsenic - 32.6 mg/kg) set in the EPA ROD for the surface soils. These action levels are based on a risk assessment conducted by EPA. EPA conducted surface soil investigations for the island including the Kinder Morgan site. Ecology and EPA in a memorandum of agreement (MOA) agreed not to duplicate investigation efforts on the island except where data gaps exist. In 1994, Ecology concurred with the EPA ROD on Harbor Island.

The lateral distribution of lead appears to be relatively uniform across the B and C Yards. Lead concentrations decrease rapidly at depth to less than 100 parts per million (ppm) at 1.5 feet below grade. At depths below 1.5 feet, total lead concentrations in soil were below 51 ppm. The occurrence of lead is most likely associated with stack emissions from an offsite former lead smelter located south of the Kinder Morgan site.

The following is a discussion of the preferred remedial action alternatives selected for the site.

3.3 Surface Soil

Based upon leachability analysis of the native impacted material and upon discussions with several contractors and disposal facilities, on-site soil fixation is not the most effective alternative to mitigate the metal impacted surface soil. TCLP testing of surface soil samples indicate that the soil can be excavated and transported to an acceptable disposal facility without fixation.

Accessible surface soil (up to 6 inches below ground surface) containing lead/arsenic concentrations above hot spot criteria have been identified in the B and C Yards, and are shown on Figures 6 and 7.

3.3.1 Area 1 – Surface Soil Excavation in B Yard

Soils exceeding the lead and arsenic action level to the extent technically practicable in the B Yard surface soil are shown on Figure 6. The delineation of soil excavation is based on available soil analytical data, and the excavated areas are anticipated to be 0.5 feet deep. The total volume of the accessible soil hot spots subject to excavation to the extent practicable in Yard B is approximately 153 cubic yards.

3.3.2 Area 2 – Surface Soil Excavation in C Yard

Soils exceeding the lead and arsenic action level in the C Yard surface soil are shown on Figure 7. The delineation of soil excavation is based on available soil analytical data, and the excavated areas are anticipated to be 0.5 feet deep. The total volume of the accessible soil hot spots subject to excavation to the extent practicable in Yard C is approximately 874 cubic yards.

3.4 Subsurface Soil

The accessible hot spots will be excavated without undermining the integrity of the aboveground storage tanks, piping, or other structures adjacent to the hot spot. For excavations adjacent to aboveground storage tanks or other structures, a 5-foot minimum distance from the structure will be maintained. In addition, a sidewall slope of 3H:1V will be maintained for excavations adjacent to structures, otherwise, a sidewall slope of 2H:1V will be maintained.

Accessible subsurface soil (6-inches below ground surface) containing concentrations of TPH above hot spot criteria have been identified in the B and C Yards, and are shown on Figures 6 and 7.

The excavated soil will be treated off-site using thermal desorption and disposed off-site. Backfilling of subsurface soils will be comprised of clean fill material or treated material that will be tested before reuse on the site to ensure that it meets minimum requirements under the regulation for TPH. Excavation, disposal and back filling will be accomplished through the legal framework of the Consent Decree.

3.4.1 AREA 3 – TPH HOT-SPOT EXCAVATION IN B YARD

Soils exceeding the action level of 20,000 mg/kg will be excavated to the degree practicable without undermining the integrity of the tanks next to the excavation areas. Soils exceeding the action level to the extent technically practicable in the B Yard subsurface soil are shown on Figure 6. The delineation of soil excavation is based on available soil analytical data. Once approximately 32 CY of non-impacted overburden soil is removed, the total volume of the accessible soil hot spots subject to excavation to the extent practicable in Yard B is approximately 4 cubic yards. A cross-section depicting hot spot soil excavation in Area 3 is shown on Figure 6A.

3.4.2 AREA 4 – TPH HOT-SPOT EXCAVATION IN C YARD

Soils exceeding the action level of 10,000 mg/kg will be excavate to the extent technically practicable without undermining the integrity of the tanks next to the excavation areas. Soils exceeding the action level to the extent technically practicable in the C Yard subsurface soil are shown on Figure 7. The delineation of soil excavation is based on available soil analytical data. Once approximately 132 CY of non-impacted overburden soil is removed, the total volume of the accessible soil hot spots subject to excavation to the extent practicable in Yard C is approximately 324 cubic yards. A cross-section depicting typical hot spot soil excavations in Area 4 is shown on Figures 7A and 7B.

3.4.3 AREA 5 – POTENTIAL TPH HOT-SPOT EXCAVATION IN A YARD

Upon successful completion of the free product removal from the Yard A, a subsurface TPH soil confirmation analytical sampling will be conducted north of A-29 and northwest of A-22, which is northwest and southwest of the Garage Building in the A Yard. If the analytical results of the TPH subsurface soil confirmation sampling confirm TPH hot spots to be present at these location, excavation of the accessible TPH hot spots using the 20,000 mg/kg action level in the A Yard subsurface soils will be implemented to the extent technically practicable. The total volume of the accessible soil hot spots subject to excavation to the extent practicable is unknown.

3.5 GROUNDWATER

A combination of cleanup actions have been selected for remediation of the shallow groundwater beneath the site.

3.5.1 AREA 6 - PARTIALLY-PENETRATING VERTICAL BARRIER FOR TPH IMPACTED GROUNDWATER IN A YARD

The preferred remedial alternative for addressing separate-phase hydrocarbons identified in selected areas of the A Yard (Figure 8) is the use of partially-penetrating down-gradient migration barriers coupled with extraction of the product as it collects against the barrier. This alternative, also known as a hanging-wall barrier, provides positive control and capture of product, yet does not create new problems in dealing with the extraction, treatment, and disposal of groundwater. The partially penetrating barrier will be used to intercept product along dominant groundwater flow paths of the property boundary. In areas with localized product, point-source removal will be implemented with oil skimming alternatives. A cross-section depicting the extent of the partially-penetrating vertical barrier is shown on Figure 8A.

By partially penetrating the shallow water-bearing zone on the down-gradient side of the free-product plume, the migration of free product will be stopped at the barrier. The trench design will include specific construction techniques to install the barrier such that site constraints, including below-grade utilities, pipeline and tank locations, roads, and buildings, will not affect the performance of the hanging wall trench.

Free-product will be removed from the groundwater immediately upgradient of the barrier through a system of individual wells placed along the length of the trench. In-well separating pumps will be installed to extract free-product only from each well. The recovered product from each well will be routed to a common collection container for temporary storage.

If groundwater monitoring indicates that the extraction of free-product only adjacent to the hanging wall is not sufficient to capture the free-product, groundwater extraction may be initiated to maintain a groundwater elevation at the hanging wall that is slightly below static groundwater in order to promote the migration of free-product towards the hanging wall.

3.5.2 AREA 7 – SITE-WIDE ACTIVE POINT SOURCE PRODUCT EXTRACTION

In areas of the A, B, C and D Yards where product is localized, free-product will be removed through point-source extraction (Figure 5). Pneumatic in-well separating pumps will be used to extract free-product only from each point-source. The pumps actively draw in water and free product, but conveys only product to the surface. The pumps are capable of recovering light petroleum products such as gasoline and diesel. Free-product observed during historical groundwater monitoring have similar properties to light petroleum products.

If groundwater monitoring indicates that the extraction of free-product only in each extraction point is not sufficient to capture the free-product, groundwater extraction may be initiated to maintain a groundwater elevation at the extraction point that is slightly below static groundwater. The lowered groundwater elevation at the extraction well would promote the migration of free-product towards the well.

3.5.3 AREA 7A – SITE-WIDE PASSIVE PRODUCT RECOVERY

Passive product recovery will be performed at selected locations of the A, B, C, and D Yards where necessary until there is no evidence of measurable petroleum hydrocarbon sheen. Passive product recovery is intended to supplement the active product recovery system as needed.

Passive product recovery will be accomplished with the installation of hydrocarbon recovery canister. The canister is equipped with a hydrophobic filter buoy for product recovery without water. The canister requires no external means of power and can be easily moved from well to well as needed.

Additionally, groundwater monitoring wells will be hand-bailed as needed during the required monthly well gauging program, as described in the Compliance Monitoring Plan, dated October 27, 1999 and approved by the Department of Ecology.

3.5.4 AREA 8 – AIR SPARGING AND NATURAL BIODEGRADATION IN C YARD

Air sparging is a proven technology for removing petroleum hydrocarbons which are present below the water table. The injection of air below the water level and into hydrocarbon-impacted soils accelerates the mobilization and recovery of the residual hydrocarbons. Additionally, the injection of air will elevate the oxygen levels (in this instance, dissolved oxygen) and will improve conditions for aerobic hydrocarbon degradation within the saturated zone. Additionally, the air sparging reduces dissolved-phase hydrocarbon concentrations as the volatile constituents are stripped from the groundwater. The combined processes of stripping and aerobic degradation of hydrocarbons should facilitate groundwater conditions toward the remedial goals outlined in the CAP for the site groundwater.

The air sparging pilot study results indicate a minimum effective sparge radius of approximately 40 feet. A plan and cross-section depicting conceptual placement of AS wells in Area 8 is shown on Figures 9 and 9A.

3.6 Conceptual Plan for Cleanup Action

3.6.1 Soil Excavation

Soil TPH hot spots that meet or exceed the TPH cleanup levels have been identified in the B and C Yards, as described in Section 2.2.3 and as shown on Figure 3. Using the delineated TPH hot spots, an excavation plan was developed to remove accessible soil. The depth of excavations is anticipated to range from 0 to 4 feet below grade. The accessible TPH hot spots will be excavated without undermining the integrity of the above ground storage tanks, piping, or other structures adjacent to the hot spot. The excavated TPH hot spot soil will be treated on- or off-site using thermal desorption and disposed of on- or off-site.

The objectives of the excavations are to remove the bulk of hydrocarbon-affected soil, improve general groundwater conditions at the source, and enhance restoration time for the impacted areas. Additionally, the Compliance Monitoring Plan (October 27, 1999), which was developed to confirm that cleanup requirements have been achieved at the site, will be implemented to monitor the on-going biodegradation of the residual TPH in soils as part of the final cleanup action. A deed restriction has also been implemented to prevent inappropriate future use of the site. A summary activities to be performed for remedial soil excavation is presented below.

- Develop and prepare site health and safety plan.
- Locate and mark all underground utilities prior to start of excavation.
- Mark excavation areas.
- Identify specific features to be protected in each Yard
- Prepare equipment staging area, decontamination station, residuals storage area, and site ingress and egress.
- Prepare temporary soil stockpile areas, if necessary.
- Delineate health and safety-regulated areas (exclusion zone, contaminant reduction zone, and support zone).
- Establish in-field criteria for depth and width of excavation – odor, color, etc.
- Maintain a minimum five-foot distance away from any above ground storage tank. Slope the sidewalls of excavations adjacent to tanks and structures with a 3:1 slope.

- Excavate contaminated soil using an excavator.

- Field screen soil during excavation and segregate potentially non-contaminated overburden from soil to be removed from the site.

- Provide dust control during excavation activities.

- Obtain soil samples from sidewalls and bottom of excavations, documenting sample locations and depths. Soil samples will be analyzed for BTEX, TPH-G, TPH-D, and TPH-O. Soil samples will be collected at approximately one sample per 20 feet along the sidewall with two soil samples collected from the bottom of each excavation.

- Obtain confirmation soil samples from non-contaminated overburden stockpiles, if necessary. The stockpile sampling frequency will be in accordance with the following Ecology guidance:

BULK CUBIC YARDS OF SOIL	MIN. NUMBER OF SAMPLES
0-100	3
101-500	5
501-1,000	7
1,001-2,000	10
>2,000	10 + 1 for each additional 500 cy

- Berms will be used to control runoff from entering excavation during any rain event. Straw bales or filter fabric will be used to protect existing catch basins from sedimentation.

- Erosion and sediment control measures will be detailed in the grading permit to be obtained from the city of Seattle. All measures will comply with Ecology's *Storm Water Management Manual for the Puget Sound Basin* (Ecology, 1992).

- If free product is encountered in an excavation, product removal will be implemented using a vacuum truck or sorbents, as needed.

3.6.1.1 Soil Disposal

Waste characterization will be performed to determine the appropriate disposal or treatment of the contaminated soil. Waste characterization soil samples from the excavation areas will be collected as described in Section 4.3.

Petroleum-contaminated soil generated from the TPH Hot Spots will either be transported off-site for landfill disposal or transported to an off-site thermal desorption treatment facility. The selection of petroleum-contaminated soil disposition will be made during the construction bidding process. The selected facility will be determined by the nature of the waste, facility acceptance criteria, and treatment limitations of the soil.

Facilities that will accept non-hazardous soil are TPS Technologies, Inc. in Tacoma, Washington, Rabanco Landfill in Roosevelt, Washington, Waste Management disposal facilities in Arlington, Oregon, or Columbia Ridge Landfill in Oregon.

3.6.1.2 Backfilling and Regrading

Backfilling and regrading will be performed upon completion of excavation activities. The sequence of steps for this phase of the cleanup action is described below:

Excavations will be backfilled with clean overburden (each excavation will be backfilled prior to commencing with the next excavation). The excavations will be backfilled and filled up to the finished surface grade. The areas will be regraded as needed to leave each area in a condition that is consistent with the surrounding undisturbed area.

3.6.2 PARTIALLY PENETRATING VERTICAL BARRIER IN A YARD

The objective of the partially penetrating vertical barrier is to intercept SPH along the downgradient flow path of the property boundary in order to prevent off-site migration of SPH. The barrier, in combination with a SPH collection system, will provide positive control and capture of product, yet will not create the additional task of managing the extraction, treatment, and disposal of groundwater.

A plan of the proposed barrier is shown on Figures 8, 8A, and 10. The barrier will include the following design parameters:

- Length of approximately 250 linear feet. The proposed length was determined to intercept the two areas in the western portion of the A yard, which were observed to contain SPH. The final length of the barrier will be determined based on the presence and location of underground utilities

- Depth of approximately 12 feet. The barrier depth is 2 feet below the minimum expected groundwater elevation. The minimum expected groundwater elevation was estimated by taking the average groundwater elevation minus the maximum groundwater fluctuation observed (from historical groundwater monitoring performed in monitoring wells in the vicinity of the barrier). A summary presenting historical groundwater elevation data, average groundwater elevations, expected maximum and minimum groundwater elevations, and proposed elevation of the bottom of the barrier is included in Appendix A.

- Method of construction. The barrier will include the installation of sheet piles along the line shown on Figure 8 and to a depth of 12 feet. In order to keep all features of the barrier below grade, a 2-foot deep trench will initially be excavated, and sheet piles ten feet in length will be installed. Sheet piles will be vibrated into place from within the trench, and the excavated soil will be returned to the trench once the installation of the barrier is completed. Joint seals will be accomplished with the installation of a cementitious or polymeric sealant between sheet piles, and will be dependent upon the material and brand of sheet piles selected. The installed barrier will have a maximum transmissivity of 2.7×10^{-6} centimeters per second.

- Disposal of excess materials. The selected method of construction is not anticipated to generate excess soil. Soils excavated prior to sheet pile installation is expected to be clean backfill material. Depending on the brand of sheet piles selected, the installation of joint seals may generate excess water used for flushing the joint cavity. Excess water will be collected in an above-ground temporary storage tank, and a sample will be collected for analysis. The water will be disposed to the sanitary sewer pending a one-time discharge authorization from the King County Wastewater Treatment Division.

3.6.2.1 SPH Collection System

The objective of the SPH collection system is to remove SPH that has been intercepted by the partially penetrating vertical barrier. The system components will include recovery sumps, recovery pumps, recovered SPH conveyance piping, compressed air supply piping, and a equipment enclosure to house the air compressor and product collection drum. Each component is described below.

- Sumps. A total of 6 sumps will be installed along the upgradient line of the barrier at approximately 50-foot intervals. Four of the sumps will be used as recovery sumps, and the two sumps located near the ends of the barrier will be used as monitoring points to verify that SPH is not migrating around the barrier. The sumps will be installed using hollow-stem auger drilling equipment. The sumps will be installed to a depth of approximately 14 feet.

- Recovery pumps. Four pneumatic in-well separating pumps will be installed in four recovery sumps. The pumps draw in water and SPH and cycle at pre-set intervals, rejecting the water downwell and pumping SPH only to the surface. All wetted parts of the pumps will be compatible with petroleum hydrocarbons.

- SPH conveyance piping. The SPH conveyance piping will be routed from the recovery sumps to an equipment enclosure, as shown on Figure 8. The SPH conveyance piping will be HDPE, which was selected based on its compatibility with petroleum hydrocarbons and ease of installation. The piping will be installed underground at a minimum depth of 18 inches below grade.

- Compressed air supply piping. Compressed air supply piping will be routed from the equipment enclosure to each of the recovery sumps, as shown on Figure 10. The air supply piping will be galvanized steel. The piping will be installed underground at a minimum depth of 18 inches below grade.

- Equipment enclosure. The equipment enclosure will house the air compressor and product collection drum. The product collection drum include an overpack drum for secondary containment. In the event of a high level alarm in the product collection tank, control panel logic will shut down the compressor and activate a solenoid valve to discontinue compressed air supply to the pumps, thus precluding overfilling of the product collection drum.

O & M will initially be performed on the partially penetrating vertical barrier on a weekly basis for the first month of operation. Frequency of monitoring will be evaluated after the first month of operation, however, monitoring will be performed at least monthly in concurrence with the required monthly well gauging program (Compliance Monitoring Plan).

3.6.3 SITE-WIDE ACTIVE POINT SOURCE PRODUCT EXTRACTION

The objective of active point source product extraction is to remove measurable thickness of SPH from on-site monitoring wells where product is localized in Yards A, B, C, and D. Active point source extraction will be applied in Wells A-4, A-6, and Well 12. The system components will include recovery pumps, recovered SPH conveyance piping, compressed air supply piping, and an equipment enclosure to house the air compressor and product collection drum. Each component is described below. A typical active product recovery well detail is shown on Figure 11.

- Recovery pumps. Pneumatic in-well separating pumps will be installed in the selected wells. The pumps will be QED Ferret™ In-Well Separating pumps, or equivalent. The pumps draw in water and SPH and cycle at pre-set intervals, rejecting the water downwell and pumping SPH only to the surface. All wetted parts of the pumps will be compatible with petroleum hydrocarbons.

- SPH conveyance piping. SPH conveyance piping will be routed from the recovery sumps to an equipment enclosure. The SPH conveyance piping will be HDPE, which was selected based on its compatibility with petroleum hydrocarbons. Portions of the piping will be installed underground at a minimum depth of 18 inches below grade. Wherever practical, SPH conveyance piping may be routed above grade, where conveyance piping will be attached to concrete walls with pipe hangers.

- Compressed air supply piping. Compressed air supply piping will be routed from the equipment enclosure to each of the recovery sumps, as shown on Figure 8. The air supply piping will be galvanized steel. Portions of the piping will be installed underground at a minimum depth of 18 inches below grade. Wherever practical, air supply piping may be routed above grade, where conveyance piping will be attached to concrete walls with pipe hangers.

- Equipment enclosure. The equipment enclosure will house the air compressor and product collection drum. The product collection drum include an overpack drum for secondary containment. In the event of a high level alarm in the product collection tank, control panel logic will shut down the compressor and activate a solenoid valve to discontinue compressed air supply to the pumps, thus precluding overfilling of the product collection drum.

O & M will initially be performed on active product recovery wells on a weekly basis for the first month of operation. Frequency of active product recovery monitoring will be evaluated after the first month of operation, however, monitoring will be performed at least monthly in concurrence with the required monthly well gauging program (Compliance Monitoring Plan).

3.6.4 Passive Product Recovery

The objective of passive product recovery is to recover SPH from on site wells which may periodically contain SPH. Passive product recover is intended to supplement the active product recovery system as needed.

Passive product recovery will be initiated in Well A-1. A PetroTrap™ product recovery canister, or equivalent, will be installed within the well. The canister is equipped with a hydrophobic filter buoy for product recovery without water. The canister requires no external means of power. A typical passive product recovery well detail is shown on Figure 12.

O & M will initially be performed on passive product recovery wells on a weekly basis for the first month of operation. Frequency of passive product recovery monitoring will be evaluated after the first month of operation, however, monitoring will be performed at least monthly in concurrence with the required monthly well gauging program (Compliance Monitoring Plan). Recovered SPH will be incorporated into a product collection drum, installed as a component for the partially penetrating vertical barrier or for the active point source extraction.

3.6.5 AIR SPARGING

The objective of air sparging is to remove dissolved hydrocarbons which are present below the water table. Air sparging will be applied to the southwestern portion of the C Yard. The air sparging system will consist of 2 existing and 15 new air sparging wells installed in the southern portion of the C Yard

Based on a conservative radius of influence of 40 feet, as determined through AS feasibility testing, the approximate distance between AS wells will be 70 feet to provide overlapping coverage between wells. AS wells will be constructed of 2-inch diameter Schedule 40 PVC with 1.5 feet of 0.020-inch slotted screen. The wells will be completed to a depth of approximately 12 feet below grade. Historically, groundwater has been observed at depths ranging from 3 to 7 feet below grade, with surface and groundwater elevations generally comparable across the C Yard. The average water column above the AS well top of screen is expected to be approximately 6 feet, with minimum and maximum water columns of 2 and 10 feet, respectively.

Based on the AS feasibility testing, air requirements for the AS system will be 85 standard cubic feet per minute (scfm) at 132 inches of water pressure (4.76 psi). Engineering design calculations for the air sparging system are included in Appendix B.

O & M of the air sparging system will initially be performed on a weekly basis for the first month of operation. Frequency of system O & M will be evaluated after the first month of operation, however, monitoring will be performed at least monthly in concurrence with the required monthly well gauging program (Compliance Monitoring Plan).

3.7 CLEANUP COSTS

Assessment and remediation activities that have been performed as part of the RI/FS or part of an interim cleanup measure are included as cleanup costs for the Kinder Morgan Terminal. Assessment, remedial design, and future remedial action costs based on the Cleanup Action Plan are estimated to be between $3,000,000 and $4,000,000. This estimate includes cost projections over a 5-year time period. A number of operational and performance factors will affect the actual cleanup cost.

4.0 DESIGN PARAMETERS

The localities targeted for cleanup include the 8 areas described in Section 3.0. The following sections provide detailed information regarding the site-specific design impacts, engineering justification (including design criteria, assumptions and calculations), and expected treatment/containment efficiencies for the various selected cleanup actions.

Final construction plans and specifications will be prepared under separate cover to detail the performance of the cleanup actions to be performed. The Final Construction Plans and Specification document will be prepared in conformance with currently accepted engineering practice and WAC 173-340-400(4)(b). Plans and specifications will be stamped and signed by a Washington State Registered Professional Engineer.

4.1 SITE-SPECIFIC CHARACTERISTICS AFFECTING DESIGN, CONSTRUCTION, AND OPERATION

Subsurface excavation will occur near numerous structures that include above-ground storage tanks, product pipelines, the tank-farm containment wall footing, and building foundations. Since the cleanup actions will be performed at an operational facility, it is critical that operational constraints be integrated into the design of the cleanup actions. Operational constraints have been incorporated into cleanup actions discussed in Section 4.2 in order to minimize the environmental and operational risk posed by the implementation of the cleanup actions.

The Terminal is an active petroleum fuel storage and distribution facility. Much of the site is occupied by large aboveground fuel storage tanks. Sensitive areas include above and below ground pipelines, spill containment dikes, trucking loading racks and traffic areas, and an office structure. Care must be taken to avoid an accidental release of product from active pipelines, truck loading racks, and storage tanks.

The site is underlain by shallow groundwater (approximately 3 to 8 feet below grade), however, groundwater is not anticipated to be an issue during performance of soil excavation activities. The soil excavation plan developed for lead and arsenic hot spot removal includes the excavation of soils up to a depth of 6 inches and groundwater will not be encountered. The excavation plan developed for TPH hot spot removal is based on soil sampling and analysis performed to date. A maximum depth of 4 feet is anticipated for excavation of soil TPH hot spots. At this anticipated maximum depth of excavation, groundwater should not be encountered.

The Harbor Island area receives a large amount of rainfall over much of the year, and much of the site is unpaved. Excavation during the winter months will be difficult due to poor trafficability and higher groundwater elevations. Additionally, surface water may accumulate within diked areas, and runoff from soil stockpile areas would hinder the progression of excavation activities. Therefore, construction activities will be scheduled during the drier summer months.

4.2 Design Criteria, Assumptions, and Calculations

4.2.1 Area 1 – Surface Soil Excavation in B Yard

Using the delineated metal hot spots (Figure 4), an excavation plan was developed to remove accessible soil. Excavation of subsurface soil containing metal hot spots concentrations within Area 1 were identified in 6 locations: 1a) between Tanks 19 and 22, 1b) northeast of Tank 32, 1c) southeast of Tank 25, 1d) west of Tank 25, 1e) east of Tank 31, and 1f) east of Tank 26.

Kinder Morgan has developed criteria for excavation work performed within the facility. For excavations adjacent to aboveground storage tanks, piping runs, or other load-bearing structures, a 5-foot minimum distance from the structure will be maintained. Based on the setback requirements, and assuming a maximum excavation depth of 0.5 foot for impacted soil, the in-place volume of impacted soil to be removed in Area 1 is estimated to be 153 CY. Soil volume calculations are presented in Appendix C.

4.2.2 Area 2 – Surface Soil Excavation in C Yard

Using the delineated metal hot spots (Figure 4), an excavation plan was developed to remove accessible soil. Excavation of subsurface soil containing metal hot spots concentrations within Area 2 were identified in 5 locations: 2a) between Tanks 43 and 44, 2b) south of Tank 42, 2c) north/northeast of Tank 37, 2d) west of Tank 39, and 2e) north/northwest of Tank 35.

Kinder Morgan has developed criteria for excavation work performed within the facility. For excavations adjacent to aboveground storage tanks, piping runs, or other load-bearing structures, a 5-foot minimum distance from the structure will be maintained. Based on the setback requirements, and assuming a maximum excavation depth of 0.5 foot for impacted soil, the in-place volume of impacted soil to be removed in Area 2 is estimated to be 874 CY. Soil volume calculations are presented in Appendix C.

4.2.3 AREA 3 – SUBSURFACE TPH SOIL HOT-SPOT EXCAVATION IN B YARD

Using the delineated TPH hot spots (Figure 6), an excavation plan was developed to remove accessible soil. Excavation of subsurface soil containing TPH hot spots concentrations within Area 3 were identified in the area southwest of Tank 22. Review of soil data indicates that the area is underlain by loose dredged sand and silt with some moisture, with groundwater occurring at a depths ranging from 4 to 7 feet below grade.

Excavation within Area 3 will require sloping of the excavation sides to prevent raveling of the excavation from below Tank 22 foundation, tank farm wall footing, pipelines, and a foundation slab for smaller tanks and transfer equipment. Since TPH concentrations in the top 2 feet of soil are expected to be below the TPH hot spot level, the top 2 feet will be removed, stockpiled, and reused in backfilling the excavation. Excavation of soils containing concentrations exceeding the TPH hot spot criteria below a depth of 2 feet will continue to the extent technically practicable considering structural and engineering limitations, which is expected to be at a depth of 4 feet below grade.

Kinder Morgan has developed criteria for excavation work performed within the facility. For excavations adjacent to aboveground storage tanks or other load-bearing structures, a 5-foot minimum distance from the structure will be maintained. In addition, a sidewall slope of 3H:1V will be maintained for excavations adjacent to structures, otherwise, a sidewall slope of 2H:1V will be maintained.

Based on the setback and sloping requirements, and assuming a maximum excavation depth of 2 feet for non-impacted soil, the in-place volume of non-impacted soil to be removed in Area 3 is estimated to be 32 CY. Based on the setback and sloping requirements, and assuming a maximum excavation depth of 4 feet for TPH hot spot soil, the in-place volume of soil exceeding the TPH hot spot criteria to be removed in Area 3 is estimated to be 4 CY. Soil volume calculations are presented in Appendix C.

4.2.4 AREA 4 – SUBSURFACE TPH SOIL HOT-SPOT EXCAVATION IN C YARD

Using the delineated TPH hot spots (Figure 7), an excavation plan was developed to remove accessible soil. Excavation of subsurface soil containing TPH hot spots concentrations within Area 4 were identified in 6 locations: 4a) southeast of Tank 44, 4b) west of Tank 44, 4c) between Tanks 39 and 42, 4d) north of Tank 37, 4e) southwest of Tank 37, and 4f) southwest of Tank 35. Review of soil data indicates that the area is underlain by loose dredged sand and silt with some moisture, with groundwater occurring at a depths ranging from 3 to 7 feet below grade.

Excavation within Area 4 will require sloping of the excavation sides to prevent raveling of the excavation from below tank foundations, tank farm wall footing, and pipelines. Concentrations of TPH in soil are expected to exceed TPH hot spot criteria at the following depth ranges for each respective area described above: 4a) southeast of Tank 44: 0.5 to 3 feet, 4b) west of Tank 44: 0.5 to 2.0 feet, 4c) between Tanks 39 and 42: 1.5 to 4 feet, 4d) north of Tank 37: 0.5 to 2 feet, 4e) southwest of Tank 37: 0.5 to 1.5 feet, and 4f) southwest of Tank 35: 0.5 to 1.5 feet. In each area, overburden soil, if not previously removed during lead/arsenic soil removal, will be stockpiled, and reused in backfilling the excavation. Excavation of soils containing concentrations exceeding the TPH hot spot criteria will be executed to the extent technically practicable considering structural and engineering limitations, which is expected to be at a maximum depth of 4 feet below grade.

Kinder Morgan has developed criteria for excavation work performed within the facility. For excavations adjacent to aboveground storage tanks or other structures, a 5-foot minimum distance from the structure will be maintained. In addition, a sidewall slope of 3H:1V will be maintained for excavations adjacent to structures, otherwise, a sidewall slope of 2H:1V will be maintained.

Based on the setback and sloping requirements the in-place volume of non-impacted soil to be removed in Area 4 is estimated to be 132 CY. Based on the setback and sloping requirements, and assuming a maximum excavation depths previously described for Subareas 4a through 4f, as described above, the in-place volume of soil exceeding the TPH hot spot criteria to be removed in Area 4 is estimated to be 324 CY. Soil volume calculations are presented in Appendix C.

4.2.5 Area 5 – Potential Subsurface TPH Soil Hot-Spot Excavation in A Yard

Upon successful completion of the free product removal from the Yard A, a subsurface TPH soil confirmation analytical sampling will be conducted. If the analytical results of the TPH subsurface soil confirmation sampling confirm TPH hot spots to be present, then excavation of the accessible subsurface TPH hot spots in the A Yard will be implemented to the extent technically practicable. The total volume of the accessible soil hot spots subject to excavation to the extent practicable is unknown. Any accessible TPH hot spots will be excavated without undermining the integrity of the above ground storage tanks, piping, or other structures adjacent to the hot spot.

Kinder Morgan has developed criteria for excavation work performed within the facility. For excavations adjacent to aboveground storage tanks or other structures, a 5-foot minimum distance from the structure will be maintained. In addition, a sidewall slope of 3H:1V will be maintained for excavations adjacent to structures, otherwise, a sidewall slope of 2H:1V will be maintained.

4.2.6 Area 6 – Partially Penetrating Vertical Barrier for SPH Recovery in A Yard

The objective of the partially penetrating vertical barrier is to intercept SPH along the downgradient flow path of the property boundary in order to prevent off-site migration of SPH. The barrier, in combination with a SPH collection system, will provide positive control and capture of product, yet will not create the additional task of managing the extraction, treatment, and disposal of groundwater.

A plan of the proposed barrier is shown on Figure 8. A preliminary underground utility investigation has determined that the installation of the barrier within the City of Seattle right-of-way would be a preferred location. Preliminary conversation with the City of Seattle Street Use Department indicates that installation of the barrier within the City easement will likely be acceptable.

The barrier will be located along the downgradient boundary of the A Yard. SPH has been observed periodically in Wells A-19 through A-22, and A-26, located in a line along the downgradient extent of the A Yard. The barrier will be located approximately 25 feet further downgradient than the line of these wells. The horizontal extent of the barrier was determined to the north by the driveway entrance, beneath which the Olympic Pipeline traverses, and to the south by the furthest extent that SPH has historically been observed.

The barrier will include the installation of sheet piles along the line shown on Figure 8 and to a depth of 12 feet. In order to keep all features of the barrier below grade, a 2-foot deep trench will initially be excavated, and sheet piles ten feet in length will be installed. Sheet piles will be vibrated into place from within the trench, and the excavated soil will be returned to the trench once the installation of the barrier is completed. Joint seals will be accomplished with the installation of a cementitious or polymeric sealant between sheet piles, and will be dependent upon the material and brand of sheet piles selected. The installed barrier will have a maximum transmissivity of 2.7×10^{-6} centimeters per second.

4.2.6.1 SPH Collection System

The objective of the SPH collection system is to remove SPH that has collected against the partially penetrating vertical barrier. The system components will include recovery sumps, recovery pumps, recovered SPH conveyance piping, compressed air supply piping, and a equipment enclosure to house the air compressor and product collection drum.

A total of 6 sumps will be installed along the upgradient line of the barrier at approximately 50-foot intervals. Four of the sumps will be used as recovery sumps, and the two sumps located near the ends of the barrier will be used as monitoring points to verify that SPH is not migrating around the barrier. The sumps will be installed using hollow-stem auger drilling equipment. The sumps will be installed to a depth of approximately 14 feet.

The product recovery sumps are situated at an interval to allow for recovery of product as it accumulates behind the barrier. Since the product recovery system will not be depressing the groundwater table, product recovery will have no effect on groundwater flow paths behind the barrier. Four pneumatic in-well separating pumps will be installed in the recovery sumps. The pumps draw in water and SPH and cycle at pre-set intervals, rejecting the water downwell and pumping SPH only to the surface.

4.2.7 Area 7 – Site-Wide Active Point Source Product Extraction

The objective of active point source product extraction is to remove measurable thickness of SPH from on-site monitoring wells where product is localized in Yards A, B, C, and D. Active point source extraction will be applied in Wells A-4, A-6, and Well 12. Historical groundwater monitoring has shown that these wells have consistently contained measurable thicknesses of SPH. Additionally, these wells are located such that underground air supply piping and underground SPH conveyance piping can be easily be routed. The system components will include recovery pumps, recovered SPH conveyance piping, compressed air supply piping, and an equipment enclosure to house the air compressor and product collection drum.

Pneumatic in-well separating pumps will be installed in the selected wells. The pumps draw in water and SPH and cycle at pre-set intervals, rejecting the water downwell and pumping SPH only to the surface.

4.2.8 Area 7A – Passive Product Recovery in Yards A, B, and C

The objective of passive product recovery is to recover SPH from on site wells which may periodically contain SPH. Passive product recover is intended to supplement the active product recovery system as needed. Initially, passive product recovery will be performed in Well A-13. Historical groundwater monitoring has shown that this well has consistently contained a measurable thickness of SPH. Additionally, this well is remotely located such that underground air supply piping and underground SPH conveyance piping could not be easily routed.

A PetroTrap™ product recovery canister, or equivalent, will be installed within the well. The canister is equipped with a hydrophobic filter buoy for product recovery without water. The canister requires no external means of power.

4.2.9 Area 8 – Air Sparging and Natural Biodegradation in C Yard

The objective of air sparging is to remove dissolved hydrocarbons which are present below the water table. Air sparging will be applied to the southwestern portion of the C Yard. The air sparging system will consist of 2 existing and 15 new air sparging wells installed in the southern portion of the C Yard.

Based on a conservative radius of influence of 40 feet, as determined through AS feasibility testing, the approximate distance between AS wells will be 70 feet to provide overlapping coverage between wells. AS wells will be constructed of 2-inch diameter Schedule 40 PVC with 1.5 feet of 0.020-inch slotted screen. The wells will be completed to a depth of approximately 12 feet below grade. Historically, groundwater has been observed at depths ranging from 3 to 7 feet below grade, with surface and groundwater elevations generally comparable across the C Yard. The average water column above the AS well top of screen is expected to be approximately 6 feet, with minimum and maximum water columns of 2 and 10 feet, respectively.

Based on the AS feasibility testing, air requirements for the AS system will be a minimum of 85 standard cubic feet per minute (scfm) at a maximum of 132 inches of water pressure (4.76 psi). Engineering design calculations for the air sparging system are included in Appendix B.

4.3 EXPECTED TREATMENT/DESTRUCTION EFFICIENCIES

4.3.1 RECOVERED PETROLEUM PRODUCT

Recovered petroleum product collected from the sumps adjacent to the partially penetrating vertical barrier, from active point source extraction, and passive point source extraction will be transferred to an on-site storage facility until the product is transported off-site to the facility where the Kinder Morgan Terminal recycles petroleum products.

4.3.2 EXCAVATED PETROLEUM IMPACTED SOILS

Soil generated by excavating TPH Hot Spots will be disposed at either a permitted landfill or at a thermal desorption treatment facility. Thermal desorption will achieve a destruction efficiency of greater than 99 percent.

The final selection of the disposal facility will occur during the project bidding process. These two disposal options have been successfully used at hundreds of similarly impacted sites throughout the Puget Sound.

4.3.3 EXCAVATED SOIL WITH LEAD AND ARSENIC

It is estimated that excavation and removal of soil impacted by lead and arsenic will be close to 99 percent effective. Some residual soil may remain beneath above-ground piping or near structures were excavation is not possible. The soil will be transported to an appropriate disposal facility and stabilized if needed prior to final disposal. The final selection of the disposal facility will occur during the project bidding process. Excavation and disposal of metal-impacted soil has been successfully used at numerous sites throughout the Puget Sound.

4.4 DEMONSTRATION OF EFFECTIVENESS & COMPLIANCE

Excavation of soil impacted by TPH, metals, and other contaminants has been successfully implemented at thousands of sites throughout the Puget Sound region. Past experience at this site and at other locations on Harbor Island demonstrates that excavation will be effective in removing accessible impacted soil. It has been further documented that removal of impacted soil will result in the improvement of groundwater quality at many of these sites.

Demonstration of compliance will include:

SOIL: Compliance with cleanup requirements will be demonstrated by sampling and testing soil samples from the excavation limits. Intrinsic biodegradation/natural attenuation of the residual TPH contaminated soil left in place will be monitored through groundwater monitoring activities in accordance with the Groundwater Compliance Monitoring and Contingency Plan (included in the Consent Decree).

GROUNDWATER: Product thickness measurements will be collected periodically from those wells historically containing measurable accumulations of product. Additionally, total product volume recovered will be recorded for the system.

Groundwater samples will be collected from monitoring wells and submitted for laboratory analysis in accordance with the Groundwater Compliance Monitoring and Contingency Plan (included in the Consent Decree) prepared for the facility (Figure 13). In addition to groundwater monitoring, field measurements of DO will be obtained during operation of the air sparging system. DO measurements provide a direct measurement of the system's aeration of the groundwater.

5.0 HEALTH AND SAFETY PLAN

A site specific health and safety plan (HASP) will be prepared for the cleanup actions by the contractor before the start of work at the site. The HASP will be prepared in accordance with the health and safety requirements of Kinder Morgan, Ecology (WAC 173-340-810), OSHA, and the Washington Industrial Safety and Health Act (WISHA) (WAC 296-24, 296-62, and 296-155). All workers involved in cleanup activities will be required to read and sign the HASP. A health and safety meeting will be conducted with the contractor, subcontractors, construction testing personnel, and applicable Kinder Morgan and KHM employees prior to commencement of cleanup activities at the site.

6.0 CONSTRUCTION TESTING AND QUALITY CONTROL

The contractor will perform construction quality control consistent with the requirements and provisions of the Final Construction Plans and Specifications, which will be submitted under separate cover. Construction quality control will include the necessary elements to ensure that contaminated materials are handled properly and that construction of the final cleanup actions are performed properly. In accordance with WAC 173-340-400(7)(b), all aspects of construction will be performed under the supervision of a P.E. registered in the state of Washington or a qualified technician under the direct supervision of the engineer. The engineer and qualified technicians under his/her supervision are the quality assurance/quality control (QA/QC) managers.

A QA/QC plan will be provided in the Final Construction Plans and Specifications document and provided to the contractor. The QA/QC plan will provide the following information:

- Project organization
- Identification of QA/QC managers and responsibilities
- Description of construction testing
- Documentation.

7.0 SPILL CONTROL AND SAFETY DESIGN

The final cleanup actions have spill control and safety features designed into the treatment components and excavation procedures. The design features are described in the following sections.

7.1 SOIL EXCAVATIONS

Procedures to control spills will be incorporated into the construction bid documents and will include the use of a lined soil stockpile area, a lined and bermed decontamination area, and a minimal amount of liquids handling. Decontamination procedures will be described in the construction specification documents. In the event of any accidental discharge, the response and cleanup actions will be consistent with Kinder Morgan's emergency response plan.

Erosion and sediment control measures will be detailed in the grading permit to be obtained from the City of Seattle. All such measures will comply with Ecology's *Storm Water Management Manual for the Puget Sound Basin* (Ecology, 1992). Erosion and sediment control measures will be implemented as necessary and may include:

- Plastic sheeting beneath and over soil stockpiles
- Construction of temporary berms and water collection sumps as necessary to prevent runoff
- Collection and storage of runoff and/or decontamination water
- Dust control to prevent airborne soil movement during excavation and loading
- Covers to be placed and secured on trucks during off-site transport of soil

7.2 PARTIALLY PENETRATING VERTICAL BARRIER

Procedures to control spills will be incorporated into the construction bid documents and will include the management and handling of hydrocarbon-affected soil, and the management and handling of hydrocarbon-affected water.

Due to the proposed method of construction for the barrier, it is not anticipated that hydrocarbon-affected soil will be encountered during installation. Depending on the material and brand of sheet piles used for the barrier, hydrocarbon-affected water may be generated during the joint-sealing process. If necessary, procedures for the management and handling of this water will be included in the construction bid documents, and are summarized in Section 8.0.

It is anticipated that hydrocarbon-affected soil and water will be generated during the installation of the recovery sumps. This material will be handled as described in Section 8.0.

The SPH recovery system is the only component of the partially penetrating vertical barrier which requires spill control and safety features and are described below.

- SPH conveyance piping. All piping used for the conveyance of recovered SPH will be Schedule 40 threaded black carbon steel or HDPE. The piping is chemically compatible with petroleum hydrocarbons, is generally resistant to corrosion and has sufficient strength to prevent damage due to normal wear and tear. Requirements for hydrostatic pressure testing of the installed piping will be included in the construction documents.

- Product collection drum. The product collection drum will include an overpack drum for secondary containment. In the event of a high level alarm in the product collection tank, control panel logic will shut down the compressor and activate a solenoid valve to discontinue compressed air supply to the pumps, thus precluding overfilling of the product collection drum. Management and handling of recovered SPH is described in Section 8.0

- Air compressor. An in-line pressure relief valve will be installed to maintain compressed air supply at a optimal and safe level.

- Control panel. The control panel will be located within the equipment enclosure and will be equipped with an emergency stop switch, which will be a maintained-contact, mushroom-top switch. When depressed, the switch will de-energize outputs to the air compressor and activate the solenoid valve to discontinue compressed air supply to the pumps.

7.3 ACTIVE POINT SOURCE PRODUCT RECOVERY

The active point source product recovery system spill control and safety features and are described below.

- SPH conveyance piping. All piping used for the conveyance of recovered SPH will be Schedule 40 threaded black carbon steel or HDPE. The piping is chemically compatible with petroleum hydrocarbons, is generally resistant to corrosion and has sufficient strength to prevent damage due to normal wear and tear. Requirements for hydrostatic pressure testing of the installed piping will be included in the construction documents.

- Product collection drum. The product collection drum will include an overpack drum for secondary containment. In the event of a high level alarm in the product collection tank, control panel logic will shut down the compressor and activate a solenoid valve to discontinue compressed air supply to the pumps, thus precluding overfilling of the product collection drum. Management and handling of recovered SPH is described in Section 8.0.

- Air compressor. An in-line pressure relief valve will be installed to maintain compressed air supply at a optimal and safe level.

- Control panel. The control panel will be located within the equipment enclosure and will be equipped with an emergency stop switch, which will be a maintained-contact, mushroom-top switch. When depressed, the switch will de-energize outputs to the air compressor and activate the solenoid valve to discontinue compressed air supply to the pumps.

7.4 Passive Product Recovery

The management and handling of recovered product from passive product recovery is described in Section 8.0.

7.5 Air Sparging System

The air sparging system safety features and are described below.

- Pressure blower/air compressor. An in-line pressure switch will be installed. In the event of a pressure exceeding normal and safe operating pressures, control panel logic will shut down the pressure blower/air compressor.

- Control panel. The control panel will be located within the equipment enclosure and will be equipped with an emergency stop switch, which will be a maintained-contact, mushroom-top switch. When depressed, the switch will de-energize outputs to the pressure blower/air compressor.

7.6 OTHER CONTROLS.

Other non-technical environmental controls will be implemented for protection of public health and the environment.

7.6.1 ACCESS RESTRICTIONS

The site is an active operating facility and has restricted access (fences, signs, work permit requirements) as part of standard operations. These restrictions are in place 24 hour/day and 7 days/week. The Access and Operating Procedures for the Kinder Morgan site is contained in Exhibit C, of the Consent Decree.

7.6.2 INSTITUTIONAL CONTROLS

Institutional controls are measures undertaken to limit or prohibit activities that may interfere with the integrity of a cleanup action or result in exposure to hazardous substances at the site. Such measures are required to assure continued protection of human health and the environment when a cleanup action results in residual concentrations of IHS that exceed MTCA Methods A or B cleanup levels and where conditional points of compliance are established. These institutional controls include placement of a deed restriction on the property use to industrial purposes or interfering with remedial actions implemented in the CAP.

8.0 MANAGEMENT OF RESIDUAL WASTES

During construction and implementation of the selected remedial actions, wastes associated with these tasks will be generated. The wastes include TPH-impacted soils from the TPH hot spot excavations, SPH from recovery operations, water and solutions from equipment decontamination, disposable sampling equipment, and disposable personal protective equipment. These wastes will be managed in accordance with all applicable local, state, and federal requirements. The following residuals management procedures will be used:

- All water generated during decontamination activities will be placed in 55-gallon drums or tanks,
- Drums or tanks will be labeled with the date filled, the location from which the contents were collected, and a description of the contents,
- Waste storage containers will be sealed and secured daily. An on-site staging area for the accumulation of drums and tanks will be established on site and containers will be stored in the designated temporary holding area until characterized for disposal,
- A record of all generated residuals as stored in drums and tanks will be maintained to expedite characterization and disposal upon completion of construction activities,
- Recovered product and product/water mixtures will be placed in a designated collection tank at the Terminal and recycled by Kinder Morgan,
- Disposable clothing and equipment will be placed in plastic bags and disposed of as solid waste.

8.1 RECOVERED PRODUCT

Product recovered by the hanging wall product recovery system and other point-source recovery systems will be stored in a storage tank located at the terminal. Kinder Morgan periodically recycles the contents of this tank.

8.2 EXCAVATED SOILS

Waste characterization sampling will be completed in-situ as described in Section 4.3 to determine the appropriate disposal or treatment of the contaminated soil. The steps for sequencing of off-site disposal or treatment are described below:

- Verify approved waste profile by designated disposal or treatment facility. The selected facility will be determined by the nature of the waste (Washington State Dangerous Waste or Problem Waste) and acceptance criteria of the receiving facility.

- Load excavated contaminated soil into trucks.
- Cover contaminated soil.
- Transport soil directly to the facility or to a local landfill transfer station.
- Document the number of trucks, the approximate volume of soil transported from the site, and the weight of the material received at the landfill or treatment facility.

Based on the results of previous waste profiling sampling of soil samples collected from the hot spot areas, it is anticipated that the soils will be treated as a non-hazardous waste.

9.0 DEMONSTRATION OF COMPLIANCE WITH CLEANUP REQUIREMENTS

The cleanup action incorporates monitoring to determine that cleanup standards are achieved and maintained after remedial actions have been completed. During the remedial actions, performance monitoring will be conducted to confirm that cleanup actions have attained cleanup standards and treatment goals. After remedial actions are performed, performance monitoring will be conducted to confirm and document that cleanup actions have attained cleanup standards and performance standards. Protection monitoring will be used to adequately protect human health and the environment during construction and operation of the cleanup actions.

This Compliance Monitoring Plan was prepared to describe the protocol and procedures that will be used to confirm that cleanup requirements have been achieved at the Kinder Morgan Terminal. The monitoring plan was prepared to satisfy the requirements of the Model Toxics Control Act (MTCA) regulations WAC 173-340-410, -720, and -820 in accordance with requirements from Exhibit F of the Consent Decree, cooperatively entered into between Kinder Morgan and Ecology.

The achievement of cleanup levels in groundwater shall be measured at points of performance and compliance located within the free product plume area and at the downgradient edge of the site. The overall objective of the compliance monitoring wells downgradient of the free product plumes and on the property boundaries is to provide additional safeguards by providing both Ecology and Kinder Morgan with early warning of potential contamination migration and basis for Contingency Plan reviews and implementation, if necessary. Sentry wells, situated off property limits and downgradient of dissolved petroleum hydrocarbon plumes, will also be used to monitor migration of dissolved petroleum constituents. Compliance monitoring well locations are shown on Figure 13.

9.1 SURFACE AND SUBSURFACE SOIL REMOVAL

Accessible surface soil (up to 6 inches below ground surface) containing lead/arsenic concentrations above hot spot criteria have been identified in the B and C Yards, and are shown on Figures 6 and 7. Subsurface soil TPH hot spots that equal or exceed the TPH cleanup levels have been identified in the B and C Yards and are shown on Figure 3.

The objectives of the excavations are to remove the bulk of hydrocarbon-affected soil, improve general groundwater conditions at the source, and enhance restoration time for the impacted areas. Additionally, the Compliance Monitoring Plan (October 27, 1999), which was developed to confirm that cleanup requirements have been achieved at the site, will be implemented to monitor the on-going biodegradation of the residual TPH in soils as part of the final cleanup action. A deed restriction has also been implemented to prevent inappropriate future use of the site.

Compliance documentation for all soil removal and treatment will be contained in a Post Excavation Report. Confirmation monitoring of these activities will be performed in accordance with Exhibit F of the GATX Consent Decree.

9.1.1 TPH

Elevated TPH concentrations exist in four general areas: (1) the southern portion of the B Yard in Area 3, (2) the northern portion of the A Yard in Area 5, (3) the southern half of the C Yard in Area 4, and (4) the area between Tanks 39 and 42 in the C Yard in Area 4.

Using the delineated TPH hot spots, an excavation plan was developed to remove accessible soil. The depth of excavations is anticipated to range from 0 to 4 feet below grade. The accessible TPH hot spots will be excavated without undermining the integrity of the above ground storage tanks, piping, or other structures adjacent to the hot spot.

Soil samples from sidewalls and bottom of excavations will be obtained to document the residual TPH concentrations the remain after the excavation has been completed. Since TPH hot spots will be excavated without undermining the integrity of the above ground storage tanks, piping, or other structures, this data will be used for Restrictive Covenant purposes and not for performance monitoring. Soil samples will be analyzed for BTEX, TPH-G, TPH-D, and TPH-O. Soil samples will be collected at approximately one sample per 20 feet along the sidewall with two soil samples collected from the bottom of each excavation.

9.1.2 ARSENIC AND LEAD

Soil samples from excavations will be obtained to document the residual metal concentrations that remain after the excavation has been completed. Since impacted areas will be excavated without undermining the integrity of the above ground storage tanks, piping, or other structures, this data will be used for Restrictive Covenant purposes and not for performance monitoring. Soil samples will be analyzed for lead and arsenic.

9.2 PRODUCT MONITORING

All monitoring wells where water level measurements are taken will be measured for free product. The product performance standard is a "measurable product thickness", and the product cleanup standard is "no visible sheen." Sheen is defined as a visible display of iridescent colors on equipment or water removed from a monitoring well. A measurable thickness of free product is defined as greater than or equal to 0.01 feet. There are presently 76 monitoring wells being used to develop groundwater elevation contours for the site.

Shallow wells located in or around a free product plume in the C Yard include Well 20, Well 21, Well 22, MW-4, Well 25 and Well 27. Shallow wells located in or around a free product plume within the A Yard, include, A-6, A-4, A-29, A-22, A-16, A-13, A-14, A-20 and A-19. A shallow well located in or around a free product plume within the B Yard is Well 12.

The objective of performance monitoring is to confirm that the cleanup action has attained cleanup standards and other performance standards as appropriate [WAC 173-340-410(1)(b)]. Performance monitoring will consist of free product monitoring during product recovery activities and groundwater sampling to evaluate the effectiveness of soil and groundwater cleanup actions and natural attenuation. To demonstrate that free product removal has been accomplished, the performance criterion will be a lack of sheen in compliance monitoring wells.

9.3 GROUNDWATER COMPLIANCE MONITORING

The achievement of cleanup levels in groundwater shall be measured at points of performance and compliance located within the product plume area and at the downgradient edge of the site. The wells at the downgradient edge of the site are considered conditional points of compliance wells. These points of compliance and performance shall consist of a network of monitoring wells located in the product plume area and on the downgradient property boundary. Other wells (sentry wells) situated off-site will also be used to document plume migration, performance standards, and to warn of any unanticipated change in off-site groundwater conditions. Exact locations of these wells are identified below and shown on Figure 13 in this report.

9.4 CONTINGENCY PLAN

A contingency plan serves as a "backup" remediation plan in the event that the Preferred Option fails or proves ineffective in a timely manner (5 years). A Contingency plan that contains conceptual engineering plan and design will be initiated and implemented within 30 days of meeting any of the following criteria;

- If the results of the groundwater monitoring program after implementing the Preferred Corrective Options indicate elevated TPH concentration above cleanup levels beyond the specified restoration time frame of 5 years, or

- Contaminants attributed to the Terminal are identified in point of compliance wells located outside of the original plume boundary, indicating renewed contaminant migration, or

- The elevated plume concentrations are not decreasing at a sufficient rate to ensure that the cleanup levels for the site will be met in the time authorized in this CAP.

Inland Groundwater Contingency Plan for Property Boundary Shall Include:

- Use of extraction well points, source identification and removal (supplemented by treatment) to prevent adverse impacts to offsite properties.

- Expand hydraulic control to ensure removal of free product from the water table.

10.0 SCHEDULE

The proposed remedial design and cleanup action schedule has been developed to meet the requirements of the Consent Decree.

TASK	SCHEDULE
Implement Remedial Design	Within 60 days of receipt of Ecology's written approval of the Final RD Work Plan
Begin remediation of accessible inland TPH hot spots	Within 90 days after receipt of Ecology's written approval of the Final RD Work Plan
Draft Post Soil Excavation Cleanup Report	Within 60 days of completion of surface and subsurface soil remediation
Complete free product removal from the site	Within 2 years after receipt of Ecology's written approval of the Final RD Work Plan

11.0 SIGNATURES OF ENVIRONMENTAL PROFESSIONALS

Engineering Design Report

The services described in this report were performed in accordance with generally accepted professional consulting principles and practices. No other warranty, either express or implied, is made. These services were performed in accordance with terms established with our client, Kinder Morgan. This report is solely for the use of our client and reliance on any part of this report by a third party is at such party's sole risk.

This report was prepared for Kinder Morgan Energy Partners.

KHM Environmental Management, Inc.

Ward Crell, R.G.
Principal Geologist

Dawna Leong, P.E.
Principal Engineer

KHM Environmental Management Inc.
18350 Redmond Way
Redmond, Washington 98052

KHM Project Number A30-01D

12.0 REFERENCES

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EPA A Guide for Corrective Action Plan Review, How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank Site, 510-B-95-007, May 1995

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APPENDIX A

GROUNDWATER ELEVATION DATA ALONG PROPOSED HANGING WALL

APPENDIX B

AIR SPARGE DESIGN CALCULATIONS

APPENDIX B

Air Sparge Design Calculations
Kinder Morgan Energy Partners
HARBOR ISLAND TERMINAL
2720 13th Avenue Southwest
Seattle, Washington

Air Sparge Design Calculations:

Groundwater Elevation Scenario	Approximate Water Column (ft. H_20)	Breakthrough pressure (psi)	Breakthrough pressure (in. H_20)
Maximum expected	10	4.76	132
Average expected	6	2.86	79
Minimum expected	2	0.866	24

Breakthrough Pressure Calculation Example:
0.433 psi/ft * 10 ft * 110% = 4.76 psi * 27.681 in. H_20/psi = 132 inches of water

<u>Pressure Requirement:</u>

Minimum: 0.9 psi or 24 in. H_20

Maximum: 4.76 psi or 132 in. H_20

<u>Flowrate Requirement:</u>

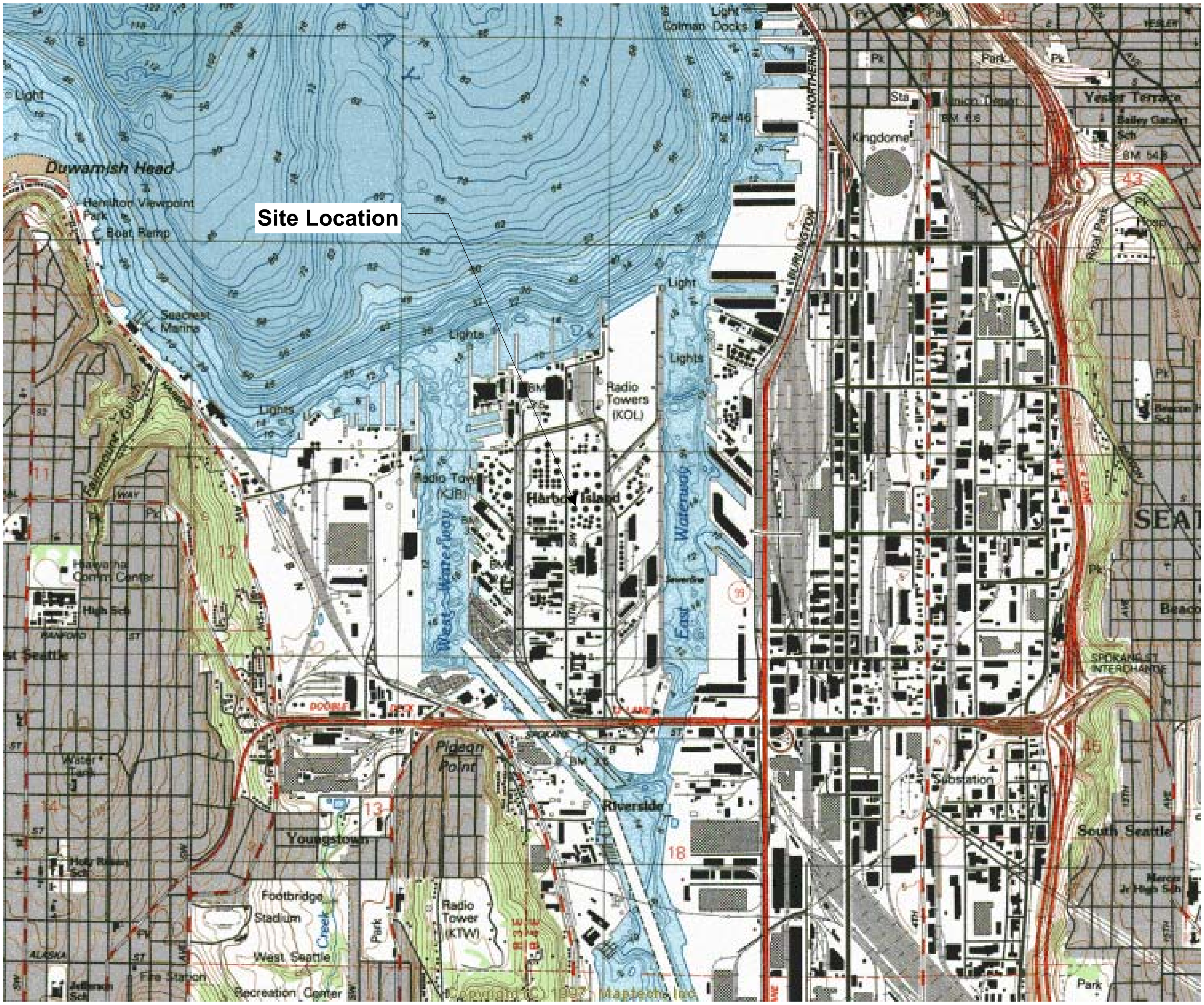
Minimum: 5 scfm/well * 17 wells = 85 scfm

Maximum: 10 scfm/well * 17 wells = 170 scfm

APPENDIX C

SOIL VOLUME CALCULATIONS

N



REFERENCES

USGS 7.5 Minute Topographic Map
Seattle South, WA 1983
Revised/Inspected: None

SCALE: 1 inch = 2083 feet

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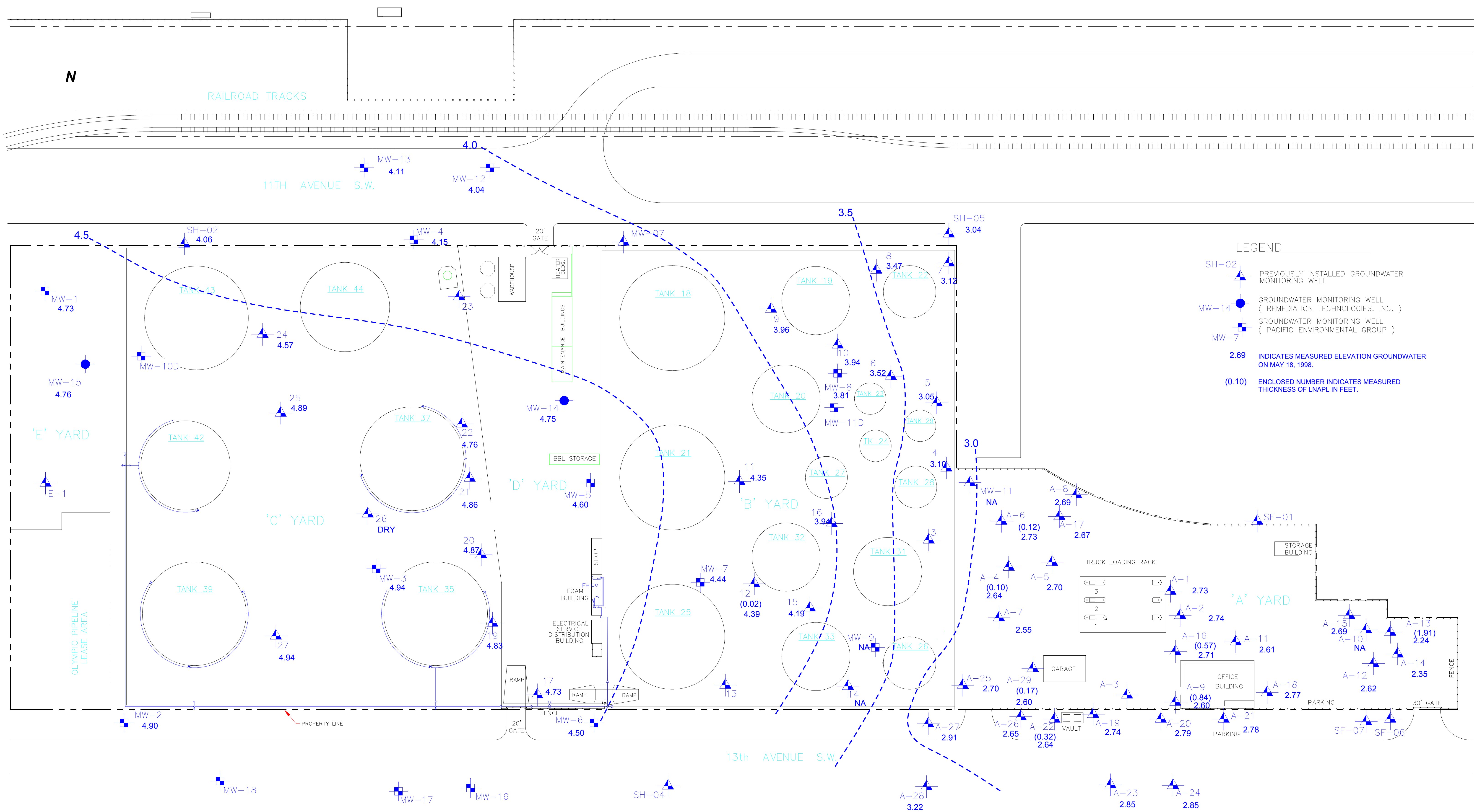
ENVIRONMENTAL MANAGEMENT INC.

Site Location Map

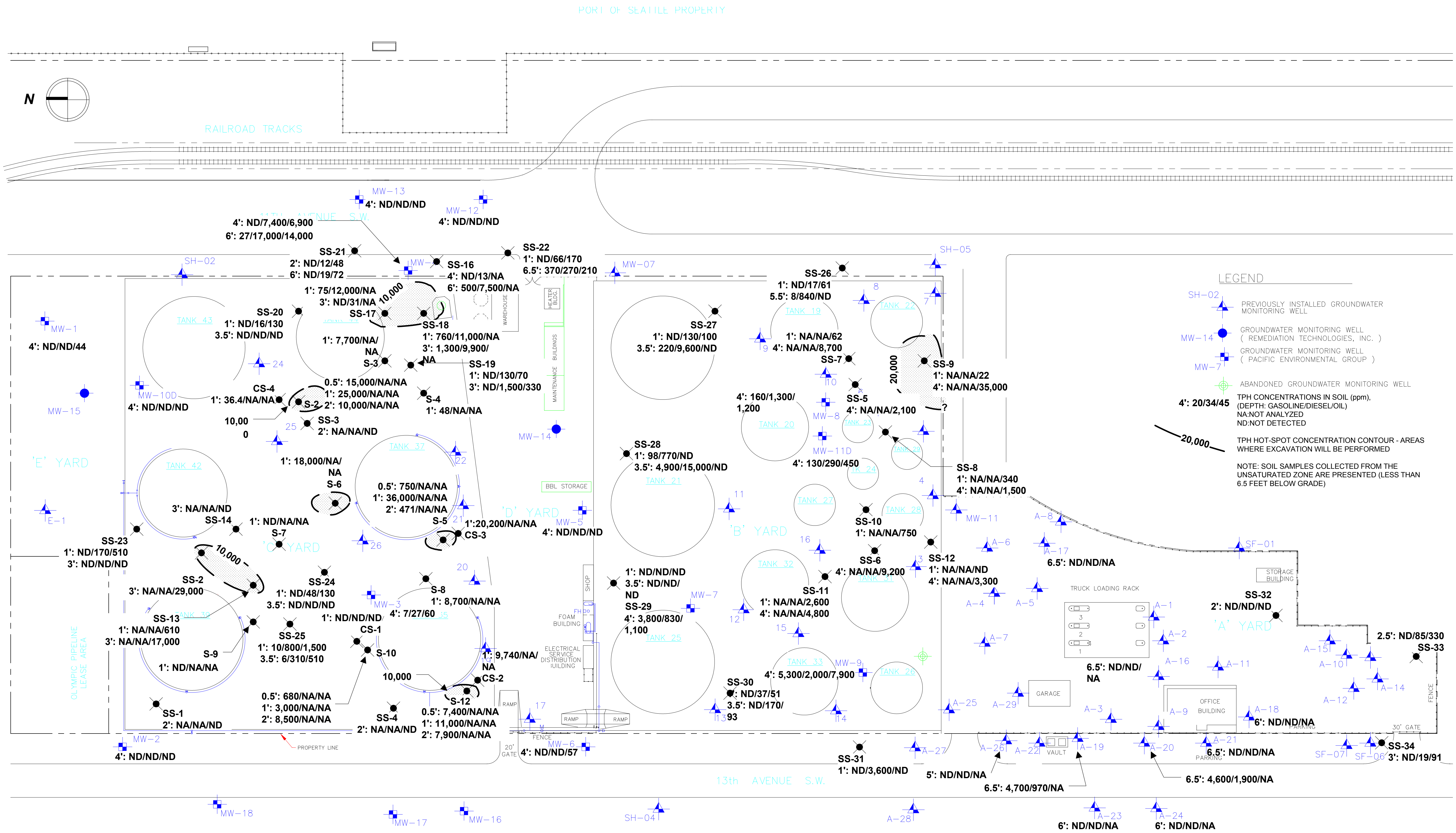
Kinder Morgan Energy Partners
Harbor Island Terminal
2720 13th Avenue Southwest
Seattle, Washington

DATE	PROJECT	FIGURE
10/6/00	A30-01D	1



SCALE

KHM ENVIRONMENTAL MANAGEMENT INC.	Site Map		
	Kinder Morgan Energy Partners Harbor Island Terminal 2720 13th Avenue Southwest Seattle, Washington		
	DATE 10/6/00	PROJECT A30-01D	FIGURE 2



0ft. 0in. 60ft. 0in. 100ft. 0in. 200ft. 0in.

SCALE

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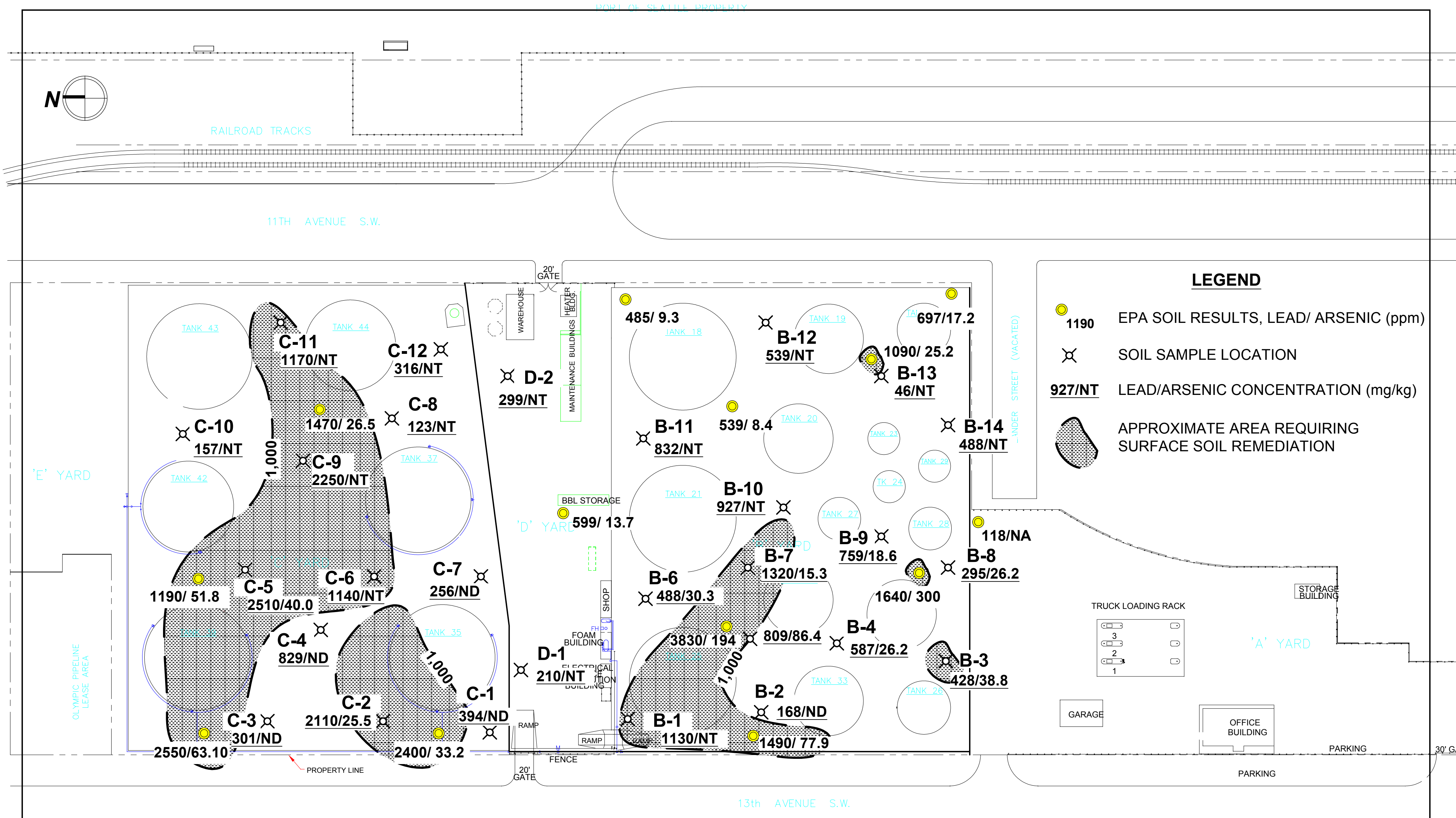
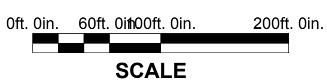
TPH Concentration Map - Soil		
Kinder Morgan Energy Partners Harbor Island Terminal 2720 13th Avenue Southwest Seattle, Washington		
DATE 10/6/00	PROJECT A30-01D	FIGURE 3





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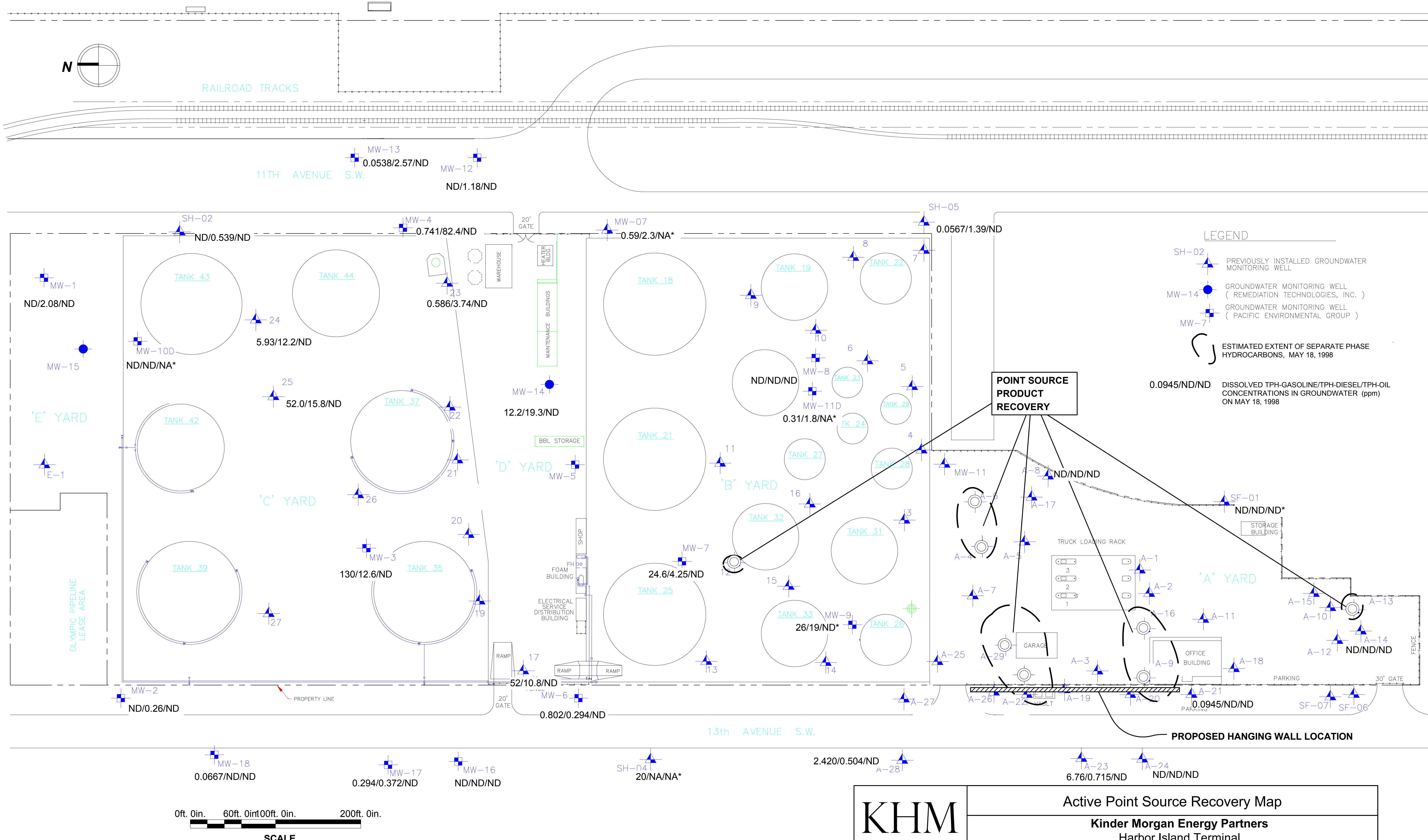
Lead / Arsenic Concentration Map - Soil

Kinder Morgan Energy Partners
Harbor Island Terminal
2720 13th Avenue Southwest
Seattle, Washington

DATE	PROJECT	FIGURE
10/6/00	A30-01D	4



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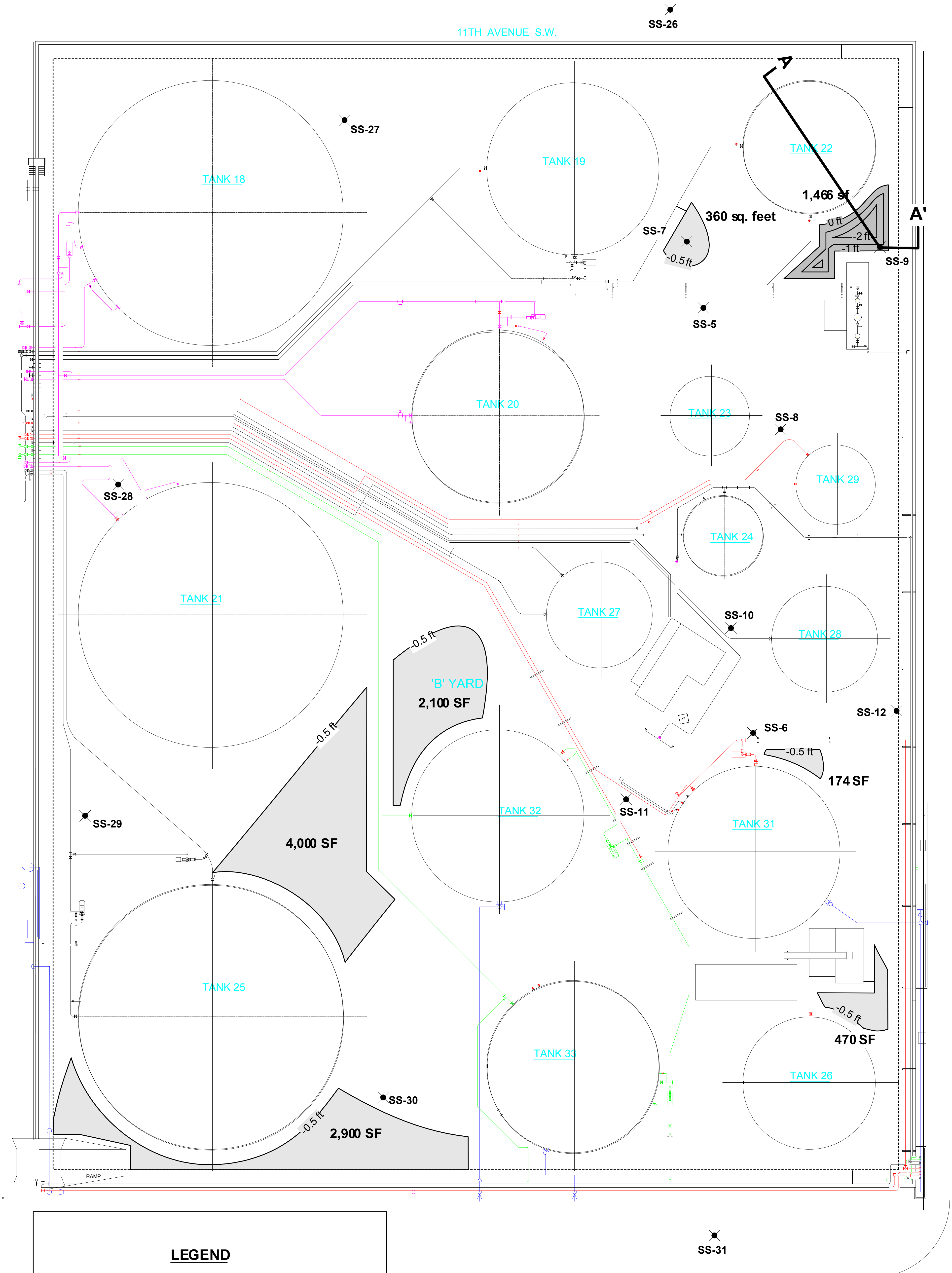
Active Point Source Recovery Map

Kinder Morgan Energy Partners
Harbor Island Terminal
2720 13th Avenue Southwest
Seattle, Washington

DATE	10/6/00	PROJECT	A30-01D	FIGURE	5



LEGEND

Shallow Soil Excavation Area (Lead / Arsenic)

Subsurface Soil Excavation Area (TPH Hot-Spots)

0 ft. 24 ft. 40 ft. 80 ft.
SCALE

VENUE S.

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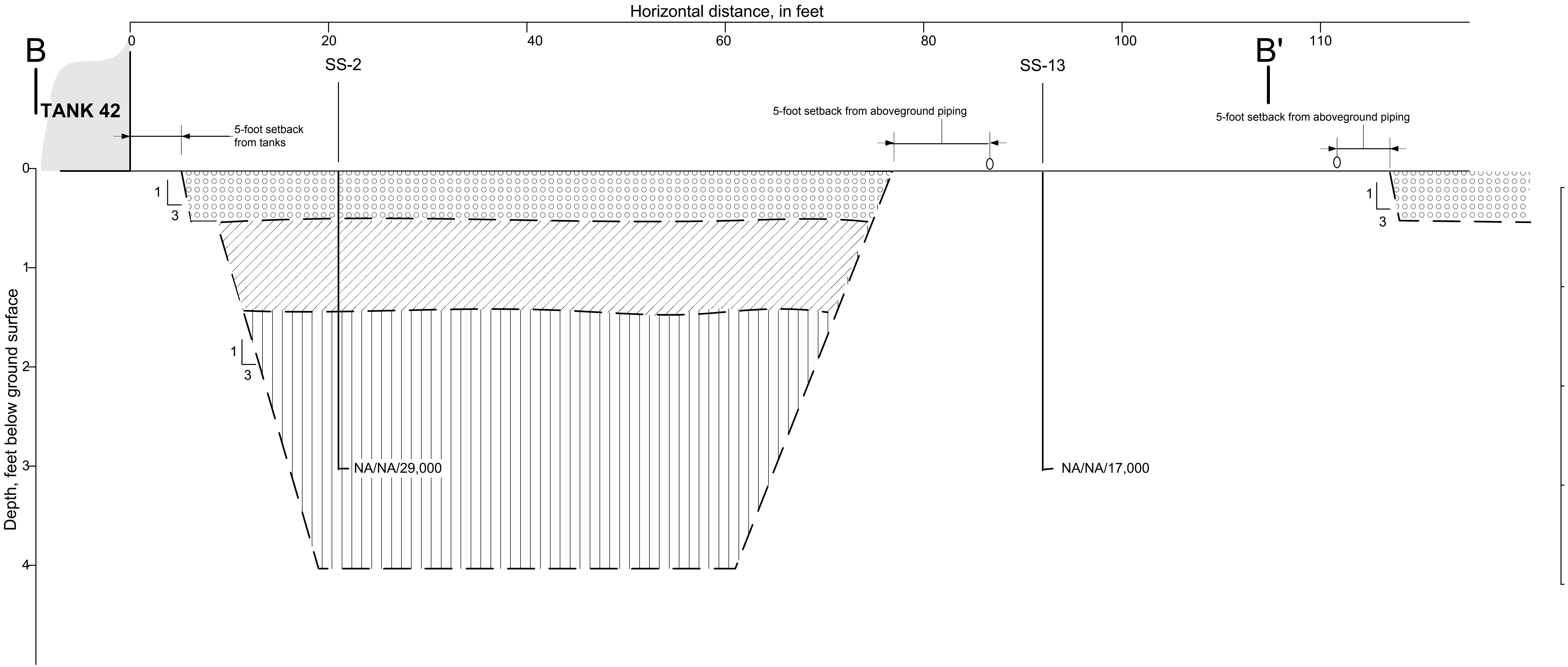
B Yard Soil Excavation Plan

Kinder Morgan Energy Partners
Harbor Island Terminal
2720 13th Avenue Southwest
Seattle, Washington

DATE	PROJECT	FIGURE
10/6/00	A30-01D	6



LEGEND

Approximate Limits of Soil Above Lead/Arsenic Hot Spot Concentration to be Excavation

Approximate Limits of Clean Overburden to be Excavated

Approximate Limits of Soil Above TPH Hot Spot Concentration to be Excavated

NA/NA/22 TPH Concentrations in Soil (ppm)
Gasoline/Diesel/Oil
NA:Not Analyzed

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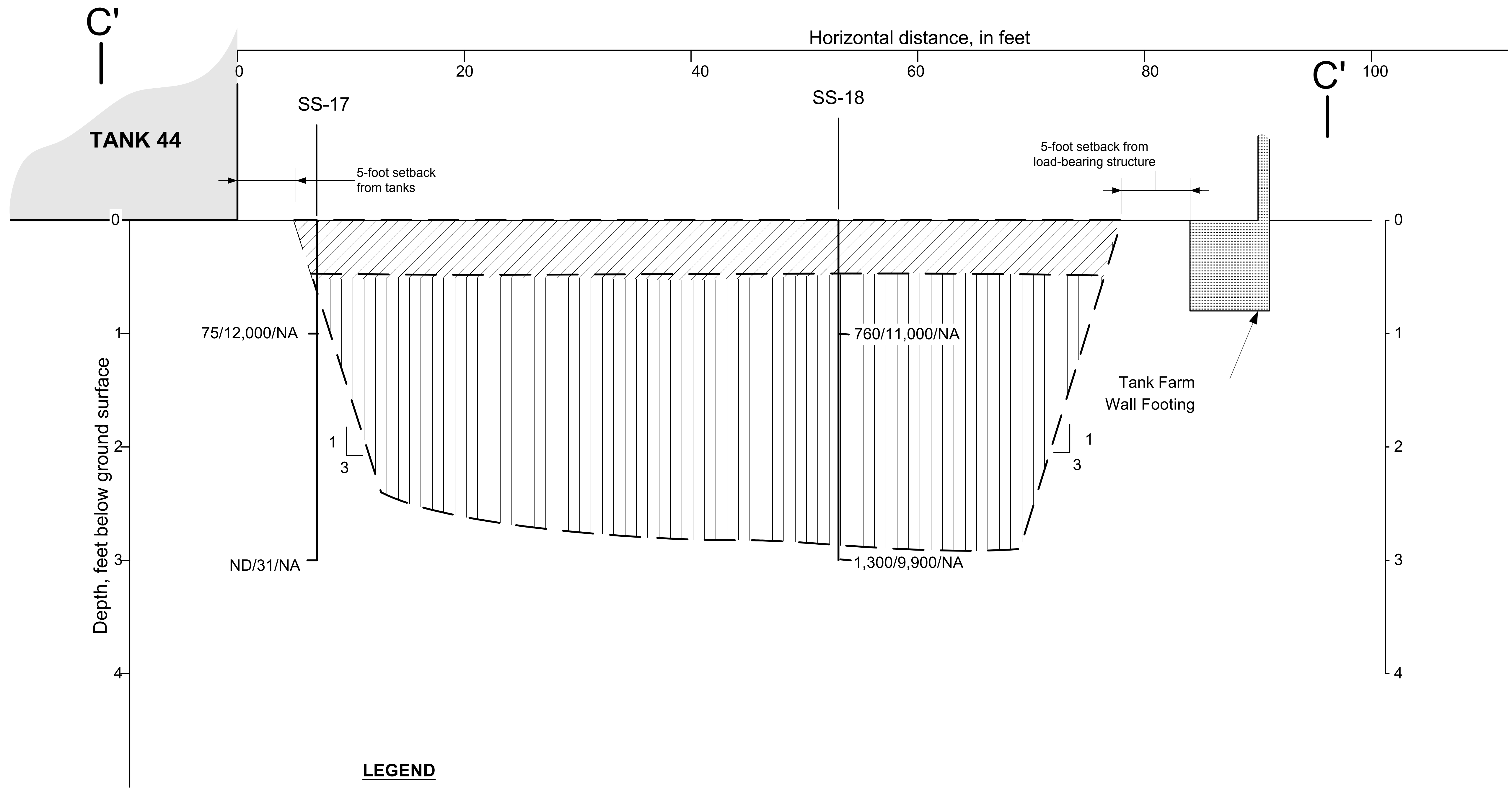
Area 4 - Soil Excavation Profile B-B"

Kinder Morgan Energy Partners
Harbor Island
2720 13th Avenue Southwest
Seattle, Washington

DATE	PROJECT	FIGURE
10/6/00	A30-01D	7A



LEGEND

Approximate Limits of Clean Overburden to be Excavated

Approximate Limits of Soil Above TPH Hot Spot Concentration to be Excavated

ND/31/NA TPH Concentrations in Soil (ppm)
Gasoline/Diesel/Oil
NA:Not Analyzed

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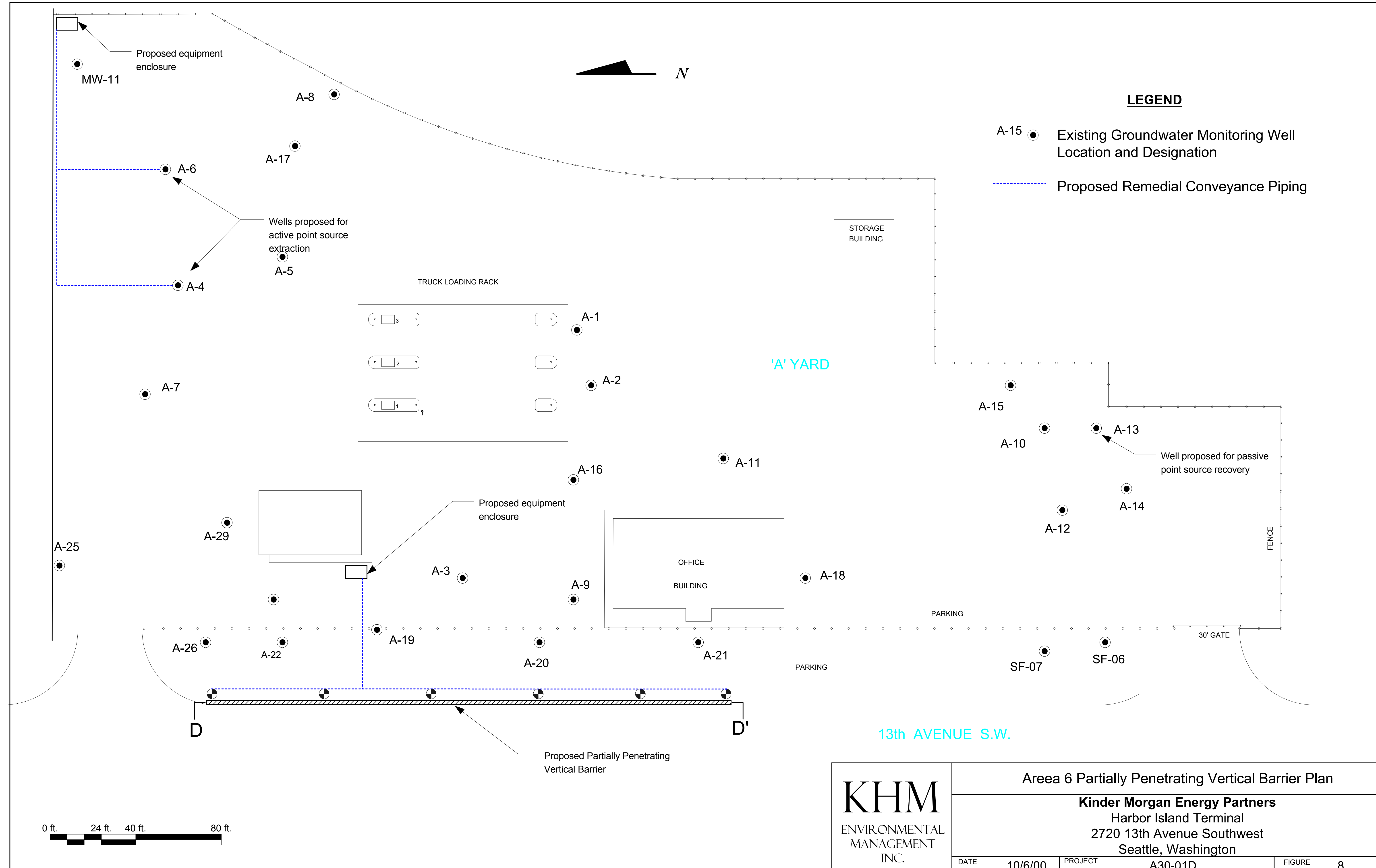
Area 4 - Soil Excavation Profile C-C'

Kinder Morgan Energy Partners
harbor Island Terminal
2720 13th Avenue Southwest
Seattle, Washington

DATE	PROJECT	FIGURE
10/26/99	A30-01D	7B



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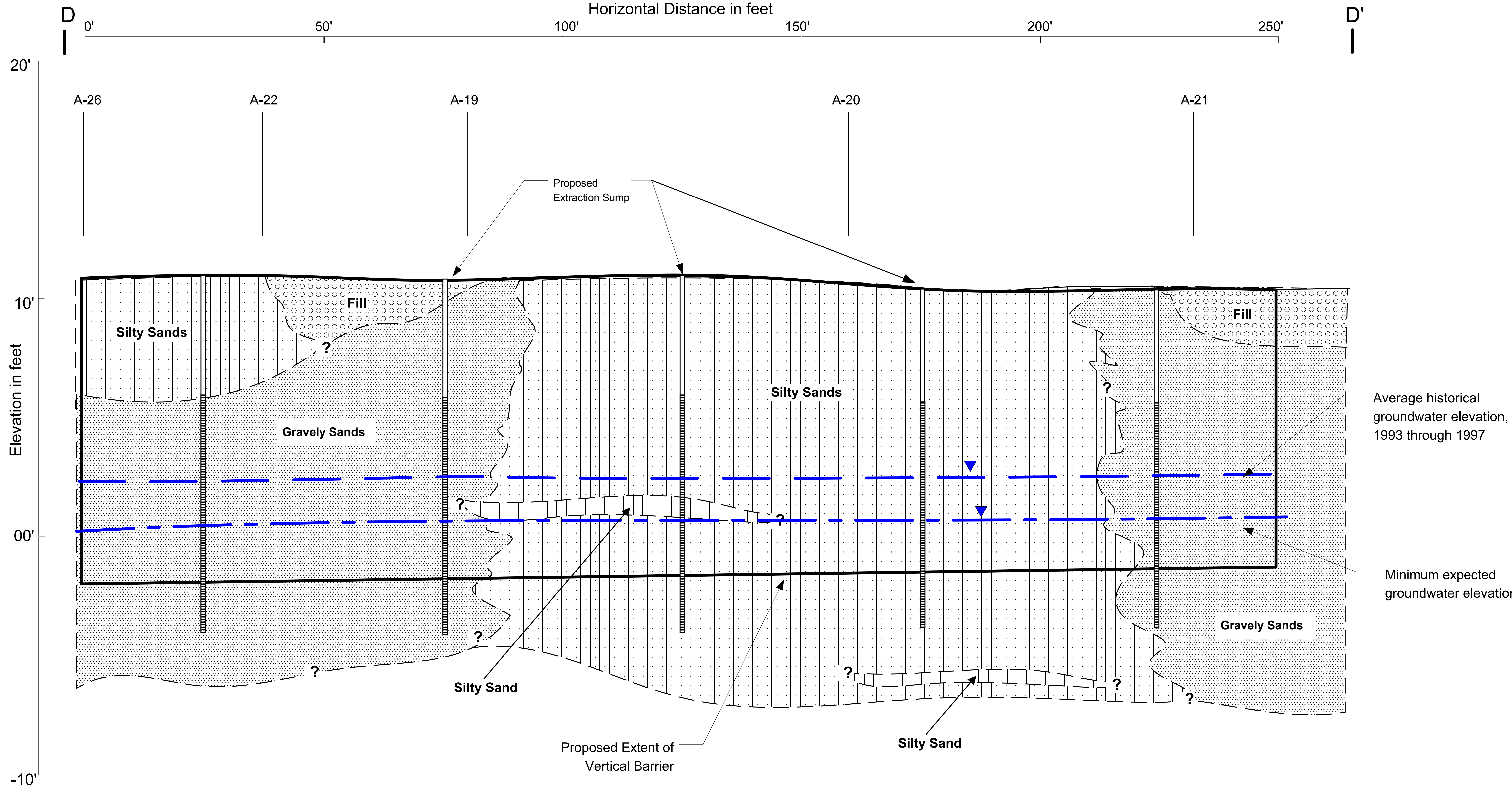
Areea 6 Partially Penetrating Vertical Barrier Plan

Kinder Morgan Energy Partners
Harbor Island Terminal
2720 13th Avenue Southwest
Seattle, Washington

DATE	PROJECT	FIGURE
10/6/00	A30-01D	8



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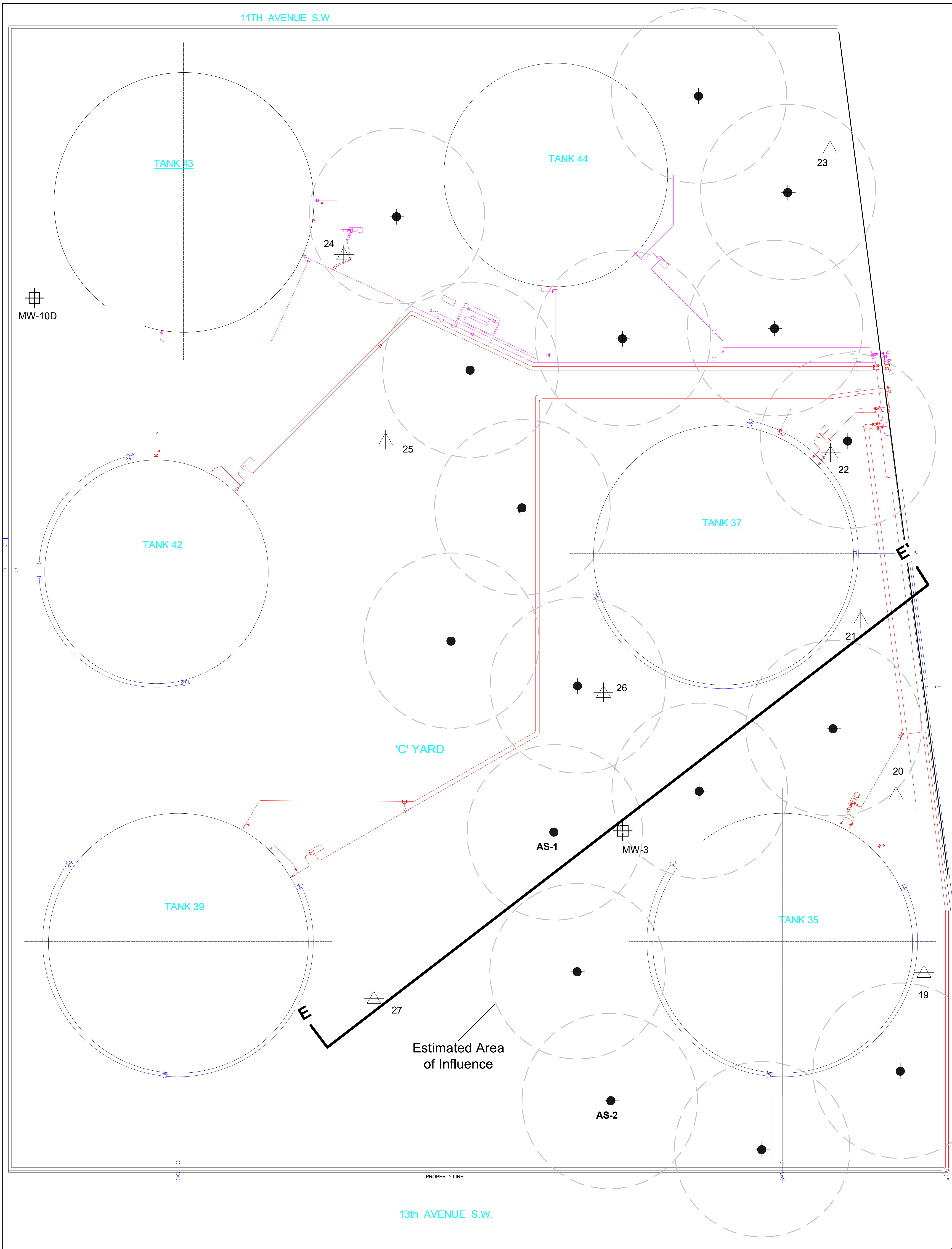
Area 6 Vertical Barrier Profile D-D'

Kinder Morgan Energy Partners
Harbor Island Terminal
2720 13th Avenue Southwest
Seattle, Washington

DATE	10/6/00	PROJECT	A30-01D	FIGURE	8A



LEGEND

- △ Existing monitoring well
- ⊕ Existing monitoring well
- ● Proposed AS well

0 ft. 24 ft. 40 ft. 80 ft.

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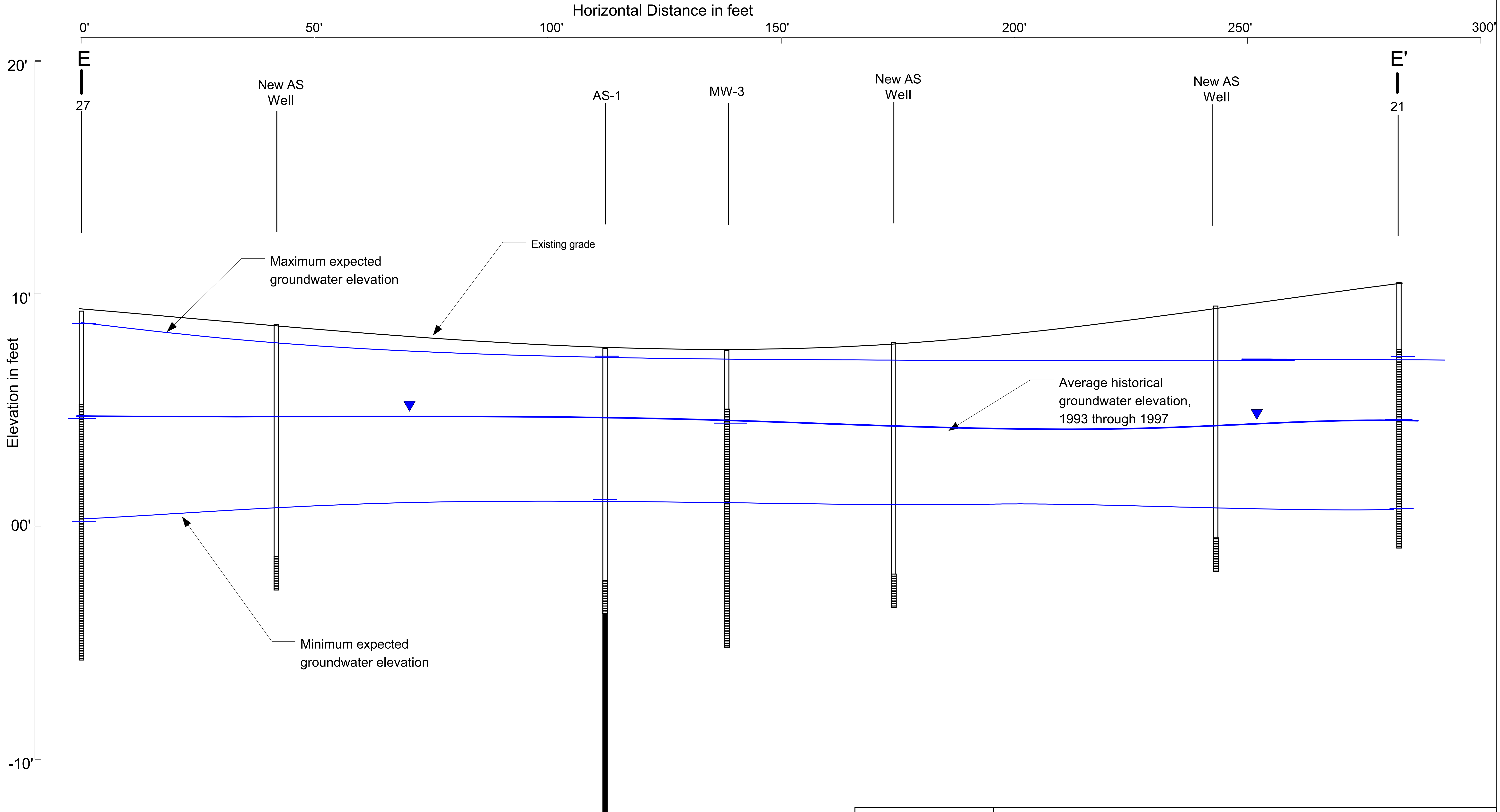
Area 8: C Yard Conceptual Air Sparging Well Layout

Kinder Morgan Energy Partners
Harbor Island Terminal
2720 13th Avenue Southwest
Seattle, Washington

DATE	PROJECT	FIGURE
10/6/00	A30-01D	9



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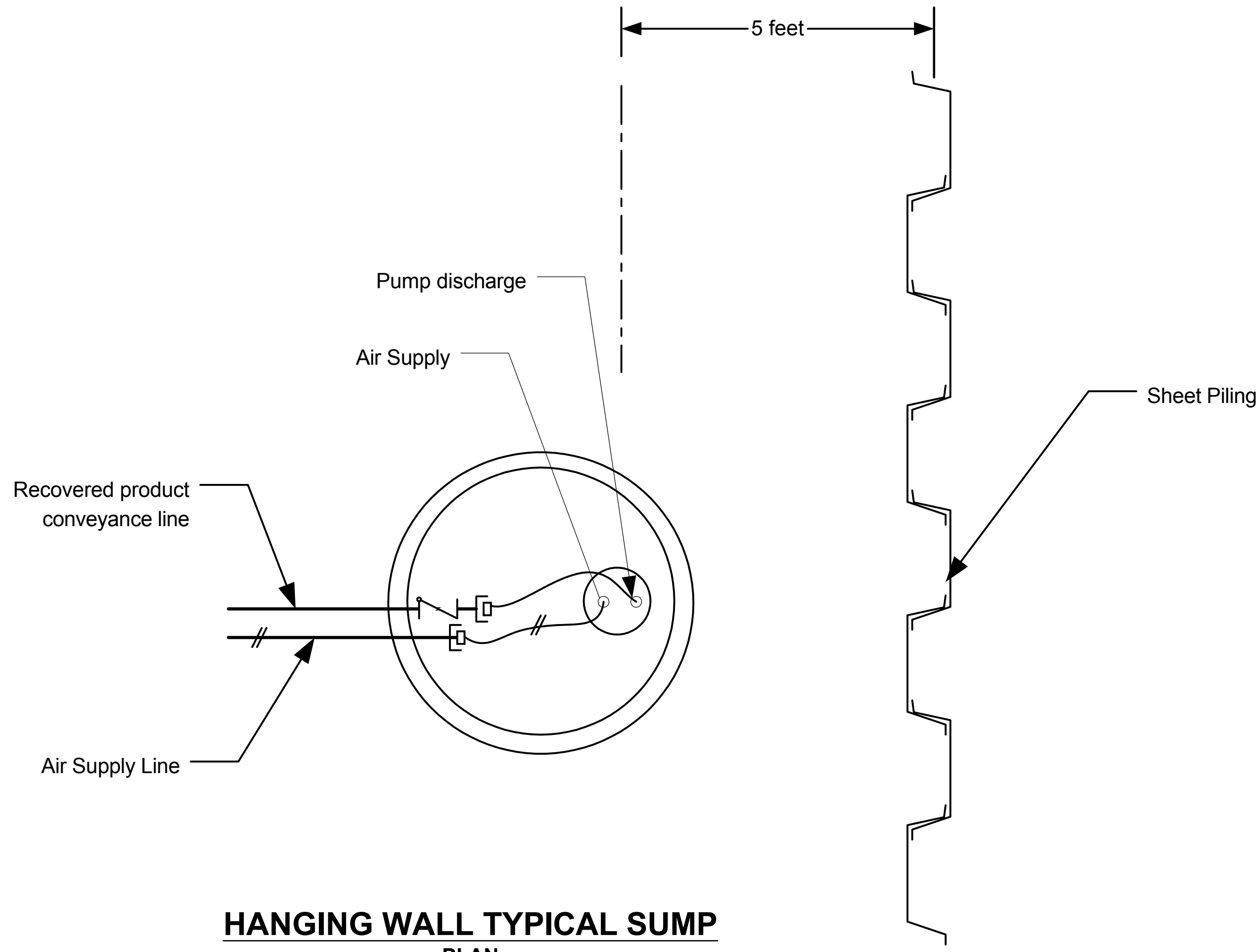
Area 8 C Yard Air Sparge Profile E-E'

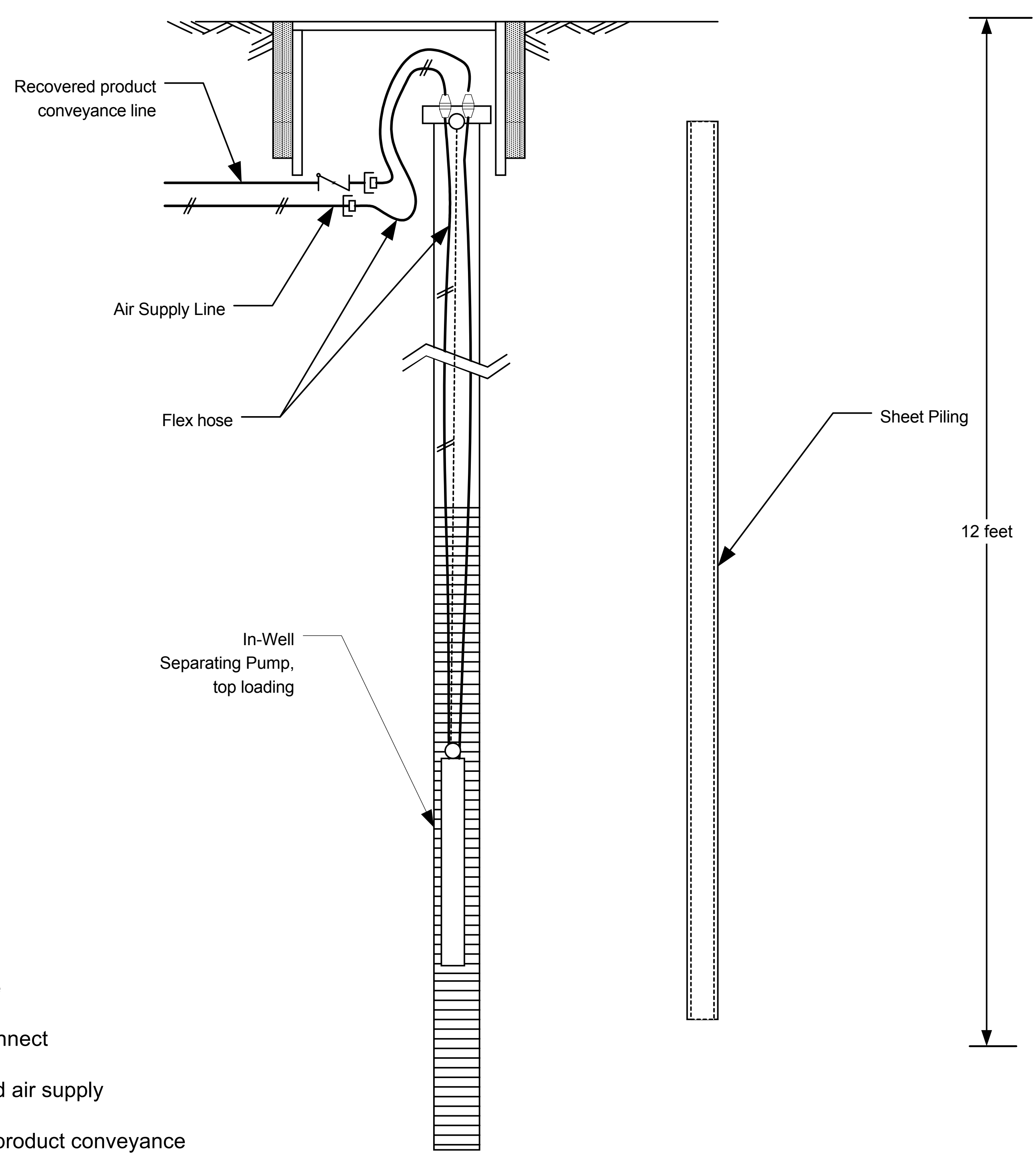
Kinder Morgan Energy Partners
Harbor Island Terminal
2720 13th Avenue Southwest
Seattle, Washington

DATE	PROJECT	FIGURE
10/6/00	A30-01D	9A



HANGING WALL TYPICAL SUMP
PLAN

Not to Scale



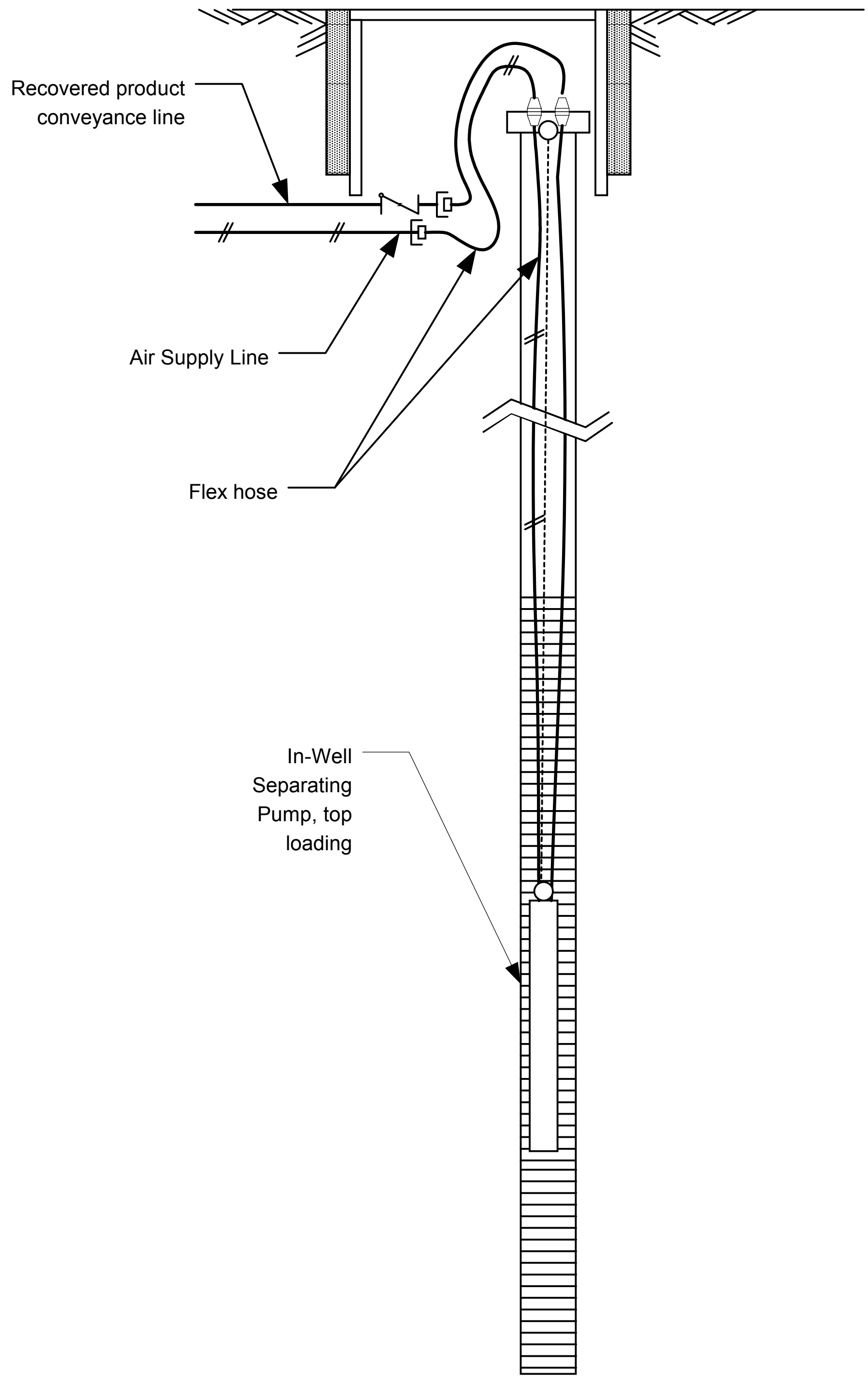
LEGEND

- Check valve
- Quick disconnect
- Compressed air supply
- Recovered product conveyance

HANGING WALL TYPICAL SUMP
PROFILE

Not to Scale

KHM ENVIRONMENTAL MANAGEMENT INC.	Area 8 Hanging Wall Sump Plan and Profile
	Kinder Morgan Energy Partners Harbor Island Terminal 2720 13th Avenue Southwest Seattle, Washington
	DATE 10/6/00 · PROJECT A30-01D · FIGURE 10



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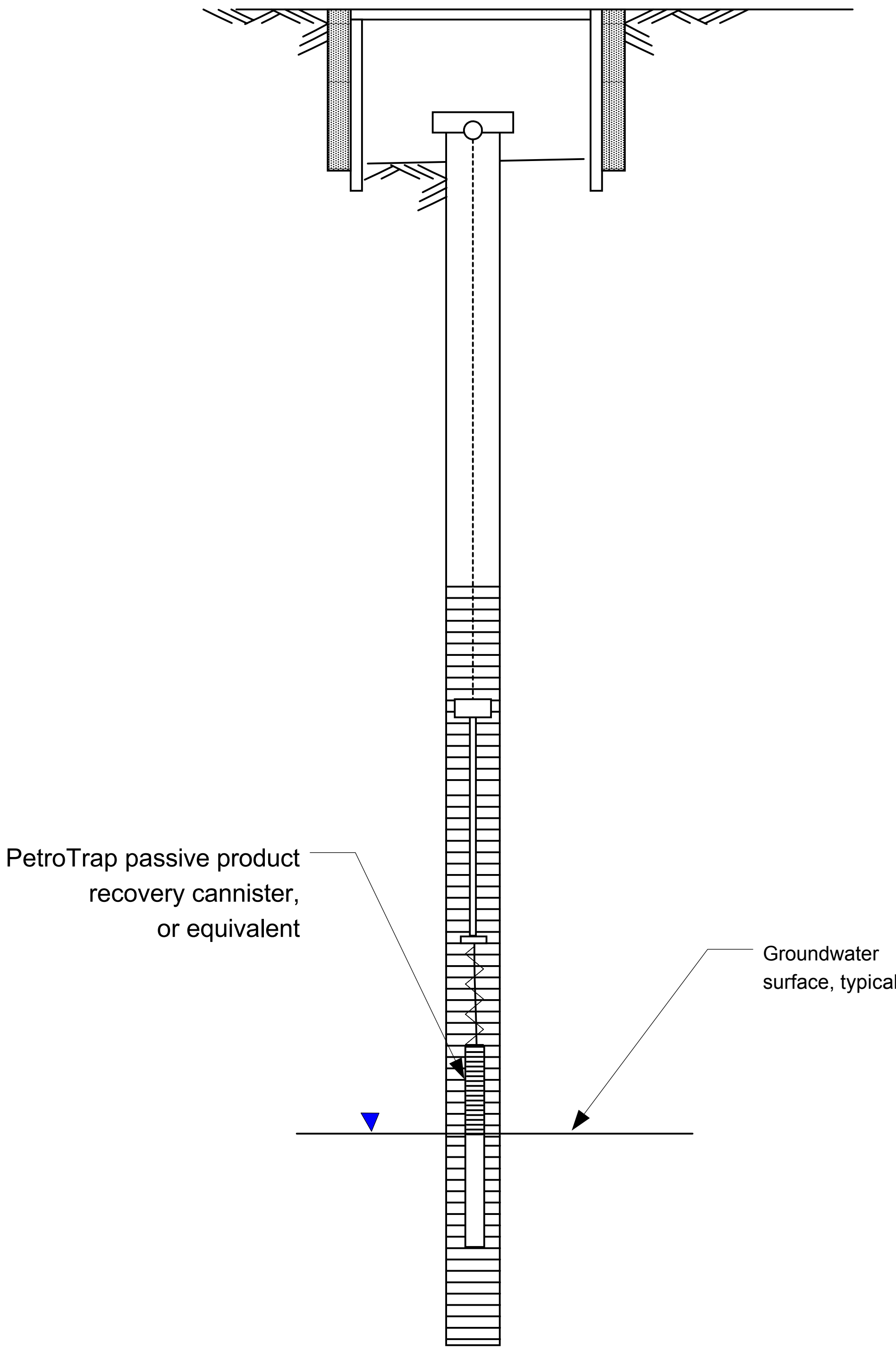
Typical Well - Active Point Source Extraction

Kinder Morgan Energy Partners
Harbor Island Terminal
2720 13th Avenue Southwest
Seattle, Washington

DATE	PROJECT	FIGURE
10/6/00	A30-01D	11



Existing groundwater
monitoring well

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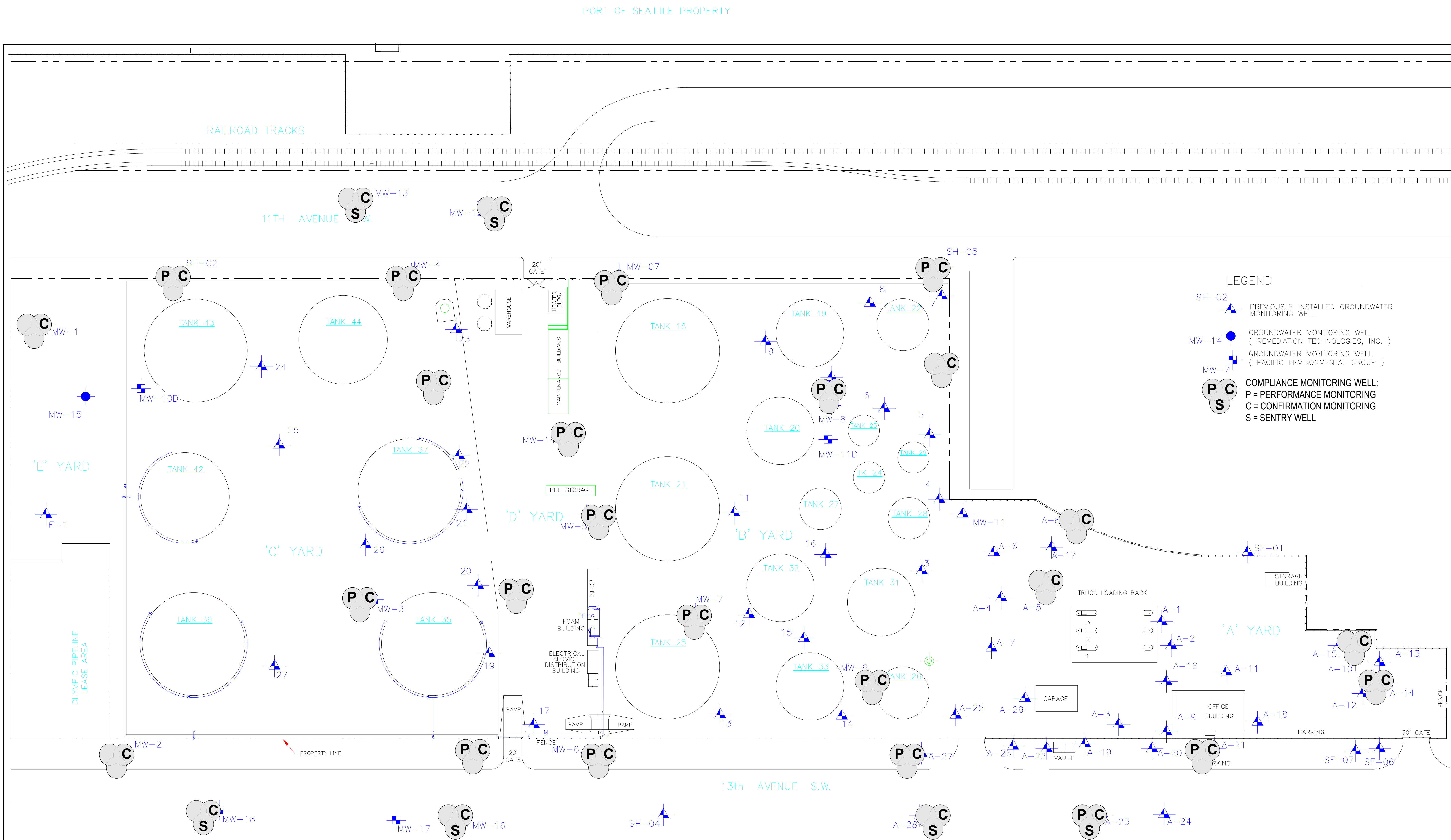
Typical Well - Passive Point Source Extraction

Kinder Morgan Energy Partners
Harbor Island Terminal
2720 13th Avenue Southwest
Seattle, Washington

DATE	PROJECT	FIGURE
10/6/00	A30-01D	12



Compliance Well Location Map

KHM ENVIRONMENTAL MANAGEMENT INC.

Kinder Morgan Energy Partners
Harbor Island Terminal
2720 13th Avenue Southwest
Seattle, Washington

DATE	PROJECT	FIGURE
10/6/00	A30-01D	13