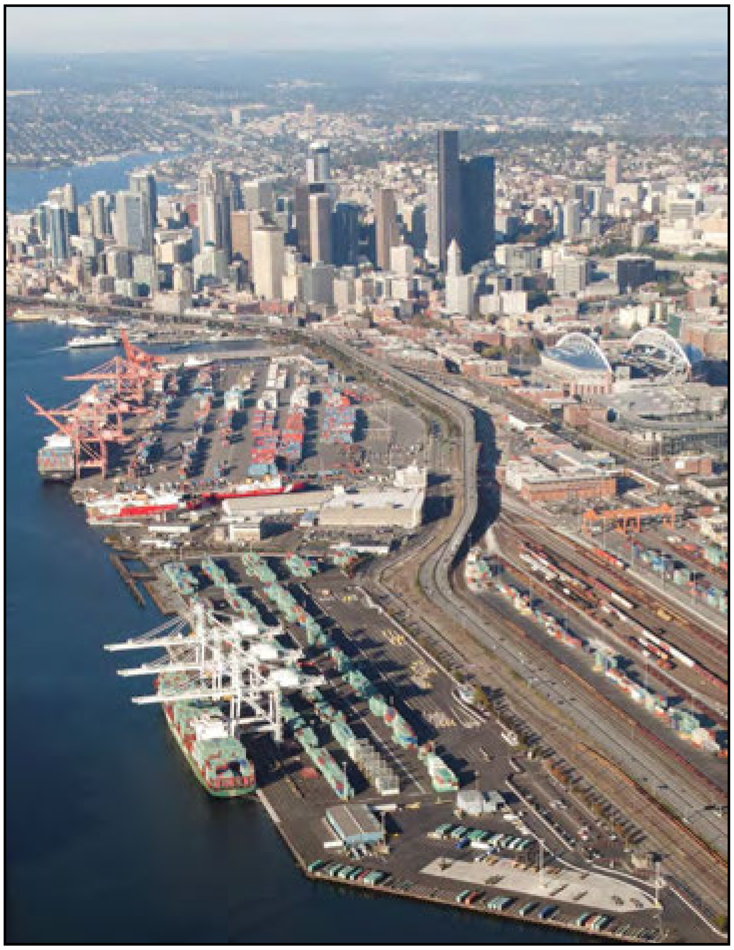
PORT OF SEATTLE TERMINAL 30
REVISED 2013 REMEDIAL INVESTIGATION/ FEASIBILITY STUDY



JANUARY 11, 2016

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REVISED 2013 REMEDIAL INVESTIGATION/ FEASIBILITY STUDY

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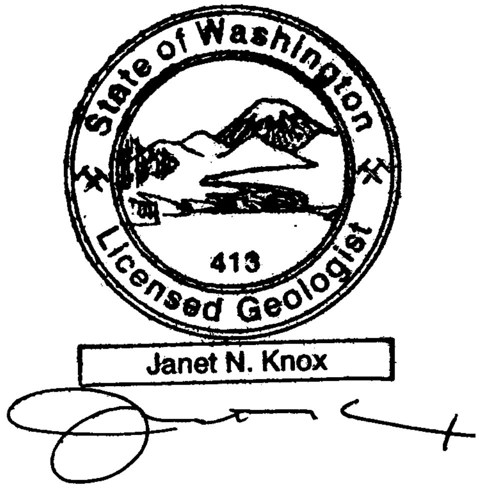
ACRONYMS USED FREQUENTLY IN THIS REPORT

AO	Agreed Order
API LDRM	American Petroleum Institute LNAPL Distribution and Recovery Model
ARAR	Applicable or Relevant and Appropriate Requirement
AS/SVE	Air-Sparge/Soil Vapor Extraction
bgs	Below Ground Surface
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
CAP	Cleanup Action Plan
CMP	Compliance Monitoring Plan
CSO	Combined Sewer Outfall
DCA	Disproportionate Cost Analysis
DRO	Diesel Range Organics
EC	Electrical Conductivity (Specific Conductance)
EPA	Environmental Protection Agency
FS	Feasibility Study
GRO	Gasoline Range Organics
ITRC	Interstate Technology & Regulatory Council
MOR	Motor Oil Range Organics
LDW	Lower Duwamish Waterway
LNAPL	Light Non-Aqueous Phase Liquid
LOR	Lubricating Oil Range
MLLW	Mean Low Low Water
MTCA	Model Toxics Control Act
MW	Monitoring Well
NAPL	Non-Aqueous Phase Liquid
PAH	Polycyclic Aromatic Hydrocarbon
RAO	Remedial Action Objective
RI	Remedial Investigation
RTG	Rubber-Tire Gantry
RW	Recovery Well
SAP	Sampling and Analysis Plan
SVOC	Semi-Volatile Organic Compound
T30	Terminal 30
TEPH	Total Extractable Petroleum Hydrocarbons
TPH	Total Petroleum Hydrocarbons
TPH-G	Total Petroleum Hydrocarbons- Gasoline Range
TPH-D	Total Petroleum Hydrocarbons- Diesel Range
TPH-O	Total Petroleum Hydrocarbons- Oil Range
TEE	Terrestrial Ecological Evaluation

SIGNATURE

This report, and Pacific Groundwater Group's work contributing to this report, were reviewed by the undersigned and approved for release.



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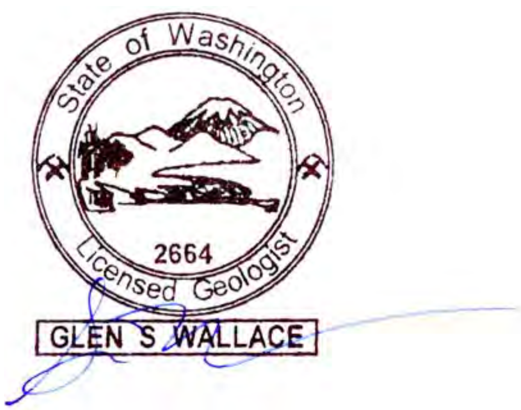

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1.0 INTRODUCTION

Since the early 1990s, petroleum contamination caused by a historical tank farm at the Port of Seattle Terminal 30 Site (site) has been the subject of a number of investigations and extensive interim actions. The progress of the Site is somewhat unique. The Port of Seattle (Port) and Washington State Department of Ecology (Ecology) entered into an Agreed Order in 1991 for a Remedial Investigation/Feasibility Study (RI/FS). Rather than proceeding though the normal Model Toxics Control Act (MTCA) sequence (investigation, remedy selection, remedy implementation) the Site has undergone a series of interim actions that removed the vast majority of contaminant mass. Additionally, the Site has undergone iterative redevelopment in the last twenty years, including significant redevelopment since the original RI/FS for the Site was completed in 1998.

This 2013 RI/FS has been developed because significant changes have occurred at the Site since the original RI/FS was performed, including physical changes from redevelopment, mass removal from interim actions, and natural attenuation of contaminants. Taking this new information into account, this 2013 RI/FS is written in accordance with WAC 173-340-350 to collect, develop, and evaluate information regarding contamination at Terminal 30 to present and recommend a remedial alternative. The location and layout of Terminal 30 are presented in Figures 1-1 and 1-2.

General Facility Information

Site Name:	Port of Seattle Terminal 30
Site Address:	1901 East Marginal Way South, Seattle, Washington
Parcel Number:	7666207830
Current Owner:	Port of Seattle, Roy Kuroiwa Project Manager
Current Operator:	SSA Marine (Port of Seattle Tenant)
Project Consultant:	Pacific Groundwater Group, Janet Knox Project Manager 2377 Eastlake Avenue East, Seattle WA 98102 206-329-0141

1.1 OVERVIEW

Environmental investigations and remediation at Terminal 30 began in the early 1980s with Chevron's discovery of petroleum contamination in soil and groundwater. The Port of Seattle purchased the property in 1985. Nearly three decades of work at the site have included considerable study, interim actions, and redevelopment actions with environmental benefits:

- Port and Ecology enter into Agreed Order (AO) for RI/FS in 1991
- Installation of a product recovery system that removed more than 171,000 gallons of product by the early 1990s

- Excavation and offsite disposal of more than 24,000 cubic yards of petroleum-impacted soil
- Construction of site-wide 12 to 16-inch thick asphalt cap
- Oxygen Release Compound injection in MW-42 area
- Installation of more than 100 monitoring and recovery wells
- Numerous technical studies and reports including and additional Data Report, Disproportionate Cost Analysis, and proposed remedy in 2008 (ENSR|AECOM, 2008a,b,e) (Section 4)
- Completion of the initial RI/FS in 1998
- Installation of sheetpile wall and stormwater system in 2008-2009
- Continuation of monitoring and product recovery during the 2000s

The remedial actions were performed with Ecology oversight under the auspices of the 1991 AO at a cost of approximately $20,000,000 and, as noted in Section 1.0, have resulted in significant reductions in contaminant mass and risk. Concurrently, the site has been redeveloped from a bulk fuel facility into a busy shipping terminal that is an integral part of the Seattle shipping industry.

1.2 REPORT ORGANIZATION

The 2013 RI and FS are presented together in this document. The RI portions of this report (Section 2) present the site background information, environmental setting, nature and extent of contamination and fate and transport analysis. The FS portions of the report (Section 3) describe remedial alternatives and disproportionate cost analysis.

1.3 WARRANTY

This work was performed, our findings obtained, and this report prepared, using generally accepted environmental practices used at this time and in this vicinity, for exclusive application to this study, and for the exclusive use of the Port of Seattle. This in in lieu of other warranties, express or implied.

2.0 REMEDIAL INVESTIGATION

This 2013 RI summarizes the site history, hydrogeology, and nature and extent of contamination. The 2013 RI is supported with detailed appendices as referenced. Discussion of the nature and extent of contamination focuses on data collected in the last 5 years with references to previous documents that include earlier data.

2.1 SITE IDENTIFICATION AND LOCATION

Terminal 30 is located approximately one mile southwest of downtown Seattle, in King County, Washington on the shoreline of the East Waterway (Figure 1-1). While Terminal 30 is 33.9 acres, the subject site of this 2013 RI/FS is approximately 11 acres in the northern portion of the property. The 1991 Agreed Order (AO) defined the “site” as a portion of Terminal 30, formerly known as Pier 32 that was acquired by the Port of Seattle (Port) from Chevron, USA on January 2, 1985. As part of the property transfer, Chevron performed a subsurface investigation in the early 1980s and concluded that free petroleum product was present in soil and groundwater.

The 1998 RI/FS adopted the AO definition of the site (Figure 1-2). For the 2013 RI/FS, the term “T30 site” will refer to the extent of petroleum contamination in the northern portion of Terminal 30, inclusive of light non-aqueous phase liquid (LNAPL), soil, and groundwater contamination; which is similar to the “site” defined in the AO (Figure 1-2). The T30 site is regulated by the Model Toxics Control Act (WAC 173-340) under the 1991 AO.

The T30 site is bordered on the north by an area of public shoreline access to the East Waterway, on the east by East Marginal Way South, on the south by the southern portion of Terminal 30, and on the west by the East Waterway. The East Waterway is an operable unit of the Harbor Island Superfund Site as ordered by the U.S. Environmental Protection Agency (EPA). The legal description of the T30 site from the AO and a chronology of past owners and operators are included in Appendix A.

2.2 PROPERTY DEVELOPMENT AND HISTORY

As described above, the AO defines the T30 site as the former Pier 32 Chevron property, which is approximately 11 acres, composed of Lots 1 through 11, Block 371 of the Seattle Tide Lands, excepting a small portion of Lot 11 (see attachment A of the Agreed Order). Terminal 30 is zoned general industrial type 1 (IG1), within the Greater Duwamish Manufacturing and Industrial Center. Land in the vicinity is similarly industrial-zoned tidelands within the Greater Duwamish Manufacturing and Industrial Center.

2.2.1 Historic Development

The history of ownership and land use of the T30 site is summarized in Figure 2-1 and Appendix A, which also includes historical aerial photographs.

Prior to about 1900, Terminal 30 and the T30 site were part of the Elliott Bay tide flat. The Elliott Bay tide flats and Duwamish estuary were extensively filled with materials from various sources including dredge spoils and hydraulic fill to thicknesses of 15 to 20 feet. As early as 1905, a Chevron bulk fuel terminal occupied the northern portion of the T30 site. From approximately 1914 through 1950, the southern portion of the T30 site was variously occupied by a lumber yard, machine shop, and ship yard. In 1950 Chevron expanded the bulk fuel terminal to the southern portion of the T30 site. Also, a service station occupied the southeastern corner of the T30 site from 1950 or before to sometime between 1969 and 1977.

The Chevron bulk fuel terminal consisted of above-ground fuel storage tanks and associated piping and equipment. The types of stored fuels listed in the AO include leaded and unleaded gasoline, diesel, and heating oil. A 1951 site plan indicates that furnace oil, stove oil, bunker fuel oil, diesel fuel, aviation fuel, Stoddard solvent, thinner, pearl oil, and gasoline were stored at the site (GeoEngineers, 1998). Table 2-1 summarizes the number of above-ground storage tanks (ASTs) at the T30 site between 1905 and 1984.

The Port purchased the T30 site from Chevron on January 2, 1985. The fuel terminal was demolished between December 1984 and about November 1985. The Port redeveloped the 33.9 acre Terminal 30 as a container terminal, which involved constructing a concrete apron along the shore, paving the property with asphalt, concrete, and constructing the Vessel Tower (then the Marine Building) and Gate House. Construction of the container terminal was completed in 1986. Additional details of the demolition and terminal construction activities are presented in Section 2-2 of the 1998 RI/FS (GeoEngineers, 1998).

In 1999, the Port constructed a cruise ship berthing facility in the southern 24 acres of Terminal 30, south of the T30 site. The cruise ship facility and container terminal continued to operate until the close of the 2008 cruise season. Two phases of construction began in 2007 to remove the cruise ship facility and convert the entirety of Terminal 30 to a container terminal. Redevelopment activities included installing a sheet pile wall to strengthen the concrete apron, constructing rubber-tired gantry (RTG) crane runways, constructing a new Gate House and gate system, and installing a new asphalt overlay. Construction to convert Terminal 30 to a container terminal was completed in June 2009. Additional demolition and construction details are presented in the 2008 Supplemental Data Report (ENSR|AECOM, 2008a: Sections 1-2 to 1-3) and the Terminal 30 Cargo Terminal Construction Report (ENSR|AECOM, 2010).

2.2.2 Current Operations

Terminal 30 and the contiguous Terminal 25 to the south are currently operated as a 70 acre container storage and transfer facility by the Port's tenant SSA Marine, who is leasing the facility through 2023. Containerized freight is transferred between ships, trucks, and temporary terminal storage using a series of rail-mounted overhead cranes and forklifts. Activities are directed from the Vessel Tower and Gate House. The Vessel Tower is within the T30 site, while the Gate House is not (Figure 1-2). The T30 site is entirely paved with asphalt; runoff is controlled by a stormwater management system operated and maintained by SSA Marine (Figure 2-2).

2.2.3 Potential Future Development

The Port anticipates continued and long-term ownership of Terminal 30 and long-term use as a container facility. The Port has no plans to redevelop this property.

2.2.4 Sheet Pile Wall

A sheet pile wall was installed in the winters of 2007-2008 and 2008-2009 (two phases) to a depth of 29 feet or bottom elevation of -11.60 feet mean low low water MLLW. The sheet pile was installed for geotechnical, not remedial, purposes and is not keyed into an aquitard.

2.2.5 Roads and Utilities Infrastructure

Vehicle access to Terminal 30 is directly from East Marginal Way and is controlled at the security Gate House. The City of Seattle provides water, electricity, and sanitary sewer service to Terminal 30. Stormwater runoff is managed by SSA Marine using best management practices. The stormwater management system treats runoff with oil/water separators and filtration media prior to discharge at outfalls to the East Waterway. Two of these outfalls, Hanford and Lander, enter the East Waterway south (upstream) of the site (Figure 2-3).

Utilities on the T30 site have been modified many times with varying levels of documentation. Most recently, additional subsurface utilities including electrical, sanitary sewer, and water were installed during the 2007-2009 container terminal construction (ENSR|AECOM 2010). Underground utilities documented in Port and Seattle Public Utility files are presented in Figure 2-2; additional abandoned or undocumented subsurface utility infrastructure may be present on the site.

2.3 NATURAL CONDITIONS

2.3.1 Physiographic Setting and Topography

Terminal 30 is located in the Puget Sound Lowland, a north-south trending topographically low region between the Olympic Mountains and the Cascade Mountain foothills. Regionally, the land surface is a product of the most recent glaciations, which ended about 15,000 years ago, and more recent alluvial processes. Locally, the topography is also the product of engineering the Lower Duwamish River (Booth and Herman, 1998).

To facilitate navigation and economic development, the lower portion of the Duwamish River was straightened and dredged between 1903 and 1905. The dredged portion of the river is referred to as the Lower Duwamish Waterway (LDW), which is described in Section 2.3.2 and includes the East Waterway adjacent to T30. Dredged material from the river was used to create Harbor Island (Weston, 1993), and to bring the elevations of the lowlands above flood levels, including Terminal 30. Fill from upland sources was also widely used during filling of the tide flat areas. By 1905, the tide flats at Terminal 30 had been filled and the T30 site was in use for bulk fuel storage. Currently, Terminal 30 is relatively flat and covered by asphalt with a surface elevation of about 18 ft MLLW (Figures 1-2 and 2-4).

2.3.2 Surface Water

The LDW flows around Harbor Island via the East and West Waterways before discharging to Elliott Bay. Terminal 30 and the T30 site are adjacent to the East Waterway at LDW river mile 0.15 (Figure 1-1). The LDW is located at the mouth of the 566 square mile Green/Duwamish River watershed.

In the LDW, freshwater from the Duwamish River overrides saltwater to create a highly-stratified saltwater wedge-type estuary. The wedge moves up and downstream due to tidal changes and the rate of freshwater discharge. Approximately 1/3 of freshwater discharge is via the East Waterway, and 2/3 via the West Waterway. At Terminal 30, the East Waterway is dominantly marine (Anchor and Windward, 2008).

The East Waterway is an operable unit of the Harbor Island Superfund Site as ordered by the EPA and is the subject of an RI/FS independent of the T30 site 2013 RI/FS.

2.3.3 Geologic Setting

2.3.3.1 Regional Geology

Seattle is located within the Puget Lowland, which has been glaciated several times, shaping the geology and hydrogeology of the area. The most recent major glacial episode was the Vashon Stade of the Frasier Glaciation that reached the central Puget Sound region about 15,000 years ago and carved the Duwamish trough. The Duwamish arm of Puget Sound opened as the glaciers retreated, followed by deposition of a large delta and tide flats in the Duwamish River valley (Booth and Herman, 1998). Deposition and infilling was punctuated by both mudflows from Mount Rainier and earthquakes along the Seattle Fault. At least four mudflows contributed to creation of the Elliott Bay delta and tide flats between about 5700 and 1000 years before present. Ruptures of the east-west trending Seattle Fault caused subsidence of the land surface in the lower portions of the Duwamish, with the most recent event about 1000 years ago causing the Elliott Bay tide flats to subside by about 3 feet. Major reworking of river and upland deposits throughout the Seattle area occurred in the early 1900s as tide flats and shorelines were filled and river channels were engineered for flood control and navigation purposes.

2.3.3.2 T30 Site Geology

This discussion of site geology is based on information presented in the 1998 RI/FS (GeoEngineers, 1998).

At Terminal 30 and the T30 site, two stratigraphic units have been identified: fill and native deposits. Fill from dredging can be difficult to physically differentiate from similar native tidal flat and alluvial deposits. Accordingly, in the 1998 RI/FS, GeoEngineers classified soils as fill or native deposits based on the approximate elevations of the units relative to the historic MLLW line. A geologic cross-section through the T30 site (Figure 2-4) is updated from the 1998 RI/FS along the profile trace presented in Figure 1-2. The cross section depicts the fill unit and native deposits, as well as the current configuration of the Terminal 30 apron and new sheet pile wall.

- Fill Unit—consists of sand and gravel with varying amounts of silt, wood, bricks, and construction debris; the unit thickens and dips westward toward the East Waterway (GeoEngineers, 1998). Fill units identified in the 1998 RI/FS by GeoEngineers were described as “laterally discontinuous,” with a lower contact approximately 15 to 20 ft below ground surface (bgs), or the approximate historic MLLW tide line. Most of the fill materials tested for grain size distribution were classified as well-sorted sands and less commonly as sandy gravels, silty sand, and silts. During construction of the Terminal 30 facility in 1984-1985, additional fill for an engineered slope was placed after dredging operations were completed (see Section 2.4.8). This fill included sand with a surface layer of rip-rap extending to the base of the East Waterway.
- Native Deposits—consist of non-glacial, fluvial and estuarine, black, fine-to-medium sand with varying amounts of silt. Shell fragments and occasional organic materials were frequently observed in the native deposits.

2.3.4 Hydrogeologic Setting and Groundwater System

Native soils and the overlying fill unit comprise a shallow water table aquifer at the T30 site. Average depth to water ranges from 8 to 14 feet across the site (Figure 2-4). See Figures 2-5 and 2-6 for well network and potentiometric surface map. Recharge to the water table aquifer originates as precipitation in uplands and unpaved areas offsite; insignificant recharge originates at the T30 site due to the asphalt cover and the stormwater management system.

In the Duwamish Valley groundwater moves from upland recharge zones downgradient to Duwamish Waterway discharge zones. Groundwater at the T30 site generally flows toward the East Waterway, although discharge to the waterway is strongly influenced by tidal fluctuations and man-made structures. The average hydraulic gradient across the site is 0.0028 ft/ft, with a slight increase near the sheet pile wall (Figure 2-6). Groundwater contours curve slightly northeast at the north end of the sheet pile wall, which is consistent with increased discharge around the end of the sheet pile wall (Appendix B). As tides rise and fall, flow between the East Waterway and the aquifer reverses in a tidal mixing zone that is relatively narrow; however, the zone of tidal influence on groundwater gradients is significantly wider. Man-made structures, especially the placement of fill in the early 1900s, and the sheet pile wall installed along the apron in 2007-2008, have altered groundwater flow at the T30 site.

Hydraulic conductivity of the shallow aquifer at the T30 site has been estimated based on tidal studies and grain size analysis (GeoEngineers, 1998). Estimates based on grain size analyses range from 0.02 to 0.1 cm/s (57 to 284 ft/day). Estimates based on tidal studies range from 0.2 to 9 cm/s (567 to 25,500 ft/day) and likely overestimate the hydraulic conductivity of the aquifer given the native and fill lithologies observed at the T30 site. The upper end of tidal study hydraulic conductivity estimates are what would be expected in clean gravels, unlike the silty sands observed in most borings at the site.

2.3.4.1 Tidal Studies and Results

Tidal changes in the East Waterway influence groundwater flow direction and gradient at T30. Tidal influence in aquifers ranges from reversals in groundwater flow and mixing near the tidal discharge point, to small variations in water levels with little influence on groundwater flow further from the discharge point. Two water-level studies were completed during the initial T30 RI/FS to assess general groundwater flow and tidal influence (GeoEngineers, 1998). Both studies occurred before the sheet pile wall was installed. The first study occurred over a 36-hour period in May 1993 and included collecting water-level measurements at 18 monitoring wells every 15-minutes using pressure transducers. The second study occurred over a 40-hour period in January 1994 at 14 monitoring wells using the same methodology.

Pacific Groundwater Group (PGG) completed an additional tidal study in November 2011 to evaluate potential effects of the sheet pile wall on the groundwater system (Appendix B). The November 2011 study used pressure transducers to monitor water levels in 18 wells and one stilling well at the northwest corner of the crane apron. Water levels were observed for five days at 15-minute intervals. The findings of the November 2011 tidal study were generally similar to results of the previous tidal studies with respect to general groundwater flow direction and average site-wide hydraulic gradient. However, the data indicate decreased tidal efficiency and increased time lag just upgradient of the wall relative to the earlier studies. This suggests that the sheet pile wall decreased tidal flushing in this area.

Data from each tidal study were used to calculate average groundwater gradients at the T30 site. GeoEngineers used the 1998 RI/FS tidal data to calculate mean groundwater elevations for each well, from which they calculated an average horizontal groundwater gradient of 0.003 ft/ft towards the East Waterway (Appendix B). Applying the same methods to data collected for the 2011 tidal study the average horizontal groundwater gradient across the T30 site is estimated to be 0.0028 ft/ft towards the waterway; which is comparable to the gradient before the sheet pile wall was installed.

The well network for the November 2011 tidal study included shallow and deep well pairs that are located near-to and upgradient of the sheet pile wall. The November 2011 average water level elevations in the deeper wells are higher than elevations in the shallower wells by 0.03 to 0.29 feet, indicating a slight net upward vertical component of groundwater flow at a time-averaged head gradient ranging from 0.0012 to 0.0145 ft/ft.

The time delay between a tidally-influenced change in a surface water body and corresponding change in groundwater is referred to as lag time. Among the tidally-influenced monitoring wells at the T30 site, the lag time of water-level changes is shortest near the East Waterway and increases with distance inland. The magnitude of water-level changes in tidally-influenced wells is greatest near the East Waterway and decreases with distance inland. Tidal efficiency is the ratio between tidal change in surface water to the corresponding water-level change in a well. Tidal efficiencies are listed in Appendix B.

Based on the results of the November 2011 tidal study relative to previous studies, the sheet pile wall has not reduced the amount of groundwater moving through the site, but appears to have reduced the tidal influence on groundwater in the nearshore area behind the wall. Compared to the pre-wall condition, the magnitude of tidal variation is generally less and the distance inland that the tidal effects propagate is less. Also, groundwater flow direction has altered at the north end of the wall.

2.3.4.2 Tidal Mixing

Surface water from the East Waterway intrudes the subsurface during periods of high tide. This causes saline, oxygen- and nutrient-enriched surface water to mix with groundwater in the near-shore aquifer. AECOM constructed a numerical tidal mixing model to estimate mixing and dilution of contaminants along a groundwater flow path from the source area through the aquifer to the discharge point at the East Waterway (ENSR|AECOM, 2008a); the model used data from the 1998 RI/FS, prior to the completion of the sheet pile wall.

Installation of the Terminal 30 sheet pile wall has reduced, but not eliminated, mixing of surface water and groundwater in the nearshore wells. Reductions in mixing are indicated by decreases in the magnitude of hydraulic response of shallow wells (see Section 2.3.4.1) and decreases in specific conductance (EC) in the nearshore wells relative to pre-sheet pile wall conditions (Appendix B; Table 2-2). For instance, EC measured at MW-58 decreased from 1,819 umhos/cm in 1999 to between 900 and 848 umhos/cm in 2011 (Table 2-2). Although tidal influence appears to have been reduced, EC in nearshore wells remains higher than values typical of upgradient groundwater (200 to 900 umhos/cm).

Based on current EC data, groundwater/surface water mixing appears to be greater through the sheet pile wall rather than under the sheet pile wall. EC values in the deeper completions of nearshore well pairs are lower than in the shallow wells, indicating relatively more groundwater and less marine surface water at depth. Groundwater and surface water likely move through imperfections (holes, gaps along seams) in the sheet pile wall. Such movement was directly observed by PGG at another site. The higher groundwater head at depth, and possibly anisotropy of aquifer hydraulic conductivity, also reduce surface water penetrations of the deeper zone.

2.3.5 Climate

The climate of the Puget Sound area is characterized as marine west coast or "Pacific Maritime." The prevailing winds move moist air inland from the Pacific Ocean, moderating both winter and summer temperatures. According to the Western Regional Climate Center (WRCC, 2012) climatic average from 1971 to 2000 for downtown Seattle weather station (457458), the annual average precipitation is 38.00 inches. Approximately three-quarters of the precipitation is distributed throughout the rainy season from October to March. On average, the driest months are July and August.

Average high temperatures are below 60 degrees Fahrenheit from October through April with average lows in the high 30s- to mid-40s. December and January are on average the coldest months and July and August are the warmest.

	Average Max. Temperature (F)	Average Min. Temperature (F)	Average Total Precipitation (in.)
Jan	47.4	36.8	4.90
Feb	50.6	38.0	4.20
Mar	54.9	40.1	3.74
Apr	59.4	43.6	2.70
May	65.1	48.7	2.00
Jun	69.6	53.1	1.61
Jul	74.4	56.6	0.95
Aug	74.6	57.1	1.29
Sep	69.5	53.1	1.71
Oct	60.6	47.0	3.28
Nov	49.9	39.6	5.72
Dec	46.8	36.9	5.90
Annual	**60.4**	**46.0**	**38.00**

http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wasurb

2.4 ENVIRONMENTAL INVESTIGATION/INTERIM ACTION SUMMARY

Many environmental investigations and interim actions have been performed at the T30 site since the early 1980s. These investigations and interim actions are briefly summarized in the following sections and Table 2-3 by media type, and graphically represented in timelines in Figures 2-1a, 2-1b, and 2-1c. Additional detail of the investigations is included in Appendix B.

2.4.1 Soil Investigations

At least seven soil investigations have been performed at the T30 site between site discovery in 1983 and completion of the container terminal in 2009. Details of each investigation are summarized in Appendix B. The initial subsurface investigations between 1983 and 1986 were performed to delineate the lateral extent of LNAPL. Subsequent environmental investigations were performed to characterize site geology, hydrogeology, and the nature and extent of contamination. In addition, a geotechnical investigation was performed in 1984.

Over 127 onsite boreholes have been advanced to 3 to 160 ft bgs through the course of the soil investigations. In addition, 10 offsite boreholes were advanced to 10 to 160 ft bgs. Generally, the constituents of concern for soil investigations have been petroleum hydrocarbons; however, samples collected for geotechnical investigations in 1984 were analyzed for priority pollutant metals. One soil sample collected in 1986 was analyzed for porosity and permeability.

Most recently, during the 2007-2009 container terminal construction activities, soil at the T30 site was characterized relative to petroleum hydrocarbon content. Soil samples were collected from the sidewalls and floors of construction excavations and analyzed for petroleum hydrocarbons in the gasoline-, diesel- and motor-oil ranges. Construction excavations were associated with a number of terminal modifications, including the landside crane berm, rubber tire gantry runways, electrical duct banks, truck scales, and sewers.

2.4.2 Groundwater Investigations

Based on the 1998 RI/FS (GeoEngineers, 1998), monitoring wells were installed at the T30 site between 1983 and 1986 to evaluate the accumulation of LNAPL at the water table; however, groundwater quality samples were not collected until the RI investigations between 1987 and 1991. Groundwater quality has been investigated extensively through:

- 10 rounds of pre-RI quarterly monitoring from 1991 to 1998
- 3 rounds of RI quarterly monitoring from 1991 to 1992
- 2 rounds of RI semi-annual monitoring in 1993 and 1994
- 2 rounds of supplemental RI monitoring in 1999 and 2003 from select wells along a transect from the nearshore through former LNAPL area
- 3 rounds of monitoring in 2004 and 2005
- 17 rounds of quarterly monitoring from 2005 to 2009
- 1 round of monitoring in 2011 plus 2 polycyclic aromatic hydrocarbon (PAH)-focused monitoring events in 2011 and 2012

The chemicals of concern for the groundwater investigations were generally petroleum hydrocarbon compounds, including benzene, toluene, ethylbenzene, and xylenes (BTEX) and total extractable petroleum hydrocarbons (TEPH; modified EPA Method 8015). Samples collected in 1993 and 1994 were also analyzed for volatile organic compounds (VOCs), semi volatile compounds (SVOCs), PAHs, chlorinated pesticides, cyanide, and general chemistry parameters. In addition to TPH and BTEX, samples collected from the transect wells in 1999 and 2003 were analyzed for SVOCs, PAHs, metals, and natural attenuation parameters. Samples collected since 2005 were analyzed for TPH, BTEX, select SVOCs, and PAHs; natural attenuation parameters were monitored in the field.

The results of groundwater sampling events performed in the last 5 years are summarized in Section 2.7 of this 2013 RI/FS. Older data can be found in the Supplemental Data Report Revision 2 (ENSR|AECOM, 2008a).

2.4.3 Surface Water Investigations

Groundwater quality discharging to the East Waterway from the T30 site was evaluated for the 1998 RI/FS (GeoEngineers, 1998). Water quality samples were collected in June 1993 and January 1994 from 7 seeps and from the East Waterway for analysis of VOCs, including BTEX. The results are summarized in the 1998 RI/FS Table 8.6 (GeoEngineers, 1998).

2.4.4 Vapor Investigations

To date, vapor investigations have not been performed at the T30 site.

2.4.5 LNAPL Gaging

The thickness of LNAPL accumulated at the water table has been measured in T30 site monitoring and recovery wells from 1984 through 2011 at varying frequencies. LNAPL thickness has decreased significantly at all wells that have had measureable product (See Section 2.7.1).

2.4.6 Tidal Investigation

As described in Section 2.3.4.1, the influence of tides in the East Waterway on groundwater at the T30 site has been investigated both before and after the geotechnical sheet pile wall was installed between 2007 and 2009. GeoEngineers performed two tidal water-level studies in May 1993 and January 1994 before the sheet pile wall was installed (GeoEngineers, 1998). Most recently and after the sheet pile wall was installed, PGG conducted a tidal water-level study in November 2011. Details of the PGG tidal study are presented in Section 2.3.4 and Appendix B of this 2013 RI/FS.

In addition, to the water-level studies described above, AECOM developed a groundwater model to estimate the combined effects of advection and tidal dispersion on groundwater concentrations downgradient of the source area (ENSR | AECOM, 2008a).

2.4.7 Interim Remedial Actions

The Port has implemented multiple interim actions at the T30 site since purchasing the property in 1985. The Port has spent approximately $20 million on remedial actions conducted in close communication with Ecology. Interim remedial actions have included engineering controls to minimize direct contact, removal of contaminated soil for offsite disposal, and recovery of LNAPL. Each remedial action is summarized below; additional detail is presented in the 1998 RI/FS (GeoEngineers, 1998) and Supplemental Data Report, Revision 2 (ENSR|AECOM, 2008a). Figure 2-1c shows the footprint of major remedial actions that have been performed.

Interim actions have been performed in association with site redevelopment, long-term LNAPL recovery, and discrete in-situ treatment in response to groundwater quality results:

- Asphalt/Concrete Cap, 1986 – The Port installed an asphalt/cement cap over the Terminal 30 facility and T30 site; the cap prevents infiltration and minimizes the soil leaching to groundwater pathway. The reported thickness of the cap varies between references; the 1998 RI/FS reports the cap is 8-inches thick and the Supplemental Data Report states the cap is 16-inches thick.
- Stormwater management system – A stormwater system was installed to manage precipitation and control runoff.
- LNAPL Recovery – Significant LNAPL, over 171,000 gallons, has been recovered from the T30 site, which has effectively reduced the contaminant mass (Figures 2-7 and 2-8). Recovery was initially accomplished with an automated pumping system, followed by direct removal during discrete events and using passive skimmers.
- LNAPL Recovery System, April 1984 to December 1992 – GeoEngineers designed and installed a dual-pump system in large diameter recovery wells to locally depress the water table and skim/pump LNAPL to underground tanks for temporary storage. Water captured by the recovery system was discharged to exfiltration galleries backfilled with gravel. Approximately 171,600 gallons of LNAPL were recovered from the system between April 1984 and December 1992. Recovery declined over time until rates were less than the shutdown criterion specified in the 1991 AO of less than 1.0 gallon per day per recovery well. In accordance with the AO, the active recovery system ceased operation in December 1992.
- LNAPL Recovery Events, June 1999 to 2009 – LNAPL was recovered during a number of discrete events from June 1999 through the end of 2009. Various recovery methods were used including vacuum trucks, hand bailing, and down-hole passive hydrocarbon skimmers.
- LNAPL Recovery Event, April 2011 – 3.76 gallons of LNAPL were recovered from the T30 site during April 2011 sampling and gauging activities (PGG, 2011). Over 99-percent of the LNAPL was recovered from wells MW-59 and RW-12. Peristaltic pumps were used to recover the product.
- LNAPL Recovery Event, November 2011 – Approximately 3.8 gallons of LNAPL was recovered from wells MW-59 and RW-12 during product bail-down tests. Peristaltic pumps were used to recover the product.
- Approximately 24,000 tons of soil were disposed of off-site during the 2008-2009 conversion from a cruise ship terminal to shipping terminal (ENSR|AECOM, 2010). 11,480 tons had either GRO concentrations greater than 200 ppm or DRO greater than 100ppm.

As part of the Port's source control efforts, Oxygen Release Compound (ORC) was injected in the vicinity of well MW-42 in response to elevated groundwater concentrations of gasoline and benzene:

- ORC Application, June 2007 – AECOM injected 200 pounds of ORC at 5 locations approximately 10 feet upgradient from MW-42 on June 4, 2007 (Jambrosic, 2007). Based on time-trends, the ORC application had a modest impact on groundwater concentrations of total petroleum hydrocarbons in well MW-42 (Appendix C).

2.5 POTENTIAL SOURCES OF CONTAMINATION

2.5.1 Potential On-site Sources of Contamination

Historically, potential on-site sources of contamination included the bulk fuel tanks, fuel loading racks, appurtenances, and buildings (GeoEngineers, 1998). Currently, there are no fueling operations at the T30 site. Best management practices, the stormwater conveyance system and oil/water separators, and the concrete/asphalt cap minimize the risk of spills being transported to the subsurface.

2.5.2 Potential Off-Site Sources of Contamination

Potential off-site sources of contamination were summarized in the 1998 RI/FS (GeoEngineers, 1998) as the following properties (Figure 2-3):

- Pier 30/31 – Now included in the south part of Terminal 30: formerly a ship building facility and foundry.
- Pier 28/29 and former slip – Now included in the south part of Terminal 30: formerly a boiler works, iron works; used as shipping terminal since 1950.
- Alaskan Way Right-of-Way – Undeveloped until 1985, used for truck parking and storage, which may have had spills/releases.
- GATX Property – Bulk fuel facility from 1920 to at least 1990, confirmed releases to soil and groundwater of petroleum hydrocarbons, PAHs, and metals (GeoEngineers, 1998 Section 3.3.1.5).
- Former Flint Ink Property – Confirmed soil contamination including PAHs, metals, and petroleum hydrocarbons; groundwater contamination includes chlorinated solvents.
- Railroad Right-of-Way– Since about 1890, the railroad occupied the area east of Marginal Way South. GeoEngineers identified some past operations that may be associated with petroleum hydrocarbon releases, but did not confirm past releases (GeoEngineers, 1998).

In March 2012 the Ecology confirmed and suspected contaminated sites list (CSCSL) included the following additional site north of Terminal 30:

- Emerald City Disposal at 9 S Massachusetts Street– Contaminants include halogenated organics in surface water and petroleum products in soil.

2.6 REGULATORY REQUIREMENTS

This section describes regulatory requirements related to constituents of concern, screening and cleanup levels for constituents of concern, and terrestrial ecological resources. The site has no identified archeological resources.

Points of compliance (POCs) and screening levels are discussed by media in the following sections. MTCA regulations specify POCs for various media that may become contaminated. The POC applies to soil, groundwater, indoor air, or surface water at or adjacent to any site where releases of hazardous substances have occurred or that have been impacted by releases from the site. MTCA also defines conditional POCs. These typically apply to a specific location as near as possible to the source of the release. However, under some site-specific circumstances, a conditional POC may be established beyond the property if approved by Ecology.

2.6.1 Terrestrial Ecological Resources

The Terrestrial Ecological Evaluations (TEE) in MTCA provides a process for evaluating potential impacts from contaminated soil to plants and wildlife.

The T30 site is unlikely to pose a threat of significant adverse effects to terrestrial ecological receptors. The site is a fully paved commercial/industrial property with little to no vegetation. Therefore, the T30 site meets the exposure pathway exclusion established in the TEE process because physical barriers prevent terrestrial plants and wildlife from being exposed to soil contamination. The site is expected to remain capped as an integral part of site operations.

2.6.2 Constituents of Concern

During RI field investigations (GeoEngineers, 1998) groundwater and soil samples were analyzed for a broad range of contaminants including VOCs, SVOCs, pesticides, PCBs, metals, cyanide, petroleum hydrocarbons, and PAHs. Potential constituents of concern that did not exceed MTCA cleanup levels did not warrant further investigation. Accordingly, the list was narrowed to the following constituents of concern (COCs) for long-term groundwater monitoring:

- Total Petroleum Hydrocarbons (TPH), including gasoline, diesel, and motor oil range hydrocarbons
- BTEX

- Polycyclic Aromatic Hydrocarbons (PAHs)

Toluene, ethylbenzene, and xylenes were not detected in groundwater at concentrations above MTCA cleanup levels during the 1998 RI/FS (GeoEngineers, 1998) or in subsequent groundwater sampling (Table 2-4), but these constituents are commonly analyzed with benzene and TPH. As described in Section 2.7.2, benzene, toluene, ethylbenzene, and xylenes were below MTCA cleanup levels in soil samples collected for the 1998 RI/FS (GeoEngineers, 1998), with the exception of toluene in one sample.

2.6.3 Soil

2.6.3.1 Pathways/Receptors/Points of Compliance

Possible soil exposure pathways include soil direct contact, leaching to groundwater, and soil to indoor air. Exposure pathways were narrowed in the 1998 RI/FS (GeoEngineers, 1998) on the basis of potential institutional and engineering controls to be included in a restrictive environmental covenant.

The requirements for soil POCs are provided by the MTCA regulations WAC 173-340-740(6). The soil POC requirements depend on the relevant exposure pathway. The requirements specified by MTCA are as follows:

- For soil direct human exposure via ingestion, inhalation, or dermal absorption, the POC includes soil throughout the site to a depth of 15 feet below ground surface.
- For soil to indoor air inhalation (vapor intrusion) the POC are the soils throughout the site from the ground surface to the water table.
- For soil leaching to groundwater/surface water, the POC are the soils throughout the site to the water table.

2.6.3.2 Site Screening Levels

For this site, MTCA Method A Industrial cleanup levels were proposed in the 1998 RI/FS, which were updated in subsequent AECOM reports (e.g. AECOM, 2008). The T30 site meets the criteria for an industrial property: it is zoned as industrial and there are no immediately adjacent residential properties on any side of the site. Also, due to its proximity to other industrial properties and its value as industrial property, it is not likely that zoning will change in the future and there is no intent to change it. Finally, there is currently no direct public access to the T30 site.

The screening levels in Table 2-5 were proposed to Ecology as applicable T30 site screening levels for soil (PGG, 2012). The screening levels are the more stringent of MTCA Method A cleanup levels for industrial land use, or soil leaching to groundwater values (Table 2-5). The soil leaching to groundwater pathway is calculated using a three-phase partitioning model described by MTCA Equation 747-1. Default values established under MTCA were used as model inputs in the calculations. Groundwater criteria in the calculations are protective of the proposed site-specific screening levels. Soil screening levels in Table 2-5 reflect the January 2012 CLARC database values.

2.6.4 Groundwater

2.6.4.1 Pathways/Receptors/Points of Compliance

Possible groundwater exposure pathways are limited to contaminated groundwater discharging to surface water, and contaminants in groundwater migrating to indoor air. Human consumption of groundwater at the T30 site is not a complete pathway. Because the T30 site and greater Seattle metropolitan region of King County is within the Seattle Public Utilities (SPU) Water Service Area, drinking water is provided by the utility from municipal sources. According to the 2013 Water System Plan, 100-percent of Seattle's drinking water is provided by the Cedar River and South Fork Tolt River surface water sources. Two well fields in the SeaTac area provide drought and emergency supply (SPU, 2012). None of these surface water or groundwater sources is near Terminal 30.

The requirements for groundwater POCs are provided by the MTCA regulations WAC 173-340-720(8). The standard POC for groundwater is throughout the site from the uppermost level of the saturated zone extending vertically to the lowest-most depth that could potentially be affected by the site. Where it is not practical to meet groundwater cleanup levels throughout a site within a reasonable time frame, a conditional POC (CPOC) may be established within the property boundary and as close as practicable to the contaminant source.

The CPOC for the Site includes monitoring wells MW-45, MW-46, MW-58[1], MW-89, and a new well to be installed southwest of MW-53, as shown in Figure 2-5. This CPOC will also be applied in the draft Cleanup Action Plan (CAP) for the site.

2.6.4.2 Site Screening Levels

Under MTCA, groundwater cleanup levels must be based on the highest beneficial use of groundwater. The highest beneficial use of groundwater is typically drinking water, unless groundwater meets the non-potability criteria in WAC-173-340-720-2. Groundwater at the T30 site meets the non-potable criteria since the groundwater does not serve as a current source of drinking water and is not a potential future source of drinking water because all nearby properties are served by SPU. Groundwater at the site directly discharges to surface water. The highest beneficial use of groundwater at the T30 site is a recharge source to surface water

[1] MW-58 is currently damaged and will be replaced with a well at the same location (Section 2.11).

in the East Waterway; therefore, surface water criteria are applicable screening levels for groundwater at the T30 site.

The groundwater screening levels in Table 2-6 were proposed to Ecology as applicable T30 site screening levels (PGG, 2012). The screening levels are based on the Terminal 30 Final Supplemental Data Report, Revision 2 (ENSR|AECOM, 2008b),the Terminal 30 Compliance Monitoring Plan (2008 CMP; ENSR|AECOM, 2008a; Ecology, 2012a). The Supplemental Data Report reviewed applicable state and federal surface water and groundwater criteria, selecting the most stringent surface water values for marine water as the T30 site screening levels.

In January 2012, current groundwater and surface water applicable or relevant and appropriate requirements (ARARs) were downloaded from the Ecology's CLARC database. The values were consistent with those presented in the Supplemental Data Report and 2008 CMP with the exceptions of toluene and ethylbenzene. The January 2012 surface water ARARs protective of human health in marine water established by the Clean Water Act are more stringent for toluene and ethylbenzene than the 2008 screening levels presented in the ENSR|AECOM documents. Therefore, the 2013 RI/FS screening levels for toluene and ethylbenzene have been updated from those presented in the 2008 reports.

Surface water criteria are not established for diesel-, heavy oil-, and gasoline-range organics, and total xylenes. Therefore, MTCA Method A groundwater criteria were selected in the Supplemental Data Report as the screening levels for those parameters. In addition, DRO and GRO cleanup levels should not result in NAPL being present in or on the groundwater when achieved (WAC 173-240-730). On June 20, 2012, Ecology clarified that the NAPL screening level for T30 would be measurable product (Ecology 2012b).

2.6.5 Surface Water

2.6.5.1 Pathways/Receptors/Points of Compliance

Possible surface water exposure pathways include human consumption of fish and aquatic organisms that have been in direct contact with impacted surface water. The saline conditions of the East Waterway prevent this from being a viable source of drinking water for people and the LDW, including the East Waterway, is not designated for use as domestic water in WAC 173-201A-602 for Water Resource Inventory Area 9.

The point of compliance for surface water is the point or points at which hazardous substances are released to surface water (WAC 173-340-730). Upland monitoring wells located between the surface water and source of contamination may be approved to establish compliance (WAC 173-340-720(8)(e). Therefore, the

CPOC wells discussed in Section 2.6.4.1 will also be used to evaluate compliance for surface water.

2.6.6 Air

2.6.6.1 Pathways/Receptors/Points of Compliance

Volatile hazardous substances in subsurface media, including soil, soil vapor, NAPL, and groundwater can migrate to indoor air by vapor intrusion. Occupants of affected buildings could then be exposed to the hazardous substances through inhalation. The POC is indoor air; however, direct quantification of VOCs in indoor air is not necessary in the Ecology Draft Vapor Intrusion Guidance (Ecology, 2009). As an alternative, the Guidance allows for estimates of indoor air VOC concentrations based on subsurface VOC concentrations. The appropriate subsurface media (groundwater, soil, soil gas, etc.) is based on the source zone of the contamination.

There are two buildings currently at the site, the T30 Vessel Tower, constructed in 1986 during container facility construction, and the Gate House, built in 2007-2008. The Vessel Tower is a three-story, slab-on-grade structure. The first floor is occupied by bathrooms and a lunch/meeting room. The upper floors are occupied by offices and workstations. The building does not have an HVAC system. Vapor intrusion is most likely to be an issue in the bottom floor, which is only intermittently occupied during lunch and other break times and includes no dedicated working spaces. The Gate House is a single story structure constructed with separation from the ground surface, and is more than 200 feet from the former extent of LNAPL.

2.6.6.2 Site Screening Levels

MTCA provides Method B unrestricted (residential) air cleanup levels and Method C industrial air cleanup levels (WAC 173-340-750). Industrial air cleanup levels are applicable at the T30 site because the buildings of concern are located on an industrial property as defined in WAC 173-340-200 and -745 and potential receptors are industrial workers.

2.7 CONTAMINANT NATURE AND EXTENT

This section describes the type of contaminants at the T30 site (nature) and the distribution of these contaminants vertically and horizontally (extent). The LNAPL extent is described for both the historic and current conditions to explain the extent of LNAPL that can accumulate in wells and that which is immobile (residual). The nature and extent of contamination in soil are based on analytical data from the 1998 RI/FS (GeoEngineers, 1998) and T30 Construction Report (ENSR|AECOM, 2010). The nature and extent of contamination in groundwater are based on the most recent five years of data for relevance to the current situation and current monitoring well network, unless older data is specifically germane. Many of the older wells have been decommissioned since the RI was written (Figure 2-5).

2.7.1 LNAPL

LNAPL extent is described for both the historic and current conditions to explain the extent of both residual (immobile) LNAPL and LNAPL in wells.

The maximum extent of historic LNAPL was reported in the 1998 RI/FS and is presented in Figure 2-8. This represents the LNAPL extent prior to significant recovery of product, and therefore represents the maximum extent of mobile LNAPL. LNAPL with measureable thickness has decreased in extent and is now restricted to the vicinity around MW-59. Sheen is present in some wells within the historic extent of LNAPL (Figure 2-8). Wells within the “sheen area” and where LNAPL is currently present are assumed to have concentrations above groundwater screening levels (Section 2.7.3).

Approximately 171,000 gallons of free product were actively recovered between 1984 and July 1991. In compliance with the AO, in July 1991 recovery yields were less than 1 gallon per day and active recovery was discontinued. By January 1991, the lateral extent of LNAPL in wells had been significantly reduced as reported in the 1998 RI/FS, based on gauging and recovery well product thickness and recovery measurements. Passive recovery was initiated following the 1998 RI/FS.

The maximum product thickness between 1984 and 1991 was 6.53 feet at MW-26 (GeoEngineers, 1998: Figure 3.6). The maximum product thickness in April, 2011 was 1.55 feet at MW-59, which had a maximum historic thickness of 3.90 feet. Other wells beyond the MW-59 area with historic product thickness had less than 0.1 feet of measurable product in April 2011 (PGG, 2011).

In the long-term LNAPL recovery program (ENSR|AECOM, 2008a), 0.1 feet of LNAPL thickness is the threshold for active recovery by bailing or similar means; thus the 0.1-feet threshold is used as a benchmark for LNAPL thickness. AECOM reported that LNAPL thickness was greater than 0.1 feet in 10 wells between 2000 and 2005, which decreased to 6 wells between 2004 and 2005 (ENSR|AECOM, 2010). LNAPL thickness greater than 0.1-feet decreased to 2 wells from 2009 Q2 to 2011 Q1.

LNAPL thickness in monitoring wells is a measure of LNAPL migration potential. The decreasing number of wells with product greater than 0.1 feet thick indicates that the area of potential LNAPL movement even on a local scale (i.e.: can enter wells) has decreased over time. Local-scale mobility is further discussed in Section 2.9.

Date	Number of Wells with LNAPL Thickness >0.1 feet	Wells
2000 to 2004	10	See Fig 2-12
2004 to 2005	4	MW-59, RW-1, RW-9, RW-12
2009 Q1	4	MW-59, RW-1, RW-9, RW-12
2009 Q2	2	MW-59, MW-64
2009 Q3	0	--
2009 Q4	2	MW-59, RW-12
2011 Q1	2	MW-59, RW-12

2.7.1.1 LNAPL Transmissivity and Saturation

Measurable product in monitoring wells indicates the presence of LNAPL above residual saturation levels[2] (Figure 2-8). Product accumulation in a well indicates that the local LNAPL is capable of draining; however, the body of LNAPL as a whole may or may not be mobile. As discussed in Appendix D, LNAPL mobility is best assessed by LNAPL transmissivity, which incorporates aquifer and product physical characteristics. The Interstate Technology & Regulatory Council (ITRC) transmissivity threshold for mobility of LNAPL is 0.1 to 0.8 ft^2/day. LNAPL bodies with transmissivity values below this range are unlikely to be mobile even on a local scale and recovery will be limited (ITRC, 2009). Mobility in this context is an empirical measure of the capability of LNAPL to migrate[3] within the area already occupied by LNAPL based on study of many sites.

Baildown recovery tests were performed in MW-59 and RW-12 to assess LNAPL transmissivity, which was calculated using standard methods described in the literature (Huntley, 2000; ASTM, 2012). Baildown tests at MW-59 and RW-12 indicate transmissivity values ranging from 4.3 to less than 0.1 ft^2/day (Appendix D: Table D3). The estimated LNAPL transmissivity values at MW-59 and RW-12 range from above to below the ITRC mobility threshold, and generally decrease with measured product thickness. LNAPL mobility is discussed in Section 2.9.2.

LNAPL saturation is a measure of the amount of LNAPL in soil pores. Greater LNAPL product thickness (as observed in wells) will result in greater LNAPL

[2] Residual saturation is a threshold at which LNAPL in pore spaces will not drain under a gravity-driven gradient. Residual saturation is a function of LNAPL physical properties and the distribution of LNAPL within the pore sizes in the aquifer/soil matrix (Appendix D).

[3] The threshold is a range based on findings of independent research. This is separate from the MTCA definition of residual saturation, which is the saturation threshold where LNAPL will no longer drain from a soil under gravity and capillary forces (WAC 173-340-747 (10)(b)).

saturation by forcing LNAPL into progressively smaller pore spaces. If sufficiently small pore spaces are occupied that capillary forces will hold the LNAPL in place against a gravitational gradient, then the increases in LNAPL saturation will also increase residual saturation. Thus, greater product thicknesses create both greater initial saturation and residual saturation[4]. This also illustrates that LNAPL saturation and mobility may have a complicated relationship if LNAPL is primarily held in small pore spaces. The LNAPL held in small pore spaces will not contribute significantly to LNAPL transmissivity because the LNAPL would have to overcome the capillary forces of the small pore spaces to move. Counterintuitively, this can lead to situations wherein a soil may have a higher LNAPL transmissivity and lower LNAPL saturation than an equivalent soil that had a greater initial thickness of LNAPL that has since drained to residual saturation. Bounding estimates of residual saturation can be made when LNAPL physical properties, lithology (or soil vanGenuchten parameters), and maximum product thickness are known.

LNAPL saturation curves calculated from historic maximum product thickness in wells and recent product thickness in wells indicate that the majority of the current LNAPL mass at the T30 site is present as residual saturation (Appendix D). Where product thickness exceeded 6 feet, maximum historic residual saturations were modeled as high as 20-percent of pore space (Appendix D), or approximately 31,000 milligrams per kilogram (mg/kg) TPH[5]. Actual residual saturations would be lower than the estimated maximum due to subsequent degradation and attenuation.

2.7.2 Soil

Soil contamination at the T30 site was initially characterized during the 1998 RI/FS study (GeoEngineers, 1998). A summary table of the 1998 RI/FS soil results as presented in the Supplemental Data Report is reproduced in Appendix E (ENSR|AECOM, 2010). The 1998 RI/FS soil samples were analyzed for an extensive analytical suite including: TPH, VOCs, SVOCs and PAHs, PCBs, chlorinated pesticides, RCRA 8 metals, and cyanide.

Investigations of the nature and extent of soil contamination performed for the 1998 RI/FS are the most recent and comprehensive. During Terminal 30 construction between 2007 and 2009, AECOM sampled soil primarily for disposal designation purposes, rather than site characterization. Confirmation samples collected from hotspot excavations were characterized for TPH and are included in Appendix E (ENSR|AECOM, 2010).

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[4] Note that this may not be the case for coarse sands or gravels where the soil matrix does not include smaller pore sizes.

[5] Concentration calculated assuming nominal porosity of 0.3, solid fraction density of 2.4 g/cm^3, and LNAPL density of 0.87 g/cm^3 based on product measurements at MW-59 (Appendix D). See also Appendix H, Table H-3.

2.7.2.1 Petroleum Hydrocarbons

The presence of petroleum hydrocarbons above cleanup levels in T30 site soil is primarily within the historic maximum LNAPL extent, with few exceptions. Soil data is graphically presented in Figures 2-9 through 2-12 for gasoline, diesel, and oil range organics. A list of locations, depths, and concentrations of TPH compounds that exceed MTCA Method A, Industrial cleanup levels is presented in Table 2-7. The complete soil data is included in Appendix E, reproduced from previous reports.

- For gasoline range organics (GRO), soil concentrations range from non-detect to 7,720 mg/kg. Samples with maximum concentrations were collected from depth intervals near the water table where LNAPL had historically accumulated as free product. Soil samples collected at the deeper sampling interval of 23 to 24 ft bgs were all below site screening levels for GRO.
- For diesel range organics (DRO), soil concentrations range from non-detect to 30,000 mg/kg. Samples with maximum DRO concentrations were collected near the water table in areas where LNAPL either is or was present. Soil samples collected at the deeper sampling interval of 23 to 24 ft bgs were all below site screening levels for DRO (2,000 mg/kg).
- For oil-range organics, detected soil concentrations range from non-detect to 36,000 mg/kg.

2.7.2.2 Other COCs

AECOM's (ENSR|AECOM, 2008a) summary of the 1998 RI/FS soil data indicates that concentrations of methylene chloride (1.6 mg/kg) and toluene (12 mg/kg) were detected above MTCA Method A Industrial, soil cleanup levels, (0.02 and 7 mg/kg, respectively) in soil samples collected between 8 and 9 ft bgs at MW-80. The methylene chloride detection was attributed to laboratory cross contamination. The toluene detection was considered to be related to the petroleum contamination at MW-80; other BTEX compounds were below soil cleanup levels at MW-80.

PAH compounds were detected at 7 of 15 locations at concentrations below MTCA Method A Industrial soil cleanup levels (Appendix E) (GeoEngineers, 1998).

Metals were evaluated during the 1998 RI/FS and pre-MPA sampling (GeoEngineers, 1998, 2003). Metals did not exceed cleanup levels in soil and were not carried beyond the 1998 RI/FS as COCs (GeoEngineers, 1998). Additional analysis of metals during pre-MPA testing indicated that metals are not elevated in site groundwater and do not warrant further consideration as COCs (data summary in AECOM, 2008).

2.7.3 Groundwater

Groundwater at T30 is impacted by petroleum releases that have resulted in a dissolved-phase DRO and GRO plume across much of the site. This groundwater plume has been monitored since the 1980s. The groundwater quality monitoring well network generally surrounds the maximum historic extent of LNAPL (Figure 2-8), which is similar in extent to the historic extent of groundwater concentrations above screening levels. This report focuses on groundwater data collected between 2007 and 2012. Previous groundwater monitoring results are summarized in the 1998 RI/FS report (GeoEngineers, 1998) and the Supplemental Data Report 2 (ENSR|AECOM, 2008a). Groundwater monitoring has focused on wells beyond the extent of free product or sheen in wells. The presence of product in wells indicates probable exceedance of screening levels and free-phase blebs of product can produce inconsistent results reducing their utility for long-term monitoring.

Exceedances of screening levels between 2007 and 2012 in groundwater included DRO, GRO, benzene, and select PAHs (Tables 2-4, 2-8a and 2-8b; Figures 2-8, and 2-13 through 2-15). GRO, DRO and benzene are the most common constituents exceeding cleanup levels. Ethylbenzene, toluene, xylenes and oil-range hydrocarbons at the T30 site are below cleanup levels in samples collected within the last 5 years. Most wells outside the historic extent of LNAPL are currently below cleanup levels for all COCs. A subset of wells also slightly exceeds screening levels for PAHs. However, comparison of PAH analytical results in unfiltered, centrifuged, and filtered groundwater samples indicates that PAH concentrations are elevated by inclusion of particulates and colloidal transport. Filtered samples had PAH concentrations below screening levels at locations where PAHs were above screening levels in unfiltered samples (Table 2-8). This indicates that dissolved-phase PAHs are below screening levels and that exceedances noted in the April 2011 monitoring data were due to bias from included soil particles.

The downgradient extent of the dissolved phase plume in concentrations above screening levels varies across the site, but in all cases is east of the waterway. As described in Section 2.7.1, currently LNAPL accumulations in T30 wells are greatest at MW-59 and RW-12. In this southern area, the dissolved phase plume does not appear to exceed screening levels at, or downgradient from, MW-45 and MW-46, located approximately 60 feet downgradient from the historic LNAPL extent and 135 feet east[6] of the sheet pile wall. In the northern portion of the plume, the dissolved plume remains above screening levels further downgradient from the historic extent of LNAPL with exceedances noted at MW-89, located approximately 110 feet downgradient from the edge of the historic extent of LNAPL and 90 feet east of the sheet pile wall. This northern area near MW-42 and MW-89 appears to have a greater portion of GRO and benzene relative to DRO than wells in the southern portion of the site (Table 2-4).

[6] The flowpath length is longer than 135 feet.

The extent of the groundwater plume has been shrinking over time. Concentration trends in nearshore wells indicate that groundwater above screening levels likely reached the near-shore tidal mixing zone historically (GeoEngineers, 1998), but currently does not. Petroleum constituent concentrations in wells around the periphery of the extent of LNAPL have, with some variation, decreased for the last five years (Tables 2-4 and 2-8; Figures 2-8, 2-13 and 2-14; Appendix F). For example, groundwater concentrations exceeded DRO screening levels at MW-87 (3,300 micrograms per liter, ug/L) in samples collected between 1993 and 1994 (GeoEngineers, 1998) and had declined to between non-detect (reporting limit 250 ug/L) and 440 ug/L in 2005 (ENSR|AECOM, 2008a). Upgradient well MW-54 has had variable concentrations since 2007 with GRO between 1.5 mg/L and non-detect at 0.25 mg/L, but still approximately an order of magnitude lower than GRO concentrations (12 milligrams per liter, mg/L) in 1994 (GeoEngineers, 1998). DRO concentrations have decreased to below screening levels at MW-77, MW-87A, and MW-49. These trends are qualitatively consistent with other dissolved-phase concentrations, the decreasing presence of measureable LNAPL thickness, and decrease in areas with sheen.

Statistical tests of plume stability generally indicate a stable to shrinking dissolved phase plume. The stability of the T30 dissolved phase plumes were evaluated using Ecology's tool for the Mann-Kendall test (Ecology, 2005) (Table 2-9; Appendix G) using data collected between 2005 and 2011. Where wells were replaced (e.g. MW-86A replaced by MW-86C), only data from the replacement well was evaluated. MW-58 was not included in analytical results because it has a broken well casing. All wells were classified as stable or shrinking for benzene, GRO, DRO, and lubricating oil range organics (LOR), except MW-76A. MW-76A has primarily had non-detect results, but two recent detections (below screening levels) resulted in the plume being classified as "expanding" for GRO and DRO, while stable for benzene and LOR at MW-76A.

2.8 CONCEPTUAL MODEL

This section describes the site conceptual model. The details of the transport pathways discussed in the conceptual model are supported by fate and transport analysis presented in Section 2.9.

T30 was operated as a bulk fuel facility for approximately 80 years before redevelopment into a shipping terminal. Petroleum releases from bulk fuel facility tanks, distribution piping, and operations seeped into and through the vadose zone to the water table where product accumulated and spread laterally. LNAPL reached documented thicknesses of up to 6.5 feet in wells. Compounds partitioned from LNAPL into a groundwater plume that migrated downgradient. No additional upland releases have been documented at the T30 site since removal of the bulk fuel facility and redevelopment of the site into Terminal 30 in the mid-1980s. Remedial actions undertaken since the mid-1980's including product recovery and excavation in conjunction with natural processes have removed the majority of the LNAPL above residual saturation. Free-product with measureable thickness is now restricted to the area surrounding MW-59. Residual or near-residual saturation conditions likely remain within a significant portion of the historic extent of LNAPL. These areas constitute a large mass of immobile LNAPL, and the bulk of the contaminant mass.

Removal of LNAPL and natural attenuation processes have resulted in a groundwater plume that has been stable or shrinking over the last 5 years (Section 2.7.3) and does not currently reach the East Waterway above screening levels. Groundwater concentrations in wells around the historic extent of LNAPL have decreased significantly, and some wells on the northern and upgradient edges of the former extent of LNAPL have transitioned from having measurable product to concentrations below screening levels; see MW-54, for example. The downgradient edge of the dissolved phase plume varies in relation to the remaining NAPL source: in the south groundwater is below screening levels within 100 feet of NAPL. The northern portion of the plume has elevated GRO further downgradient from observed sheen. No wells along the sheet pile wall (MW-87A, MW-86B, MW-85A, and MW-84A) currently have concentrations above screening levels.

2.9 FATE AND TRANSPORT

This section discusses the fate and transport of contaminants as LNAPL, in the vadose zone, in the dissolved phase in groundwater, and in the vapor phase.

2.9.1 LNAPL Conceptual Model

Appendix D includes a discussion of LNAPL transmissivity, mobility, saturation, and the relationships of these properties and processes to measureable product thickness in wells.

2.9.2 LNAPL Fate and Transport

Historic product releases at the T30 site resulted in a laterally-extensive zone of LNAPL with variable thickness (Figure 2-8). The maximum observed thickness between 1985 and 1991 was 6.5 feet near RW11A, with typical maximum thicknesses between 3 and 4 feet (Section 2.7.1). Historic product thicknesses resulted in capillary entry pressures great enough to enable product to enter small pores and reach higher saturation levels than would be predicted from current product thicknesses. Areas of the T30 site with high initial saturation result in high residual saturation (Appendix D LNAPL saturation curves).

LNAPL is not expected to move beyond current areas with measurable thickness of LNAPL. Lateral migration requires both adequate LNAPL transmissivity and a natural gradient sufficient to overcome capillary forces (water versus NAPL). The current LNAPL transmissivities are at or near zero where residual LNAPL exists but there is zero thickness in wells. Any gradient due to mounding dissipated long ago, and field data indicate the natural groundwater gradient is less than that required to move LNAPL by overcoming capillarity.

LNAPL transmissivity was estimated for the areas of the T30 site that currently have the greatest thickness of accumulated product. The transmissivity estimates range from below to above the ITRC mobility threshold range (Appendix D). LNAPL transmissivity will decrease with product thickness assuming constant aquifer characteristics and LNAPL physical properties. Therefore, even though LNAPL transmissivity estimates at MW-59 and RW-12 suggest possible LNAPL mobility, the LNAPL body as a whole is not expected to migrate under current hydrogeologic conditions. Because the thickness of the LNAPL decreases away from MW-59, the margins of the LNAPL body will have LNAPL transmissivity below the mobility threshold. In order for the LNAPL to migrate, a sufficient driving force would be required to overcome the capillary entry pressure at the margins of the measurable product. Therefore, LNAPL transport by lateral migration is not likely at the T30 site.

The lateral extent of measurable free product has been decreasing since the mid-1980s and product thickness is not observed to be increasing at any wells. Areas where LNAPL saturation has decreased to residual levels (defined as the level at which gravity drainage would no longer occur, but sheen may still be present in wells), the primary transport pathways will be through dissolution into groundwater.

2.9.3 Vadose Zone Fate and Transport

Contaminant transport in the vadose zone is primarily through recharge percolating through the vadose zone and leaching contaminants from residual and adsorbed NAPL. Recharge is low at the T30 site due to nearly complete coverage of the site with 12- to 16-inches of asphalt and operation of a stormwater collection system (Figures 2-2 and 2-4). Water that manages to percolate into and through the vadose zone may leach contaminants to underlying groundwater. Screening levels in Table 2-5 account for the soil leaching to groundwater pathway. Soil leaching to groundwater is not expected to be a significant pathway at the T30 site.

LNAPL and adsorbed contaminants in the vadose zone biodegrade. Biodegradation calculations for DRO in soil using literature biodegradation rates indicate degradation from maximum expected TPH concentrations to screening levels over 30 to 60 years (Appendix H). Hot spots where biodegradation processes are impaired, such as in buried drums or pipes, would be expected to have lower degradation rates than indicated in the literature.

2.9.4 Groundwater Fate and Transport

Groundwater in contact with petroleum-impacted soil and LNAPL produces a dissolved groundwater plume across much of the site (Figures 2-8, 2-13, 2-14). The dissolved plume is subject to the following major fate and transport phenomena:

- Sorption
- Dispersion
- Tidal mixing
- Biodegradation

2.9.4.1 Sorption

Contaminant mobility in groundwater is related to solubility and sorption to the aquifer matrix. Larger molecules generally have lower solubility and higher partition coefficients, which indicate reduced mobility in groundwater relative to the contaminants made of smaller molecules. Reduced mobility can be summarized by a "retardation factor". Table H-1 (Appendix H) includes aqueous solubilities, soil/water partition coefficients, and retardation factors for PAH and BTEX compounds. DRO and GRO are mixtures of compounds/molecules of differing characteristics. Formulations vary widely between refineries, age of fuels, and source crude used to produce fuels. BTEX compounds are common components of typical gasoline formulations; diesel fuels are dominantly heavier, with less-volatile compounds such as naphthalene and anthracene with lower concentrations of BTEX compounds. The BTEX compounds common to GRO have lower retardation factors (less sorption) than the heavier compounds common to DRO (more sorption) indicating relatively higher GRO mobility than DRO mobility in groundwater. This is consistent with the greater extent of GRO and BTEX compounds than DRO in the MW-42/MW-89 area.

PAHs partition strongly to soil particles and high retardation coefficients. They have low solubility and low mobility in groundwater. Aqueous solubilities for PAHs are much lower than BTEX compounds and soil-water partitioning coefficients are generally much higher than BTEX compounds (Appendix H). Analytical results from unfiltered, filtered and centrifuged samples collected at MW-58, and MW-86C support a conceptual model in which PAH compounds are predominantly sorbed to soil particles. Concentrations in filtered samples were lower than in unfiltered samples (Tables 2-8a and 2-8b). PAHs are not likely to migrate significantly due to their strong sorption to soil particles. Groundwater transport of PAH compounds to surface water is most likely an incomplete pathway.

2.9.4.2 Dispersion

Dispersion spreads-out contaminants in three dimensions relative to simple advection (plug flow). Maximum concentrations are reduced dispersion along contaminant flow paths. Tidal fluctuations increase dispersion relative to sites with more consistent groundwater levels, but this process is separate from tidal mixing.

2.9.4.3 Tidal Mixing

Tidal mixing occurs only in the nearshore area. High tides result in entry of marine water into the aquifer. At low tide the gradient reverts to generally westward flow. Thus, the average concentration of any groundwater contaminant in this zone is reduced. The amount of mixing varies from a maximum at the marine/aquifer interface, to zero at the landward limit of mixing.

2.9.4.4 Biodegradation

Biodegradation occurs as microbes in the aquifer metabolize petroleum compounds, thus reducing contaminant mass. Biodegradation of petroleum compounds follows a metabolic pathway in which the contaminant is an electron donor and oxygen, nitrogen, and other compounds act as electron acceptors. Degradation begins with the aerobic metabolic pathway resulting in decreases in dissolved oxygen and oxidation-reduction potential. As oxygen is depleted, metabolism shifts to anaerobic metabolic pathways in which nitrate and sulfate concentrations decrease accompanied by further decreases oxidation-reduction potential, and increases carbon dioxide and methane.

Data collected by AECOM (ENSR|AECOM, 2008a) demonstrated decreasing dissolved oxygen, nitrate, and sulfate concentrations coupled with elevated methane and carbon dioxide concentrations within and down gradient of the source area that are consistent with active biodegradation in the aquifer. Decreases in sulfate coupled with increases in methane in the former LNAPL area indicate that biodegradation in the source area is sulfate-reducing and methanogenic.

Biodegradation rates are commonly expressed as half-lives. A half-life is the time required to reduce the contaminant concentration by half. Biodegradation half-lives were calculated by AECOM on an intra-well basis and did not include from estimates of attenuation caused by dispersion and tidal mixing. The biodegradation half-lives varied across the site depending on the constituent and the geochemical conditions (ENSR|AECOM, 2008a). The mean DRO biodegradation half-lives were 5.3 years for all wells and 3.7 years in the zone immediately down gradient of the former extent of LNAPL. Half-lives from intra-well analyses reflect both the dissolved phase degradation and partitioning with the sorbed contaminant mass.

Appendix H includes projections of groundwater concentrations over 80 years for a range of initial concentrations and observed biodegradation half-lives (ENSR|AECOM, 2008a). These calculations indicate that groundwater concentrations would be expected to reach DRO screening levels within 30 to 70 years. Similar calculations for soil using literature biodegradation rates for DRO also indicate a range from 30 to 60 years for degradation from the maximum DRO concentrations to screening levels (Appendix H). Hot spots where biodegradation processes are impaired, such as in buried drums or pipes would be expected to have longer degradation half-lives.

Decreased tidal response after installation of the sheet pile resulted in a theoretical (potential) decrease in biodegradation and dispersion behind the sheet pile wall. Decreased tidal response is expected to decrease the dissolved oxygen content, thus decreasing biodegradation rates.

2.9.5 Vapor Fate and Transport

Volatile hazardous substances can partition to soil gas and potentially migrate from the subsurface to indoor air. Vapor intrusion is a potential exposure pathway where volatile hazardous substances are present in the subsurface and occupied buildings are in the vicinity of the contamination. Vapor transport in the subsurface begins with partitioning between contaminants present in the subsurface as LNAPL, dissolved in groundwater, or sorbed to soil particles.

Vapor transport likely occurs over distances greater than Ecology's 100-foot rule of thumb for vapor transport from contamination source areas (Ecology, 2009). The asphalt cap at the site will significantly reduce mixing and dilution with the atmosphere allowing the potential for longer lateral transport distances. Because the Vessel Tower is within 100 feet of the "sheen area", it is assumed that soil gas in the vicinity has the potential to exceed soil gas screening levels. Where NAPL is present, soil gas sampling is the Ecology-recommended method for evaluating soil gas concentrations.

Benzene is the most likely compound to exceed the indoor air or sub-slab vapor criteria due to its volatility (high Henry's Law coefficient) and toxicity relative to other site COCs such as toluene or DRO. Benzene is identified as a volatile hazardous substance in Ecology's Draft Vapor Intrusion Guidance and has an indoor air threshold of 0.32 micrograms per cubic meter (ug/m^3), and sub-slab soil gas threshold of 3.1 ug/m^3 just below the slab (Ecology, 2009). These concentrations correspond to an equilibrium groundwater concentration of 2.4 ug/L with standard assumptions regarding dilution during vadose zone and trans-slab transport. When residual LNAPL is present in the subsurface, soil gas data is the Ecology-recommended method for assessing potential vapor intrusion, as opposed to assessing vapor intrusion based on shallow groundwater concentrations.

The Vessel Tower is a three-story slab on grade structure. The first floor is occupied by bathrooms and a lunch/meeting room, and the upper two floors are occupied by offices and workstations. The building does not have an HVAC system. Heating is provided through wall-mount heaters. Seasonal cooling is provided by opening windows and using cross-ventilation. Vapor intrusion is most likely to be an issue in the bottom floor, which is only intermittently occupied during lunch and other break times and includes no dedicated working spaces. The Gate House is a single story structure constructed with separation from the ground surface, and is more than 200 feet from the former extent of LNAPL. Vapor intrusion is unlikely to be an issue at the Gate House.

2.10 AREAS THAT EXCEED SCREENING LEVELS

Portions of the T30 site that exceed screening levels are identified by the presence of LNAPL indicated by measurable thickness, and by groundwater and soil samples with concentrations above screening levels. Areas of LNAPL, groundwater, and soil meeting these criteria are discussed below and presented in Figure 2-15:

- *LNAPL:* Measureable free-product remains in the area near MW-59.
- *Groundwater*: Areas with groundwater concentrations above screening levels are within the historic extent of LNAPL plus downgradient wells MW-42 and MW-89. Groundwater exceeds screening levels at existing CPOC well MW-89, but not at any other existing CPOC wells.
- *Soil*: Soil above screening levels is largely present within the historic extent of LNAPL[7] (Figure 2-15).

Section 3 discusses applicable remedial alternatives, feasibility, and associated costs.

2.11 DATA GAPS

This section describes remaining data gaps at the T30 site at the completion of this RI[8].

MW-58 is damaged and should be replaced with a well that will provide more reliable monitoring data. A down-hole camera was used to inspect MW-58 on December 8, 2011 and a crack was visible at the top of the screen interval. MW-58 accumulates significant quantities of sediment, suggesting there may be additional damage deeper in the well that was not observable during the video.

Groundwater samples have not been collected at the location of the proposed additional CPOC well to be located southwest of MW-53 (Figure 2-5).

Soil gas concentrations have not been characterized at the Vessel Tower.

[7] Separate, smaller areas of soil contamination above screening levels are present outside of the historic tank farm facility boundary at the West Vault and South Vault (Figure 2-5, Appendix A). The contamination in these areas does not appear to be contiguous with T30 contamination and is therefore not considered a part of the T30 site.
[8] Groundwater data gaps associated with MW-58 and CPOC wells were subsequently filled during well replacement, installation, and groundwater sampling activities conducted in August and October of 2013 (Appendix J).

3.0 FEASIBILITY STUDY

The purpose of this feasibility study (FS) is to develop and evaluate cleanup alternatives to enable a remedial action to be selected for the T30 site. The FS builds on the characterization of LNAPL and petroleum-related COCs in soil and groundwater as described previously in the remedial investigation. The FS is organized into the following sections:

- Section 3.1 identifies remedial action objectives (RAOs)
- Section 3.2 presents an initial screening of remedial technologies for applicability to the T30 site
- Section 3.3 describes the remedial alternatives to be evaluated
- Section 3.4 evaluates the remedial alternatives against the MTCA requirements and criteria specified in WAC 173-340-360
- Section 3.5 presents the disproportionate cost analysis (DCA)
- Section 3.6 presents the FS summary and conclusions

3.1 REMEDIAL ACTION OBJECTIVES

RAOs are specific goals the remedial action must achieve to adequately protect human health and the environment, and to therefore be considered viable alternatives. RAOs must address all affected media and can be action-specific or media-specific. RAOs incorporate the screening levels developed in Section 2.6. The RAOs identified for the T30 site are:

- RAO-1: Prevent or limit risks from direct human contact with soil or groundwater
- RAO-2: Prevent or limit risks from groundwater impacting surface water quality

These RAOs can be achieved through a combination of remedial technologies, monitoring, and institutional controls. It is probable that some RAOs will be met earlier than others.

Each of the remedial alternatives described in Section 3.3 achieve the above RAOs and meet all of the MTCA threshold requirements (WAC 173-340-360(2)(a); Section 3.4.1); each alternative is therefore a viable remedial alternative under MTCA.

Based on the T30 monitoring well network, contaminated groundwater does not reach surface water above screening levels (Section 2.7; Figure 2-16). Groundwater GRO concentrations currently exceed screening levels at existing CPOC well

MW-89, but not other COCs. CPOC wells are placed as close to the contamination as practical and remedial effects at CPOC wells will be monitored as a component of achieving the RAOs.

3.2 SCREENING OF REMEDIAL TECHNOLOGIES

Various remedial technologies have proven effective at reducing contamination at petroleum-impacted sites. This section describes the initial screening process used to assess available technologies for applicability to the T30 site. Those remedial technologies considered applicable are advanced to the detailed evaluation of the FS (Section 3.4).

3.2.1 Capping/Containment

Capping and containment remedies involve physical barriers, natural or engineered, that limit exposure of human and terrestrial ecology to contaminated soil and limit migration of contaminated soil via erosion or mechanical disturbance. The use of low-permeable capping with stormwater collection systems minimizes infiltration and potential leaching from soil to groundwater.

This remedial technology can achieve RAO-1 if paired with institutional controls, and currently achieves RAO-2 based on existing groundwater data. Capping and containment are a component of all remedial alternatives described and evaluated in Sections 3.3 and 3.4.

3.2.2 Institutional Controls

Institutional controls limit or prohibit activities that may interfere with the integrity of a remedial action and potentially result in exposure to hazardous substances. Institutional controls may include physical measures such as fences, and formal land use restrictions such as deed restrictions, restrictive covenants, or maintenance requirements. For this site, institutional controls would include restrictive environmental covenants limiting activities that could lead to potential human contact with hazardous substances. If paired with capping/containment, the institutional controls would include requirements for inspections and maintenance of the cap.

This technology can achieve RAO-1 if paired with capping/containment. Institutional controls do not contribute to achieving RAO-2.

Institutional controls are components of remedial alternatives described and evaluated in Sections 3.3 and 3.4.

3.2.3 Excavation

Excavation and offsite disposal of contaminated soil is a permanent remedial technology that reduces contaminant masses in soil, reduces LNAPL, and can also expedite groundwater remediation.

Site-wide excavation and partial or targeted excavation scenarios were considered during the initial screening of technologies for the T30 site. There are features of the T30 site that may limit complete excavation of contaminated soil, including the shallow water table, contamination below the water table, and significant infrastructure above and below grade.

Sitewide excavation can achieve RAO-1 and RAO-2. Sitewide excavation was considered during a previous disproportionate cost analysis (ENSR|AECOM, 2010) that indicated significant disruption to the site and disproportionate costs. Therefore, sitewide excavation is screened out due to the disproportionate cost and site disruption relative to the benefits of the remedial technology.

Partial or targeted excavation alone will not achieve RAO-1 or RAO-2. This remedial technology is therefore one component of remedial alternatives described and evaluated in Sections 3.3 and 3.4.

3.2.4 In-Situ Chemical Oxidation

In-situ chemical oxidation (ISCO) is a permanent remedial technology that degrades contaminants in place by injecting oxidants into soil and groundwater. Oxidants react with the contaminants and produce substances such as carbon dioxide and water. However, there may be many chemical reaction steps required to reach those end points.

In theory, ISCO could achieve the RAO-1 and RAO-2 for the T30 site; however, in practice it is difficult to achieve the necessary contact of oxidants with contaminated soil and LNAPL. Therefore, ISCO is not likely to achieve the RAOs at the T30 site and this technology is screened out from further evaluation.

3.2.5 Biostimulation

Biostimulation is a permanent remedial technology that degrades contaminants in place through augmentation of naturally-occurring bacterial populations. The most common form of biostimulation at petroleum-impacted sites is adding oxygen through air sparging, or injecting compounds that release oxygen over a period of time.

In theory, biostimulation could achieve the RAO-1 and RAO-2 at the T30 site: however, in practice it would be difficult to achieve the RAOs using biostimulation alone. Injectable oxygen-releasing compounds are most appropriate and cost effective where the contaminant mass (sorbed and dissolved) has relatively low oxygen demand. However, the T30 site has a large contaminant mass in soil and groundwater that would require large amounts of biostimulants to meet the stoichiometric oxygen demand. Direct injection of oxygen in air or enriched mixtures through sparge or vadose zone points can be more technically-effective and cost-effective for sites with larger contaminant mass or project scales.

Therefore, biostimulation using injectable compounds is screened out from further evaluation because of significant technical constraints and costs associated with sitewide implementation at the T30 site. Biostimulation through direct injection of oxygen could achieve RAO-1 and RAO-2 and is maintained as a remedial technology (see also Section 3.2.6).

3.2.6 Air Sparge-Soil Vapor Extraction

Air Sparge-Soil Vapor Extraction (AS/SVE) systems reduce concentrations of volatile petroleum fractions through direct extraction, and through aerobic biostimulation of the saturated and vadose zones. AS/SVE systems are generally considered more effective for extraction of constituents with vapor pressures greater than 0.5 to 1 millimeters of mercury (mmHg; 0.07 to 0.13 kiloPascals, kPa) at 20 degrees Celsius, Henry's Law coefficient greater than 0.01 (dimensionless), or boiling points below 250 to 300 degrees Celsius (Suthersan, 1999; EPA, 2004).

The constituents of concern identified in cleanup areas at the T30 site include a range of hydrocarbon compounds; however, diesel-range hydrocarbons are most prevalent (Section 2.7). AS/SVE is effective for remediation of gasoline-range hydrocarbons (including benzene) in soil and groundwater, which exceed screening levels at the T30 site. The low vapor pressure of diesel[9] reduces the effectiveness of extraction by AS/SVE as a remedial alternative at the T30 site. Also, AS/SVE is not effective for extraction of PAHs.

The primary remedial process of AS/SVE at the T30 site would be biostimulation and bioventing, with secondary remedial action through extraction of volatile petroleum hydrocarbons. Case studies show that AS/SVE biostimulation is effective at reducing concentrations of GRO, DRO, and PAHs, although degradation half-lives for PAHs may be much longer than other constituents (Suthersan, 1999; EPA, 2004). Previous work by AECOM documented active biodegradation of DRO and lighter petroleum constituents across the site, which the AS/SVE system will augment (ENSR|AECOM, 2008a). AS/SVE could achieve RAO-1 and RAO-2 through the reduction in volatile hydrocarbons and biostimulation effects in the vadose and saturated zones. Therefore, AS/SVE is incorporated in the remedial alternatives for further evaluation in Section 3.4.

[9] Average diesel vapor pressures are expected to be below 2 mmHg at 20 degrees Celsius. The boiling point of diesel ranges from 200 to 338 degrees Celsius (EPA, 2004); the volatility of diesel mixtures varies with formulation and age.

3.2.7 Thermal Desorption

Thermal desorption is a permanent remedial technology that reduces soil and groundwater concentrations through heating, volatilization of contaminants, and extraction. Given the shallow depth to water at the T30 site, heating would be achieved through steam injection. Vapors generated by thermal desorption remedies are extracted through an SVE system and burned off, or collected in a knock-out drum or carbon canister for recycling/disposal depending on the vapor concentration range and system design. Mass balance between injected and extracted steam would be monitored to ensure that condensation in the treatment zone would not result in dilution and/or mobilization of contaminants. Thermal desorption mobilizes and extracts higher molecular weight compounds than AS/SVE systems. Thermal desorption volatilizes diesel range organics (C_{10}-C_{28}), but effectiveness is significantly limited for hydrocarbons larger than C_{20} (TerraTherm, 2012).

Thermal desorption would remove contaminant mass, but this technology alone would not achieve RAO-1 or RAO-2 because longer-chained hydrocarbons such as PAHs would remain in place.

Thermal desorption technology is incorporated in the remedial alternatives for further evaluation for the T30 site because of the reduction petroleum hydrocarbon compounds in the volatile to less than C_{20} range.

3.2.8 LNAPL Removal

LNAPL removal involves mechanical extraction by pumps, bailing, or other related technologies for disposal offsite. Surfactants such as cosolvent flushing can be used to enhance LNAPL removal.

As described in the remedial investigation, measurable free product is present in the vicinity of MW-59. LNAPL recovery from the existing well network in the vicinity of MW-59 is unlikely to reduce LNAPL mass significantly in less than 20 years. However, installation of additional wells can significantly enhance recovery over the existing configuration.

LNAPL removal would decrease the contaminant mass, but would not achieve RAO-1 or RAO-2 as a sole remedial technology. LNAPL removal is included in remedial alternatives as a component of integrated technologies that are further described and evaluated in Sections 3.3 and 3.4.

Surfactant-enhanced LNAPL recovery is not recommended for the T30 site. The surfactants work primarily by enhancing contaminant solubility, which could increase potential for migration towards the East Waterway.

3.2.9 Natural Attenuation

Natural attenuation is occurring at the T30 site through biodegradation and dilution mechanisms. Natural attenuation will be active at the site for all of the remedial technologies identified above regardless of whether monitored natural attenuation[10] is a formal component of the selected remedial alternative.

This technology can achieve RAO-1 and RAO-2 if paired with institutional controls. Natural attenuation is not formally considered as an active remedial technology, but is recognized as occurring at the site and is inherently part of all alternatives described in Section 3.3.

3.3 DESCRIPTION OF REMEDIAL ALTERNATIVES

This section describes the assembly of remedial technologies into remedial alternatives (Table 3-1). Each alternative includes a discussion of the combined remedial technologies, comparison of the alternative to the RAOs, and a cost estimate and schedule for implementation of the alternative.

All of the remedial alternatives include maintenance of an asphalt cap and institutional controls for residual contamination.

Groundwater monitoring for 30 years is included in all remedial alternatives. The actual monitoring schedule will be negotiated with Ecology in the future. For cost purposes, the assumed monitoring frequency is semi-annual for years 1 and 2, annual monitoring for years 3 through 5, biannual monitoring years 7 through 15, and every 5 years thereafter to 30 years. Alternative 4 includes a higher monitoring frequency over the first decade of monitoring with semi-annual in years 1 through 5 and annual monitoring in years 6 through 10.

All cost estimates presented in this FS are preliminary and are provided for the purposes of comparing the order of magnitude of likely costs between alternatives. A cost basis for each alternative is provided in Appendix I. An updated cost estimate will be developed for the selected remedial alternative during the design phase.

Cost estimates are not bids, quotes for services, or engineer's estimates based on detailed design work. These cost estimates are intended solely for comparison of costs between alternatives and were prepared using general cost estimating techniques, rule-of-thumb estimates, and from experience with similar tasks, equipment, and materials. In select alternatives, costs have been taken, or modified from, quotes provided by vendors, or suppliers based on general information

[10] In this FS the term "natural attenuation" is used to refer to the process of contaminant mass reduction through natural processes; it is not used to imply formal compliance with the monitored natural attenuation criteria outlined in MTCA and Ecology guidance documents (Ecology, 2004).

about the remedial alternative. Cost estimates include contingency costs, Washington state sales tax, and adjustments for inflation and present day value of future expenditures using Ecology guidelines (Ecology, 2011).

3.3.1 Alternative 1: In-Situ Thermal Desorption

Alternative 1 includes installation and operation of a thermal desorption system to heat up, volatilize, and extract petroleum hydrocarbons from soil, groundwater, and LNAPL at the T30 site; maintaining the asphalt cap; institutional controls; and compliance groundwater monitoring. Extracted hydrocarbons would be either incinerated or condensed and collected for disposal or recycling depending on the vapor concentrations and final system design.

Figure 3-1 presents the expected treatment area for the thermal desorption system based on the extent of soil contamination. System installation would have a significant impact on terminal operations during the required trenching, drilling, and system operation; terminal operation disruption is included in alternative costs (Appendix I).

3.3.1.1 Comparison to Remedial Action Objectives

Alternative 1 meets the following RAOs:

- RAO-1: Direct contact with contaminated soil or groundwater would be mitigated through maintenance of the asphalt cap and institutional controls. After thermal treatment, some soil concentrations will likely exceed screening levels for hydrocarbon fractions larger than C20 and in areas not treated due to subsurface heterogeneity.
- RAO-2: Contaminated groundwater exceeds screening levels at existing CPOC well MW-89. There is a small risk that contaminants may be mobilized by thermal treatment downgradient of the CPOC, requiring groundwater monitoring and contingency actions. Therefore, during treatment RAO-2 may not be achieved. RAO-2 would be met due to reduction in contaminant mass and lower residual contaminant solubility.

Following treatment, this alternative would significantly reduce the contaminant mass, but with varying efficacy. Residual soil contaminant mass could have reduced leachability and groundwater concentrations would likely be below screening levels for most of the site, likely maintaining RAO-2 as in current site conditions. Subsurface heterogeneity could leave localized areas with COC concentrations above soil and groundwater screening levels.

3.3.1.2 Estimated Cost and Schedule

The estimated cost to implement Alternative 1 is $24.8 million (Table 3-1; Appendix I). It is anticipated that the thermal desorption system would operate for 1 year. Groundwater monitoring would continue for approximately 30 years.

3.3.2 Alternative 2: Expanded Sheen-Area AS/SVE with Targeted Excavation

Alternative 2 involves expanded AS/SVE to reduce soil and groundwater concentrations in the sheen area plus targeted excavation to remove LNAPL in the area around MW-59 (Figure 3-2).

The AS/SVE system would consist of two sets of AS/SVE horizontal well sets similar to the system outlined in Alternative 3b. The primary effect of the AS/SVE would be in-situ biostimulation and biodegradation of soil and groundwater contaminants.

Targeted excavation in the vicinity of MW-59 would be conducted to the extent that free product is observed accumulating at the water table exposed in excavations, or to the extent practical within the constraints of buried utilities, site infrastructure, or terminal schedule. Excavated soil would be taken to an offsite facility for disposal. Sidewall soil concentrations are expected to exceed default MTCA residual LNAPL saturation screening levels (2,000 mg/kg) because site soils are silty sands, which can exceed the residual saturation of coarse sand and gravelly soils used in the default MTCA calculations (WAC 173-340 Table 747-5; see Appendix D for LNAPL residual saturation profiles at MW-59 and RW-12). The excavation is estimated to produce approximately 14,000 cubic yards of impacted soil.

Implementation of this alternative would require temporary removal of the asphalt cap, RTG tracks, and utility infrastructure in the excavation area. Excavation and reconstruction activities would significantly impact terminal use. Costs associated with shipping terminal disruption are included in the cost estimate (Table 3-1; Appendix I).

3.3.2.1 Comparison to Remedial Action Objectives

Alternative 2 meets the following RAOs:

- RAO-1: Direct contact with contaminated soil or groundwater would be mitigated through maintenance of the asphalt cap and institutional controls before and after treatment. While Alternative 2 will remove contaminant mass, it relies on capping and institutional controls to achieve RAO-1. Direct contact risk would be elevated during excavation activities.

- RAO-2: Contaminated groundwater exceeds screening levels at existing CPOC well MW-89. RAO-2 would be met through progressive reduction in contaminant mass in the sheen area.

This alternative would reduce soil and groundwater concentrations in the saturated and vadose zones; however subsurface heterogeneity could leave localized areas with COC concentrations above soil and groundwater screening levels (hot spots).

3.3.2.2 Estimated Cost and Schedule

The estimated cost to implement Alternative 2 is $9.5 million (Table 3-1; Appendix I). Excavation and site reconstruction are expected to take approximately 6 months and the AS/SVE system is expected to operate for an additional 5 years to address residual groundwater contamination. Compliance monitoring is estimated to occur for 30 years.

3.3.3 Alternative 3: Sheen-Area AS/SVE Treatment with LNAPL Recovery

Alternative 3 includes installation and operation of an AS/SVE system in the sheen area plus LNAPL recovery in the MW-59 area from an expanded well network. Two configurations of the AS/SVE system are presented: Alternative 3a (Targeted) includes AS/SVE wells across the downgradient extent of the sheen area (Figure 3-3); Alternative 3b (Expanded) includes two pairs of horizontal AS/SVE wells through the upgradient and downgradient extents of the sheen area (Figure 3-4).

3.3.3.1 Alternative 3a Configuration

The remediation system for this alternative uses standard AS/SVE wells and approximately ten LNAPL recovery wells (Figure 3-3). The AS wells would be screened at approximately 8 feet below the water table between the MW-39 and MW-53 areas. The SVE recovery pipes (horizontal) would be screened in the vadose zone. The third component of the AS/SVE system would be a blower system to inject air at the AS wells and to remove and treat extracted air and vapors from the SVE recovery pipes. The blower assembly would nominally be located near the T30 Vessel Tower. Operating the AS wells at 150 standard cubic feet per minute (scfm), the system would deliver approximately 1,500 kg of oxygen per day in the pumped air. This flow rate would maintain oxygen concentrations near saturation in groundwater near the AS wells. Assuming 1% of delivered oxygen is consumed by biodegradation, and a stoichiometric demand of 3.5 kg of oxygen for 1 kg of TPH biodegradation, this flow rate would account for approximately 1,500 kg/year of biodegradation. The air flow would enhance biodegradation in vadose zone soil and extract volatile compounds via the SVE recovery pipes. SVE would be operated at a vacuum adequate to match air flow at the AS wells, and would be coupled with either a thermal oxidizer or carbon filter system to control discharged vapor concentrations.

Approximately ten new LNAPL recovery wells would be installed in a grid pattern near MW-59 to enhance product recovery efforts (Figure 3-3). LNAPL would be recovered from the wells on a schedule determined by the recharge rate using dedicated skimmers, pumps, or other extraction technologies.

3.3.3.2 Alternative 3b Configuration

The remediation system for Alternative 3b would consist of two pairs of horizontal AS/SVE wells near the upgradient and downgradient extents of the sheen area (Figure 3-4), thereby expanding the treatment area beyond that of Alternative 3a to the vicinity of MW-59, MW-54, and RW-5. Use of horizontal wells instead of traditional vertical wells would reduce impacts to site operations. An additional blower system would be added near the North Substation to operate the upgradient AS/SVE wells. Total blower capacity for the two sets of paired wells would be approximately 400 scfm delivering approximately 4,000 kg of oxygen per day in the pumped air. Again, this flow would maintain elevated oxygen concentrations in groundwater near the AS wells. Assuming 1% of delivered oxygen is consumed by biodegradation, and a stoichiometric demand of 3.5 kg of oxygen for 1 kg of TPH biodegradation, this flow rate would account for approximately 4,100 kg/year of biodegradation.

Approximately ten new LNAPL recovery wells would be installed in a grid pattern near MW-59 to enhance product recovery efforts (Figure 3-4). LNAPL would be recovered from the wells on a schedule determined by the recharge rate.

3.3.3.3 Comparison to Remedial Action Objectives

Alternatives 3a and 3b meet the following RAOs:

- RAO-1: Direct human contact with contaminated soil or groundwater would be mitigated through maintenance of the asphalt cap and institutional controls. While Alternatives 3a and 3b will remove contaminant mass, they rely on capping and institutional controls to achieve RAO-1.
- RAO-2: Contaminated groundwater exceeds screening levels at existing CPOC well MW-89. Implementation of the AS/SVE system will reduce concentrations at the CPOC. Groundwater monitoring and contingency plans would provide mitigation against potential future impacts to surface water. Risk to surface water would decrease with progressive reduction in contaminant mass throughout the sheen area.

This alternative would reduce soil and groundwater concentrations in the saturated and vadose zones; however subsurface heterogeneity could leave localized areas with COC concentrations above soil and groundwater screening levels (hot spots).

3.3.3.4 Estimated Cost and Schedule

The estimated cost to implement Alternative 3a is $2.7 million (Table 3-1; Appendix I). It is anticipated that the AS/SVE system would operate for 5 years. Groundwater monitoring would continue for approximately 30 years.

The estimated cost to implement Alternative 3b is $5.1 million (Table 3-1; Appendix I). It is anticipated that the AS/SVE system would operate for 5 years. Groundwater monitoring would continue for approximately 30 years.

3.3.4 Alternative 4: Compliance Monitoring with LNAPL Recovery

Alternative 4 includes compliance monitoring and LNAPL recovery near MW-59. LNAPL would be recovered from a network of 10 additional recovery wells near MW-59 by vacuum truck, bailing, and/or pumping (Figure 3-5). Recovery well spacing would be approximately 30 feet with adjustments for nearby infrastructure including utilities and RTG alignments (Figure 2-2). Recovered LNAPL would be disposed of offsite.

AECOM estimated approximately 300 gallons of remaining recoverable LNAPL in the MW-59/RW-12 vicinity (ENSR|AECOM, 2008a). The API LNAPL Distribution and Recovery Model (LDRM) indicates that approximately 70-percent of LNAPL is recoverable from a silty sand with a maximum historic LNAPL thickness of 6 feet[11] and current thickness of 1.5 feet (Charbeneau, R., 2007a,b; see also Appendix D). Recovery is expected to take 10 to 15 years based on API LDRM model results.

3.3.4.1 Comparison to Remedial Action Objectives

Alternative 4 meets the following RAOs:

- RAO-1: Direct contact with contaminated soil or groundwater would be mitigated through maintenance of the asphalt cap and institutional controls. LNAPL recovery would reduce overall remediation timeframe for the MW-59 area.
- RAO-2: Contaminated groundwater exceeds screening levels at existing CPOC well MW-89, and would meet RAO-2 through natural attenuation processes. Groundwater monitoring and contingency actions would provide additional mitigation against potential future impacts to surface water.

This alternative would be expected to reduce soil and groundwater concentrations in the bulk of the site to below screening levels over approximately 30 to 60 years

[11] The maximum observed product thickness in wells near MW-59 was 6 feet.

based on observed biodegradation half-lives and soil residual saturation estimates (Section 2.8; Appendix H). Groundwater flow is expected to remain consistent at the site and the probability of contingency action being required in response to expansion of the dissolved phase plume or migration of LNAPL is low. However, subsurface heterogeneity could leave localized areas with COC concentrations above soil and groundwater screening levels (hot spots). This Alternative would not be expected to meet screening levels at 1 to 2 of the CPOC wells for several years as natural degradation processes reduce concentrations.

3.3.4.2 Estimated Cost and Schedule

The estimated cost to implement Alternative 4 is $1.7 million (Table 3-1; Appendix I). It is anticipated that the LNAPL recovery would persist for 10 to 15 years on a decreasing frequency. Groundwater monitoring would continue for approximately 30 years.

3.4 EVALUATION OF ALTERNATIVES

MTCA requires that cleanup alternatives be compared to criteria to evaluate the adequacy of achieving the intent of the regulations and as a basis for comparing their relative merits. The evaluation of each T30 cleanup alternative against the MTCA criteria specified in WAC 173-340-360 is summarized in Table 3-2 and presented in the following sections. Consistent with MTCA, the cleanup alternatives were evaluated with respect to:

- Threshold requirements (Section 3.4.1)
- Restoration timeframe (Section 3.4.2)
- Permanent solutions to the maximum extent practicable (Section 3.4.3)
- Consideration of public concerns (Section 3.4.4)

All remedial alternatives discussed in Section 3.3 are viable alternatives under MTCA. Each alternative achieves the applicable RAOs and meets all MTCA threshold requirements discussed below.

3.4.1 Threshold Requirements

Under MTCA, a cleanup alternative must meet the following threshold requirements (WAC 173-340-360(2)(a)):

- Protect human health and the environment
- Comply with cleanup standards
- Comply with applicable state and federal laws
- Provide for compliance monitoring

Compliance with the threshold requirements under MTCA is presumed to be protective of human health and the environment once the cleanup standards are met for all affected media. Also, any cleanup action performed in accordance with the requirements of MTCA is assumed to be in compliance with cleanup standards and applicable state and federal laws. The following sections identify how each cleanup alternative complies with the threshold requirements.

3.4.1.1 Protect Human Health and the Environment

Alternatives 1 through 4 protect human health and the environment through containment and institutional controls during the remedial action, contaminant reduction, and groundwater compliance monitoring.

3.4.1.2 Comply with Cleanup Standards

Alternatives 1 through 4 all comply with MTCA cleanup standards through the various cleanup technologies employed, and achievement of the applicable RAOs (Section 3.1).

3.4.1.3 Comply with State and Federal Laws

Alternatives 1 through 4 all comply with state and federal laws through compliance with identified ARARs (Section 2.6) and compliance with MTCA regulations.

3.4.1.4 Provide for Compliance Monitoring

Compliance monitoring requirements (WAC 173-340-410(1)) include protection monitoring during construction, operation, and maintenance of the cleanup action; performance monitoring to confirm progress of the cleanup action; and confirmation monitoring to confirm the cleanup action has been attained and the long-term effectiveness of the cleanup action.

Alternatives 1 through 4 all include Compliance Monitoring.

3.4.2 Requirement for a Reasonable Restoration Timeframe

MTCA identifies a number of factors to be considered when establishing a reasonable restoration timeframe. A cleanup action is considered to have achieved restoration once cleanup standards have been met. Restoration timeframes for Alternatives 1 through 4 are estimated to range between 30 and 70 years (Table 3-2). The basis for considering these timeframes to be reasonable is summarized in the bullets below:

- *Potential risks to human health and the environment:* the site currently presents minimal risk to human health and environment despite the size of the impacted area and presence of LNAPL. The risk to direct contact and surface water quality is limited by the presence of a 12 to 16-inch asphalt cap, and natural attenuation processes (including both dilution and degradation) that reduce groundwater concentrations to below screening levels before discharge to adjacent surface water.

- *Availability of alternative water supplies*: alternative water supplies are required by local code (Section 2.6.4.1).
- *Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site*: current use of the site is not impacted by the presence of the contamination; all Terminal 30 site activity occurs above the paved surface. However, the site operations are impacted by remediation efforts. Surrounding properties are paved and industrial, or the East Waterway.
- *Likely effectiveness and reliability of institutional controls*: institutional controls are likely to be effective at preventing direct contact with soil and consumption of groundwater.
- *Practicability of achieving a shorter restoration timeframe*: the level of effort required to shorten the restoration timeframe varies by remedial alternative. The practicability of achieving a shorter restoration timeframe is addressed as part of the DCA evaluation presented in Section 3.5.
- *Ability to control and monitor migration of hazardous substances from the site*: existing monitoring wells provide adequate monitoring coverage at the site. Existing data indicate that the groundwater plume is stable and/or shrinking, and that existing LNAPL is stable and unlikely to migrate.
- *Toxicity of the hazardous substances at the site*: the toxicity of hazardous substances at the site would be reduced through either in-situ detoxification/degradation or removal by excavation/extraction.

3.4.3 Permanent Solutions to the Maximum Extent Practicable

MTCA requires that cleanup actions be permanent to the maximum extent practicable, and identifies a number of criteria to evaluate whether this requirement is achieved (WAC 173-340-360(3)).

All of the alternatives presented in Section 3.3 are permanent solutions because they reduce contaminant concentrations so that no further action is required to meet RAOs. The primary difference between the alternatives with respect to permanence is the rate of contaminant mass reduction, which is evaluated through the analysis of the reasonable restoration timeframe.

3.4.4 Requirement for Consideration of Public Concerns

Consideration of public concerns is part of the site cleanup process under MTCA (WAC 173-340-600). Ecology will publish a notice in the Site Register when the

2013 RI/FS report and subsequent draft CAP have been reviewed by the agency (WAC 173-340-515(4)(d)). There will be a formal public review and comment period of 30 days for the 2013 RI/FS and draft CAP, during which time comments from the public may be submitted. Those comments will be considered and addressed as applicable in the final 2013 RI/FS or final CAP.

3.5 DISPROPORTIONATE COST ANALYSIS

In the DCA, cleanup alternatives are arranged from most to least permanent based on the criteria specified in WAC 173-340-360(3)(f). The DCA then compares the relative environmental benefits of each alternative against those provided by the most permanent alternative.

Costs are disproportionate to benefits if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the lower cost alternative (WAC 173-340-360(3)(e)(i)).

Two or more alternatives could exhibit different costs, but with equivalent benefits. In this case, MTCA specifies that the least costly alternative shall be selected (WAC 173-340-360(3)(e)(ii)(C)).

The DCA for the T30 site is described below and based on information provided in Sections 3.3 and 3.4, and Tables 3-1 and 3-2. There are six DCA evaluation criteria established by MTCA. For each criteria, the remedial alternatives were assigned a relative rank from 1 to 10, where 10 is the highest benefit. The ranks were then multiplied by a weighting factor associated with each DCA evaluation criterion and totaled to determine an overall benefit ranking score for the remedial alternatives. Weighting factors are based on Ecology guidance and Ecology-accepted weighting factors that have been used for similar sites. The six evaluation criteria and associated weighting factors are:

- Overall protectiveness: 30 percent
- Permanence: 20 percent
- Long-term effectiveness: 20 percent
- Short-term risk management: 10 percent
- Implementability: 10 percent
- Considerations of public concerns: 10 percent

Evaluation weighting scores are assigned based on professional judgment relative to the other alternatives.

3.5.1 Comparative Evaluation of Alternatives

The DCA is based on a comparative analysis of the alternatives against the six evaluation criteria. Relative rankings are discussed below and are summarized in Table 3-2. The following subsections provide the comparative evaluation of the alternatives and their ranking scores between 1 (low) and 10 (high).

3.5.1.1 Overall Protectiveness

Overall protectiveness includes the degree to which existing risks are reduced, the remediation timescale, risks associated with remedial alternative implementation, and overall improvement in environmental quality. The most significant differentiators in overall protectiveness at the T30 site are the risks during implementation and the remediation timescales because the site is currently protective and all are permanent solutions. Overall protectiveness is scored on a scale ranging from 10 for a remedial alternative that would provide rapid remediation with little risk during implementation, to a score of 0 for a remedial alternative that would provide no protection.

- Alternative 1 is ranked highest for overall protectiveness with a score of 9 based on the relatively rapid reduction in contaminant mass and typical immobility of residual contamination with thermal desorption.
- Alternative 2 is assigned a score of 8. The alternative uses permanent measures that expedite cleanup, but increases short-term risks during excavation.
- Alternative 3 (3a and 3b) is assigned a score of 8. This alternative has less initial contaminant removal than Alternatives 1 or 2, but less risk during implementation than Alternative 2. The overall remediation time is similar to Alternative 2.
- Alternative 4 is assigned a score of 5. The remediation timeframe is longer than Alternatives 1 through 3, but there is little risk during implementation.

3.5.1.2 Permanence

Each of the remedial alternatives would permanently reduce contaminant mass at the site through extraction and in-situ degradation. All of the alternatives include institutional controls. Alternatives are ranked on a scale from 10 for complete destruction or removal of contaminants to 0 for reduction of contaminants that is completely reversible over short time periods, or removal that would not result in reduction in toxicity.

- Alternative 1 is assigned a score of 10 because it directly removes contaminant mass for offsite disposal and/or recycling.

- Alternative 2 is assigned a score of 8 because it removes LNAPL and impacted soils for offsite disposal and/or recycling coupled with permanently degrading constituents in place using biodegradation with some removal through the SVE system.
- Alternative 3 (3a and 3b) is assigned a score of 8 because it permanently degrades constituents in place using biodegradation with some removal through the SVE system and LNAPL recovery.
- Alternative 4 is assigned a score of 4 because it uses permanent contaminant reduction and recovery of LNAPL, but its long restoration timeframe provides a potential that site conditions may change.

3.5.1.3 Long-Term Effectiveness

Long-term effectiveness includes the degree of certainty that an alternative would be successful, reliable over the time constituents are expected to remain above cleanup levels, the magnitude of residual risk, and the effectiveness of controls required to manage treatment residues and remaining waste. All four of the alternatives are expected to be effective over the long term as they all have a relatively high certainty of reducing or preventing risk of exposure to human health and the environment. The primary difference is the timeframe after implementation necessary for concentrations to reach applicable cleanup levels and the relative importance of institutional controls in mitigating potential exposure. WAC 173-340-360(3)(e)(iv) ranks the long-term effectiveness of cleanup action components from reuse or recycling at the highest ranking, through in-situ destruction, immobilization, offsite-disposal, and institutional controls at the lowest ranking.

- Alternative 1 is assigned a score of 9 because it removes contaminants and either destroys them or collects them for recycling. Residual contamination would be largely immobile. Institutional controls are expected to remain effective over the duration of the remedial alternative.
- Alternative 2 is assigned a score of 8 because it rapidly removes LNAPL from the MW-59 area and enhances in-situ degradation/destruction through AS/SVE. However, the bulk of the contaminant mass is residual/sorbed throughout the former extent of LNAPL, so the magnitude of residual risk will be higher than Alternative 1. Institutional controls are expected to remain effective over the duration of the remedial alternative.
- Alternative 3 (3a and 3b) is assigned a score of 8 because it enhances in-situ degradation/destruction through AS/SVE, and recovers LNAPL for offsite disposal. However, residual contamination would remain for the long term. Institutional controls are expected to remain effective over the duration of the remedial alternative.
- Alternative 4 is assigned a score of 4 because it permanently reduces contaminant mass through biodegradation, and recovers LNAPL for offsite disposal.

However, concentrations will not degrade as quickly as in alternatives 1 through 3, so the magnitude of the residual risk will be greater. Institutional controls are expected to remain effective over the duration of the remedial alternative.

3.5.1.4 Management of Short-Term Risks

The primary short term risks are direct contact with contaminated soil or groundwater, and discharge to surface water. Groundwater discharging to surface water is currently below screening levels and this short term risk is mitigated by monitoring in all remedial alternatives. Direct contact with soil and groundwater is mitigated by institutional controls and an asphalt/concrete cap. Alternatives are ranked from a score of 10 for an alternative with no opportunity for exposure during implementation to a score of 0 for an alternative with extended uncontrolled exposure to contaminated media.

- Alternative 1 is assigned a score of 8 because of risk during extensive drilling.
- Alternative 2 is assigned a score of 3 because of risk during soil handling and work in an open excavation.
- Alternative 3 (3a and 3b) is assigned a score of 9 because of risk during drilling operations, and LNAPL recovery.
- Alternative 4 is assigned a score of 3 because of the time required to meet screening levels at the CPOC, risk during drilling operations, and LNAPL recovery.

3.5.1.5 Technical and Administrative Implementability

The remedial alternatives presented in Section 3.3 have all been demonstrated to be technically possible at similar sites. The primary limitation on implementation of the remedial alternatives is access for construction operations and integration with existing facility operations. Terminal 30 cargo operations utilize the entire site for storage and transport of shipping containers including substantial traffic along designated traffic lanes and storage areas. Excavation, trenching, and drilling-intensive remedial alternatives will impact cargo terminal operations. Short-duration site-work including groundwater monitoring can be scheduled around cargo terminal operations with minimal impact. Alternatives are ranked from a score of 10 for a project that has no restrictions on implementation to a score of 0 for an alternative that is not implementable under existing site conditions. For example, excavation of the full site would receive a score of 0 due to the complete shutdown of terminal operations.

- Alternative 1 is assigned a score of 3 because of significant impacts on site operations during protracted drilling and trenching for the thermal oxidation system installation.

- Alternative 2 is assigned a score of 1 because of significant impacts on site operations including complete shutdown of a significant portion of the site for the duration of excavation followed by additional drilling for AS/SVE implementation.
- Alternative 3a is assigned a score of 8 because of potential impacts during drilling of LNAPL and (vertical) AS/SVE wells.
- Alternative 3b is assigned a score of 7 because of potential impacts during drilling of LNAPL and (horizontal) AS/SVE wells.
- Alternative 4 is assigned a score of 7 because of potential impacts during drilling of LNAPL recovery wells it has the few limitations on implementation.

3.5.1.6 Consideration of Public Concerns

Public concerns regarding the cleanup will be solicited and responded to during the 2013 RI/FS public comment period. For the purposes of this FS, all alternatives are given a ranking of 9 for consideration of public concerns. The evaluation of alternatives against consideration of public concerns criterion is subject to change based on public comments.

3.5.2 Comparison of Overall Benefits (Relative Benefit Scores)

Cumulative scores are similar for all remedial alternatives because the site is currently protective of direct contact and groundwater above screening levels does not currently reach surface water.

Alternative 1 has the highest weighted overall benefit score based on permanence, long-term effectiveness, management of short-term risk, and implementability (Table 3-2). Alternative 2 had the lowest implementability balanced against higher scores for overall protectiveness and permanence. Alternatives 3 and 4 had lower scores for overall protectiveness, but had much higher scores for implementability. The weighting of the scores resulted in a narrow range of overall benefit scores ranging from 5.3 to 8.5:

- Alternative 1 Benefit Score: 8.5
- Alternative 2 Benefit Score: 7.2
- Alternative 3a Benefit Score: 8.0
- Alternative 3b Benefit Score: 7.9
- Alternative 4 Benefit Score: 5.0

3.5.3 Comparison of Estimated Costs

Present day values for Remedial Alternatives range from $1.7 million to $25.2 million as follows:

- Alternative 1 Estimated Cost: $24.8 million
- Alternative 2 Estimated Cost: $9.5 million
- Alternative 3a Estimated Cost: $2.7 million
- Alternative 3b Estimated Cost: $5.1 million
- Alternative 4 Estimated Cost: $1.7 million

3.5.4 Cost-Benefit Ratios

Cost-benefit ratios were calculated by dividing the estimated cost by $100,000 and then dividing that quantity by the relative benefit score (Table 3-2). Thus, lower cost-benefit ratios are preferred. Cost-benefit ratios range from 3.4 for Alternatives 3a and 4 to 29 for Alternative 1 (Figure 3-6).

3.5.5 Conclusions and Summary of Disproportionate Cost Analysis

The costs and benefits associated with the remedial alternatives are compared using a DCA, as outlined in MTCA. The DCA compares the relative environmental benefits of each alternative against those provided by the most permanent alternative evaluated. Alternatives that exhibit disproportionate costs are considered impracticable. An alternative is disproportionate if the incremental increase in cost is greater than the incremental increase in benefit of a lower cost alternative (WAC 173-340-360(3)(e)). Where the benefits of two alternatives are equivalent, MTCA specifies that the lower cost alternative shall be selected (WAC 173-340-360(3)(e)(ii)(C)).

The estimated alternative costs, overall benefit scores, DCA criteria, and MTCA threshold criteria are summarized in Table 3-2 and presented graphically in Figure 3-6.

3.5.5.1 Comparison to Most Practicable Permanent Alternative

Alternative 3a is the most practicable permanent solution for the site. All alternatives are permanent solutions and Alternative 3a has the lowest cost-benefit ratio of options with an acceptable overall benefit score; Alternative 4 has a significantly lower overall benefit score than Alternative 3a. Therefore, all other options are compared against Alternative 3a for the test of disproportionate cost in Table 3-2. The incremental cost and benefit difference analysis shows all alternatives to be disproportionately expensive relative to Alternative 3a except Alternative 4 (Table 3-2, Rows D, E, F). The incremental cost difference between alternatives is greater than the increase in the benefit score from alternative to alternative (Table 3-2 and Figure 3-6). Benefit scores range from 38-percent lower-than to 6-percent higher-than Alternative 3a while estimated costs range 37-percent lower to 819-percent higher than Alternative 3a. Alternative 4 has a 38-percent lower benefit score and 37-percent lower cost and similar to Alternative 3a and is therefore not disproportionate to Alternative 3a despite the lower benefit score.

3.5.5.2 Summary

The incremental cost and benefit difference analysis shows all alternatives to be disproportionately expensive relative to Alternative 3a, except for Alternative 4 which ranked similarly at the conclusion of the DCA. However, Alternative 3a has a significantly higher benefit score and is therefore preferred over Alternative 4.

3.6 FEASIBLITY STUDY SUMMARY AND CONCLUSIONS

The Remedial Investigation (Section 2) defined and documented physical characteristics, source areas, and the nature and extent of contamination. Data from the RI were used in the FS process to develop and evaluate remedial alternatives for the site.

The FS developed remedial alternatives for the site, evaluated the alternatives against criteria defined by MTCA, provided a comparative analysis of the alternatives to assess the relative environmental benefits of each, and compared the relative benefits of each against their costs to identify the alternative that uses the most permanent solutions to the maximum extent practicable.

3.6.1 Preferred Alternative

The preferred alternative is Alternative 3a, Targeted Sheen-Area AS/SVE with LNAPL Recovery, based on the objectives and evaluations presented in Sections 3.1 through 3.5. Alternative 3a uses permanent solutions to the maximum extent practicable within the site constraints. This option is described in Section 3.3.3.1.

As shown in Table 3-2, the DCA finds that Alternative 3a provides the greatest environmental benefit for the least cost (3.4 cost to benefit ratio). Alternative 3a is preferred over Alternative 4 because it will reach screening levels at the CPOC in a shorter time frame and has a greater overall benefit score.

Alternative 3a has more effective product recovery through combined AS/SVE and LNAPL recovery than Alternative 4, and therefore also requires less frequent long-term groundwater monitoring than Alternative 4.

3.6.2 Implementation of Site Cleanup and Potential Contingency Actions

The selected cleanup action will be presented in a Cleanup Action Plan (CAP), which will describe the cleanup action and will specify cleanup standards and compliance monitoring requirements. The CAP will be finalized after Ecology and public review. Given the complexity of the site, implementation will proceed under a phased approach, including engineering and design, permitting, construction, development and filing of institutional controls, and long-term compliance monitoring and maintenance (as applicable). This process will include optimization of the design to improve system performance and interaction with site operations. Monitoring will be optimized concurrent with design optimization.

The CAP will include a contingency plan to address unsatisfactory remediation performance of the preferred cleanup alternative. Criteria for determining poor remediation performance may include statistical demonstration of a migrating and/or expanding plume, unsatisfactory timeframes for achieving cleanup levels at the CPOC, or demonstrated immediate threat to human health and the environment. The CAP will include a process for assessing and selecting an appropriate contingency response should an issue arise. Typical contingency actions at petroleum-impacted sites include reconfiguration of remediation systems (i.e., additional sparge points), nutrient amendment (i.e., biostimulation), hydraulic control (i.e., pump and treat), and targeted injections of oxygen-releasing or oxidizing compounds. The proposed contingency actions will be presented to Ecology for approval before implementation.

4.0 REFERENCES

Anchor Environmental, L.L.C and Windward Environmental LLC, December 2008. East Waterway Operable Unit Supplemental Remedial Investigation/Feasibility Study Final Conceptual Site Model and Data Gaps Analysis Report. Consultant's report prepared for the Port of Seattle for submittal to the U.S. Environmental Protection Agency Region 10.

ASTM, 2012. Standard Guide for Estimation of LNAPL Transmissivity. Designation E2856-11e. January, 2012.

Booth and Herman, 1998, Duwamish Basin Groundwater Pathways, Conceptual Model Report. Prepared for City of Seattle Office of Economic Development and King County Office of Budget and Strategy Planning, April 1998.

Charbeneau, R., 2007a. LNAPL *Distribution and Recovery Model (LDRM) Volume 1: Distribution and Recovery of Petroleum Liquids in Porous Media*. API Publication 4760. January, 2007.

Charbeneau, R., and Beckett, G., 2007b. *LNAPL Distribution and Recovery Model (LDRM) Volume 2: User and Parameter Selection Guide*. API Publication 4760. January, 2007.

Cruz, J. 2012. Personal Communication regarding sampling and filtering PAHs. March 20, 2012.

Ecology, 2004. Guidance on Remediation of Petroleum-Contaminated Ground Water By Natural Attenuation (Rev. 3.3: for SAB). Washington State Department of Ecology – Toxics Cleanup Program. September 1, 2004.

Ecology, 2005. User's Manual: Natural Attenuation Analysis Tool Package for Petroleum-Contaminated Ground Water. Washington State Department of Ecology Toxics Cleanup Program. Publication 05-09-091A (Version 1.0). July 2005.

Ecology, 2009. Draft Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action. Publication 09-09-047.

Ecology, 2011. Guidance for Remediation of Petroleum Contaminated Sites. Washington State Department of Ecology Publication No. 10-09-057. September, 2011.

Ecology 2012a. Ecology online CLARC Database. *https://fortress.wa.gov/ecy/clarc/Reporting/CLARCReporting.aspx.* Accessed January 2012.

Ecology, 2012b. June 20 Meeting Notes, 2012.

ENSR|AECOM, 2008. First Annual Groundwater Monitoring Report, January – December 2007, ENSR, April.

ENSR|AECOM, 2008a. Supplemental Data Report, Revision 2. Prepared for Port of Seattle Terminal 30 by ENSR., Seattle, Washington. June.

ENSR|AECOM, 2008b. Disproportionate Cost Analysis. Prepared for Port of Seattle Terminal 30 by ENSR, Seattle, Washington. June.

ENSR|AECOM, 2008c. Construction Completion Report. Prepared for Port of Seattle Terminal 30 by ENSR. Seattle, Washington. September.

ENSR|AECOM, 2008d. Terminal 30 Monitoring Well Installation Completion Report. Prepared for Port of Seattle Terminal 30 by ENSR. Seattle, Washington. July.

ENSR|AECOM, 2008e. Terminal 30 Compliance Monitoring Plan. Prepared for Port of Seattle Terminal 30 by ENSR. Seattle, Washington. June.

ENSR|AECOM, 2009. Monitoring Well Modifications and Monitoring Well Installation Letter at Port of Seattle Terminal 30 in Seattle, Washington. Prepared for Port of Seattle Terminal 30 by ENSR. Seattle, Washington. July.

ENSR|AECOM, 2010. Terminal 30 Cargo Terminal Construction Completion Report. Prepared for Port of Seattle Terminal 30 by AECOM. Seattle, Washington. January 2010.

Environmental Protection Agency, 2004. How to Evaluate Alternative Cleanup Technologies for Underground Storage Sites, A Guide of Corrective Action Plan Reviewers. EPA 510-R-04-002. May 2004.

GeoEngineers, Inc., 1998. Terminal 30 Final Report Remedial Investigation/ Feasibility Study. Prepared for the Port of Seattle. December.

GeoEngineers, 1999. Framework, Monitoring Plan Addendum, Chevron/Port of Seattle T30. Seattle, Washington. June 22, 1999.

GeoEngineers, 1999. Summary Memorandum First Round Pre- MPA Field Effort, Chevron/Port of Seattle Facility at Terminal 30. GeoEngineers Inc. June 29, 1999.

GeoEngineers, 2003. Draft Summary Memorandum Second Round Pre-MPA Investigation. GeoEngineers Inc. February 28, 2003.

Huntley, D., 2000. Analytic Determination of Hydrocarbon Transmissivity from Baildown Tests. Groundwater, v. 38, no 1. Jan-Feb 2000.

Interstate Technology & Regulatory Council, 2009. Evaluating LNAPL Remedial Technologies for Achieving Project Goals. December, 2009.

Jambrosic, Aaron, June 7, 2007. Email communication from Aaron Jambrosic, RETEC, to Roy Kuroiwa, Port of Seattle, re: T30 Recent Field Activities. Attachments include ORC application field notes.

Pacific Groundwater Group, 2011. April 2011 Groundwater Sampling and Product Gaging Event—Terminal 30, Port of Seattle. July 25, 2011.

Pacific Groundwater Group, 2012. Terminal 30 Site Screening Levels. Technical Memorandum to Department of Ecology. February 2, 2012.

Seattle Public Utilities, April 2012. 2013 Water System Plan. Our Water. Our Future. Volume I Public Review Draft.

Suthersan, S, and Payne, F., 1999. Remediation Engineering Design Concepts. CRC Press.

TerraTherm, 2012. Personal communication to Glen Wallace.

Western Regional Climate Center (WRCC), 2012. Seattle Urban Site, Washington (457458). Data accessed June 2012 at *http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa7458*.

Weston, R., 1993. Harbor Island Remedial Investigation Report. Two Volumes. Prepared for US EPA, Region 10. Roy. F. Weston, Inc., Seattle, WA.

Notes: ENSR|AECOM references include reports prepared by ENSR, ENSR|AECOM, and AECOM.

Washington State Department of Ecology references listed as Ecology

Table 2-1. On-Site Storage tanks 1905 through 1984

Port of Seattle Terminal 30

Year	Number of Above-Ground Storage Tanks	Tank Locations
1905	10	Northern portion of Pier 32
1914	19	Northern portion of Pier 32
1916	31	Northern portion of Pier 32
1950	27	Pier 32
1984	21	Pier 32

Data from GeoEngineers (GeoEngineers, 1998)

Table 2-2. Summary of Groundwater Field Parameters

Port of Seattle Terminal 30

Well	Date	Dissolved Oxygen	Oxidation Reduction Potential	pH	Specific Conductivity	Temperature	Water Level
		mg/L	*mV*	*std. units*	*umhos/cm*	*C*	*feet*
MW39	1/1/1999				602		
MW42	4/19/2011	0	-109	6.58	7,860	13.7	9.74
MW45	4/19/2011	0	-169	6.74	829	12.4	9.06
MW46	4/19/2011	0	-181	7.2	1,960	12.7	8.9
MW52A	4/19/2011	0	-170	6.77	1,150	12.8	8.93
MW58	1/1/1999				1,819		
MW58	4/19/2011	0	-118	6.38	900	14.3	10.98
MW58	11/8/2011	0.7	-161	6.88	846	15.36	10.6
MW72	1/1/1999				30,533		
MW76A	4/19/2011	0	-135	6.66	865	13.2	8.18
MW81A	4/19/2011	0	-127	6.59	900	13.8	8.59
MW84A	4/19/2011	0	-164	7.28	1,180	14.7	14.2
MW84A	11/8/2011	1.94	-168	7.59	1,040	14.4	13.03
MW84B	4/19/2011	0.86	-95	6.66	961	13	11.27
MW84B	11/8/2011	2.84	-130	6.92	983	15.8	11.16
MW85A	4/19/2011	2.58	-117	7.58	4,890	11.6	10.55
MW85A	11/8/2011	0.99	-155	7.63	6,370		11.01
MW85B	4/19/2011	0	-228	7.16	5,310	14	14
MW85B	11/8/2011	0.5	-187	7.56	3,700	14.2	13.12
MW86B	4/19/2011	3.45	-248	6.82	2,700	11.7	11.89
MW86B	11/8/2011	0.51	-218	6.96	1,850	14.85	12.21
MW86C	4/19/2011	0	-144	6.78	2,130	13	11.03
MW86C	11/8/2011	1.55	-181	7.05	2,290	14.21	11.66
MW87A	4/19/2011	0.72	7	6.73	2,460	12.3	9.86
MW87A	11/8/2011	0.38	-207	6.74	4,051	15.98	11.34
MW87B	4/19/2011	0	-191	7.45	869	14.5	13.84
MW87B	11/8/2011	0.31	-140	8.08	797	14.11	13.87
MW88	4/19/2011	0	-189	8.9	204	12.7	8.94
MW89	4/19/2011	0.64	-117	6.59	3,450	13.3	9.54
MW90	4/19/2011	0	-112	6.56	1,410	13.5	9.81
MW91	4/19/2011	0	-132	6.69	1,020	13.6	7.81

No result indicates that the field parameter was not analyzed for or not reported.

Table 2-3. Summary of Investigation and Remedial Action Reports

Port of Seattle Terminal 30

Report Year	Report or Letter Title	Report Reference(s)	Report Prepared For	Included Media [1]			
				Groundwater	Soil	LNAPL	Infrastructure
1984	Subsurface Site Assessment in Support of Design of NAPL Recovery System	GeoEngineers, 1984 to	Chevron	X	X	X	
1984	Subsurface Exploration and Geotechnical Study	Hart Crowser, 1984	Chevron	X	X	X	
1983 to 1984	Monthly Progress Reports Nos. 1 thru 14	GeoEngineers, 1984 to	Chevron	X	X	X	
1984-1985	Terminal 30 Construction and Dredging	GeoEngineers 1984 to	Port				
1986	Subsurface Investigation and Product Recovery Assessment	GTI, 1986	Port	X			
1991	Agreed Order Attachment C: Work Plan for State RI/FS	Parametrix, 1991	Port				
1993	Harbor Island Remedial Investigation Report	Roy F. Weston, 1993	U.S. EPA				
1993	Sediment Quality Evaluation, Terminal 30 Expansion Project	Parametrix, 1993	Port				
1998	Final Report Remedial Investigation Focused Feasibility Study, ChevronIPort of Seattle T-30, Seattle, Washington	GeoEngineers, 1998	Port	X	X	X	X
1999	Summary Memorandum First Round Pre-MPA Field Effort, Chevron/Port of Seattle Facility at Terminal 30. GeoEngineers Inc.	GeoEngineers, 1999b	Port	X		X	
2003	Draft Summary Memorandum Second Round Pre-MPA Investigation. GeoEngineers Inc.	GeoEngineers, 2003	Port	X		X	
2006	Supplemental Data Report, Revision 1, Terminal 30, Port of Seattle, Seattle, Washington	RETEC, 2006a	Port	X		X	
2006	Letter to Ecology Re: February and March 2006 Groundwater Sampling Results	RETEC, 2006b	Port	X		X	
2006	Letter to Ecology Re: May 2006 Groundwater Sampling Results	RETEC, 2006c	Port	X		X	
2006	Letter to Ecology Re: August 2006 Groundwater Sampling Results	RETEC, 2006d	Port	X		X	
2007	Letter to Ecology Re: November 2006 Groundwater Sampling Results	RETEC, 2007a	Port	X		X	
2007	Letter to Ecology Re: February 2007 Groundwater Sampling Results	RETEC, 2007b	Port	X		X	
2007	Letter to Ecology Re: May 2007 Groundwater Sampling Results	RETEC, 2007c	Port	X		X	
2007	Letter to Ecology Re: August 2007 Groundwater Sampling Results	RETEC, 2007d	Port	X		X	
2008	Terminal 30 Compliance Monitoring Plan	ENSR|AECOM, 2008b	Port	X		X	
2008	Terminal 30 Final Supplemental Data Report, Revision 2	ENSR|AECOM, 2008c	Port	X		X	
2008	Terminal 30 Monitoring Well Installation Completion Report	ENSR|AECOM, 2008d	Port				X
2008	Letter to Ecology Re: November 2007 Groundwater Sampling Results	ENSR|AECOM, 2008e	Port	X		X	
2008	First Annual Groundwater Monitoring Report, January – December 2007	ENSR|AECOM, 2008f	Port	X		X	
2009	Monitoring Well Modifications and Monitoring Well Installation Letter at Port of Seattle Terminal 30 in Seattle, Washington	ENSR|AECOM, 2009	Port				X
2009	Groundwater Sampling Event – Terminal 30, Port of Seattle	ENSR|AECOM, 2009a-d	Port	X		X	
2010	Terminal 30 Cargo Terminal Construction Completion Report	ENSR|AECOM, 2010	Port		X		X
2011	April 2011 Groundwater Sampling and Product Gaging Event—Terminal 30, Port of Seattle	PGG, 2011	Port	X		X	

[1] Presents data or information that may have been included in previous reports.

Table 2-4. Summary of Groundwater Petroleum Hydrocarbon Concentrations

Port of Seattle Terminal 30

	Date	GRO	DRO	MOR	Benzene	Toluene	Ethylbenzene	Xylenes	m, p-Xylene	o-Xylene
Screening Level		*0.8*	*0.5*	*0.5*	*23*	*15,000*	*2,100*	*1,000*	*1,000*	*1,000*
Units		*mg/L*	*mg/L*	*mg/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*
MW-17	10/13/2004	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-17	5/9/2005	0.15	0.26		1.04	0.5 U	0.5 U	1 U		
MW-29	3/7/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-39	1/1/1999									
MW-39	10/13/2004	**1.7**	**120**	**28**	**28**	1 U	2.7		4.3	1 U
MW-42	10/13/2004	**0.85**	**0.9**	0.5 U	**120**	3	3.1		8.7	2.6
MW-42	5/9/2005	**4.47**	0.327		**769**	14	176	131		
MW-42	8/2/2005	**1.62**	**1.58**		**328**	9.56	35.1	35.4		
MW-42	11/29/2005	**3.8**	**2.12**		**763**	17.7	101	77.3		
MW-42	2/13/2006	**1.3**	0.25 U	0.5 U	**65**	2	12		28	4
MW-42	5/8/2006	**2.6**	0.31	0.5 U	**880**	19	110		53	9
MW-42	8/22/2006	**2.1**	0.25 U	0.5 U	**500**	15	73	47	40	7.9
MW-42	11/20/2006	**3.5**	0.25 U	0.5 U	**540**	14	100	61	52	9.1
MW-42	2/26/2007	**2**	0.25 U	0.5 U	530 J	13	87		37	6.8
MW-42	5/29/2007	**1**	0.25 U	0.5 U	**160**	5.6	19		11	3
MW-42	8/8/2007	**1.3**	0.25 U	0.5 U	**240**	9.1	27		15	4
MW-42	11/7/2007	**1.8**	0.25 U	0.5 U	**450**	13	29		18	4.8
MW-42	2/12/2008	0.42 NJ	0.25 U	0.5 U	16	1 U	5		2.4	1 U
MW-42	5/5/2008	**0.83**	0.25 U	0.5 U	**190**	6.7	2.5		3.4	1.8
MW-42	8/11/2008	**1.1**	0.25 U	0.5 U	**150**	6.2	11		5.9	2.2
MW-42	11/11/2008	0.67	0.25 U	0.5 U	**34**	1.8	5.6		3.5	1 U
MW-42	2/17/2009	0.66	0.25 U	0.5 U	**100**	3.6	3.6		2.1	1.1
MW-42	5/18/2009	1.9 J	0.25 U	0.5 U	**210**	9.5	8		5.5	2.5
MW-42	8/18/2009	**2.1**	0.25 U	0.5 U	**360**	14	16		12	5 U
MW-42	11/16/2009	**1.2**	0.25 U	0.5 U	52 J	6.1	4.9		6.5	2.4
MW-42	4/19/2011	**1.2**	0.23	0.25 U	**83**	7.1	3.4	6.3	2.9	0.7
MW-45	10/13/2004	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	5/9/2005	0.05 U	0.25 U		0.5 U	0.5 U	0.5 U	1 U		
MW-45	8/2/2005	0.05 U	0.25 U		0.5 U	0.5 U	0.5 U	1 U		
MW-45	12/1/2005	0.05 U	0.243 U		0.5 U	0.5 U	0.5 U	1 U		
MW-45	2/13/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	5/8/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	8/22/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-45	11/20/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-45	2/26/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	5/29/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	8/8/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	11/7/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	2/12/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	5/5/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	8/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	11/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	2/17/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	5/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	8/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-45	4/19/2011	0.05 U	0.05 U	0.25 U	0.5 U	0.5 U	0.5 U	1 U		
MW-46	12/1/2005	0.05 U	2.39 J		0.5 U	0.5 U	0.5 U	1 U		
MW-46	2/13/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-46	5/8/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-46	8/22/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-46	11/20/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-46	2/26/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-46	5/29/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-46	8/8/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-46	11/7/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-46	2/12/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-46	5/5/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-46	8/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-46	11/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U

Table 2-4. Summary of Groundwater Petroleum Hydrocarbon Concentrations
Port of Seattle Terminal 30

	Date	GRO	DRO	MOR	Benzene	Toluene	Ethylbenzene	Xylenes	m, p-Xylene	o-Xylene
Screening Level		*0.8*	*0.5*	*0.5*	*23*	*15,000*	*2,100*	*1,000*	*1,000*	*1,000*
Units		*mg/L*	*mg/L*	*mg/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*
MW-46	2/17/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-46	5/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-46	8/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-46	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-46	4/19/2011	0.05 U	0.05 U	0.25 U	0.5 U	0.5 U	0.5 U	1 U		
MW-49	3/7/2006	0.72	**2.1**	0.5 U	1 U	1 U	1.7	2 U	1 U	1 U
MW-49	11/7/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-49	2/12/2008	0.27 NJ	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-49	5/5/2008	0.35	0.44	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-52	5/8/2006	0.27 N	**0.67**	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-52A	8/22/2006	0.67	0.25 U	0.5 U	1 U	1 U	1.4	2 U	1 U	1 U
MW-52A	11/20/2006	0.37 NJ	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-52A	2/26/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-52A	5/29/2007	0.48 NJ	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-52A	8/8/2007	0.42 NJ	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-52A	11/7/2007	0.61 NJ	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-52A	2/12/2008	0.9 NJ	**0.75**	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-52A	5/5/2008	0.69	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-52A	8/11/2008	0.71	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-52A	11/11/2008	0.32	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-52A	2/17/2009	0.44	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-52A	5/18/2009	0.5	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-52A	8/18/2009	0.68	**0.54**	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-52A	11/16/2009	0.29	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-52A	4/19/2011	0.26	0.4	0.25 U	0.5 U	0.5 U	0.5 U	1.3		
MW-53	3/7/2006	0.25 U	**1.7**	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-54	3/7/2006	**0.82**	0.25 U	0.5 U	1 U	1 U	1.3	2 U	1 U	1 U
MW-54	11/7/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-54	2/12/2008	0.73 NJ	**1.6**	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-54	5/5/2008	**1.5**	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-54	8/11/2008	**1.2**	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-58	1/1/1999									
MW-58	10/13/2004	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-58	5/9/2005	0.05 U	0.25 U		0.5 U	0.5 U	0.5 U	1 U		
MW-58	8/2/2005	0.05 U	0.368		0.5 U	0.5 U	0.5 U	1 U		
MW-58	11/29/2005	0.05 U	0.236 U		0.5 U	1.76	0.5 U	1 U		
MW-58	2/13/2006	0.25 U	0.25 U	0.5 U	1 U	19	1 U		1 U	1 U
MW-58	5/8/2006	0.25 U	0.25 U	0.5 U	1 U	2.3	1 U		1 U	1 U
MW-58	8/22/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-58	11/20/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-58	2/26/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-58	5/29/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-58	8/8/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-58	11/7/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-58	2/12/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-58	5/5/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-58	8/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-58	11/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-58	2/17/2009	0.35	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-58	5/18/2009	0.38	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-58	8/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-58	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-58	4/19/2011	0.41	0.19	0.25 U	0.5 U	1.5	0.67	1.5		
MW-58	11/8/2011									
MW-59	10/13/2004	**0.95**	**5**	1 U	1 U	1 U	1.1		1 U	1 U
MW-72	1/1/1999									
MW-72	10/13/2004	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-72A	8/2/2005	0.05 U	0.25 U		0.5 U	0.5 U	0.5 U	1 U		
MW-72A	11/29/2005	0.05 U	0.238 U		0.5 U	0.5 U	0.5 U	1 U		

PgG

Table 2-4. Summary of Groundwater Petroleum Hydrocarbon Concentrations

Port of Seattle Terminal 30

	Date	GRO	DRO	MOR	Benzene	Toluene	Ethylbenzene	Xylenes	m, p-Xylene	o-Xylene
Screening Level		*0.8*	*0.5*	*0.5*	*23*	*15,000*	*2,100*	*1,000*	*1,000*	*1,000*
Units		*mg/L*	*mg/L*	*mg/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*
MW-72A	2/13/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-72A	5/8/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-72A	8/22/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-72A	11/20/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-72A	2/26/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-72A	5/29/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-72A	8/8/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-76	10/13/2004	0.25 U	0.25 U	0.5 U						
MW-76	5/9/2005	0.0932	0.25 U		0.5 U	0.5 U	0.5 U	1 U		
MW-76	8/2/2005	0.0651	0.25 U		0.5 U	0.5 U	0.5 U	1 U		
MW-76	11/29/2005	0.128	0.238 U		0.5 U	0.5 U	0.5 U	1.19		
MW-76	2/13/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-76	5/8/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-76	8/22/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-76	11/20/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-76	2/26/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-76	5/29/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-76	8/8/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-76A	5/5/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-76A	8/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-76A	11/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-76A	2/17/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-76A	5/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-76A	8/18/2009	0.25 U	0.3	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-76A	11/16/2009	0.28	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-76A	4/19/2011	0.13	0.34	0.25 U	0.5 U	0.5 U	0.5 U	1 U		
MW-77	3/7/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-77	11/7/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-77	2/12/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-77	5/5/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-77	8/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-78	10/13/2004	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-78A	8/2/2005	0.098	0.25 U		0.539	0.5 U	0.5 U	1 U		
MW-79	10/13/2004	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-79	5/9/2005	0.25 U	0.25 U		2.5 U	2.5 U	2.5 U	5 U		
MW-79A	8/2/2005	0.0806	0.25 U		0.5 U	0.5 U	0.5 U	1 U		
MW-81	10/13/2004	0.25 U	0.28 NJ	0.5 U						
MW-81	5/9/2005	0.0897	0.25 U		0.5 U	0.5 U	0.5 U	1 U		
MW-81	8/2/2005	0.0627	0.336		0.5 U	0.5 U	0.5 U	1 U		
MW-81	11/29/2005	0.138	0.458		0.5 U	0.5 U	0.5 U	1.02 J		
MW-81	2/13/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-81	5/8/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-81	8/22/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-81	11/20/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-81	2/26/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-81	5/29/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-81	8/8/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-81	11/7/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-81	2/12/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-81	5/5/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-81	8/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-81	11/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-81A	5/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-81A	8/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-81A	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-81A	4/19/2011	0.05 U	0.05 U	0.25 U	0.5 U	0.65 U	0.5 U	1 U		
MW-84	10/13/2004	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-84	5/9/2005	0.05 U	0.25 U		0.5 U	0.5 U	0.5 U	1 U		
MW-84	8/2/2005	0.05 U	0.25 U		0.5 U	0.5 U	0.5 U	1 U		

Table 2-4. Summary of Groundwater Petroleum Hydrocarbon Concentrations
Port of Seattle Terminal 30

	Date	GRO	DRO	MOR	Benzene	Toluene	Ethylbenzene	Xylenes	m, p-Xylene	o-Xylene
Screening Level		*0.8*	*0.5*	*0.5*	*23*	*15,000*	*2,100*	*1,000*	*1,000*	*1,000*
Units		*mg/L*	*mg/L*	*mg/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*
MW-84	11/29/2005	0.05 U	0.236 U		0.5 U	0.5 U	0.5 U	1 U		
MW-84	2/13/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-84	5/8/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-84	8/22/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-84	11/20/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-84	2/26/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-84	5/29/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-84	8/8/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-84A	5/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-84A	8/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-84A	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-84A	4/19/2011	0.05 U	0.05 U	0.25 U	0.5 U	0.65 U	0.5 U	1 U		
MW-84A	11/8/2011									
MW-84B	5/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-84B	8/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-84B	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-84B	4/19/2011	0.05 U	0.16	0.25 U	0.5 U	0.65 U	0.5 U	1 U		
MW-84B	11/8/2011									
MW-85	10/13/2004	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85	5/9/2005	0.05 U	0.25 U		0.5 U	0.5 U	0.5 U	1 U		
MW-85	8/2/2005	0.05 U	0.25 U		0.5 U	0.5 U	0.5 U	1 U		
MW-85	11/29/2005	0.05 U	0.24 U		0.5 U	0.5 U	0.5 U	1 U		
MW-85	2/13/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85	5/8/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85	8/22/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-85	11/20/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-85	2/26/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85	5/29/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85	8/8/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85A	5/5/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85A	8/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85A	11/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85A	2/17/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85A	5/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85A	8/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85A	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85A	4/19/2011	0.05 U	0.05 U	0.25 U	0.5 U	0.65 U	0.5 U	1 U		
MW-85A	11/8/2011									
MW-85B	5/5/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85B	8/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85B	11/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85B	2/17/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85B	5/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85B	8/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85B	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-85B	4/19/2011	0.05 U	0.05 U	0.25 U	0.5 U	0.65 U	0.5 U	1 U		
MW-85B	11/8/2011									
MW-86	10/13/2004	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86A	8/2/2005	0.0981	0.27		0.5 U	0.5 U	0.5 U	1.24		
MW-86A	11/29/2005	0.105	**0.525**		0.5 U	0.5 U	0.5 U	1 U		
MW-86A	2/13/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86A	5/8/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86A	8/22/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-86A	11/20/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-86A	2/26/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86A	5/29/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86A	8/8/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86B	5/5/2008	0.38	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86B	8/11/2008	0.28	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U

Table 2-4. Summary of Groundwater Petroleum Hydrocarbon Concentrations

Port of Seattle Terminal 30

	Date	GRO	DRO	MOR	Benzene	Toluene	Ethylbenzene	Xylenes	m, p-Xylene	o-Xylene
Screening Level		*0.8*	*0.5*	*0.5*	*23*	*15,000*	*2,100*	*1,000*	*1,000*	*1,000*
Units		*mg/L*	*mg/L*	*mg/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*
MW-86B	11/11/2008	0.27	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86B	2/17/2009	**0.91**	0.25 U	0.5 U	1 U	1 U	1		1 U	1 U
MW-86B	5/18/2009	0.47	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86B	8/18/2009	0.3	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86B	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86B	4/19/2011	0.21	0.087	0.25 U	0.5 U	1.5	0.88	1.8	1 U	0.5 U
MW-86B	11/8/2011									
MW-86C	5/5/2008	0.3	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86C	8/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86C	11/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86C	2/17/2009	0.31	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86C	5/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86C	8/18/2009	0.25 UJ	0.25 U	0.5 U	1 UJ	1 UJ	1 UJ		1 UJ	1 UJ
MW-86C	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-86C	4/19/2011	0.25	0.069	0.25 U	0.5 U	1.2	0.5 U	1.6	1 U	0.5 U
MW-86C	11/8/2011									
MW-87	10/13/2004	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87	5/9/2005	0.159	0.25 U		0.5 U	0.5 U	0.5 U	1 U		
MW-87	8/2/2005	0.199	0.44		0.5 U	0.5 U	0.5 U	1 U		
MW-87	11/29/2005	0.297	**1.37**		0.5 U	0.5 U	0.5 U	2.5		
MW-87	2/13/2006	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87	5/8/2006	0.29 N	**0.64**	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87	8/22/2006	0.3	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-87	11/20/2006	0.31 NJ	0.25 U	0.5 U	1 U	1 U	1 U	2 U	1 U	1 U
MW-87	2/26/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87	5/29/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87	8/8/2007	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87A	5/5/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87A	8/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87A	11/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87A	2/17/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87A	5/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87A	8/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87A	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87A	4/19/2011	0.05 U	0.05 U	0.25 U	0.5 U	0.5 U	0.5 U	1 U		
MW-87A	11/8/2011									
MW-87B	5/5/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87B	8/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87B	11/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87B	2/17/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87B	5/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87B	8/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87B	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-87B	4/19/2011	0.05 U	0.05 U	0.25 U	0.5 U	0.5 U	0.5 U	1 U		
MW-87B	11/8/2011									
MW-88	5/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-88	8/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-88	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-88	4/19/2011	0.05 U	0.05 U	0.25 U	0.5 U	0.65 U	0.5 U	1 U		
MW-89	5/5/2008	**1.2**	0.25 U	0.5 U	1 U	1 U	1.5		1 U	1 U
MW-89	8/11/2008	**0.85**	0.25 U	0.5 U	1.4	1 U	1.1		1 U	1 U
MW-89	2/17/2009	0.4	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-89	5/18/2009	**0.84**	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-89	8/18/2009	**0.92**	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-89	11/16/2009	**1.1**	0.25 U	0.5 U	1 U	1.9	1.3		1 U	1 U
MW-89	4/19/2011	**0.88**	0.22	0.25 U	0.5 U	3.4	0.5 U	5.6	1.4	0.5 U
MW-90	5/5/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-90	8/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-90	11/11/2008	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-90	2/17/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U

Table 2-4. Summary of Groundwater Petroleum Hydrocarbon Concentrations

Port of Seattle Terminal 30

	Date	GRO	DRO	MOR	Benzene	Toluene	Ethylbenzene	Xylenes	m, p-Xylene	o-Xylene
Screening Level		*0.8*	*0.5*	*0.5*	*23*	*15,000*	*2,100*	*1,000*	*1,000*	*1,000*
Units		*mg/L*	*mg/L*	*mg/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*	*ug/L*
MW-90	5/18/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-90	8/18/2009	0.25 UJ	0.25 U	0.5 U	1 UJ	1 UJ	1 UJ		1 UJ	1 UJ
MW-90	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-90	4/19/2011	0.05 U	0.05 U	0.25 U	0.5 U	0.5 U	0.5 U	1 U		
MW-91	5/5/2008	0.61	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-91	8/11/2008	0.47	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-91	11/11/2008	0.27	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-91	2/17/2009	0.41	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-91	5/18/2009	0.51	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-91	8/18/2009	0.45	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-91	11/16/2009	0.25 U	0.25 U	0.5 U	1 U	1 U	1 U		1 U	1 U
MW-91	4/19/2011	0.17	0.05 U	0.25 U	0.5 UG	0.5 UG	0.9 G	1 UG		
RW-11A	5/5/2008	**0.89**	0.25 U	0.5 U	**47**	1 U	1.4		1 U	1 U
RW-11A	8/11/2008	**0.95**	0.25 U	0.5 U	**41**	1.4	1.4		1 U	1 U
RW-5A	5/5/2008	**1.3**	0.25 U	0.5 U	1 U	1 U	1.6		1 U	1 U

DRO: Diesel Range Organics

GRO: Gasoline Range Organics

MOR: Motor Oil Range Hydrocarbons

DRO, GRO and MOR results prior to 1998 analyzed by EPA Method 8015; analyses after 1998 by method NWTPH-Gx/Dx.

U: Non-detect at shown reporting limit

J: Estimated value or reporting limit

G: sample analyzed from container not approved for analytical method; result should be considered an estimate.

N: estimated or presumed presence of constituent.

No result indicates constituent not analyzed for

Bold with shading indicates result above screening level

Table 2-5. Soil Screening Levels
Port of Seattle Terminal 30

Constituent	2013 RI/FS Soil Screening Levels (mg/kg)	2008 CMP Soil Cleanup Levels (mg/kg)	Soil, Method A, Industrial Land Use, Table Value (mg/kg)	Soil Leaching to Groundwater Protective of Surface Water[1,2] (mg/kg)
PAH Compounds				
Acenaphthene	**NV**	NV	Researched-No Data	66
Acenaphthylene	**NV**	NV	Not Researched	--
Anthracene	**NV**	NV	R-ND	12,273
Benzo[a]anthracene	**NV**	NV	R-ND	0
Benzo[a]pyrene	**0.35**	2	2	0.35
Benzo[b]fluoranthene	**0.44**	NV	R-ND	0.44
Benzo[g,h,i]perylene	**NV**	NV	NR	NV
Benzo[k]fluoranthene	**0.44**	NV	R-ND	0.44
Chrysene	**0.14**	NV	R-ND	0.14
Dibenzo[a,h]anthracene	**0.64**	NV	R-ND	0.64
Fluoranthene	**89**	NV	R-ND	89
Fluorene	**547**	NV	R-ND	547
Indeno[1,2,3-cd]pyrene	**1.25**	NV	R-ND	1.25
Naphthalene	**5**	5	5	138
Phenanthrene	**NV**	NV	NR	NV
Pyrene	**3,532**	NV	R-ND	3,532
Semivoliatile Organic Compounds				
2-Methylnaphthalene	**NV**	NV	NR	NV
BTEX Compounds				
Benzene	**0.03**	0.03	0.03	0.13
Toluene	**7**	7	7	109
Ethylbenzene	**6**	6	6	18
Xylenes (total)	**9**	9	9	9.1
Xylene;m-	**NV**	NV	R-ND	NV
Xylene;o-	**NV**	NV	R-ND	NV
Xylene;p-	**NV**	NV	NR	NV
Petroleum Hydrocarbons				
Tph, diesel range organics	**2,000**	2,000	2000	NV
Tph, heavy oils	**2,000**	2,000	2000	NV
Tph: gasoline range organics, benzene present	**30**	30	30	NV
Tph: gasoline range organics, no detectable benzene	**100**	100	100	NV

"R-ND" means research has been conducted and no data exists in the database for this parameter.
"NR" means research has not been conducted and no value exists in the database for this parameter.
"NV" indicates that no value is available.
[1]Soil leaching to groundwater pathway calculated using MTCA Equation 747-1 and CLARC default values when available.
[2]Soil leaching to groundwater pathway protective of screening levels in Table 1.

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Table 2-6. Groundwater Screening Levels

Port of Seattle Terminal 30

Constituent	2013 RI/FS Groundwater Screening Levels (ug/L)	2008 Supplemental Data Report/CMP Cleanup Levels (ug/L)	Groundwater ARAR - Federal Primary Maximum Contaminant Level (MCL, ug/L)	Groundwater ARAR State Primary Maximum Contaminant Level (MCL, ug/L)	Groundwater, Method A, Table Value (µg/L)	Surface Water ARAR Aquatic Life (Note 1)	Surface Water ARAR Human Health Fresh Water Clean Water Act §304 (µg/L)	Surface Water ARAR Human Health Fresh Water National Toxics Rule, 40 CFR 131 (µg/L)	Surface Water ARAR Human Health Marine Clean Water Act §304 (µg/L)	Surface Water ARAR Human Health Marine National Toxics Rule, 40 CFR 131 (µg/L)	Surface Water, Method B, Carcinogen, Standard Formula Value (µg/L)	Surface Water, Method B, Non-Carcinogen, Standard Formula Value (µg/L)
PAH Compounds												
Acenaphthene	**643**	643	NR	NR	R-ND	R-ND	670	NR	990	NR	NR	642.79
Acenaphthylene	**NV**	NV	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Anthracene	**25,900**	25,900	NR	NR	R-ND	R-ND	8300	9600	40000	110000	NR	25925.93
Benzo(a)anthracene	**0.018**	0.018	NR	NR	R-ND	R-ND	0.0038	0.0028	0.018	0.0311	0.296	NR
Benzo(a)pyrene	**0.018**	0.018	0.2	0.2	0.1	R-ND	0.0038	0.0028	0.018	0.0311	0.03	NR
Benzo(b)fluoranthene	**0.018**	0.018	NR	NR	R-ND	R-ND	0.0038	0.0028	0.018	0.0311	0.296	NR
Benzo(g,h,i)perylene	**NV**	NV	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzo(k)fluoranthene	**0.018**	0.018	NR	NR	R-ND	R-ND	0.0038	0.0028	0.018	0.0311	2.96	NR
Chrysene	**0.018**	0.018	NR	NR	R-ND	R-ND	0.0038	0.0028	0.018	0.0311	29.6	NR
Dibenzo(a,h)anthracene	**0.018**	0.018	NR	NR	R-ND	R-ND	0.0038	0.0028	0.018	0.0311	0.0296	NR
Dibenzofuran	**NV**	NV	NR	NR	R-ND	NR	NR	NR	NR	NR	NR	NR
Fluoranthene	**90**	90	NR	NR	R-ND	R-ND	130	300	140	370	NR	90.18
Fluorene	**3,460**	3,460	NR	NR	R-ND	R-ND	1100	1300	5300	14000	NR	3456.79
Indeno(1,2,3-cd)pyrene	**0.018**	0.018	NR	NR	R-ND	R-ND	0.0038	0.0028	0.018	0.0311	0.296	NR
Naphthalene	**4940**	4940	NR	NR	160	R-ND	NR	NR	NR	NR	NR	4938.27
Phenanthrene	**NV**	NV	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Pyrene	**2590**	2590	NR	NR	R-ND	R-ND	830	960	4000	11000	NR	2592.59
Semivoliatile Organic Compounds												
2-Methylnaphthalene	**NV**	NV	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
BTEX Compounds												
Benzene	**23**	23	5	5	5	R-ND	2.2	1.2	51	71	22.66	1990.00
Toluene	**15,000**	48,500	1000	1000	1000	R-ND	1300	6800	15000	200000	NR	19400
Ethylbenzene	**2,100**	6,910	700	700	700	R-ND	530	3100	2100	29000	NR	6913.58
Xylenes (total)	**1,000**	1,000	10000	10000	1000	R-ND	NR	NR	NR	NR	NR	NR
Petroleum Hydrocarbons												
Tph, diesel range organics	**500**	500	NR	NR	500	R-ND	NR	NR	NR	NR	NR	NR
Tph, heavy oils	**500**	500	NR	NR	500	R-ND	NR	NR	NR	NR	NR	NR
Tph: gasoline range organics, benzene present*	**800**	800	NR	NR	800	R-ND	NR	NR	NR	NR	NR	NR
Tph: gasoline range organics, no detectable benzene*	**1,000**	1,000	NR	NR	1000	R-ND	NR	NR	NR	NR	NR	NR

"R-ND" means research has been conducted and no data exists in the database for this parameter ("Researched- No Data").

"NR" means research has not been conducted and no value exists in the database for this parameter ("Not Researched').

"NV" indicates that no value is available.

Note 1: The following ARARs were all listed as "Researched-No Data": Surface Water ARAR - Aquatic Life - Fresh/Acute - Ch. 173-201A WAC; Surface Water ARAR - Aquatic Life - Fresh/Acute - Clean Water Act §304; Surface Water ARAR - Aquatic Life - Fresh/Acute - National Toxics Rule - 40 CFR 131; Surface Water ARAR - Aquatic Life - Fresh/Chronic - Ch. 173-201A WAC; Surface Water ARAR - Aquatic Life - Fresh/Chronic - Clean Water Act §304; Surface Water ARAR - Aquatic Life - Fresh/Chronic - National Toxics Rule, 40 CFR 131; Surface Water ARAR - Aquatic Life - Marine/Acute - Ch. 173-201A WAC; Surface Water ARAR - Aquatic Life - Marine/Acute - Clean Water Act §304; Surface Water ARAR - Aquatic Life - Marine/Acute - National Toxics Rule, 40 CFR 131; Surface Water ARAR - Aquatic Life - Marine/Chronic - Ch. 173-201A WAC; Surface Water ARAR - Aquatic Life - Marine/Chronic - Clean Water Act §304; Surface Water ARAR - Aquatic Life - Marine/Chronic - National Toxics Rule, 40 CFR 131.

Table 2-7. Summary of Soil Samples with Concentrations in Exceedance of Screening Levels

Port of Seattle Terminal 30

Sample ID	Depth	Year	GRO	DRO	Oil-Range
Units	*ft*		*mg/kg*	*mg/kg*	*mg/kg*
Screening Level	--		30 / 100 *	2,000	2,000
E/W Duct 2 Comp	1 to 4	2007	**31**	250	760
E/W Duct 3 Bottom	5.5 to 6	2007	**330**	**2,100**	590
ET-1-0109	2	2009	**3,130**	**3,790**	1,470
EX-Bottom	8 to 8.5	2008	34 U	**10,000**	**3,400**
EX-E.Sidewall	4 to 8	2008	30 U	**12,000**	**11,000**
EX-NESW	4 to 7	2008	11 U	**6,100**	**7,000**
EX-W.Sidewall	4 to 8	2008	11 U	**2,200**	1,600
MW-74-4	10.5 to 11.0	1992	**50**	130	43
MW-77-3	8 to 9	1992	**7,700**	**6,300**	1900 U
MW-78-5	12.0 to 12.5	1992	**3,500**	**3,800**	1000 U
MW-78A-9-10.5-0805	9 to 10.5	2005	**6,710**	**5,870**	**2,390**
MW-79-2	5.5 to 6.5	1992	970 U	**3,700**	970 U
MW-79A-9.5-10.5-0805	9.5 to 10.5	2005	**7,720**	**7,980**	2500 U
MW-80-3	8.0 to 9.0	1992	4800 U	**30,000**	4800 U
Pothole 1 0-4	0 to 4	2007	110 U	**7,500**	**5,300**
RTG EAST 1	2	2007	**740**	**4,100**	420
RTG EAST 10	2	2007	**140**	510	920
RTG EAST 2	2	2007	**93**	360	180
RTG EAST 7	2	2007	**360**	420	210
RTG EAST 8	2	2007	**61**	46	160
RTG WEST 1	2	2007	**440**	**3,600**	770
RTG WEST 2	2	2007	**120**	620	580
S.Vault-10.5-11	10.5 to 11	2008	15 U	**15,000**	**14,000**
S.Vault-North-7.0-8.5	7 to 8.5	2008	6.6	1,900	**3,400**
SS 10 8to9	8 to 9	2007	**1,800**	**12,000**	570 U
SS 170 8to9	8 to 9	2007	**4,600**	**6,700**	**2,600**
SS 300 0to5	0 to 5	2007	**96**	**6,800**	**11,000**
SS 300 8to9	8 to 9	2007	**980**	**2,600**	1,700
SS 450 0to4	0 to 4	2007	**46**	10	18
SS 450 6to7	6 to 7	2007	**4,800**	**4,100**	1,200
SS 585 5to6	5 to 6	2007	**220**	44	24
SS-0	6	2007	**450**	1,700	1,300
SS-0-6	0 to 6	2007	**290**	**2,100**	150
SS-274	3	2007	**1,600**	**30,000**	**36,000**
TS-3-0-4	0 to 4	2007	12	**3,700**	**6,500**
W. Vault-1-3-4	3 to 4	2008	11 U	**6,000**	860
W. Vault-NWSW	4 to 8	2008	11 U	**5,900**	900
W. Vault-SWSW	4 to 8	2008	11 U	**3,300**	750

See Appendix E for complete historic soil data.

GRO: Gasoline Range Organics

DRO: Diesel Range Organics

* GRO screening level is 30 mg/kg if benzene also present; benzene assumed present.

Bold indicates exceedance of screening levels.

NA: not available.

U: non-detect at shown reporting limit

See Figures 2-9 thorugh 2-12 for sample locations.

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Table 2-8a. Summary of Groundwater PAH and SVOC Concentrations
Port of Seattle Terminal 30

Well	Sample Date	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene
Screening Level (ug/L)		*NV*	*643*	*NV*	*25,900*	*0.018*	*0.018*	*0.018*	*NV*	*0.018*	*0.018*	*0.018*	*NV*	*90*	*3,460*	*0.018*	*4,940*	*NV*	*2,590*
MW-17	10/13/2004	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-17	5/9/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-39	10/13/2004	14	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-42	10/13/2004	1.8	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1.3	1 U	1 U
MW-42	5/9/2005	27.5	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	37.5	10 U	10 U
MW-42	8/2/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	13.6	10 U	10 U
MW-42	11/29/2005	17	0.318	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U		0.0952 U	0.368	0.0952 U	21.3	0.19	0.0952 U
MW-42	2/13/2006	11	0.17	0.02 J	0.01	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.09	0.01 U	0.24	0.01 U	17	0.14	0.01 U
MW-42	5/8/2006	17 J	0.22 J	0.024 J	0.015 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.1 J	0.019	0.28 J	0.01 U	30 J	0.12	0.031
MW-42	8/22/2006	7.8 B	0.15	0.016	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.074	0.012	0.19	0.01 U	11 B	0.074	0.022
MW-42	11/20/2006	18 B	0.19	0.02	0.022	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.097	0.012	0.26	0.01 U	18 B	0.14	0.022
MW-42	2/26/2007	20 B	0.21	0.025 J	0.02	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.13	0.012	0.32	0.01 U	18 B	0.16	0.026
MW-42	5/29/2007	0.57	0.084	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.032	0.01 U	0.087	0.01 U	1.2	0.015	0.021
MW-42	8/8/2007	6.2 J	0.15	0.013 J	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.015	0.01 U	0.066	0.017	0.18	0.01 U	9.3	0.053 J	0.039
MW-42	11/7/2007	8.3	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	5.6	1 U	1 U
MW-42	2/12/2008	1	0.074	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.027	0.012	0.072	0.01 U	0.67 B	0.043	0.026
MW-42	5/5/2008	0.9	0.15	0.01 U	0.01	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.041	0.014	0.13	0.01 U	0.63	0.028	0.026
MW-42	8/11/2008	6.3 B	0.22	0.02 J	0.02	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01	0.01 U	0.09	0.02	0.21	0.01 U	4.7 B	0.11	0.03
MW-42	11/11/2008	7.1 B	0.18 B	0.01 U	0.042 B	0.01 B	0.01 U	0.01 U	0.01 U	0.01 U	0.015 B	0.01 U	0.077 B	0.05 B	0.26 B	0.01 U	4.6 B	0.2 B	0.06 B
MW-42	2/17/2009	1.2	0.11	0.01 U	0.01	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.046	0.016	0.13	0.01 U	2.1	0.059	0.029
MW-42	5/18/2009	4.1	0.15	0.01 U	0.011	0.01 U	0.01 U	0.01 U	0.015 U	0.01 U	0.01 U	0.01 U	0.073	0.014	0.17	0.01 U	3.4	0.083	0.028
MW-42	8/18/2009	8.2	0.23	0.025 J	0.011	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.087	0.013	0.23	0.01 U	6.7	0.1 B	0.024
MW-42	11/16/2009	8.2	0.2	0.025 J	0.011	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.11	0.012	0.24	0.01 U	4	0.13	0.025
MW-42	4/19/2011		0.34	0.62	0.05 U	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.05 U	0.5	0.018 U	1.8	0.18	0.05 U
MW-45	10/13/2004	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-45	5/9/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-45	8/2/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-45	12/1/2005	0.0943 U	0.623	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U		0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U
MW-45	2/13/2006	0.02	0.38	0.01 J	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.06	0.01 U	0.01 U
MW-45	5/8/2006	0.026	0.24	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.012	0.01 U	0.01 U	0.019	0.01 U	0.01 U	0.059 B	0.01 U	0.016
MW-45	8/22/2006	0.01 U	0.53	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
MW-45	11/20/2006	0.01 U	0.76	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.02	0.01 U	0.051	0.01 U	0.01 U	0.01 U	0.01 U
MW-45	2/26/2007	0.01 U	3.8	0.021	0.011	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.48	0.01 U	0.98	0.01 U	0.01 U	0.3	0.01 U
MW-45	5/29/2007	0.01 U	0.91	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.056	0.01 U	0.12	0.01 U	0.03	0.023	0.01 U
MW-45	8/8/2007	0.01 U	0.46	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.022	0.01 U	0.01 U
MW-45	11/7/2007	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-45	2/12/2008	0.01 U	0.41	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.011	0.01 U	0.017	0.01 U	0.01 U	0.01 U	0.01 U
MW-45	5/5/2008	0.01 U	0.18	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01	0.01 U	0.042	0.01 U	0.01 U
MW-45	8/11/2008	0.01 U	0.25	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.03 B	0.01 U	0.01 U
MW-45	11/11/2008	0.055 B	0.41 B	0.01 U	0.027 B	0.015 B	0.01 U	0.01 U	0.01 U	0.01 U	0.014 B	0.01 U	0.02 B	0.069 B	0.11 B	0.01 U	0.093 B	0.17 B	0.058 B
MW-45	2/17/2009	0.014	0.44	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.025	0.01 U	0.035	0.01 U	0.048	0.01 U	0.01 U
MW-45	5/18/2009	0.021	0.13	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.014 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.012	0.01 U	0.082	0.01 U	0.01 U
MW-45	8/18/2009	0.015	0.3	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.021	0.01 U	0.01 U
MW-45	11/16/2009	0.019	0.31	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.018	0.01 U	0.022	0.01 U	0.017	0.01 U	0.01 U
MW-45	4/19/2011		0.52	0.05 U	0.05 U	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.05 U	0.05 U	0.018 U	0.05 U	0.05 U	0.05 U

Table 2-8a. Summary of Groundwater PAH and SVOC Concentrations

Port of Seattle Terminal 30

Well	Sample Date	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene
Screening Level (ug/L)		*NV*	*643*	*NV*	*25,900*	*0.018*	*0.018*	*0.018*	*NV*	*0.018*	*0.018*	*0.018*	*NV*	*90*	*3,460*	*0.018*	*4,940*	*NV*	*2,590*
MW-46	12/1/2005	0.0952 U	0.118	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U		0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U
MW-46	2/13/2006	0.01	0.02	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.02	0.01	0.01 U
MW-46	5/8/2006	0.01 U	0.017	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.024	0.01 U	0.01 U	0.01 U	0.019	0.022
MW-46	8/22/2006	0.01 U	0.052	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.047	0.01 U	0.01 U	0.01 U	0.049	0.034
MW-46	11/20/2006	0.01 U	0.061	0.01 U	0.019	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.044	0.01 U	0.01 U	0.01 U	0.063	0.036
MW-46	2/26/2007	0.01 U	0.032	0.01 U	0.01	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.036	0.01 U	0.01 U	0.01 U	0.029	0.033
MW-46	5/29/2007	0.01 U	0.027	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.031	0.01 U	0.01 U	0.018	0.031	0.029
MW-46	8/8/2007	0.014	0.032	0.01 U	0.014	0.016	0.01 U	0.01 U	0.01 U	0.01 U	0.012	0.01 U	0.01 U	0.076	0.01 U	0.01 U	0.018	0.054	0.059
MW-46	11/7/2007	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-46	2/12/2008	0.01 U	0.03	0.01 U	0.013	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.042	0.01 U	0.01 U	0.01 U	0.046	0.04
MW-46	5/5/2008	0.01	0.074	0.01 U	0.023	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.051	0.01 U	0.01 U	0.024	0.064	0.05
MW-46	8/11/2008	0.01 U	0.12	0.01 U	0.04	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.05	0.01	0.01 U	0.03 B	0.12	0.06
MW-46	11/11/2008	0.026 B	0.079 B	0.01 U	0.06 B	0.018 B	0.014 B	0.012 B	0.01 U	0.012 B	0.02 B	0.01 U	0.01 U	0.065 B	0.015 B	0.01 U	0.059 B	0.12 B	0.058 B
MW-46	2/17/2009	0.012	0.098	0.01 U	0.022	0.012	0.017	0.015	0.011	0.016	0.017	0.01 U	0.01 U	0.066	0.032	0.01 U	0.1	0.11	0.072
MW-46	5/18/2009	0.01 U	0.021	0.01 U	0.01 U	0.016	**0.028**	**0.019**	0.035 U	**0.02**	**0.025**	**0.022**	0.01 U	0.04	0.01 U	**0.03**	0.032	0.018	0.044
MW-46	8/18/2009	0.01 U	0.033	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.017	0.01 U	0.01 U	0.017	0.015 U	0.018
MW-46	11/16/2009	0.01 U	0.062	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.02	0.01 U	0.01 U	0.014	0.029	0.02
MW-46	4/19/2011		0.05 U	0.05 U	0.05 U	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.05 U	0.05 U	0.018 U	0.05 U	0.05 U	0.05 U
MW-49	11/7/2007	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-49	2/12/2008	0.12	0.34	0.022	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.012	0.01	0.078	0.01 U	0.081 B	0.066	0.016
MW-49	5/5/2008	0.082	0.32	0.028	0.015	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.014	0.01 U	0.01 U	0.015	0.085	0.01 U	0.093	0.052	0.013
MW-52	5/8/2006	0.16	0.15	0.016	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.066	0.036	0.21	0.01 U	0.01 U	0.19	0.027
MW-52A	8/22/2006	19 B	0.83	0.12	0.078	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.31	0.021	0.92	0.01 U	0.44 B	0.58 J	0.019
MW-52A	11/20/2006	0.72 B	0.12	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.016	0.01 U	0.055	0.01 U	0.078 B	0.028	0.01 U
MW-52A	2/26/2007	2.6 B	0.21	0.026 J	0.014	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.084	0.01 U	0.22	0.01 U	0.11 B	0.18	0.01 U
MW-52A	5/29/2007	3	0.45	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.13	0.01	0.43	0.01 U	0.32	0.15	0.01
MW-52A	8/8/2007	7.6	0.55	0.074 J	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.19	0.01 U	0.63	0.01 U	0.32	0.34	0.01 U
MW-52A	11/7/2007	3.9	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-52A	2/12/2008	11	0.63	0.08	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.22	0.012	0.7	0.01 U	0.5 B	0.52	0.017
MW-52A	5/5/2008	11	0.63	0.087	0.026	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.18	0.013	0.72	0.01 U	0.82	0.41	0.011
MW-52A	8/11/2008	6.5	0.6	0.09	0.05	**0.02**	0.01	**0.02**	0.02	**0.02**	**0.03**	**0.02**	0.26	0.03	0.75	**0.02**	0.38 B	0.51	0.03
MW-52A	11/11/2008	0.037 B	0.18 J	0.028 J	0.091 J	0.13 B	0.074 B	0.058 B	0.032	0.058 B	0.092 B	0.015	0.043 J	0.31 J	0.29 J	**0.031**	0.17 B	0.64 J	0.26 J
MW-52A	2/17/2009	0.096	0.28	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.14	0.011	0.39	0.01 U	0.23 J	0.28	0.01
MW-52A	5/18/2009	8.6	0.6	0.092	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.24	0.011	0.66	0.01 U	0.38	0.41 J	0.013
MW-52A	8/18/2009	12	0.8	0.12 J	0.023 J	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.3	0.01 U	0.86	0.01 U	0.31	0.44	0.01 U
MW-52A	11/16/2009	0.075	0.19	0.029 J	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.095	0.01 U	0.23	0.01 U	0.074	0.19	0.01 U
MW-52A	4/19/2011		0.94	0.05 U	0.05 U	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.05 U	1.2	0.018 U	0.05 U	0.8	0.05 U
MW-54	11/7/2007	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-54	2/12/2008	0.026	0.54	0.04	0.046	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.23	0.043	0.7	0.01 U	0.38 B	0.048	0.041
MW-54	5/5/2008	0.056	0.94	0.1	0.11	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.54	0.062	2	0.01 U	0.68	0.089	0.045
MW-54	8/11/2008	0.03	0.99	0.1 J	0.11	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.59	0.06	1.8	0.01 U	0.71 B	0.06	0.04
MW-58	10/13/2004	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-58	5/9/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-58	8/2/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-58	11/29/2005	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 UJ	0.0943 UJ	0.0943 UJ	0.0943 UJ	0.0943 UJ	0.0943 UJ	0.0943 U		0.0943 UJ	0.0943 U	0.0943 U	0.0943 U	0.0943 UJ	0.0943 UJ

PgG

Table 2-8a. Summary of Groundwater PAH and SVOC Concentrations

Port of Seattle Terminal 30

Well	Sample Date	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene
Screening Level (ug/L)		*NV*	*643*	*NV*	*25,900*	*0.018*	*0.018*	*0.018*	*NV*	*0.018*	*0.018*	*0.018*	*NV*	*90*	*3,460*	*0.018*	*4,940*	*NV*	*2,590*
MW-58	2/13/2006	0.02	0.88	0.01	0.01	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01	0.12 B	0.05	0.01 U	0.05	0.01	0.1 B
MW-58	5/8/2006	0.01	0.77	0.013	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.073	0.054	0.01 U	0.01 U	0.016	0.064
MW-58	8/22/2006	0.01 U	0.12	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.051	0.01	0.01 U	0.01 U	0.011	0.046
MW-58	11/20/2006	0.01 U	0.28	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.05	0.01	0.01 U	0.01 U	0.011	0.041
MW-58	2/26/2007	0.01 U	0.74	0.01 U	0.011	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.1	0.051	0.01 U	0.01 U	0.011	0.08
MW-58	5/29/2007	0.01 U	0.12	0.011	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.034	0.014	0.01 U	0.012	0.01 U	0.03
MW-58	8/8/2007	0.01 U	0.23	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.045	0.012	0.01 U	0.013	0.01 U	0.039
MW-58	11/7/2007	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-58	2/12/2008	0.023	0.64	0.016	0.015	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.02	0.12	0.14	0.01 U	0.089 B	0.032	0.099
MW-58	5/5/2008	0.23	2.2	0.051	0.4	**0.054**	0.01 U	0.012	0.01 U	0.01 U	**0.04**	0.01 U	0.088	1	0.76	0.01 U	1.4	0.68	0.7
MW-58	8/11/2008	0.1 B	1.8	0.04	0.45	**0.02**	0.01 U	0.01 U	0.01 U	0.01 U	**0.03**	0.01 U	0.09	0.91	0.63	0.01 U	0.59 B	0.55	0.59
MW-58	11/11/2008	0.13 B	2.7 B	0.032 J	0.93 B	0.08 B	0.01 U	0.01 U	0.01 U	0.01 U	0.08 B	0.01 U	0.21 B	2.1 B	0.79 B	0.01 U	0.84 B	1.2 B	1.3 B
MW-58	2/17/2009	0.34	4.4	0.072	0.5	**0.046**	0.01 U	0.01 U	0.01 U	0.01 U	**0.043**	0.01 U	0.46	1.6	1.9	0.01 U	2.3	1.6	1.1
MW-58	5/18/2009	0.11	3.2	0.07	0.55	**0.063**	0.01 U	0.01 U	0.01 U	0.01 U	**0.059**	0.01 U	0.26	2	1.5	0.01 U	0.7	1.2	1.3
MW-58	8/18/2009	0.029	1.8	0.031 J	0.3	**0.042**	0.01 U	0.01 U	0.01 U	0.01 U	**0.046**	0.01 U	0.098	1.3	0.72	0.01 U	0.28	0.4	0.84
MW-58	11/16/2009	0.061	3	0.042 J	0.3	**0.049**	0.01 U	0.01 U	0.01 U	0.01 U	**0.058**	0.01 U	0.25	1.4	1.2	0.01 U	0.61	0.57	0.93
MW-58	4/19/2011		4.9	0.12	0.45	**0.084**	0.018 U	0.018 U	0.05 U	0.018 U	**0.081**	0.018 U		1.9	2.7	0.018 U	1.1	2	1.3
MW-58	11/8/2011	0.1 U	1.8	0.1 U	0.27	**0.053**	0.01 U	0.01	0.1 U	0.01 U	**0.057**	0.01 U		1.1	1	0.01 U	0.1 U	0.59	0.85
MW-58	4/19/2012	2.5 U	2.5 U	2.5 U	2.5 U	0.5 U	0.5 U	0.5 U	2.5 U	0.5 U	0.5 U	0.5 U		2.5 U	2.5 U	0.5 U	2.5 U	3.3	2.5 U
MW-59	10/13/2004	60	2.6	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1.1	1 U	5	1 U	1 U	6	1 U
MW-72	10/13/2004	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-72A	8/2/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-72A	11/29/2005	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U		0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U	0.0952 U
MW-72A	2/13/2006	0.01 U	0.01	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01	0.01 U	0.01 U
MW-72A	5/8/2006	0.015	1.7	0.024	0.019	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.011	0.01 U	0.014	0.58	0.03	0.01 U	0.092 B	0.01 U	0.44
MW-72A	8/22/2006	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
MW-72A	11/20/2006	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
MW-72A	2/26/2007	0.01 U	0.2	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.058	0.01 U	0.01 U	0.01 U	0.01 U	0.07
MW-72A	5/29/2007	0.01 U	1	0.017	0.019	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.031	0.48	0.034	0.01 U	0.046	0.022	0.33
MW-72A	8/8/2007	0.01 U	0.024	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.033	0.01 U	0.01 U
MW-76	11/29/2005	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U		0.123	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.111
MW-76	2/13/2006	0.01 U	0.04	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.03	0.01 U	0.01 U
MW-76	5/8/2006	0.01 U	0.026	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
MW-76	8/22/2006	0.01 U	0.026	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
MW-76	11/20/2006	0.01 U	0.049	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.058 B	0.01 U	0.01 U
MW-76	2/26/2007	0.01 U	0.046	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
MW-76	5/29/2007	0.01 U	0.019	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.022	0.01 U	0.01 U
MW-76	8/8/2007	0.011	0.032	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.025	0.01 U	0.01 U
MW-76A	5/5/2008	1.3	0.99	0.2	0.05	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.15	0.011	1.6	0.01 U	0.28	0.52	0.014
MW-76A	8/11/2008	0.4 B	0.93	0.18 J	0.03	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01	0.01 U	0.08	0.02	1.3	0.01 U	0.1 B	0.18	0.02
MW-76A	11/11/2008	0.013 B	0.59 B	0.1 J	0.026 J	0.017 B	0.01 U	0.01 U	0.01 U	0.01 U	0.013 B	0.01 U	0.02 U	0.025 J	0.4 B	0.01 U	0.12 J	0.067 J	0.024 J
MW-76A	2/17/2009	0.035	0.48	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.048	0.01 U	0.67	0.01 U	0.063 J	0.045	0.01 U
MW-76A	5/18/2009	0.045 J	1.5	0.23	0.053	0.01 U	0.01 U	0.01 U	0.014 U	0.01 U	0.01 U	0.01 U	0.16	0.01 U	1.7	0.01 U	0.11	0.17	0.016
MW-76A	8/18/2009	0.092	1.5	0.39 J	0.05	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.2	0.01 U	2.1	0.01 U	0.2 U	0.38	0.011
MW-76A	11/16/2009	0.022	0.54	0.12 J	0.037	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.049	0.01 U	0.68	0.01 U	0.052	0.095	0.012

PgG

Table 2-8a. Summary of Groundwater PAH and SVOC Concentrations
Port of Seattle Terminal 30

Well	Sample Date	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene
Screening Level (ug/L)		*NV*	*643*	*NV*	*25,900*	*0.018*	*0.018*	*0.018*	*NV*	*0.018*	*0.018*	*0.018*	*NV*	*90*	*3,460*	*0.018*	*4,940*	*NV*	*2,590*
MW-76A	4/19/2011		1.8	0.05 U	0.043	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.05 U	2.2	0.018 U	0.05 U	0.72	0.05 U
MW-77	11/7/2007	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-77	2/12/2008	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
MW-77	5/5/2008	0.01 U	0.016	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.063	0.01 U	0.01 U
MW-77	8/11/2008	0.02	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.08 B	0.01 U	0.01 U
MW-78	10/13/2004	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-78A	8/2/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-79	10/13/2004	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-79	5/9/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-79A	8/2/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-81	11/29/2005	2.91	19.8	0.151	2.01	**0.477**	0.0943 U	0.0943 U	0.0943 U	0.0943 U	**0.33**	0.0943 U		9.15	9.81	0.0943 U	5.04	13.2	10
MW-81	2/13/2006	1.4	28 J	0.19	0.7	**0.19**	0.1 U	0.1 U	0.1 U	0.1 U	**0.12**	0.1 U	6.8	2.9	9.4	0.1 U	8.2	1.3	1.7
MW-81	5/8/2006	3.6	30	0.28	1.4	**0.26**	0.1 U	0.1 U	0.1 U	0.1 U	**0.19**	0.1 U	11	4.1	15	0.1 U	11	9.7	2.4
MW-81	8/22/2006	1.7	38	0.1 U	2.7	**0.59**	0.1 U	**0.12**	0.1 U	**0.11**	**0.37**	0.1 U	12	14	20	0.1 U	0.23	25	5.7
MW-81	11/20/2006	1.5	17	0.1 J	1	**0.53**	**0.12**	**0.16**	0.1 U	**0.18**	**0.33**	0.1 U	4.3	4.9	7	0.1 U	4.2	6	2.8
MW-81	2/26/2007	0.61 B	14	0.1 U	0.36	**0.12**	0.1 U	0.1 U	0.1 U	0.1 U	**0.11**	0.1 U	3.5	1.4	5.8	0.1 U	3.4 B	1.2	0.76
MW-81	5/29/2007	2.6	20	0.14 J	1.5	**0.46**	**0.09**	**0.16**	0.02	**0.08**	**0.24**	0.01 U	6.4	4.7	8.8	**0.02**	2.7	10	2.6
MW-81	8/8/2007	1.5	23	0.15	1.7	**0.52**	0.1 U	**0.1**	0.1 U	**0.1**	**0.31**	0.1 U	7.1	8.6	11	0.1 U	0.39	14	4.3
MW-81	11/7/2007	4.7	24	1 U	2	1 U	1 U	1 U	1 U	1 U	1 U	1 U	9.3	8.2	13	1 U	3.1 J	18	4.3
MW-81	2/12/2008	3.1	18	0.13	0.46	**0.24**	0.1 U	**0.16**	0.1 U	0.1 U	**0.14**	0.1 U	4.5	1.5	6.8	0.1 U	8.4	3.2	0.85
MW-81	5/5/2008	0.77	16	0.1 U	0.97	**0.34**	0.1 U	**0.11**	0.1 U	0.1 U	**0.2**	0.1 U	5.3	3.5	8.5	0.1 U	1.2	7	2.2
MW-81	8/11/2008	1.4	30	0.18	2.4 J	**0.72**	0.3 J	0.3 J	0.06 J	0.3 J	0.76 J	0.03 J	9.8	9.9	16	0.06 J	0.12 B	24	6.2 J
MW-81	11/11/2008	0.73 B	6 B	0.038 J	0.19 B	0.027 B	0.01 U	0.01 U	0.01 U	0.01 U	0.022 B	0.01 U	1.1 B	0.48 B	1.7 B	0.01 U	5.5 B	1.1 B	0.28 B
MW-81A	5/18/2009	0.01 U	0.019	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.17	0.01 U	0.01 U
MW-81A	8/18/2009	0	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.034	0.01 U	0.01 U
MW-81A	11/16/2009	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01	0.01 U	0.01 U
MW-81A	4/19/2011		0.05 U	0.05 U	0.05 U	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.05 U	0.05 U	0.018 U	0.05 U	0.05 U	0.05 U
MW-84	10/13/2004	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-84	5/9/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-84	8/2/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-84	11/29/2005	0.0943 U	1.44	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U		0.208	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.272
MW-84	2/13/2006	0.02	3	0.01 U	0.01	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.09 B	0.01	0.01 U	0.03	0.01 U	0.15 B
MW-84	5/8/2006	0.01 U	1.4	0.016	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.039	0.01 U	0.01 U	0.01 U	0.015	0.064
MW-84	8/22/2006	0.01 U	1.7	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.013	0.058	0.01 U	0.01 U	0.01 U	0.01 U	0.09
MW-84	11/20/2006	0.01 U	1.4	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.06	0.01 U	0.01 U	0.01 U	0.01 U	0.1
MW-84	2/26/2007	0.01 U	2.1	0.01 U	0.012	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.068	0.012	0.01 U	0.01 U	0.01 U	0.1
MW-84	5/29/2007	0.01 U	2.5	0.01 U	0.014	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.083	0.012	0.01 U	0.08	0.015	0.12
MW-84	8/8/2007	0.014	1.5	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.076	0.01 U	0.01 U	0.033	0.01 U	0.13
MW-84A	5/18/2009	0.61	160	0.51	1	0.013	0.01 U	0.01 U	0.014 B	0.01 U	0.014	0.01 U	0.92	0.58	5.9	0.01 U	1.5	2.8	0.36
MW-84A	8/18/2009	1 U	110	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	3.2	1 U	1 U	1.7 B	1 U
MW-84A	11/16/2009	0.025	54	0.28	0.18	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01	0.01 U	0.01 U	0.16	1	0.01 U	0.083	0.63	0.12
MW-84A	4/19/2011		1.2	0.05 U	0.05 U	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.05 U	0.05 U	0.018 U	0.05 U	0.05 U	0.05 U
MW-84A	11/8/2011	0.1 U	1	0.1 U	0.1 U	0.01 U	0.01 U	0.01 U	0.1 U	0.01 U	0.01 U	0.01 U		0.1 U	0.1 U	0.01 U	0.1 U	0.1 U	0.1 U
MW-84B	5/18/2009	0.013	0.69	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.075	0.018	0.01 U
MW-84B	8/18/2009	0.01 U	0.47	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.014	0.01 U	0.01 U

PGG

Table 2-8a. Summary of Groundwater PAH and SVOC Concentrations

Port of Seattle Terminal 30

Well	Sample Date	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene
Screening Level (ug/L)		*NV*	*643*	*NV*	*25,900*	*0.018*	*0.018*	*0.018*	*NV*	*0.018*	*0.018*	*0.018*	*NV*	*90*	*3,460*	*0.018*	*4,940*	*NV*	*2,590*
MW-84B	11/16/2009	0.01 U	1.2	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.013	0.01 U	0.01 U
MW-84B	4/19/2011		87	0.5	0.092	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.13	0.24	0.018 U	0.05 U	0.41	0.077
MW-84B	11/8/2011	0.1 U	100	0.54	0.11	0.01 U	0.01 U	0.01 U	0.1 U	0.01 U	0.01 U	0.01 U		0.12	0.25	0.01 U	0.1 U	0.69	0.1 U
MW-85	10/13/2004	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-85	5/9/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-85	8/2/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-85	11/29/2005	0.0943 U	0.266	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U		0.164	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.128
MW-85	2/13/2006	0.01 U	0.29	0.01 U	0.01	0.01	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.16 B	0.01 U	0.01 U	0.02	0.01 U	0.11 B
MW-85	5/8/2006	0.01 U	0.7	0.012	0.01	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.2	0.01 U	0.01 U	0.01 U	0.01 U	0.13
MW-85	8/22/2006	0.01 U	0.037	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.1	0.01 U	0.01 U	0.01 U	0.01 U	0.058
MW-85	11/20/2006	0.01 U	0.016	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.073	0.01 U	0.01 U	0.01 U	0.01 U	0.05
MW-85	2/26/2007	0.01 U	0.12	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.076	0.01 U	0.01 U	0.01 U	0.01 U	0.051
MW-85	5/29/2007	0.01 U	0.23	0.01 U	0.01 U	**0.019**	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.12	0.01 U	0.01 U	0.012	0.013	0.085
MW-85	8/8/2007	0.011	0.026	0.01 U	0.01 U	0.017	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.12	0.01 U	0.01 U	0.022	0.01 U	0.084
MW-85A	5/5/2008	0.022	0.043	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.017	0.012	0.01 U	0.015	0.019	0.027
MW-85A	8/11/2008	0.03	0.13	0.03	0.13	**0.08**	**0.07**	**0.06**	0.08	**0.11**	**0.12**	**0.08**	0.08	0.12	0.12	**0.08**	0.03 B	0.13	0.13
MW-85A	11/11/2008	0.031 B	0.17 B	0.01 U	0.025 B	0.012 B	0.01 U	0.01 U	0.01 U	0.01 U	0.014 B	0.01 U	0.015 B	0.049 B	0.084 B	0.01 U	0.21 B	0.13 B	0.061 B
MW-85A	2/17/2009	0.012	0.026	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.016	0.019	0.01 U	0.073	0.031	0.028
MW-85A	5/18/2009	0.012	0.022	0.01 U	0.011	**0.027**	**0.028**	**0.031**	0.034 U	**0.02**	**0.036**	**0.023**	0.01 U	0.058	0.014	**0.032**	0.044	0.052	0.076
MW-85A	8/18/2009	0.01 U	0.041	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.017	0.017	0.01 U	0.025	0.017 U	0.025
MW-85A	11/16/2009	0.01 U	0.03	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.011	0.01 U	0.028	0.013	0.013
MW-85A	4/19/2011		0.05 U	0.05 U	0.05 U	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.05 U	0.05 U	0.018 U	0.05 U	0.05 U	0.05 U
MW-85A	11/8/2011	0.1 U	0.1 U	0.1 U	0.1 U	0.01 U	0.01 U	0.01 U	0.1 U	0.01 U	0.01 U	0.01 U		0.1 U	0.1 U	0.01 U	0.1 U	0.1 U	0.1 U
MW-85B	5/5/2008	3.3	15	0.16	0.27	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.52	0.29	8.7	0.01 U	15	6.1	0.12
MW-85B	8/11/2008	1.4 B	9	0.07	0.25	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.5	0.25	5.1	0.01 U	8.2 B	4.6	0.11
MW-85B	11/11/2008	5.3 B	22 B	0.24	0.61 B	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	1.3 B	0.5 B	12 B	0.01 U	26 B	12 B	0.24 B
MW-85B	2/17/2009	1.1	14	0.11	0.24	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.67	0.31	8.3	0.01 U	11	6.5	0.14
MW-85B	5/18/2009	0.72	16	0.18	0.34	0.01 U	0.01 U	0.01 U	0.014 U	0.01 U	0.01 U	0.01 U	0.53	0.3	7.8	0.01 U	1.9	7.3	0.14
MW-85B	8/18/2009	0.14	9.5	0.1	0.17	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.31	0.19	4.8	0.01 U	1.2	2.1	0.092
MW-85B	11/16/2009	0.087	8.6	0.092	0.08	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.18	0.17	1.9	0.01 U	0.44	0.011	0.079
MW-85B	4/19/2011		10	0.16	0.23	0.018 U	0.018 U	0.018 U	0.1 U	0.018 U	0.018 U	0.018 U		0.31	6.1	0.018 U	0.1	5.4	0.13
MW-85B	11/8/2011	0.1 U	12	0.15	0.33	0.01 U	0.01 U	0.01 U	0.1 U	0.01 U	0.01 U	0.01 U		0.34	7.6	0.01 U	0.39	8.4	0.14
MW-86	10/13/2004	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-86A	8/2/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-86A	11/29/2005	0.0943 U	0.749	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U		0.272	0.0943 U	0.0943 U	0.102	0.0943 U	0.298
MW-86A	2/13/2006	0.01	0.32	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.16 B	0.01 U	0.01 U	0.04	0.03	0.16 B
MW-86A	5/8/2006	0.01 U	0.28	0.01 U	0.021	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.2	0.01 U	0.01 U	0.01 U	0.01 U	0.2
MW-86A	8/22/2006	0.01 U	0.22	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.18	0.01 U	0.01 U	0.01 U	0.01 U	0.18
MW-86A	11/20/2006	0.01 U	0.032	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.062	0.01 U	0.01 U	0.01 U	0.01 U	0.087
MW-86A	2/26/2007	0.01 U	0.074	0.01 U	0.021	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.091	0.01 U	0.01 U	0.01 U	0.01 U	0.12
MW-86A	5/29/2007	0.014	0.17	0.01 U	0.014	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.13	0.01 U	0.01 U	0.02	0.01 U	0.17
MW-86A	8/8/2007	0.015	0.09	0.01 U	0.013	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.096	0.01 U	0.01 U	0.033	0.01 U	0.15
MW-86B	5/5/2008	0.5	6.4	0.055	0.17	**0.026**	0.01 U	0.01 U	0.01 U	0.01 U	**0.019**	0.01 U	0.13	0.97	0.84	0.01 U	1.3	0.25	0.64
MW-86B	8/11/2008	0.02 B	3.3	0.03 J	0.09	0.01	0.01 U	0.01 U	0.01 U	0.01 U	0.01	0.01 U	0.04	0.54	0.34	0.01 U	0.11 B	0.06	0.37
MW-86B	11/11/2008	0.035 B	5.4 B	0.048 J	0.2 B	**0.034**	0.01 U	0.01 U	0.01 U	0.01 U	**0.027**	0.01 U	0.054	0.81 B	0.62 B	0.01 U	0.16 B	0.11 B	0.56 B

PgG

Table 2-8a. Summary of Groundwater PAH and SVOC Concentrations

Port of Seattle Terminal 30

Well	Sample Date	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene
Screening Level (ug/L)		*NV*	*643*	*NV*	*25,900*	*0.018*	*0.018*	*0.018*	*NV*	*0.018*	*0.018*	*0.018*	*NV*	*90*	*3,460*	*0.018*	*4,940*	*NV*	*2,590*
MW-86B	2/17/2009	0.026	5.1	0.073	0.2	**0.025**	0.01 U	0.01 U	0.01 U	0.01 U	**0.019**	0.01 U	0.13	0.32	1.2	0.01 U	0.12	0.2	0.55
MW-86B	5/18/2009	0.065	6.1	0.07	0.33	**0.03**	0.01 U	0.01 U	0.01 U	0.01 U	**0.024**	0.01 U	0.16	1.2	1.8	0.01 U	0.17	0.69	0.75
MW-86B	8/18/2009	0.021	4.2	0.054 J	0.22	**0.024**	0.01 U	0.01 U	0.01 U	0.01 U	**0.021**	0.01 U	0.056	0.85	1.1	0.01 U	0.068	0.083	0.59
MW-86B	11/16/2009	0.01 U	5.7	0.057	0.18	**0.026**	0.01 U	0.01 U	0.01 U	0.01 U	**0.026**	0.01 U	0.056	0.83	1.4	0.01 U	0.048	0.03	0.57
MW-86B	4/19/2011		5.1	0.063	0.18	**0.026**	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.9	0.86	0.018 U	0.05 U	0.16	0.58
MW-86B	11/8/2011	0.1 U	6.9	0.1 U	0.31	**0.027**	0.01 U	0.01 U	0.1 U	0.01 U	**0.019**	0.01 U		0.89	2.3	0.01 U	0.12	0.64	0.65
MW-86B	4/19/2012	2.5 U	7.8	2.5 U	2.5 U	0.5 U	0.5 U	0.5 U	2.5 U	0.5 U	0.5 U	0.5 U		2.5 U	2.5 U	0.5 U	2.5 U	2.5 U	2.5 U
MW-86C	5/5/2008	0.35	4.2	0.048	0.12	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.13	0.31	0.74	0.01 U	1.2	0.24	0.3
MW-86C	8/11/2008	0.02 B	2.8	0.02 J	0.06	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.03	0.37	0.17	0.01 U	0.06 B	0.14	0.3
MW-86C	11/11/2008	0.011 B	3.3 B	0.025 J	0.15 B	0.049 B	0.023 B	0.035 B	0.013	0.027 B	0.05 B	0.01 U	0.019 B	0.51 B	0.3 B	0.014	0.058 B	0.38 B	0.43 B
MW-86C	2/17/2009	0.1	4.4	0.049	0.16	**0.021**	0.013	0.011	0.01 U	0.012	**0.025**	0.01 U	0.16	0.73	0.99	0.01 U	0.52	0.15	0.57
MW-86C	5/18/2009	0.091	2.7	0.029	0.091	0.01 U	0.01 U	0.01 U	0.014 U	0.01 U	0.01 U	0.01 U	0.063	0.34	0.54	0.01 U	0.32	0.31	0.3
MW-86C	8/18/2009	0.014	3.8	0.031 J	0.11	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.049	0.33	0.72	0.01 U	0.052	0.07	0.29
MW-86C	11/16/2009	0.034	5	0.033 J	0.098	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.061	0.52	0.76	0.01 U	0.078	0.027	0.37
MW-86C	4/19/2011		4.2	0.054	0.15	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.42	1.3	0.018 U	1.3	0.73	0.34
MW-86C	11/8/2011	0.1 U	5.6	0.1 U	0.18	0.01 U	0.01 U	0.01 U	0.1 U	0.01 U	0.01 U	0.01 U		0.46	1.8	0.01 U	0.17	0.45	0.38
MW-87	10/13/2004	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
MW-87	5/9/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-87	8/2/2005	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
MW-87	11/29/2005	0.0943 U	0.445	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U	0.0943 U		0.0943 U	0.392	0.0943 U	0.0943 U	0.0943 U	0.0943 U
MW-87	2/13/2006	0.02	0.2	0.02 J	0.01	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.02	0.01 U	0.15	0.01 U	0.06	0.01 U	0.01 U
MW-87	5/8/2006	0.024	0.2	0.02	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.016	0.01 U	0.14	0.01 U	0.044 B	0.01 U	0.01 U
MW-87	8/22/2006	0.01 U	0.3	0.042	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.024	0.011	0.25	0.01 U	0.05 B	0.01 U	0.01 U
MW-87	11/20/2006	0.01 U	0.15	0.011 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.09	0.01 U	0.059 B	0.01 U	0.01 U
MW-87	2/26/2007	0.01 U	0.11	0.012 J	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.084	0.01 U	0.01 U	0.01 U	0.01 U
MW-87	5/29/2007	0.014	0.12	0.014 J	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01	0.012	0.094	0.01 U	0.078	0.01 U	0.01 U
MW-87	8/8/2007	0.024	0.12	0.016 J	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01	0.01 U	0.087	0.01 U	0.078	0.01 U	0.01 U
MW-87A	5/5/2008	0.013	0.17	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.025	0.01 U	0.054	0.01 U	0.011
MW-87A	8/11/2008	0.02 B	0.03	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.05 B	0.01 U	0.01
MW-87A	11/11/2008	0.01 U	0.022 B	0.01 U	0.049 B	**0.025**	0.012	0.014	0.01 U	0.014	**0.026**	0.01 U	0.01 U	0.053 B	0.017 B	0.01 U	0.055 B	0.058 B	0.047 B
MW-87A	2/17/2009	0.01	0.012	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.011	0.01 U	0.05	0.01 U	0.01 U
MW-87A	5/18/2009	0.036	0.027	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.014	0.01 U	0.01 U	0.01 U	0.16	0.01 U	0.01 U
MW-87A	8/18/2009	0.021	0.072	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.015	0.01 U	0.027	0.01 U	0.01 U
MW-87A	11/16/2009	0.015	0.063	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.017	0.01 U	0.01 U
MW-87A	4/19/2011		0.18	0.05 U	0.05 U	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.05 U	0.069	0.018 U	0.05 U	0.05 U	0.05 U
MW-87A	11/8/2011	0.1 U	0.41	0.1 U	0.1 U	0.01 U	0.01 U	0.01 U	0.1 U	0.01 U	0.01 U	0.01 U		0.1 U	0.1 U	0.01 U	0.1 U	0.1 U	0.1 U
MW-87B	5/5/2008	0.076	3.5	0.044	0.16	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.5	1.4	2.1	0.01 U	0.23	0.28	0.57
MW-87B	8/11/2008	0.15 B	0.47	0.01 U	0.11	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.05	0.16	0.3	0.01 U	0.2 B	0.63	0.1
MW-87B	11/11/2008	0.075 B	0.52 B	0.012 J	0.068 B	0.012	0.01 U	0.01 U	0.01 U	0.01 U	**0.023**	0.01 U	0.074	0.27 B	0.41 B	0.01 U	0.067 B	0.96 B	0.18 B
MW-87B	2/17/2009	0.52	1.4	0.017	0.15	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.29	0.44	1	0.01 U	0.84	2.4	0.26
MW-87B	5/18/2009	0.25	0.7	0.01 U	0.082	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.13	0.27	0.47	0.01 U	0.47	1.4	0.16
MW-87B	8/18/2009	0.078	0.32	0.01 U	0.047	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.031	0.15	0.25	0.01 U	0.087	0.74 B	0.087
MW-87B	11/16/2009	0.22	0.89	0.012	0.14	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.07	0.42	0.76	0.01 U	0.26	2.5	0.25
MW-87B	4/19/2011		2.2	0.031	0.39	**0.019**	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		1.6	1.5	0.018 U	0.57	5.1	0.87
MW-87B	11/8/2011	0.1	2.8	0.1 U	0.2	0.01 U	0.01 U	0.01 U	0.1 U	0.01 U	0.01 U	0.01 U		0.78	1	0.01 U	0.1	6.7	0.49

Table 2-8a. Summary of Groundwater PAH and SVOC Concentrations

Port of Seattle Terminal 30

Well	Sample Date	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Dibenzofuran	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene
Screening Level (ug/L)		*NV*	*643*	*NV*	*25,900*	*0.018*	*0.018*	*0.018*	*NV*	*0.018*	*0.018*	*0.018*	*NV*	*90*	*3,460*	*0.018*	*4,940*	*NV*	*2,590*
MW-88	5/18/2009	0.022	0.84	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.014 B	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.069	0.14	0.01 U
MW-88	8/18/2009	0.018	0.72	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.012	0.021	0.01 U
MW-88	11/16/2009	0.01 U	0.92	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.011	0.01 U	0.01 U
MW-88	4/19/2011		0.55	0.05 U	0.05 U	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.05 U	0.05 U	0.018 U	0.05 U	0.05 U	0.05 U
MW-89	5/5/2008	0.54	2.3	0.085	0.19	0.015	0.01 U	0.01 U	0.01 U	0.01 U	0.016	0.01 U	0.39	0.22	1.3	0.01 U	1.5	0.94	0.19
MW-89	8/11/2008	0.14	1.9	0.05 J	0.16	**0.04**	**0.04**	**0.04**	0.04	**0.04**	**0.07**	**0.04**	0.17	0.16	0.61	**0.04**	0.53 B	0.57	0.16
MW-89	2/17/2009	0.052	1.6	0.033 J	0.079	0.011	0.01 U	0.01 U	0.01 U	0.01 U	0.011	0.01 U	0.078	0.11	0.44	0.01 U	0.24	0.37	0.1
MW-89	5/18/2009	0.021	0.91	0.02	0.038	0.011	0.01 U	0.01 U	0.015 U	0.01 U	0.014	0.01 U	0.054	0.1	0.24	0.01 U	0.15	0.015	0.1
MW-89	8/18/2009	0.016	1.2	0.031 J	0.072	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.012	0.01 U	0.081	0.1	0.45	0.01 U	0.2	0.17	0.098
MW-89	11/16/2009	0.064	0.99	0.027	0.026	0.015	0.01 U	0.01 U	0.01 U	0.01 U	**0.02**	0.01 U	0.09	0.15	0.27	0.01 U	0.25	0.01 U	0.16
MW-89	4/19/2011		1.2	0.053	0.064	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.11	0.66	0.018 U	0.05 U	0.27	0.087
MW-90	5/5/2008	0.01 U	0.053	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.011	0.01 U	0.09	0.01 U	0.01 U
MW-90	8/11/2008	0.03 B	0.02	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.03 B	0.01 U	0.01 U
MW-90	11/11/2008	0.036 B	0.063 B	0.01 U	0.045 B	0.012 B	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.029 B	0.011 B	0.01 U	0.072 B	0.07 B	0.03 B
MW-90	2/17/2009	0.013	0.028	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.056	0.01 U	0.01 U
MW-90	5/18/2009	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.032	0.01 U	0.01 U
MW-90	8/18/2009	0.01 U	0.057	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.063	0.01 U	0.02	0.012	0.01 U
MW-90	11/16/2009	0.01 U	0.02	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.011	0.01 U	0.04	0.01 U	0.01 U
MW-90	4/19/2011		0.05 U	0.05 U	0.05 U	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.05 U	0.05 U	0.018 U	0.05 U	0.05 U	0.05 U
MW-91	5/5/2008	0.01 U	0.31	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.014	0.01 U	0.079	0.01 U	0.41	0.033	0.01 U
MW-91	8/11/2008	0.01 U	0.15	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.03	0.01 U	0.14 B	0.01	0.01 U
MW-91	11/11/2008	0.014 B	0.15 B	0.01 U	0.021 B	0.012 B	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.036 B	0.017 B	0.01 U	0.15 B	0.098 B	0.032 B
MW-91	2/17/2009	0.023	0.23	0.013	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.04	0.01 U	0.053	0.021	0.01 U
MW-91	5/18/2009	0.019 U	0.5	0.027 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.074	0.01 U	0.32	0.011	0.01 U
MW-91	8/18/2009	0.014 J	0.3	0.021 J	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.059	0.01 U	0.19	0.018 U	0.01 U
MW-91	11/16/2009	0.01 U	0.22	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.019	0.01 U	0.075	0.01 U	0.01 U
MW-91	4/19/2011		0.28	0.05 U	0.05 U	0.018 U	0.018 U	0.018 U	0.05 U	0.018 U	0.018 U	0.018 U		0.05 U	0.066	0.018 U	0.05 U	0.05 U	0.05 U
RW-11A	5/5/2008	4.7	0.45	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.16	0.019	0.97	0.01 U	0.59	0.17	0.025
RW-11A	8/11/2008	10 J	0.51 J	0.1 J	0.02 J	0.01 UJ	0.01 UJ	0.01 UJ	0.01 UJ	0.01 UJ	0.01 UJ	0.01 UJ	0.27 J	0.01 UJ	1 J	0.01 UJ	1.6 J	0.4 J	0.01 UJ
RW-5A	5/5/2008	0.01 U	0.26	0.014	0.028	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.033	0.04	0.073	0.01 U	0.35	0.01 U	0.054

All results micrograms per liter (ug/L)

PAH: Polyaromatic Hydrocarbon; SVOC: Semi-Volailte Organic Compound

U: Non-detect at indicated reporting limit

E: Estimated value, poor peak resolution

J: Estimated value

B: Constituent detected in blank

NV: No value

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Table 2-8b. Summary of Centrifuged and Filtered Groundwater PAH and SVOC Concentrations

Port of Seattle Terminal 30

Constituent	Analyte Comment	Sample Date	Screening Level	MW58 Sample	MW58 Reanalysis	MW84A Sample	MW84B Sample	MW85A Sample	MW85B Sample	MW86B Sample	MW86B Reanalysis	MW86C Sample	MW87A Sample	MW87B Sample
2-Methylnaphthalene	Semi-Volatile	11/8/2011	*NV*	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U		0.1 U	0.1 U	0.1
2-Methylnaphthalene	Field Filtered 0.45-micron	4/19/2012	*NV*	0.24						0.15 U				
2-Methylnaphthalene	Semi-Volatile	4/19/2012	*NV*	2.5 U						2.5 U				
2-Methylnaphthalene	Lab-Filtered 0.7-micron	4/19/2012	*NV*	2.5 U						2.5 U				
Acenaphthene	PAH Compound	11/8/2011	*643*	1.8		1	100	0.1 U	12	6.9	5.5 E	5.6	0.41	2.8
Acenaphthene	Centrifuged	11/8/2011	*643*	1.6	1.3	0.9	81 J	17	10	4.2	3.8 E	5.4	0.27	0.84
Acenaphthene	PAH Compound	4/19/2012	*643*	2.5 U						7.8				
Acenaphthene	Field Filtered 0.45-micron	4/19/2012	*643*	2.8						4.5				
Acenaphthene	Lab-Filtered 0.7-micron	4/19/2012	*643*	6.4						6.9				
Acenaphthylene	PAH Compound	11/8/2011	*NV*	0.1 U		0.1 U	0.54	0.1 U	0.15	0.1 U	0.11	0.1 U	0.1 U	0.1 U
Acenaphthylene	Centrifuged	11/8/2011	*NV*	0.1 U	0.1 U	0.1 U	0.45	0.1	0.14	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Acenaphthylene	PAH Compound	4/19/2012	*NV*	2.5 U						2.5 U				
Acenaphthylene	Field Filtered 0.45-micron	4/19/2012	*NV*	0.054						0.067				
Acenaphthylene	Lab-Filtered 0.7-micron	4/19/2012	*NV*	2.5 U						2.5 U				
Anthracene	PAH Compound	11/8/2011	*25,900*	0.27		0.1 U	0.11	0.1 U	0.33	0.31	0.37	0.18	0.1 U	0.2
Anthracene	Centrifuged	11/8/2011	*25,900*	0.24	0.15	0.1 U	0.1 U	0.1 U	0.29	0.21	0.23	0.18	0.1 U	0.14
Anthracene	PAH Compound	4/19/2012	*25,900*	2.5 U						2.5 U				
Anthracene	Field Filtered 0.45-micron	4/19/2012	*25,900*	0.05 U						0.05 U				
Anthracene	Lab-Filtered 0.7-micron	4/19/2012	*25,900*	2.5 U						2.5 U				
Benzo(a)anthracene	PAH Compound	11/8/2011	*0.018*	**0.053**		0.01 U	0.01 U	0.01 U	0.01 U	**0.027**	**0.025**	0.01 U	0.01 U	0.01 U
Benzo(a)anthracene	Centrifuged	11/8/2011	*0.018*	**0.041**	**0.038**	0.01 U	0.01 U	0.01 U	0.01 U	**0.022**	**0.031**	0.01 U	0.01 U	0.01 U
Benzo(a)anthracene	PAH Compound	4/19/2012	*0.018*	0.5 U						0.5 U				
Benzo(a)anthracene	Field Filtered 0.45-micron	4/19/2012	*0.018*	0.01 U						0.01 U				
Benzo(a)anthracene	Lab-Filtered 0.7-micron	4/19/2012	*0.018*	0.5 U						0.5 U				
Benzo(a)pyrene	PAH Compound	11/8/2011	*0.018*	0.01 U		0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Benzo(a)pyrene	Centrifuged	11/8/2011	*0.018*	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Benzo(a)pyrene	PAH Compound	4/19/2012	*0.018*	0.5 U						0.5 U				
Benzo(a)pyrene	Field Filtered 0.45-micron	4/19/2012	*0.018*	0.01 U						0.01 U				
Benzo(a)pyrene	Lab-Filtered 0.7-micron	4/19/2012	*0.018*	0.5 U						0.5 U				
Benzo(b)fluoranthene	PAH Compound	11/8/2011	*0.018*	0.01		0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Benzo(b)fluoranthene	Centrifuged	11/8/2011	*0.018*	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Benzo(b)fluoranthene	PAH Compound	4/19/2012	*0.018*	0.5 U						0.5 U				
Benzo(b)fluoranthene	Field Filtered 0.45-micron	4/19/2012	*0.018*	0.01 U						0.01 U				
Benzo(b)fluoranthene	Lab-Filtered 0.7-micron	4/19/2012	*0.018*	0.5 U						0.5 U				
Benzo(g,h,i)perylene	PAH Compound	11/8/2011	*NV*	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.01 U	0.1 U	0.1 U	0.1 U
Benzo(g,h,i)perylene	Centrifuged	11/8/2011	*NV*	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.01 U	0.1 U	0.1 U	0.1 U
Benzo(g,h,i)perylene	PAH Compound	4/19/2012	*NV*	2.5 U						2.5 U				
Benzo(g,h,i)perylene	Field Filtered 0.45-micron	4/19/2012	*NV*	0.05 U						0.05 U				
Benzo(g,h,i)perylene	Lab-Filtered 0.7-micron	4/19/2012	*NV*	2.5 U						2.5 U				
Benzo(k)fluoranthene	PAH Compound	11/8/2011	*0.018*	0.01 U		0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Benzo(k)fluoranthene	Centrifuged	11/8/2011	*0.018*	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Benzo(k)fluoranthene	PAH Compound	4/19/2012	*0.018*	0.5 U						0.5 U				
Benzo(k)fluoranthene	Field Filtered 0.45-micron	4/19/2012	*0.018*	0.01 U						0.01 U				
Benzo(k)fluoranthene	Lab-Filtered 0.7-micron	4/19/2012	*0.018*	0.5 U						0.5 U				
Chrysene	PAH Compound	11/8/2011	*0.018*	**0.057**		0.01 U	0.01 U	0.01 U	0.01 U	**0.019**	**0.018**	0.01 U	0.01 U	0.01 U
Chrysene	Centrifuged	11/8/2011	*0.018*	**0.04**	**0.036**	0.01 U	0.01 U	0.01 U	0.01 U	0.016	**0.023**	0.01 U	0.01 U	0.01 U
Chrysene	PAH Compound	4/19/2012	*0.018*	0.5 U						0.5 U				
Chrysene	Field Filtered 0.45-micron	4/19/2012	*0.018*	0.01 U						0.01 U				
Chrysene	Lab-Filtered 0.7-micron	4/19/2012	*0.018*	0.5 U						0.5 U				

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Table 2-8b. Summary of Centrifuged and Filtered Groundwater PAH and SVOC Concentrations

Port of Seattle Terminal 30

Constituent	Analyte Comment		Screening	MW58		MW84A	MW84B	MW85A	MW85B	MW86B		MW86C	MW87A	MW87B
		Sample Date	Level	Sample	Reanalysis	Sample	Sample	Sample	Sample	Sample	Reanalysis	Sample	Sample	Sample
Dibenzo(a,h)anthracene	PAH Compound	11/8/2011	*0.018*	0.01 U		0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Dibenzo(a,h)anthracene	Centrifuged	11/8/2011	*0.018*	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Dibenzo(a,h)anthracene	PAH Compound	4/19/2012	*0.018*	0.5 U						0.5 U				
Dibenzo(a,h)anthracene	Field Filtered 0.45-micron	4/19/2012	*0.018*	0.01 U						0.01 U				
Dibenzo(a,h)anthracene	Lab-Filtered 0.7-micron	4/19/2012	*0.018*	0.5 U						0.5 U				
Fluoranthene	PAH Compound	11/8/2011	*90*	1.1		0.1 U	0.12	0.1 U	0.34	0.89	1.1	0.46	0.1 U	0.78
Fluoranthene	Centrifuged	11/8/2011	*90*	0.93	0.92	0.1 U	0.11	0.1 U	0.31	0.74	0.79	0.44	0.1 U	0.56
Fluoranthene	PAH Compound	4/19/2012	*90*	2.5 U						2.5 U				
Fluoranthene	Field Filtered 0.45-micron	4/19/2012	*90*	0.05 U						0.05 U				
Fluoranthene	Lab-Filtered 0.7-micron	4/19/2012	*90*	2.5 U						2.5 U				
Fluorene	PAH Compound	11/8/2011	*3,460*	1		0.1 U	0.25	0.1 U	7.6	2.3	2.5 E	1.8	0.1 U	1
Fluorene	Centrifuged	11/8/2011	*3,460*	0.89	0.69	0.1 U	0.22	0.1 U	6.5	1.7	1.7	2	0.1 U	0.66
Fluorene	PAH Compound	4/19/2012	*3,460*	2.5 U						2.5 U				
Fluorene	Field Filtered 0.45-micron	4/19/2012	*3,460*	0.63						1				
Fluorene	Lab-Filtered 0.7-micron	4/19/2012	*3,460*	3.2						2.5 U				
Indeno(1,2,3-cd)pyrene	PAH Compound	11/8/2011	*0.018*	0.01 U		0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Indeno(1,2,3-cd)pyrene	Centrifuged	11/8/2011	*0.018*	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Indeno(1,2,3-cd)pyrene	PAH Compound	4/19/2012	*0.018*	0.5 U						0.5 U				
Indeno(1,2,3-cd)pyrene	Field Filtered 0.45-micron	4/19/2012	*0.018*	0.01 U						0.01 U				
Indeno(1,2,3-cd)pyrene	Lab-Filtered 0.7-micron	4/19/2012	*0.018*	0.5 U						0.5 U				
Naphthalene	PAH Compound	11/8/2011	*4,940*	0.1 U		0.1 U	0.1 U	0.1 U	0.39	0.12	0.14	0.17	0.1 U	0.1
Naphthalene	Centrifuged	11/8/2011	*4,940*	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.3	0.1 U	0.1 U	0.15	0.1 U	0.1 U
Naphthalene	PAH Compound	4/19/2012	*4,940*	2.5 U						2.5 U				
Naphthalene	Field Filtered 0.45-micron	4/19/2012	*4,940*	1.1						0.05 U				
Naphthalene	Lab-Filtered 0.7-micron	4/19/2012	*4,940*	2.5 U						2.5 U				
Phenanthrene	PAH Compound	11/8/2011	*NV*	0.59		0.1 U	0.69	0.1 U	8.4	0.64	0.74	0.45	0.1 U	6.7
Phenanthrene	Centrifuged	11/8/2011	*NV*	0.52	0.17	0.1 U	0.6	0.15	7.3	0.43	0.47	0.91	0.1 U	2.3
Phenanthrene	PAH Compound	4/19/2012	*NV*	3.3						2.5 U				
Phenanthrene	Field Filtered 0.45-micron	4/19/2012	*NV*	0.076						0.063				
Phenanthrene	Lab-Filtered 0.7-micron	4/19/2012	*NV*	2.6						2.5 U				
Pyrene	PAH Compound	11/8/2011	*2,590*	0.85		0.1 U	0.1 U	0.1 U	0.14	0.65	0.77	0.38	0.1 U	0.49
Pyrene	Centrifuged	11/8/2011	*2,590*	0.8	0.72	0.1 U	0.1 U	0.1 U	0.14	0.55	0.61	0.37	0.1 U	0.35
Pyrene	PAH Compound	4/19/2012	*2,590*	2.5 U						2.5 U				
Pyrene	Field Filtered 0.45-micron	4/19/2012	*2,590*	0.05 U						0.05 U				
Pyrene	Lab-Filtered 0.7-micron	4/19/2012	*2,590*	2.5 U						0.5 U				

Lab filtration used a 0.7-micron filter
Field filtration used a 0.45-micron filter
All results micrograms per liter (ug/L)
PAH: Polyaromatic Hydrocarbon; SVOC: Semi-Volailte Organic Compound
U: Non-detect at indicated reporting limit
E: Estimated value, poor peak resolution
NV: No value
Analyte comment "PAH Compound" indicates that the sample split was analyzed without filter or centrifuge sample preparation.

Table 2-9. Summary of Plume Stability Analysis Results

Port of Seattle Terminal 30

Well ID	GRO	DRO	Oil-Range	Benzene
MW45	Stable	Stable	Stable	Stable
	71.8%	71.8%	71.8%	71.8%
MW46	Stable	Stable	Stable	Stable
	71.8%	71.8%	71.8%	71.8%
MW81A	Stable	Stable	Stable	Stable
	62.5%	62.5%	62.5%	62.5%
MW88	Stable	Stable	Stable	Stable
	62.5%	62.5%	62.5%	62.5%
MW42	Shrinking	Stable	Stable	Shrinking
	94.2%	48.2%	71.8%	99.7%
MW52A	Stable	Stable	Stable	Stable
	61.5%	81.0%	72.1%	72.1%
MW76A	Expanding	Expanding	Stable	Stable
	86.2%	86.2%	72.6%	72.6%
MW90	Stable	Stable	Stable	Stable
	72.6%	72.6%	72.6%	72.6%
MW91	Shrinking	Stable	Stable	Stable
	94.6%	72.6%	72.6%	72.6%
MW84A	Stable	Stable	Stable	Stable
	62.5%	62.5%	62.5%	62.5%
MW84B	Stable	Stable	Stable	Stable
	62.5%	62.5%	62.5%	62.5%
MW85A	Stable	Stable	Stable	Stable
	72.6%	72.6%	72.6%	72.6%
MW85B	Stable	Stable	Stable	Stable
	45.2%	45.2%	45.2%	45.2%
MW86B	Shrinking	Stable	Stable	Stable
	86.2%	72.6%	72.6%	72.6%
MW86C	Stable	Stable	Stable	Stable
	54.8%	72.6%	72.6%	72.6%
MW87A	Shrinking	Stable	Stable	Stable
	72.6%	72.6%	72.6%	72.6%
MW87B	Stable	Stable	Stable	Stable
	72.6%	72.6%	72.6%	72.6%
MW89	Stable	Stable	Stable	Shrinking
	50.0%	71.9%	71.9%	88.1%

GRO: Gasoline Range Organics

DRO: Diesel Range Organics

% values are the Mann-Kendall confidence level

Calculation sheets included in Appendix G

MW-58 excluded from analysis due to broken well casing

Shading color indicates Shrinking or Expanding statistical result

All MW-76A results below screening levels with 4 detections (32 analyses) above reporting limits since 2008 (Table 2-4).

Table 3-1. Summary of Remedial Alternatives
Port of Seattle Terminal 30

	Alternative 1	Alternative 2	Alternative 3a	Alternative 3b	Alternative 4
	In-Situ Thermal Desorption	**Expanded Sheen-Area AS/SVE with Targeted Excavation**	**Targeted Sheen Area AS/SVE with LNAPL Recovery**	**Expanded Sheen Area AS/SVE with LNAPL Recovery**	**Compliance Monitoring with LNAPL Recovery**
Remedial Alternative Components	**Figure 3-1** - Groundwater Monitoring - Thermal Desorption in Area Defined by Original Extent of LNAPL - Soil Containment - Institutional Controls	**Figure 3-2** - Groundwater Monitoring - Excavation of LNAPL in MW-59 Area to Water Table at Approximately 10ft bgs - Expanded Sheen-Area treatment (similar to Alternative 3b) - Soil Containment - Institutional Controls	**Figure 3-3** - Groundwater Monitoring - LNAPL Recovery at Existing Wells - AS/SVE Treatment at MW-42 Area - Soil Containment - Institutional Controls	**Figure 3-4** - Groundwater Monitoring - LNAPL Recovery at Expanded Well System AS/SVE Treatment at MW-42 Area - Soil Containment - Institutional Controls -	**Figure 3-5** - Groundwater Monitoring - LNAPL Recovery at Expanded Well System Soil Containment - Institutional Controls -
Remedial Action by Media					
LNAPL	- LNAPL Recovery by AS/SVE	- LNAPL Removal by Excavation	- LNAPL Recovery	- LNAPL Recovery	- LNAPL Recovery
Soil	- Thermal Treatment - Containment - Institutional Controls	- Excavation - Containment - Institutional Controls	- Vapor Extraction - Biostimulation - Containment - Institutional Controls	- Vapor Extraction - Biostimulation - Containment - Institutional Controls	- Containment - Institutional Controls
Groundwater	- Thermal Treatment	- Biostimulation - Vapor Extraction	- Biostimulation - Vapor Extraction	- Biostimulation - Vapor Extraction	- Natural Attenuation
Remedial Alternative Costs					
30-Year Implementation Cost Present Day Value (PDV)	**$ 24,800,000**	**$ 9,500,000**	**$ 2,700,000**	**$ 5,100,000**	**$ 1,700,000**
Implementation Logistics and Impacts					
Short-Term Implementation Footprint	Site-wide, phased installation of injection and extraction wells and line trenching; 40 ft by 40 ft footprint for steam generator, knockout drums, and blower equipment	Closure of 50% of RTG, minimum 300 ft by 300 ft area near MW-59 to accommodate excavation perimeter, equipment, and traffic; concurrent 100 ft by 100 ft footprint to drill horizontal wells	100 ft by 100 ft area for drill rig and support vehicles to install LNAPL recovery and horizontal wells. Footprint moves with drilling location	100 ft by 100 ft area for drill rig and support vehicles to install LNAPL recovery and horizontal wells. Footprint moves with drilling location	100 ft by 100 ft area for drill rig and support vehicles
Short-Term Implementation Impacts / Disruption in Business	Phased closure of portions of the site to install wells, line trenching, and equipment over approximately 3 months; estimated 9- to 12-month thermal treatment duration	6-month closure of 50% of RTG, access restriction to geographic core of terminal during excavation and drilling	Footprint introduces impact to truck traffic during drilling, scheduled during off-hours/weekends as possible	Footprint introduces impact to truck traffic during drilling, scheduled during off-hours/weekends as possible	Off-hours installation of LNAPL recovery wells in MW-59 area
Long-Term Implementation Footprint	Footprint for support vehicle and personnel during groundwater monitoring after completion of treatment phase	20 ft by 30 ft footprint for AS/SVE blower and exhaust treatment equipment; periodic footprint for support vehicle and staff during groundwater monitoring	20 ft by 30 ft footprint for AS/SVE blower and exhaust treatment equipment; periodic footprint for support vehicle and personnel during groundwater monitoring and LNAPL recovery	20 ft by 30 ft footprint at two AS/SVE blower and exhaust treatment equipment locations; periodic footprint for support vehicle and personnel during groundwater monitoring and LNAPL recovery	Footprint for support vehicle and personnel during groundwater monitoring and LNAPL recovery
Long-Term Implementation Impact / Disruption in Business	Periodic impact associated with groundwater monitoring	Periodic impact associated with groundwater monitoring, LNAPL recovery, and AS/SVE operations at blowers	Periodic impact associated with groundwater monitoring, LNAPL recovery, and AS/SVE operations at blowers	Periodic impact associated with groundwater monitoring and AS/SVE operations at blowers	Periodic impact associated with groundwater monitoring and LNAPL recovery

Notes:

Agency oversight costs are calculated using the smaller of a fixed percentage (10%) of direct costs or $1,000,000 (Appendix H).
Port of Seattle PM costs are calculated using the smaller of a fixed percentage (20%) of direct costs or $1,000,000 (Appendix H).
LNAPL is light non aqueous phase liquid.
Net Present Day Value (PDV) Discount Rate is: 2%.
PDV discount rate based on OMB Circular A-94 Appendix C 30-year real rate.
Costs include 2.8% inflation based on construction cost index.
PDV and inflation cost estimates are calculated using recommendations in Ecology *Draft Guidance for Remediation of Petroleum Contaminated Sites* (Publication 10-09-057; Section 11.5).
Washington (WA) state sales tax applied to all direct costs excluding labor. Sales tax is not applied to contingency, oversight, or project management costs.
RTG: Rubber Tire Gantry; concrete tracks for a mobile crane that moves containers.

PgG

Table 3-2. Disproportionate Cost Analysis and Comparison to MTCA Criteria
Port of Seattle Terminal 30

			Alternative 1	Alternative 2	Alternative 3b	Alternative 3a	Alternative 4
			In-Situ Thermal Desorption	**Expanded Sheen Area AS/SVE with Targeted Excavation**	**Expanded Sheen-Area AS/SVE with LNAPL Recovery**	**Targeted Sheen-Area AS/SVE with LNAPL Recovery**	**Compliance Monitoring with LNAPL Recovery**
Weighted Benefits Ranking for Disproportionate Cost Analysis (Score 1-10)							
Weighting	*Criteria*		*Scores and Explanations:*				
30%	Overall Protectiveness		9 This alternative will be most protective.	8 This alternative will achieve overall protection.	8 This alternative will achieve overall protection.	8 This alternative will achieve overall protection.	5 This alternative is expected to continue exceeeding screening levels at CPOC wells for several years.
20%	Permanence		10 Alternative uses containment, contaminant removal, and enhanced in-situ degradation.	8 Alternative uses containment, contaminant removal/disposal, and enhanced in-situ degradation.	7 Alternative uses containment, some contaminant removal, and enhanced in-situ degradation.	7 Alternative uses containment, some contaminant removal, and enhanced in-situ degradation.	4 Alternative uses containment, some contaminant removal, and in-situ degradation.
20%	Long Term Effectiveness		9 Alternative reduces contaminant mass and reduces mobility of residual contaminant mass.	8 Alternative effective in targeted areas, Site-wide effectiveness similar to Alternative 4.	8 Alternative makes use of containment, product removal and enhanced biodegradation processes.	8 Alternative makes use of containment, product removal and enhanced biodegradation processes.	4 Alternative makes use of containment, product removal and natural biodegradation processes.
10%	Management of Short Term Risk		8 Effective short-term management; potential for contact during drilling of injection and extraction wells.	6 Less effective short-term management; increased direct-contact exposure risk and inhalation risk during excavation.	9 Effective short term management; possible contact during AS/SVE installation, LNAPL recovery or groundwater monitoring.	9 Effective short term management; possible contact during AS/SVE installation, LNAPL recovery or groundwater monitoring.	3 Exceeds screening levels at CPOC; little site disturbance, possible contact during LNAPL recovery or groundwater monitoring.
10%	Implementability		3 Somewhat implementable; implementation requires establishing long-term footprint for Thermal equipment; significant interim Site impact for drilling and operations setup.	1 Low implementability; requires shutdown of significant portion of site during targeted excavation in addition to interim and long-term footprint associated with AS/SVE system.	7 Implementable; implementation requires establishing long-term footprint for AS/SVE equipment and interim footprint for drilling 4 horizontal wells and operations setup.	8 Implementable; implementation requires establishing long-term footprint for AS/SVE equipment and interim footprint for drilling 2 horizontal wells and operations setup.	7 Most implementable; implementable with minor additional infrastructure. Minimal impact to site operations with proper scheduling and coordination.
10%	Consideration of Public Concerns		9 Unknown pending public comment.	9 Unknown pending public comment.	9 Unknown pending public comment.	9 Unknown pending public comment.	9 Unknown pending public comment.
		Equations for DCA Comparisons [3]					
MTCA Overall Benefit Score (1-10)		*Row A)*	**8.5**	**7.2**	**7.9**	**8.0**	**5.0**
Disproportionate Cost Analysis							
Estimated Remedy Cost		*Row B)*	$24,800,000	$9,500,000	$5,100,000	$2,700,000	$1,700,000
Most Practicable Permanent Solution						Yes	
Lowest Cost Alternative							Yes
Relative Cost/Benefit Ratio (divided by 100,000)		*Row C) = (Row B / 100,000) / Row A*	29.2	13.2	6.5	3.4	3.4
Incremental Increase/Decrease in Relative Benefit to Most Practicable Permanent Alternative		*Row D) = Row A values: [Alt(n) - Alt(3a)] / Alt(3a)*	6%	-10%	-1%	0%	-38%
Incremental Increase/Decrease in Cost to Most Practicable Permanent Alternative		*Row E) = Row B values: [Alt(n) - Alt(3a)] / Alt(3a)*	764%	291%	91%	0%	1%
Costs Disproportionate to Incremental Benefits (Relative to Alternative 3a)? [2]		*Row F) "Yes " if (Row E) > (Row D)*	Yes	Yes	Yes	No	Yes
Remedy Permanent to the Maximum Extent Practicable			Yes	Yes	Yes	Yes	Yes
Meets Remediation Objectives			Yes	Yes	Yes	Yes	Yes

PgG

Table 3-2. Disproportionate Cost Analysis and Comparison to MTCA Criteria
Port of Seattle Terminal 30

	Alternative 1	Alternative 2	Alternative 3b	Alternative 3a	Alternative 4
	In-Situ Thermal Desorption	**Expanded Sheen Area AS/SVE with Targeted Excavation**	**Expanded Sheen-Area AS/SVE with LNAPL Recovery**	**Targeted Sheen-Area AS/SVE with LNAPL Recovery**	**Compliance Monitoring with LNAPL Recovery**
Compliance With MTCA Threshold Criteria					
Protect Human Health and the Environment	Yes	Yes	Yes	Yes	Yes
Comply with Cleanup Standards	Yes	Yes	Yes	Yes	Yes
Comply with Applicable State and Federal Laws	Yes	Yes	Yes	Yes	Yes
Provide for Compliance Monitoring	Yes	Yes	Yes	Yes	Yes
Restoration Time Frame	30 years	30 years	30 years	30 years	30 to 70 years
Potential Risk to Human Health and the Environment	Low	Low	Low	Low	Low
Practicability of Achieving Shorter Restoration Time	See DCA, above	See DCA, above	See DCA, above	See DCA, above	See DCA, above
Current Use of Site, Surrounding Area, and Resources	Active Shipping Terminal	Active Shipping Terminal	Active Shipping Terminal	Active Shipping Terminal	Active Shipping Terminal
Future Use of Site, Surrounding Area, and Resources	Active Shipping Terminal	Active Shipping Terminal	Active Shipping Terminal	Active Shipping Terminal	Active Shipping Terminal
Availability of Alternative Water Supplies [1]	Required by Local Code	Required by Local Code	Required by Local Code	Required by Local Code	Required by Local Code
Likely Effectiveness/Reliability of Institutional Controls	High	High	High	High	High
Ability to Monitor/Control Migration of Hazardous Substances	High	High	High	High	High
Toxicity of Hazardous Substances at the Site	Moderate	Moderate	Moderate	Moderate	Moderate
Natural Processes That Reduce Concentrations	Yes	Yes	Yes	Yes	Yes
Overall Reasonable Restoration Time Frame	Yes	Yes	Yes	Yes	Yes

Notes:

LNAPL is light non aqueous phase liquid.

Remedial Alternative cost details in Table 3-1 and Appendix J.

DCA: Disproportionate Cost Analysis

[1] See Section 2.6.3.1

[2] Costs are disproportionate to benefits if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative.

[3] DCA Relative Benefits as in WAC 173-340-360(2)(b)(i) and WAC 173-340-360(3)(f)

"Permanent solution" means a cleanup action in which cleanup standards of WAC 173-340-700 through 173-340-760 can be met without further action being required at the site being cleaned up or any other site involved with the cleanup action, other than the approved disposal of any residue from the treatment of hazardous substances.

Overall Benefit Score weighting factors taken from Ecology NWRO RI/FS template.

Terminal 30

1991 AO Site Boundary

Sections

0 Feet 2,000

0 Miles 0.5

N

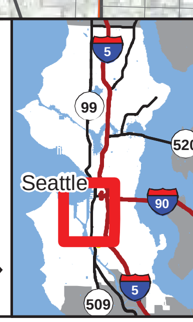

Figure 1-1

T30 Site Vicinity Map

Port of Seattle
Terminal 30

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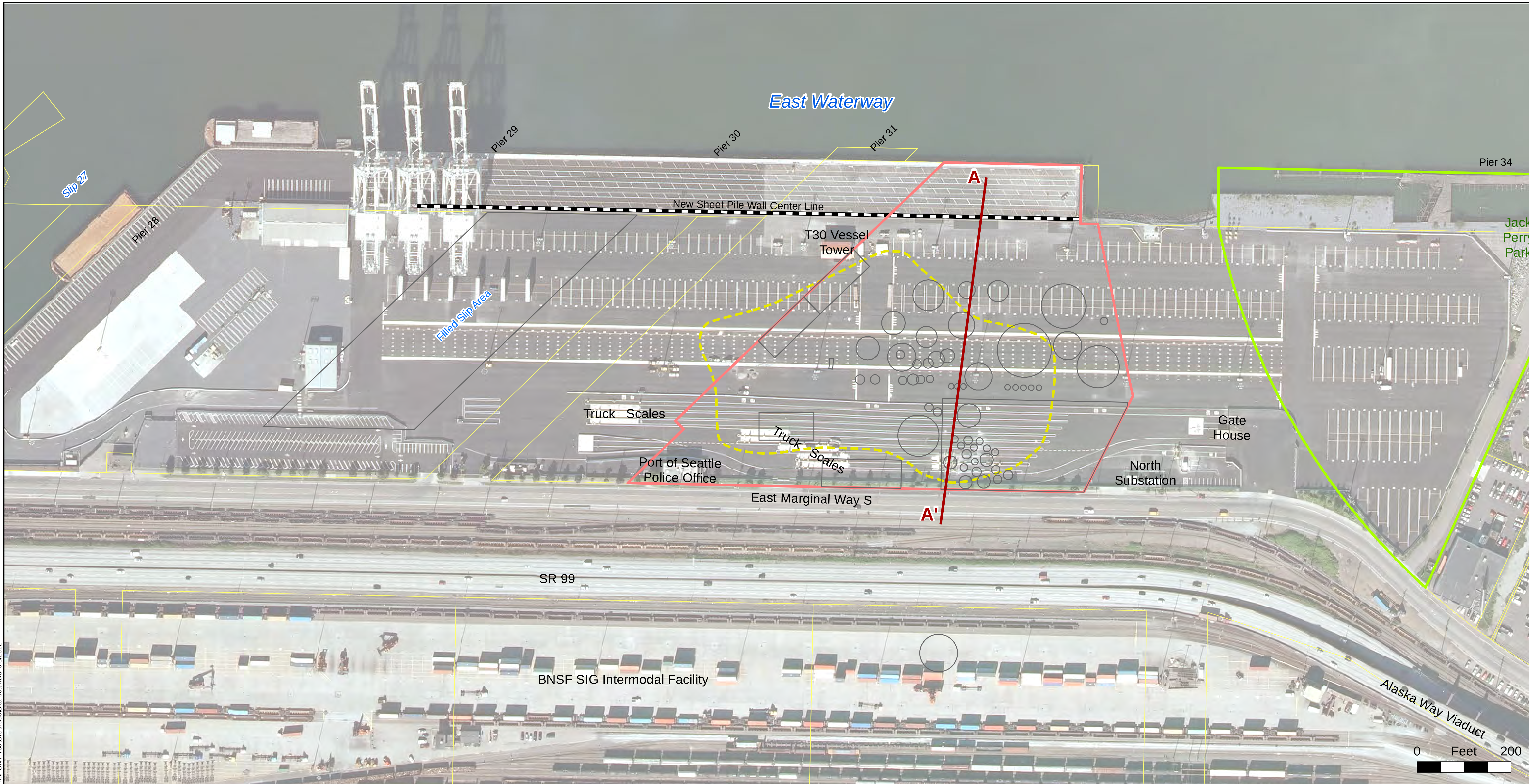

1991 AO Site Boundary
Maximum Extent of Product Plume 1984-1991 (GeoEngineers, 1998)
Historic Structures
Former GATX Property
Parcel Outline
Cross Section Alignment
Section A-A' in Figure 2-4

2009 USGS Orthophoto

Figure 1-2
T30 AO Site Map

Port of Seattle
Terminal 30

PGG

Figure 2-1a. Site Timeline (1900 - 1979)

Port of Seattle Terminal 30

		North Site		South Site	
Decade	Year	Owner	Site Use	Owner	Site Use
	1900		Elliot Bay Tide Flats		Elliot Bay Tide Flats
	1901				
	1902				
	1903				
1900s	1904				
	1905	Chevron	1905: Bulk Fuel Terminal		
	1906				
	1907				
	1908				
	1909				
	1910				
	1911				
	1912				
	1913				
1910s	1914			Stetson and Post (Lumber Yard); Stetson and Ross (Machine Shop)	1914 (est): Lumber Yard and Machine Shop
	1915				
	1916				
	1917				
	1918				
	1919				
	1920			Nelson and Katz Shipbuilding Company	1920: Shipbuilding
	1921				
	1922				
	1923				
1920s	1924				
	1925				
	1926				
	1927				
	1928				
	1929				
	1930				
	1931				
	1932				
	1933				
1930s	1934				
	1935				
	1936				
	1937				
	1938				
	1939				
	1940				
	1941				
	1942				
	1943				
1940s	1944				
	1945				
	1946				
	1947				
	1948				
	1949				
	1950			Chevron	1950: Bulk Fuel Terminal
	1951				
	1952				
	1953				
1950s	1954				
	1955				
	1956				
	1957				
	1958				
	1959				
	1960				
	1961				
	1962				
	1963				
1960s	1964				
	1965				
	1966				
	1967				
	1968				
	1969				
	1970				
	1971				
	1972				
	1973				
1970s	1974				
	1975				
	1976				
	1977				
	1978				
	1979				

See Figure 2-1b for continued timeline 1980 through 2012.

No reported envrionmental investigations or remedial actions 1900 through 1979.

North and South refer to separate parcels prior to 1950. Note changes in site use in Appendix A air photos and Sanborn maps from 1905 through 1950.

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Figure 2-1b. Site Timeline (1980 - 2012)
Port of Seattle Terminal 30

Decade	Year	Owner	Site Use	Construction Activities	Environmental Investigations	Interim Actions			Major Documents and Reports [2]
1980s	1980	Chevron	Bulk Fuel Terminal						
	1981								
	1982								
	1983				Soil and Groundwater Investigations and Monitoring (Incl. two tidal studies)				
	1984			Demolition of Bulk Fuel Terminal & Construction of Container Terminal-Apron and Bulkhead		Continuous Hydraulic Product Recovery	East Waterway Dredging		
	1985							Asphalt Cap [1]	
	1986	Port of Seattle	Container Terminal						
	1987								
	1988								
	1989								
1990s	1990								Agreed Order Signed
	1991								
	1992								
	1993								
	1994								
	1995								
	1996								
	1997								
	1998				Pre-MPA Investigations				GeoEngineers Final RI/FS (GeoEngineers, 1998)
	1999			Cruise Ship Terminal Construction		Discrete Product Recovery Events			GeoEngineers Draft Summary Memorandum First Round Pre-MPA (GeoEngineers, 1999)
2000s	2000		Cruise Ship Terminal						
	2001								
	2002								
	2003								GeoEngineers Draft Summary Memorandum Second Round Pre-MPA (GeoEngineers, 2003)
	2004				Groundwater Monitoring and LNAPL Gauging				
	2005								
	2006								
	2007			Container Terminal Construction: Sheet Pile Wall, Gate House, and stormwater system upgrades			Soil Excavation	*New Asphalt*	
	2008		Container Terminal						AECOM Supplemental Data Report v2; Compliance Monitoring Plan (ENSR|AECOM, 2008a,b)
	2009								
2010s	2010								Cargo Terminal Construction Report (ENSR|AECOM, 2010)
	2011								
	2012								PGG RI/FS (This Report)

See Figure 2-1a for site history 1900 through 1979.

[1] Sitewide 16-inch thick asphalt cap after 2007.

[2] See Table 2-1 for additional details and reports.

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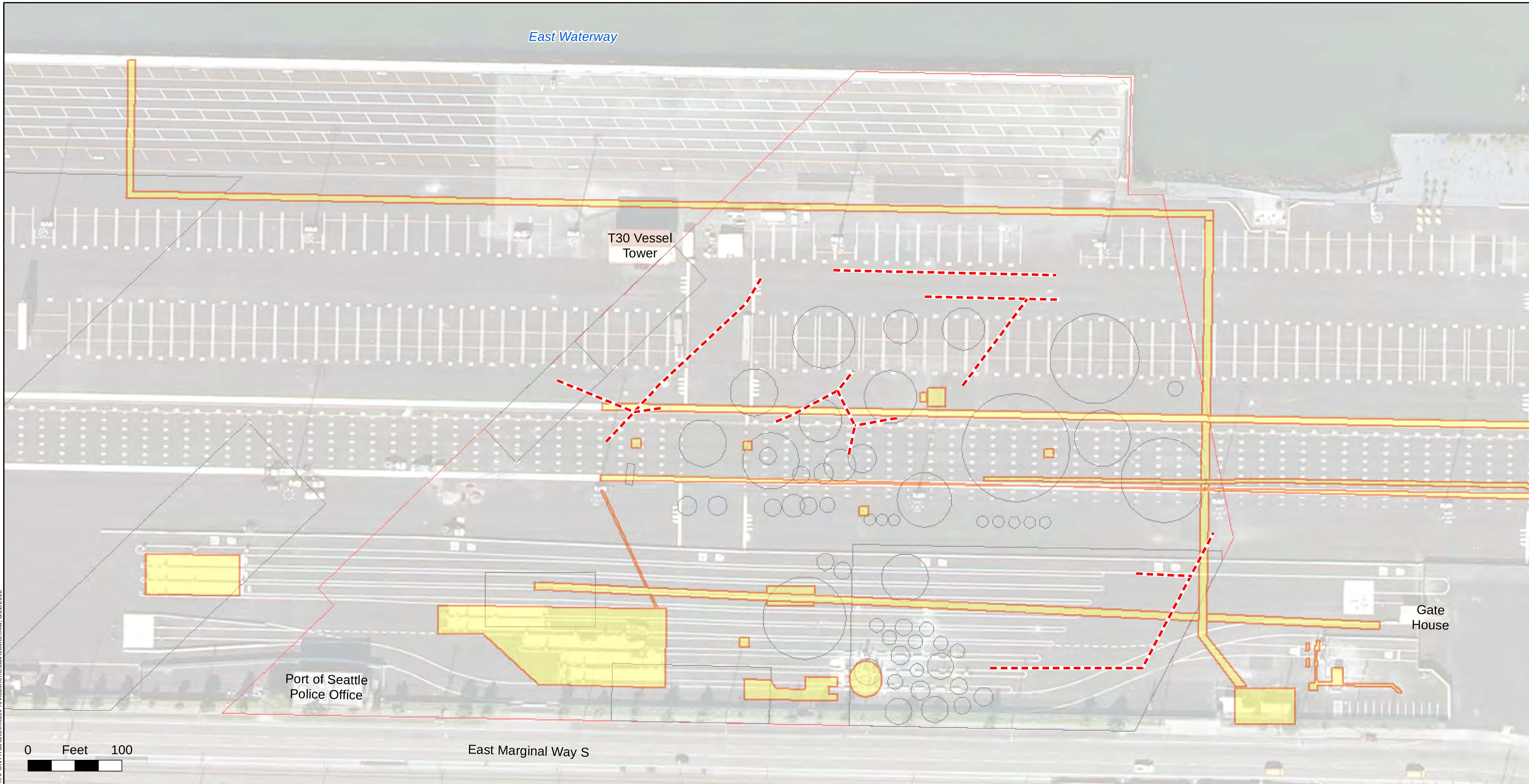


Excavations During 2007-2009 Redevelopment
(11,480 tons of petroleum-impacted soil disposed off-site; ENSR|AECOM, 2010)
See Tables 6-1 & 6-2 of ENSR|AECOM (2010) for details

LNAPL Recovery System (> 171,000 gallons; GeoEngineers, 1998)

Historic Structures

1991 AO Site Boundary

Note: 24,185 tons of soil were disposed of off-site, of which 11,480 tons met Type II disposal criteria as petroleum impacted. Type II criteria were: greater than 100ppm GRO or greater than 200ppm combined DRO and MOR (ENSR|AECOM, 2010).

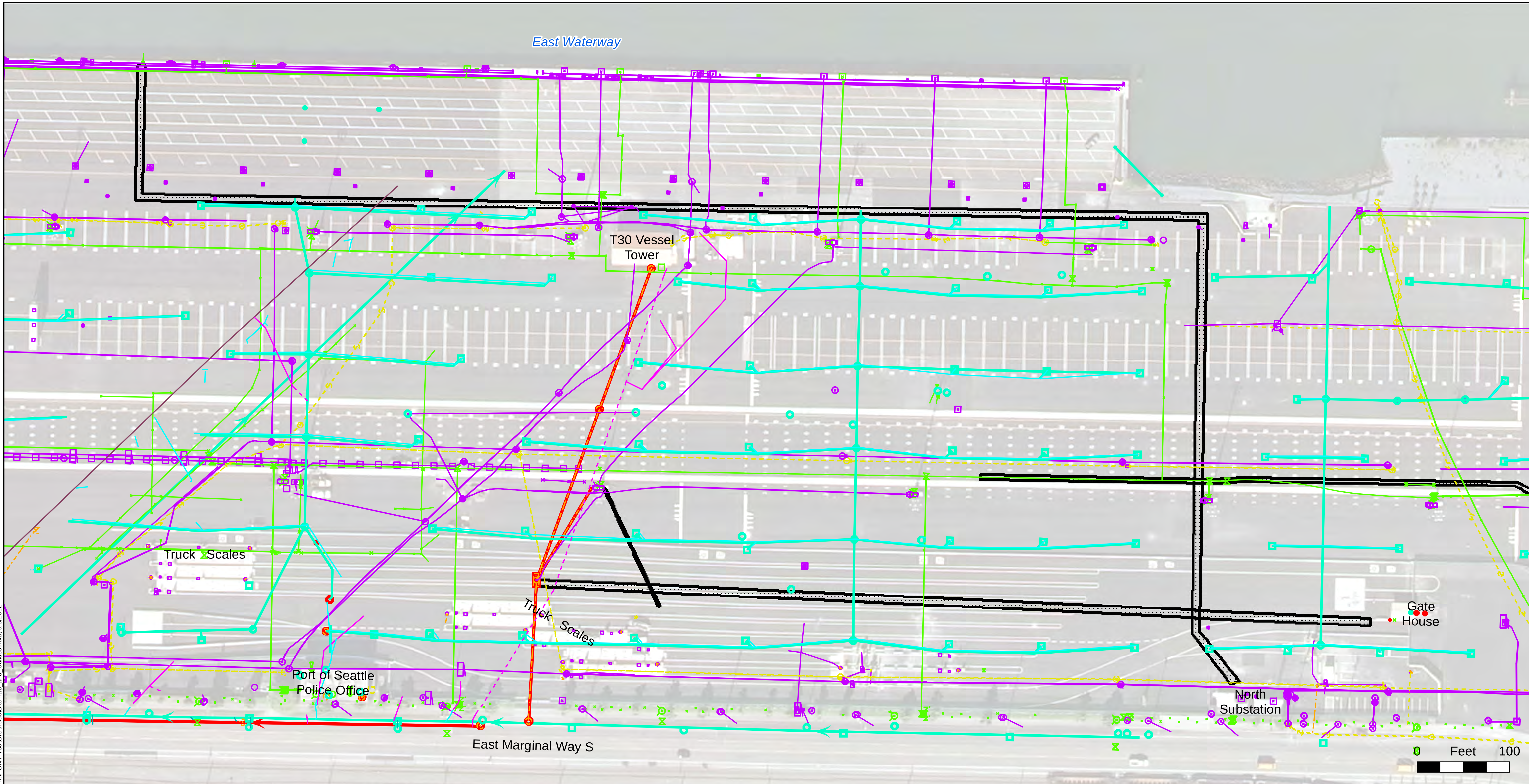
2009 USGS Orthophoto

Figure 2-1c

Previous Remedial Actions

Port of Seattle
Terminal 30

PgG



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Underground Utilities (As Documented by Port of Seattle and SPU)

- Unknown
- Power
- Sanitary Sewer
- Stormwater
- Telephone
- Water
- Construction Completion Report Utility Replacment Areas (ENSR|AECOM, 2010)

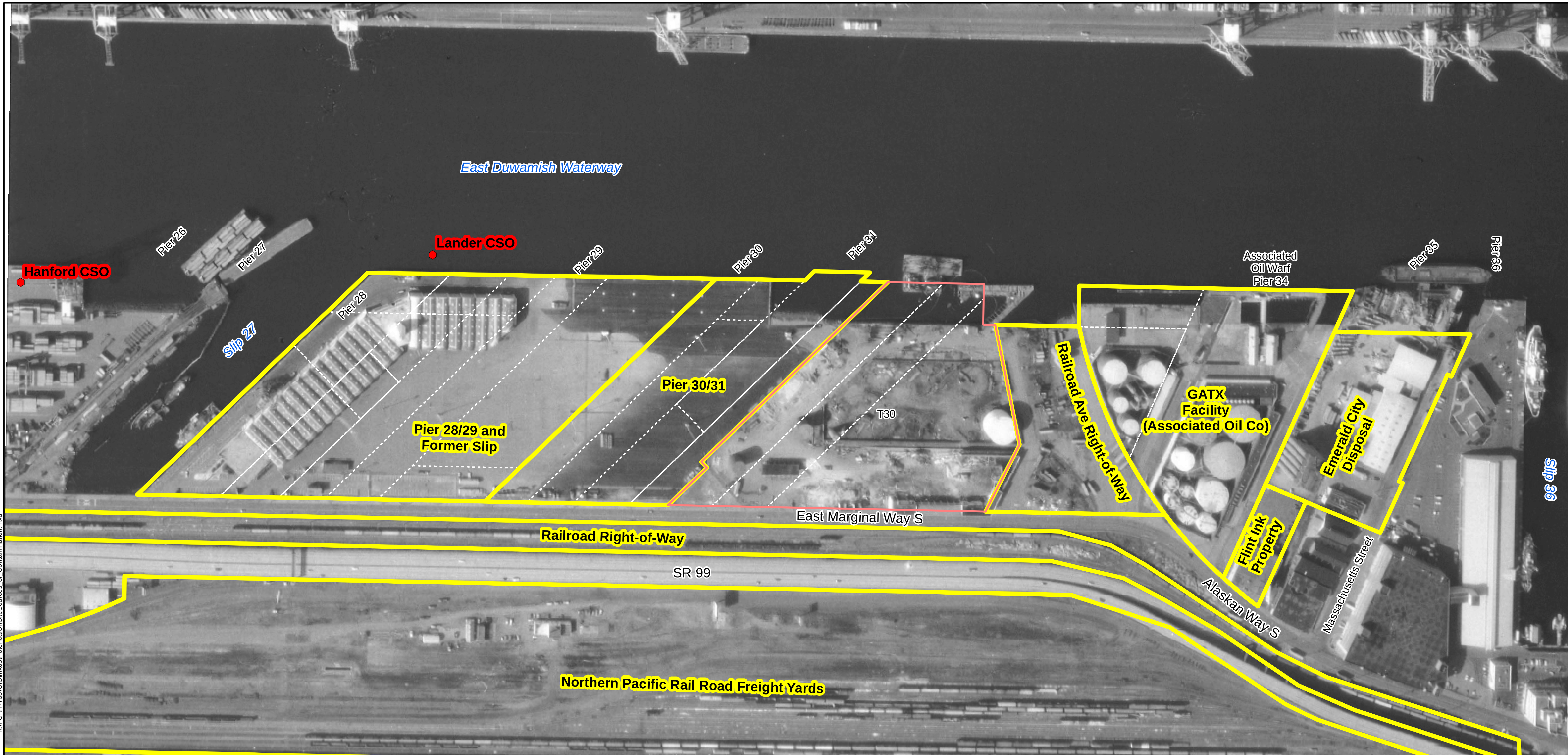
Notes:
Co-located utilities may plot on top of each other;
Isolated catch basins or apron drains may not show connections to stormwater system;
Isolated power utilities marked on map may have connecting buried utilities lines that are not documented in available records

2009 USGS Orthophoto

Figure 2-2
Site Map with Utilities

Port of Seattle
Terminal 30

PgG



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- Lander and Hanford CSO
- Sites Identified as Potential Sources of Contamination
- 1991 AO Site Boundary

N

0 Feet 300

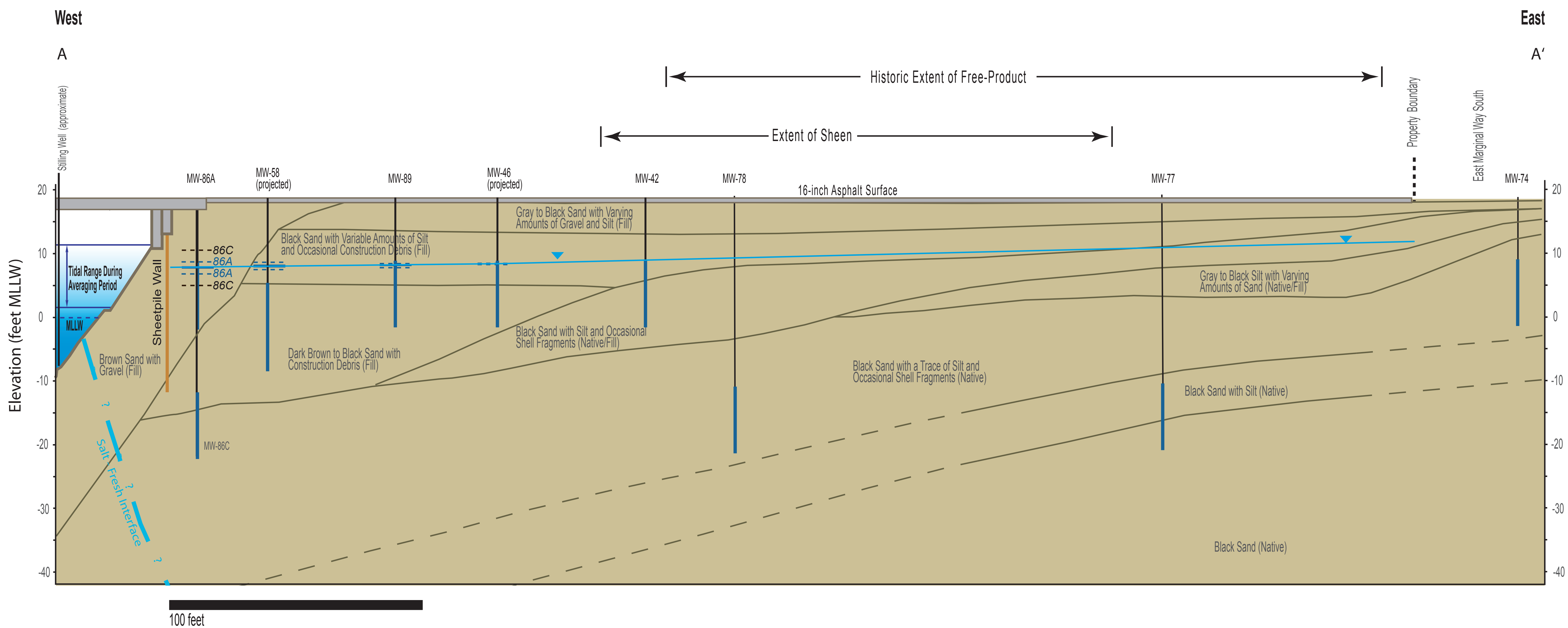
1985 aerial photo has been georeferenced and not orthorectified.
For reference purposes only.

Figure 2-3

Potential Off-Site
Sources of Contamination

Port of Seattle
Terminal 30

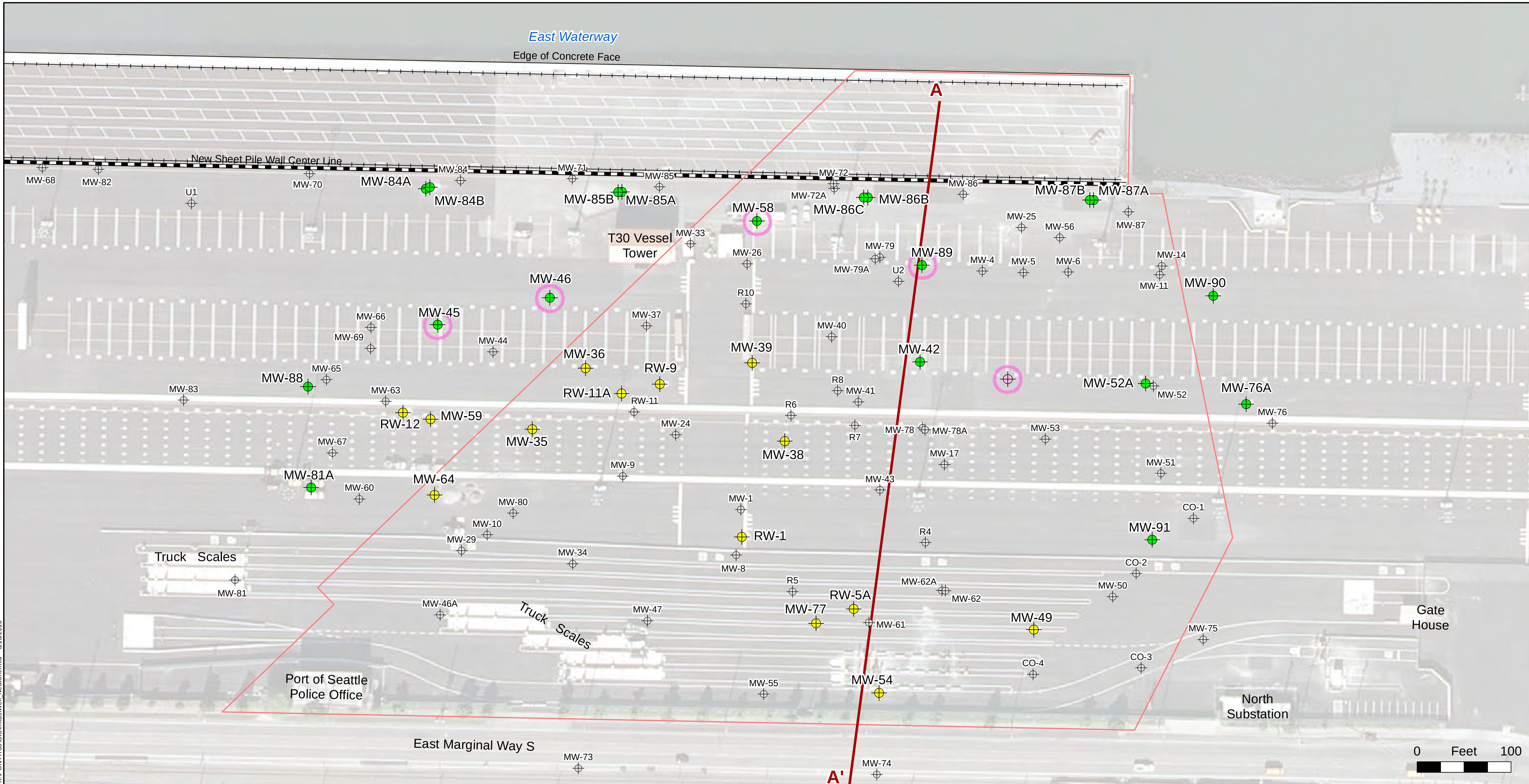
PgG



Notes:
2.5x Vertical Exaggeration.
Geology modified from GeoEngineers (1998) Figure 6.5.
Water table based on average water level during 2011 tidal study.
Features such as pilings and cranes omitted for clarity.
MLLW: Mean Low Low Water.
Horizontal dashed lines at each well indicate maximum and minimum water level during 2011 tidal study.
MW-58 and MW-46 projected into section at distance from sheetpile wall to illustrate tidal variation.

Figure 2-4. Conceptual Geologic Cross Section
Port of Seattle Terminal 30

PGG



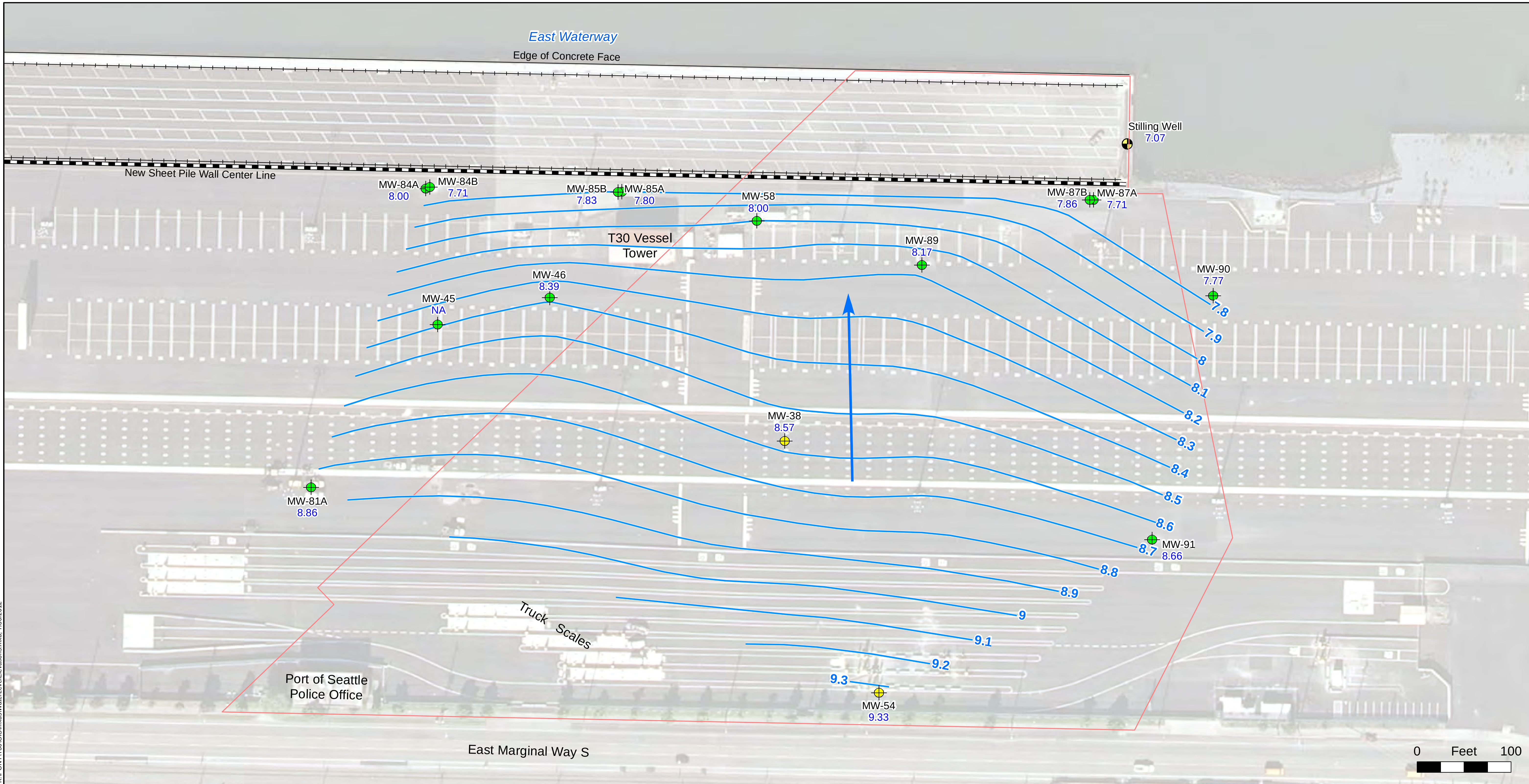
- Gaging/Recovery Well
- Water Quality Monitoring Well
- Decommissioned Wells
- Conditional Point of Compliance (CPOC) Wells
- Proposed New CPOC Well
- 1991 AO Site Boundary
- Cross Section Alignment
  Section A-A' in Figure 2-4

2009 USGS Orthophoto

Figure 2-5
Well Network

Port of Seattle
Terminal 30

PgG



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Average Water Level Elevation Contours

Gaging/Recovery Well

Water Quality Monitoring Well

Stilling Well

7.71 Time-Averaged / Density Corrected Water Level Elevations

Vertical Datum: MLLW

1991 AO Site Boundary

Groundwater Flow Direction

Water level elevations based on averaged elevations from 2011 tidal study

N

2009 USGS Orthophoto

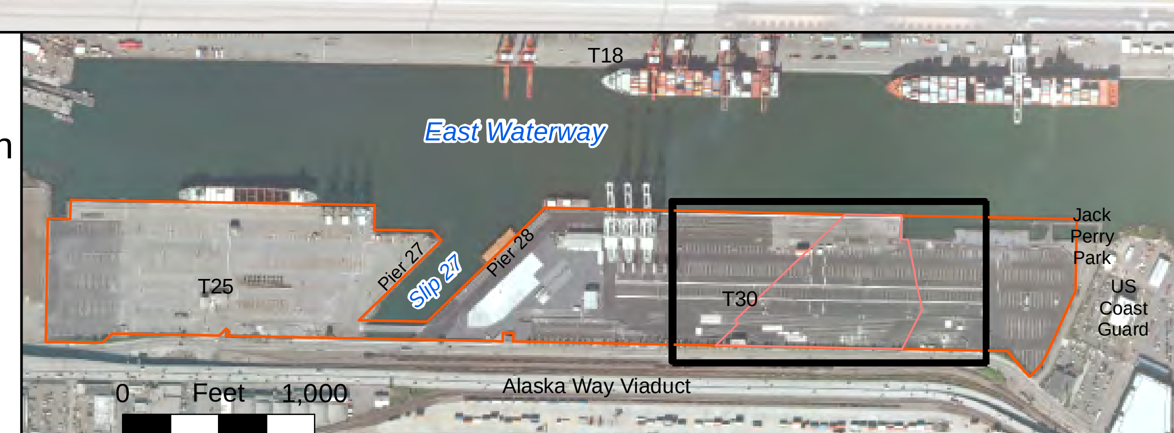


Figure 2-6

Water Level Contour Map

Terminal 30

Port of Seattle

PgG

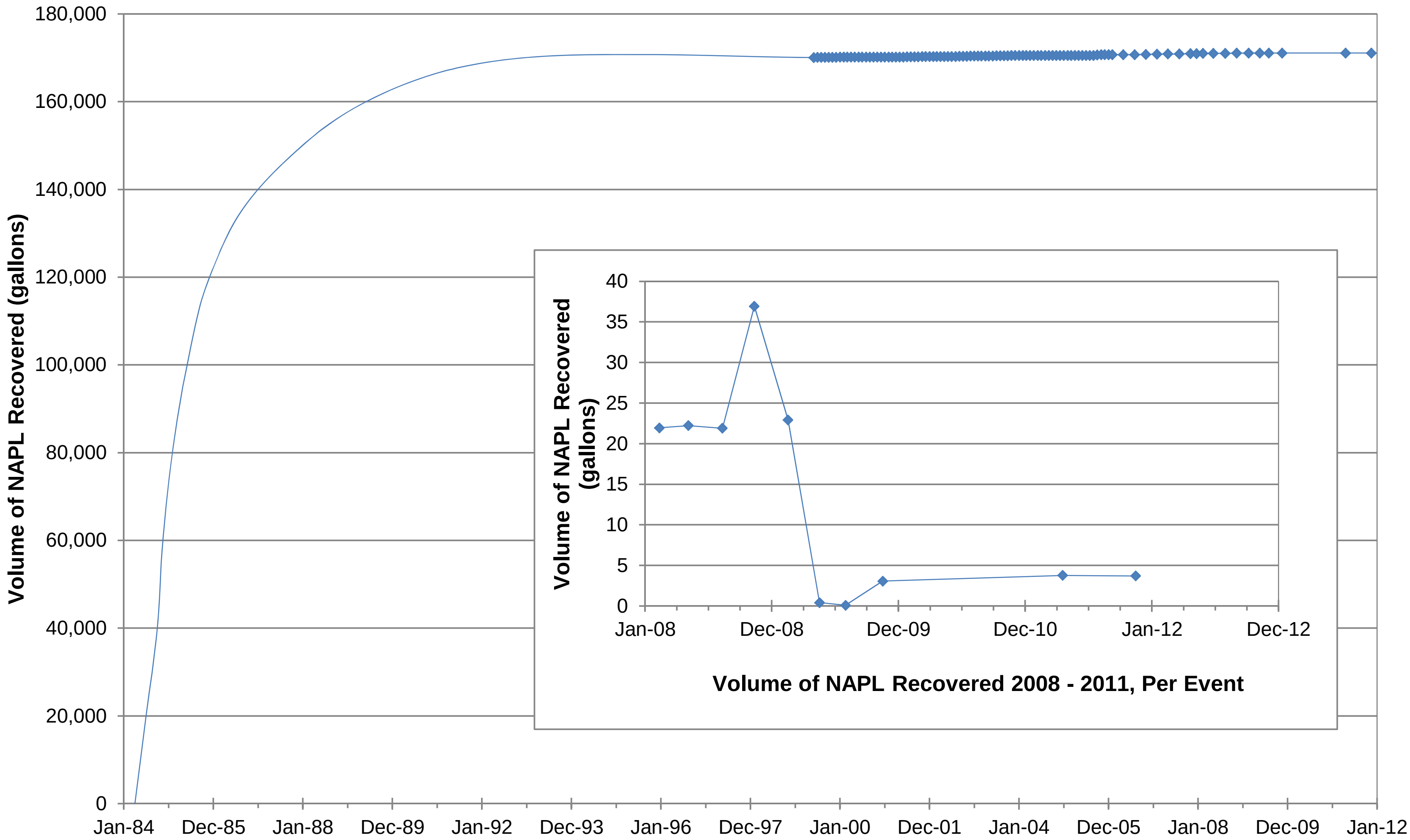
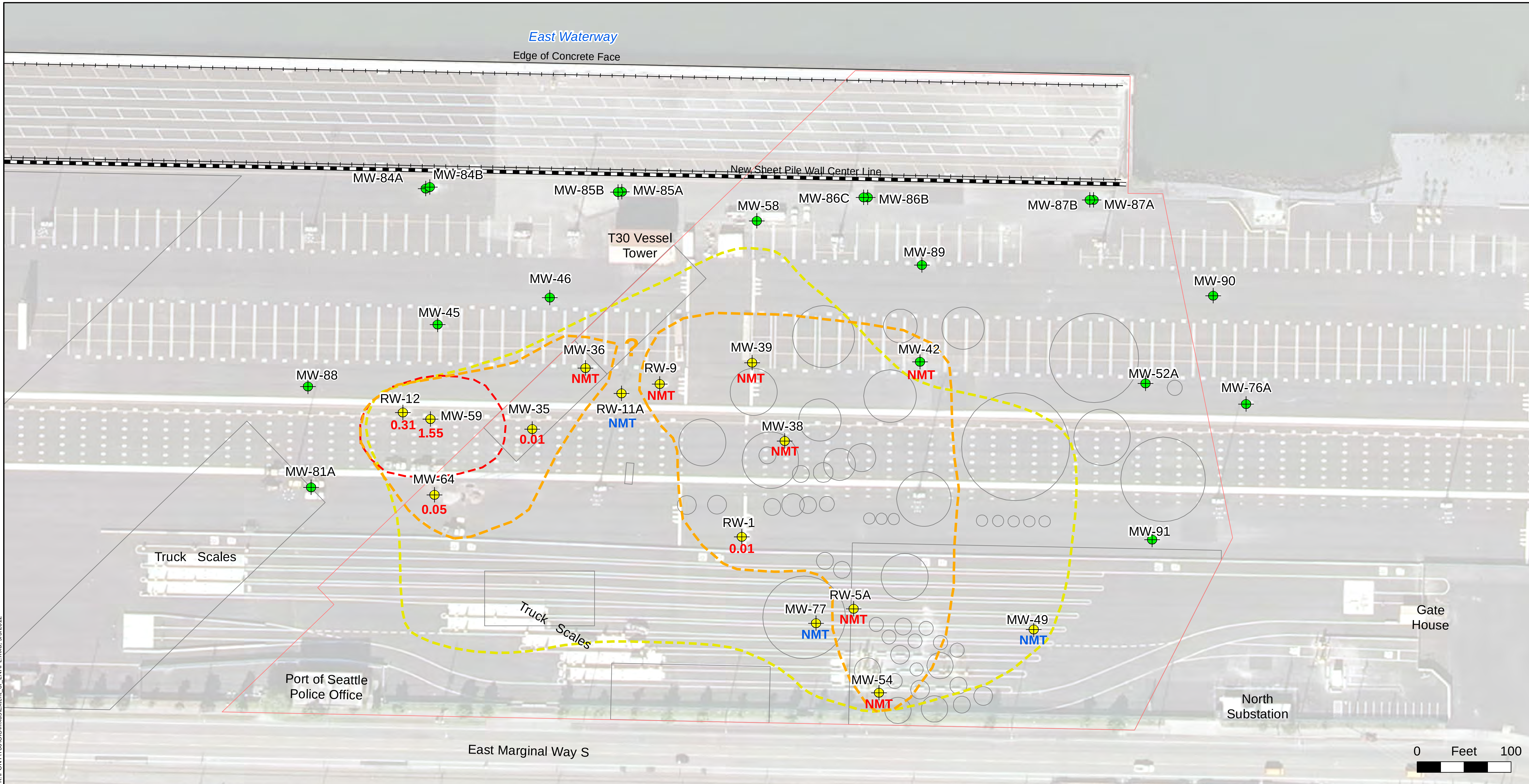


Figure 2-7. Product Recovery
Port of Seattle Terminal 30

PGG



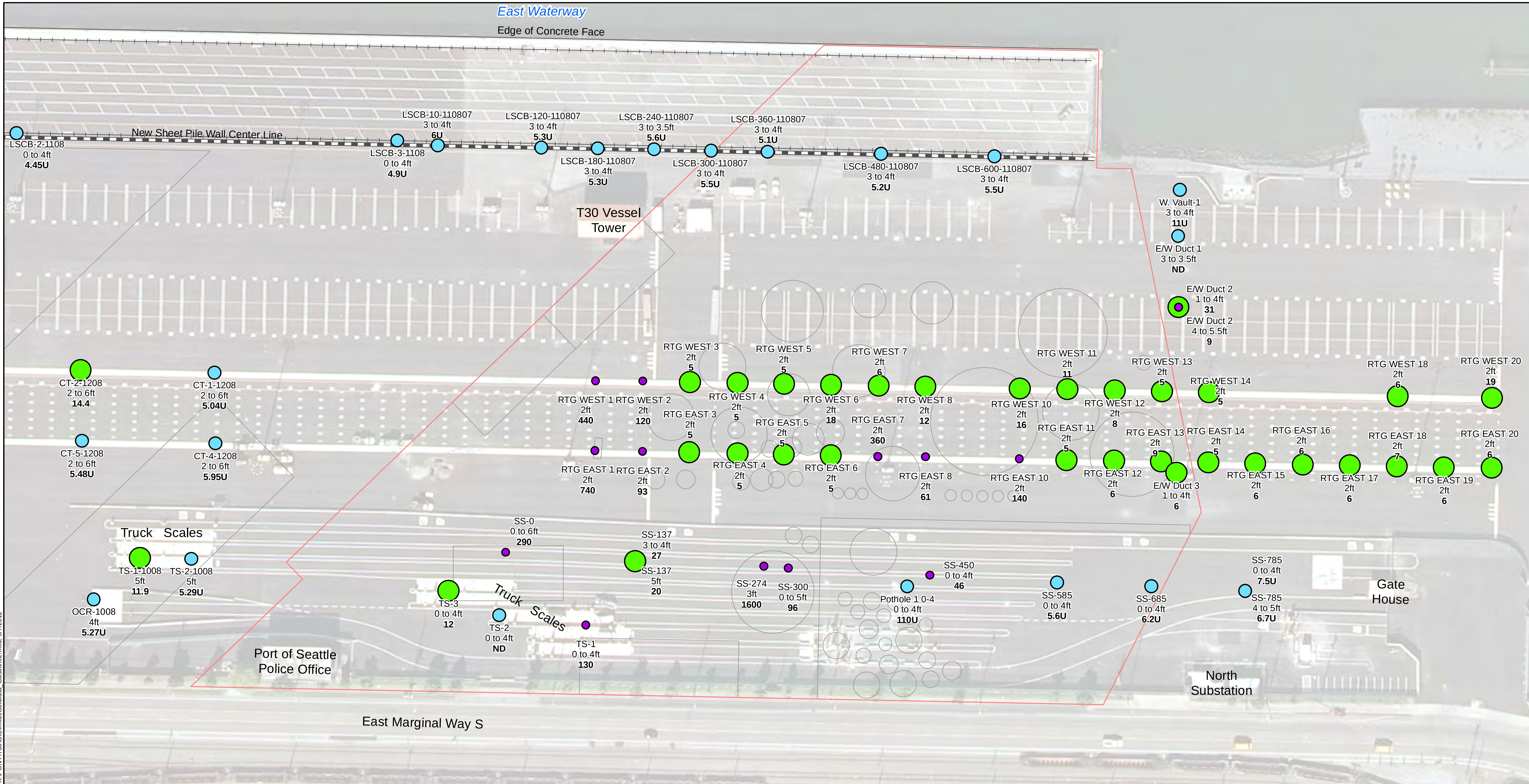
- Gaging/Recovery Well
- Water Quality Monitoring Well
- **1.55** LNAPL Thickness (feet) April 2011
  - NMT= No Measureable Thickness, Sheen Present;
  - NMT= No Measureable Thickness, No Sheen Present;
- Maximum Extent of Product Plume 1984-1991 (GeoEngineers, 1998)
- LNAPL > 0.1 Feet - April 2011
- Sheen Area - April 2011
- 1991 AO Site Boundary
- Historic Structures

2009 USGS Orthophoto

Figure 2-8
Extent of LNAPL and Sheen

Port of Seattle
Terminal 30

PgG



Sample Location

TS-3 = Location ID
0 to 4ft = Depth
12 = **Result in mg/kg**

Sample Result (mg/kg)

- Non-Detect
- Detect, Concentration Below Screening Level (30 mg/kg)
- Detect, Concentration Above Screening Level (30 mg/kg)

- Historical Structures
- 1991 AO Site Boundary

ND = Non-Detect, Reporting Limit Not Known
U = Non-Detect, Reporting Limit Shown

Data from:
Terminal 30 Cargo Terminal Construction Completion Report (AECOM, 2010);
1998 RI/FS Report (GeoEngineers, 1998)

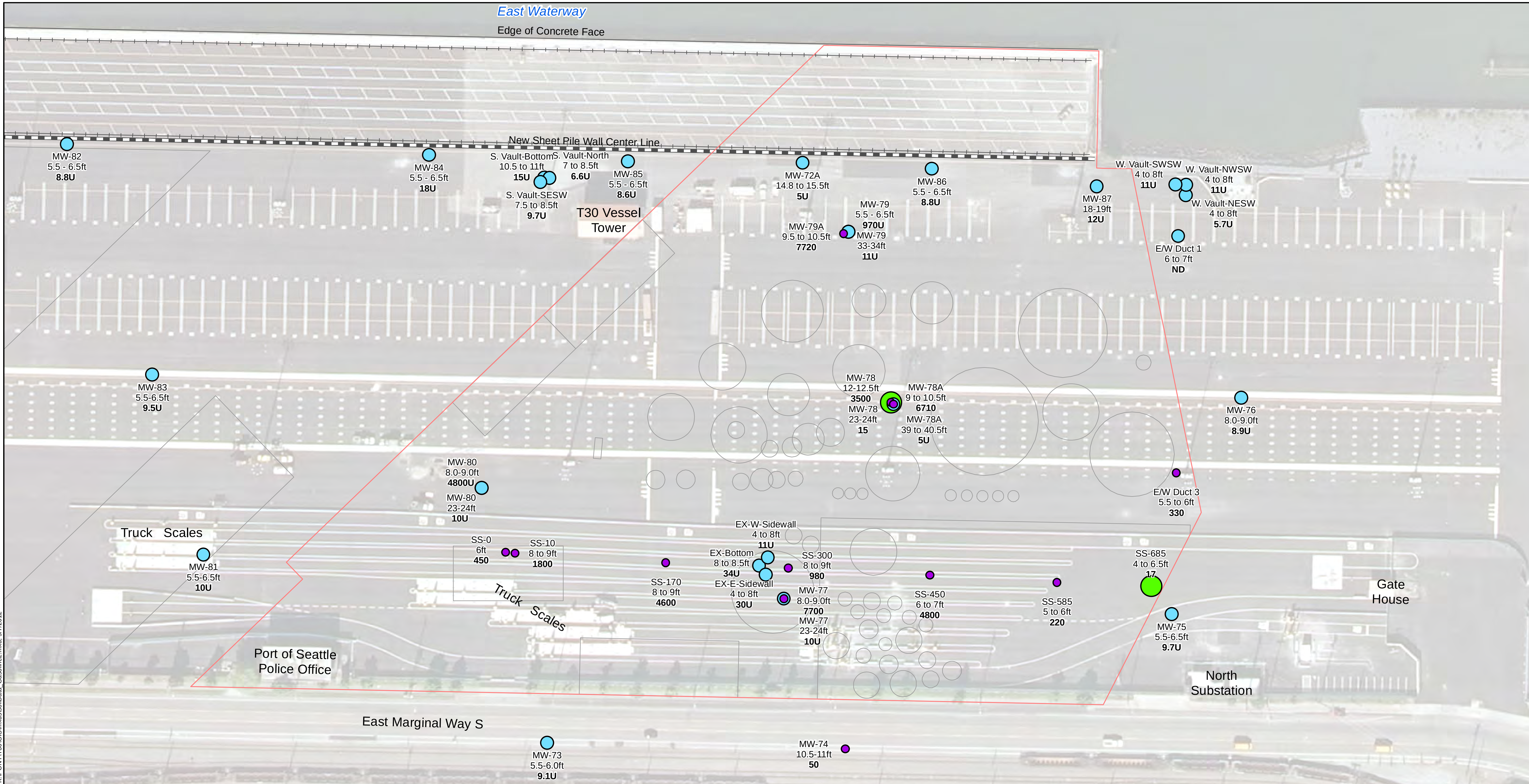
0 Feet 100

2009 USGS Orthophoto

Figure 2-9a
Soil Analytical Results,
Gasoline Range Organics
0 to 5 feet Below Ground Surface

Port of Seattle
Terminal 30

PGG



Sample Location

TS-3 = Location ID
0 to 4ft = Depth
12 = **Result in mg/kg**

ND = Non-Detect, Reporting Limit Not Known
U = Non-Detect, Reporting Limit Shown

Data from:
Terminal 30 Cargo Terminal Construction Completion Report (AECOM, 2010);
1998 RI/FS Report (GeoEngineers, 1998)

Sample Result (mg/kg)

- Non-Detect
- Detect, Concentration Below Screening Level (30 mg/kg)
- Detect, Concentration Above Screening Level (30 mg/kg)

- Historical Structures
- 1991 AO Site Boundary

N
0 Feet 100

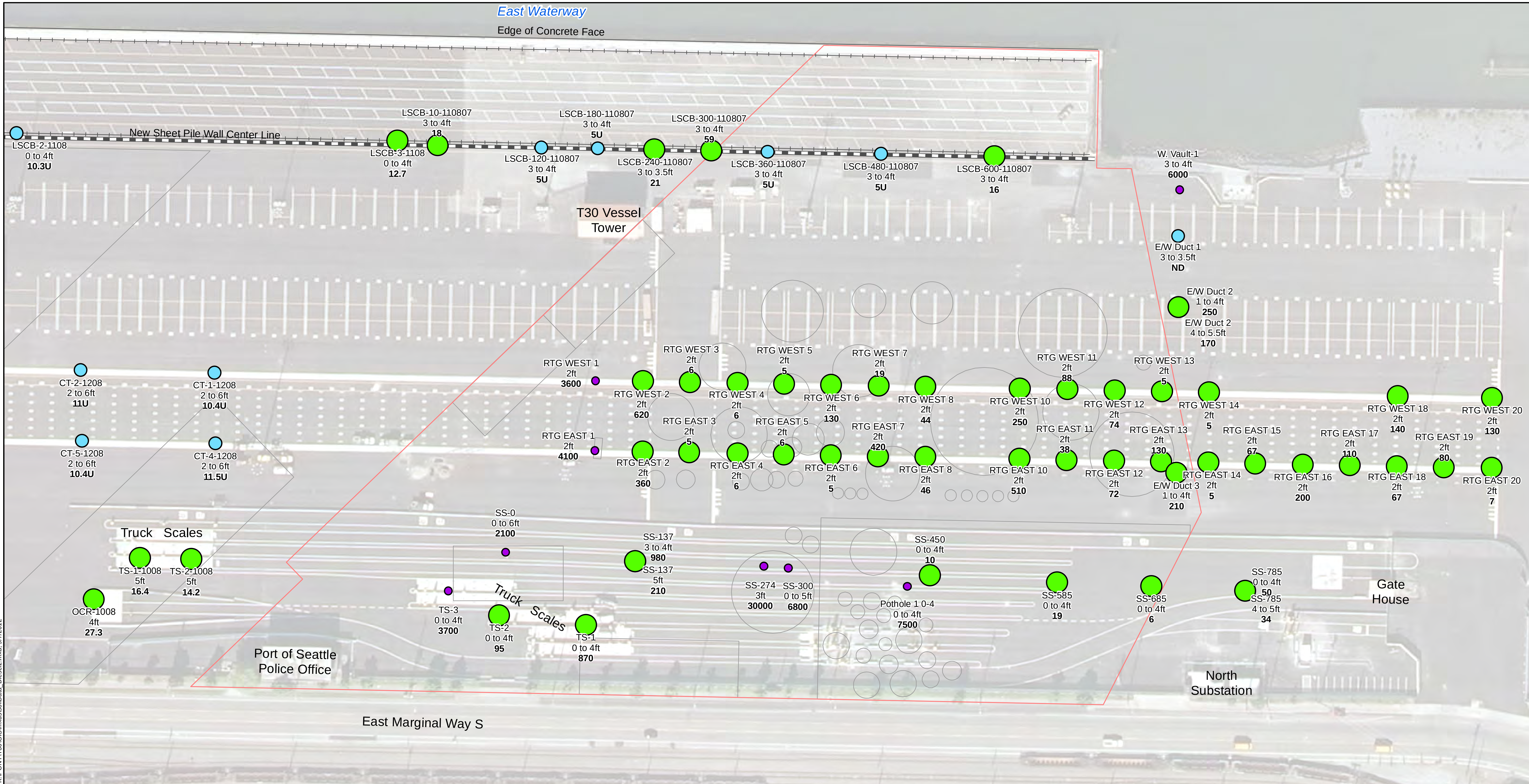
2009 USGS Orthophoto

Figure 2-9b

Soil Analytical Results, Gasoline Range Organics Deeper than 5 feet Below Ground Surface

Port of Seattle
Terminal 30

PgG



Sample Location

TS-2 = Location ID
0 to 4ft = Depth
95 = **Result in mg/kg**

Sample Result (mg/kg)

- Non-Detect
- Detect, Concentration Below Screening Level (2000 mg/kg)
- Detect, Concentration Above Screening Level (2000 mg/kg)
- Historical Structures
- 1991 AO Site Boundary

ND = Non-Detect, Reporting Limit Not Known
U = Non-Detect, Reporting Limit Shown

Data from:
Terminal 30 Cargo Terminal Construction Completion Report (AECOM, 2010);
1998 RI/FS Report (GeoEngineers, 1998)

0 Feet 100

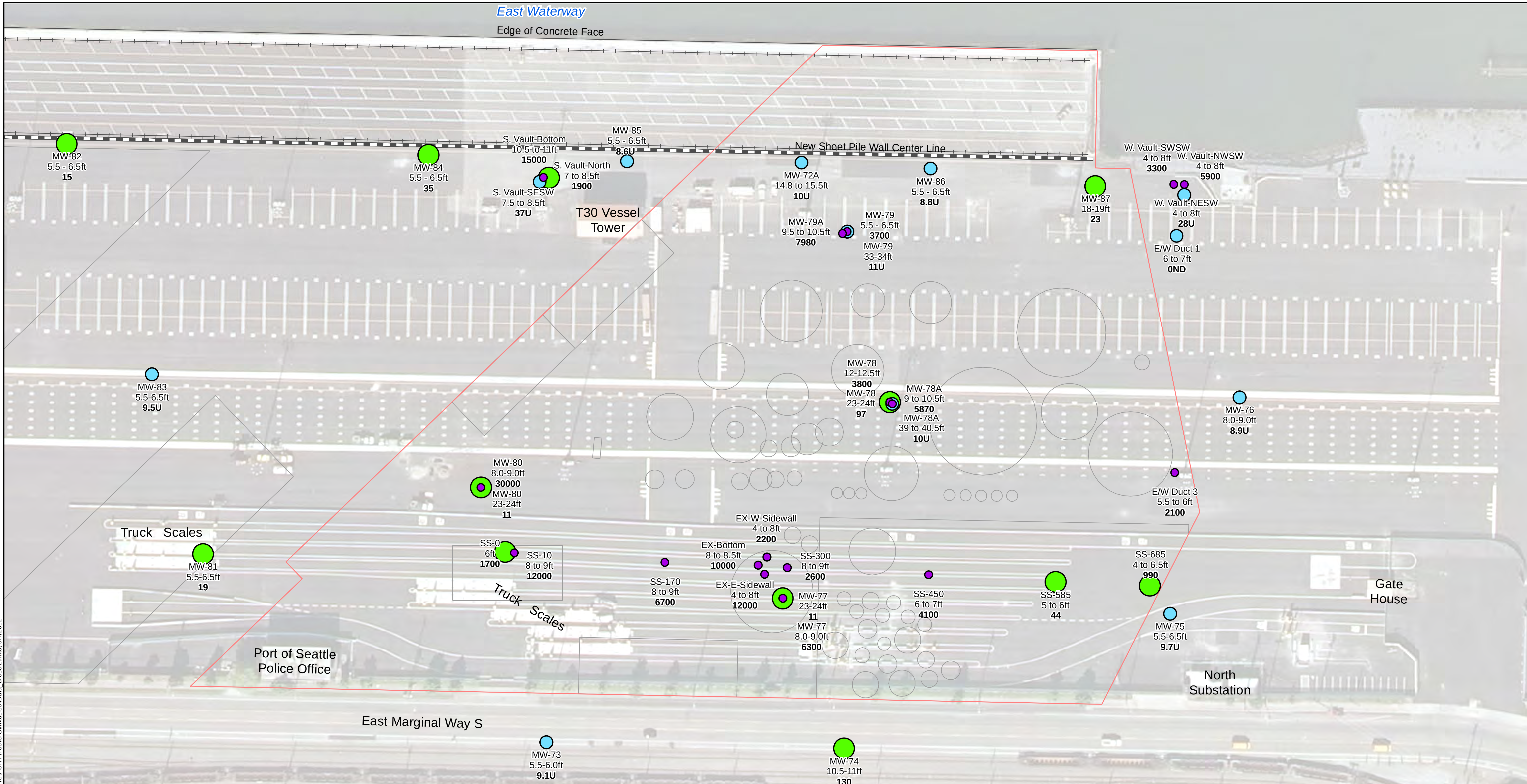
2009 USGS Orthophoto

Figure 2-10a

Soil Analytical Results,
Diesel Range Organics
0 to 5 feet Below Ground Surface

Port of Seattle
Terminal 30

PGG



Sample Location

MW-81 = Location ID
5.5-6.5ft = Depth
19 = **Result in mg/kg**

Sample Result (mg/kg)

- Non-Detect
- Detect, Concentration Below Screening Level (2000 mg/kg)
- Detect, Concentration Above Screening Level (2000 mg/kg)

- Historical Structures
- 1991 AO Site Boundary

ND = Non-Detect, Reporting Limit Not Known
U = Non-Detect, Reporting Limit Shown

Data from:
Terminal 30 Cargo Terminal Construction Completion Report (AECOM, 2010);
1998 RI/FS Report (GeoEngineers, 1998)

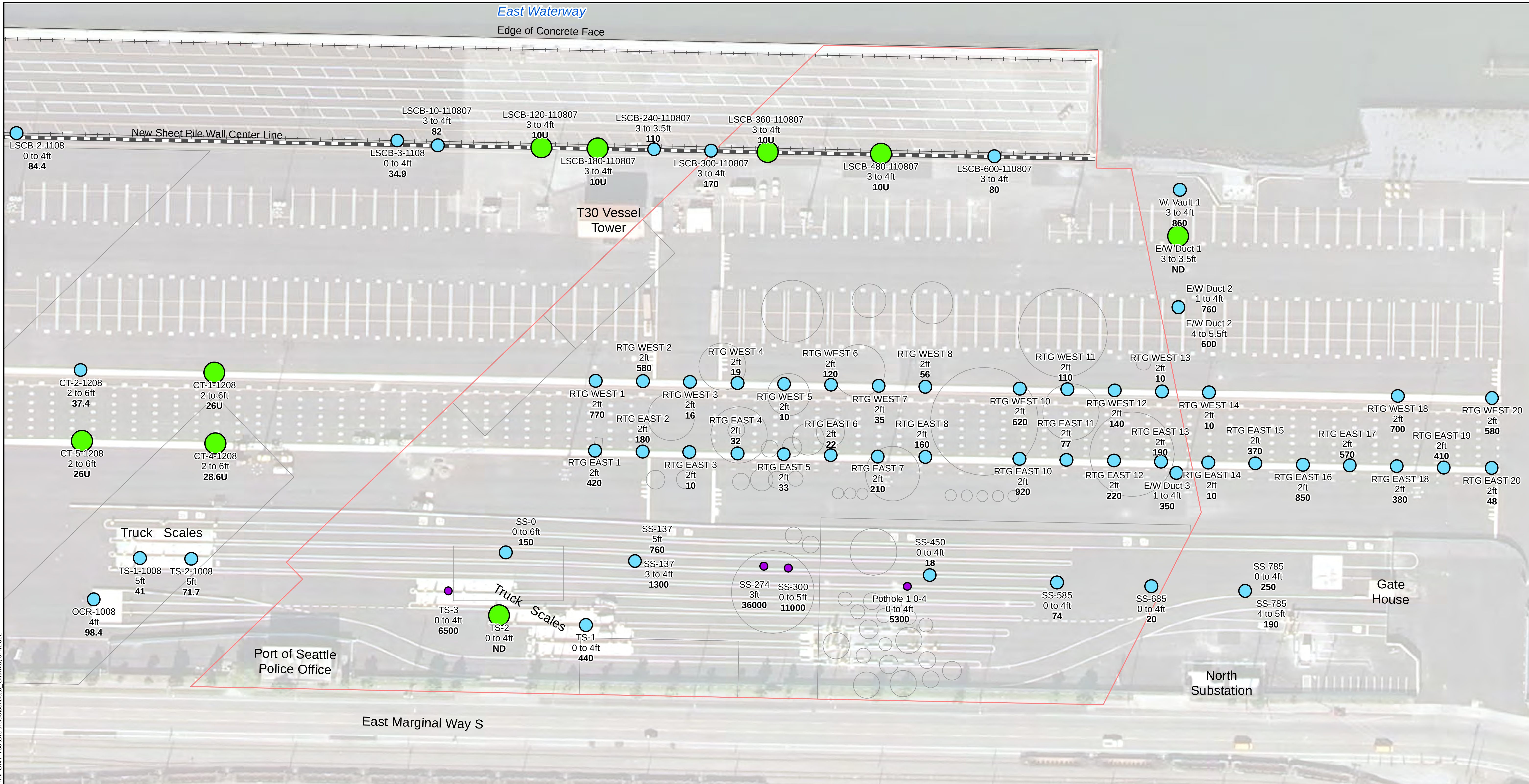
0 Feet 100

2009 USGS Orthophoto

Figure 2-10b
Soil Analytical Results, Diesel Range Organics Deeper than 5 feet Below Ground Surface

Port of Seattle
Terminal 30

PgG



Sample Location

SS-0 = Location ID
0 to 6ft = Depth
150 = Result in mg/kg

Sample Result (mg/kg)

- Non-Detect
- Detect, Concentration Below Screening Level (2000 mg/kg)
- Detect, Concentration Above Screening Level (2000 mg/kg)

Historical Structures

1991 AO Site Boundary

ND = Non-Detect, Reporting Limit Not Known
U = Non-Detect, Reporting Limit Shown

Data from:
Terminal 30 Cargo Terminal Construction Completion Report (AECOM, 2010);
1998 RI/FS Report (GeoEngineers, 1998)

N

0 Feet 100

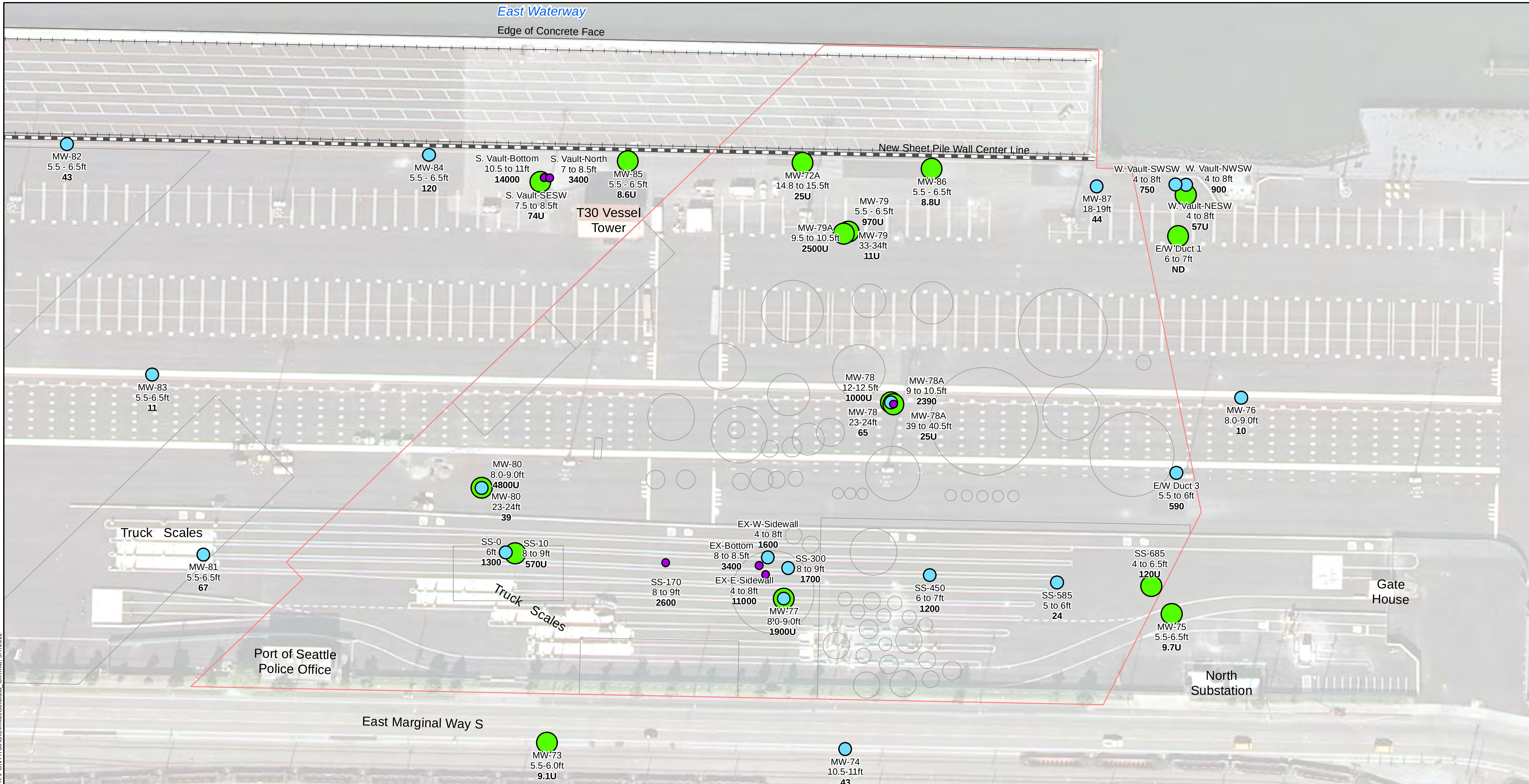
2009 USGS Orthophoto

Figure 2-11a

Soil Analytical Results,
Oil Range Organics
0 to 5 feet Below Ground Surface

Port of Seattle
Terminal 30

PGG



Sample Location

SS-0 = Location ID
0 to 6ft = Depth
150 = **Result in mg/kg**

Sample Result (mg/kg)

- Non-Detect
- Detect, Concentration Below Screening Level (2000 mg/kg)
- Detect, Concentration Above Screening Level (2000 mg/kg)

- Historical Structures
- 1991 AO Site Boundary

ND = Non-Detect, Reporting Limit Not Known
U = Non-Detect, Reporting Limit Shown

Data from:
Terminal 30 Cargo Terminal Construction Completion Report (AECOM, 2010);
1998 RI/FS Report (GeoEngineers, 1998)

N
0 Feet 100

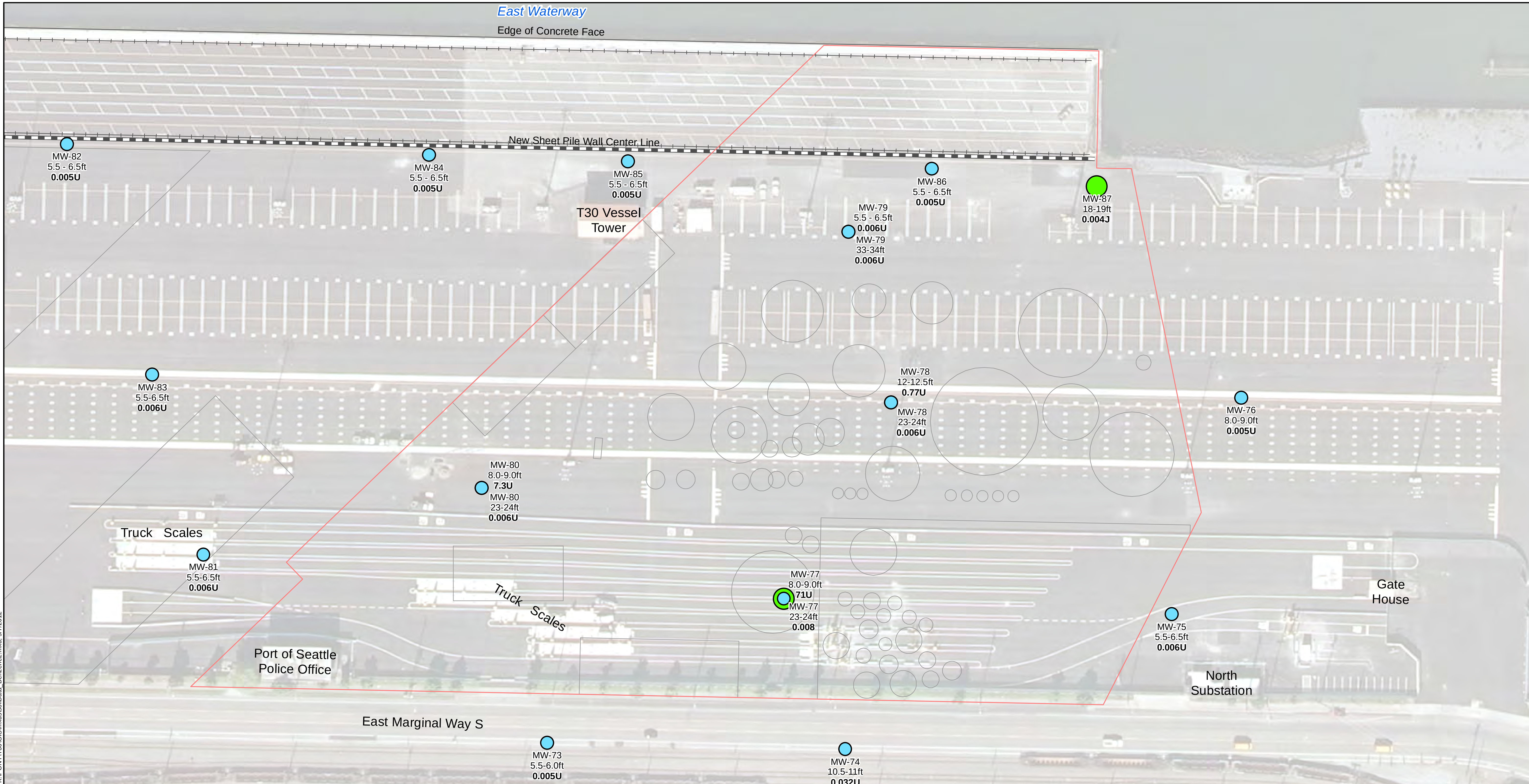
2009 USGS Orthophoto

Figure 2-11b

Soil Analytical Results, Oil Range Organics Deeper than 5 feet Below Ground Surface

Port of Seattle
Terminal 30

PGG



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Sample Location

MW-81 = Location ID
5.5-6.5ft= Depth
0.006U = Result in mg/kg

Sample Result (mg/kg)

Non-Detect

Detect, Concentration Below Screening Level (0.03 mg/kg)

Detect, Concentration Above Screening Level (0.03 mg/kg)

Historical Structures

1991 AO Site Boundary

ND = Non-Detect, Reporting Limit Not Known
U = Non-Detect, Reporting Limit Shown
J = Extimated Value

Data from:
Terminal 30 Cargo Terminal Construction Completion Report (AECOM, 2010);
1998 RI/FS Report (GeoEngineers, 1998)

N
0 Feet 100

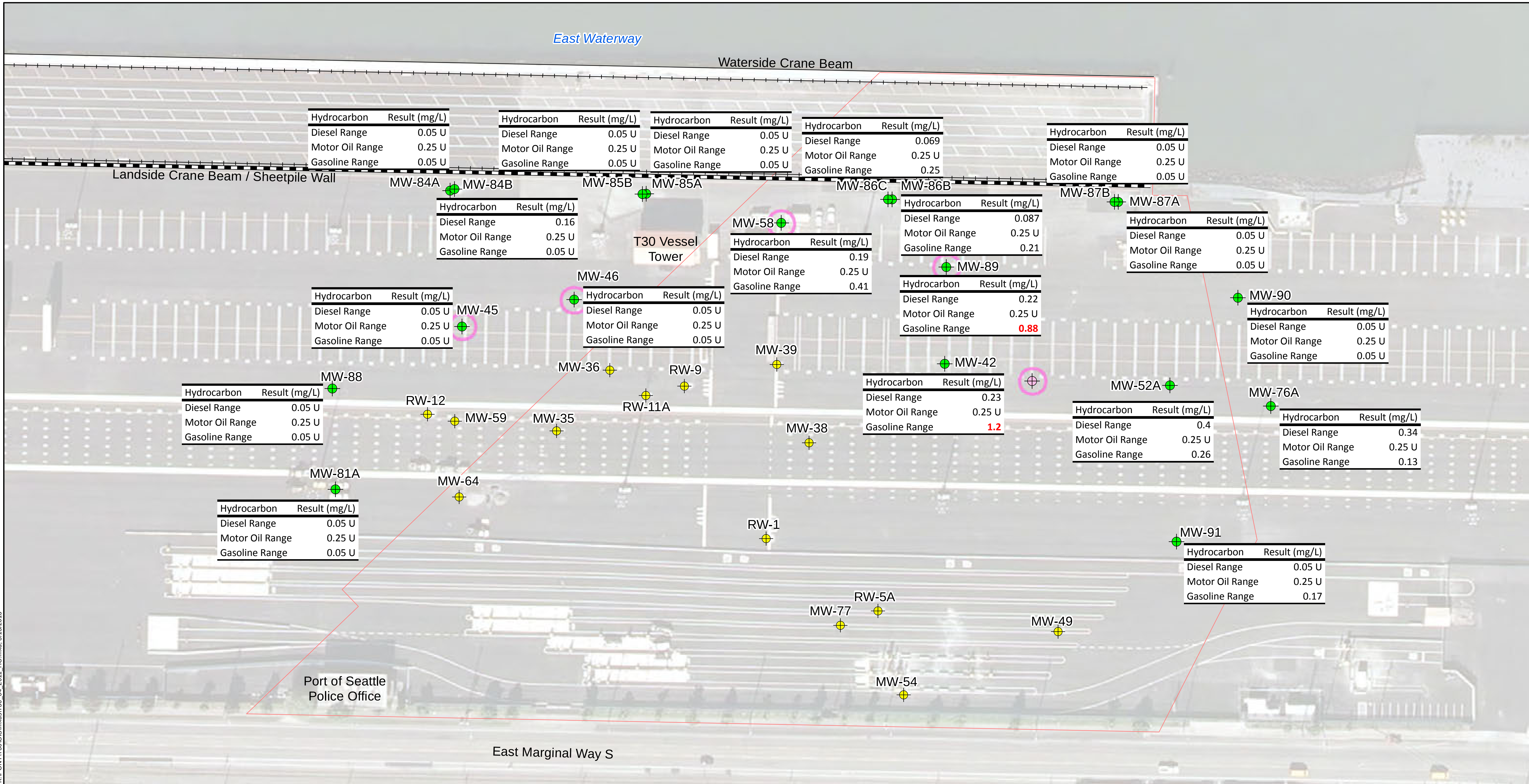
2009 USGS Orthophoto

Figure 2-12

Soil Analytical Results, Benzene Deeper than 5 feet Below Ground Surface

Port of Seattle
Terminal 30

PgG



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Water Quality Monitoring Well

Gaging/Recovery Well

Conditional Point of Compliance (CPOC) Wells

Proposed New CPOC Well

1991 AO Site Boundary

Terminal 30 Action Levels

Hydrocarbon	Action Level (ug/L)
Diesel Range	0.5
Motor Oil Range	0.5
Gasoline Range	0.8

See Table 2-4

1.2: result exceeds site action level

U: parameter not detected; associated number is lab reporting limit

0 Feet 100

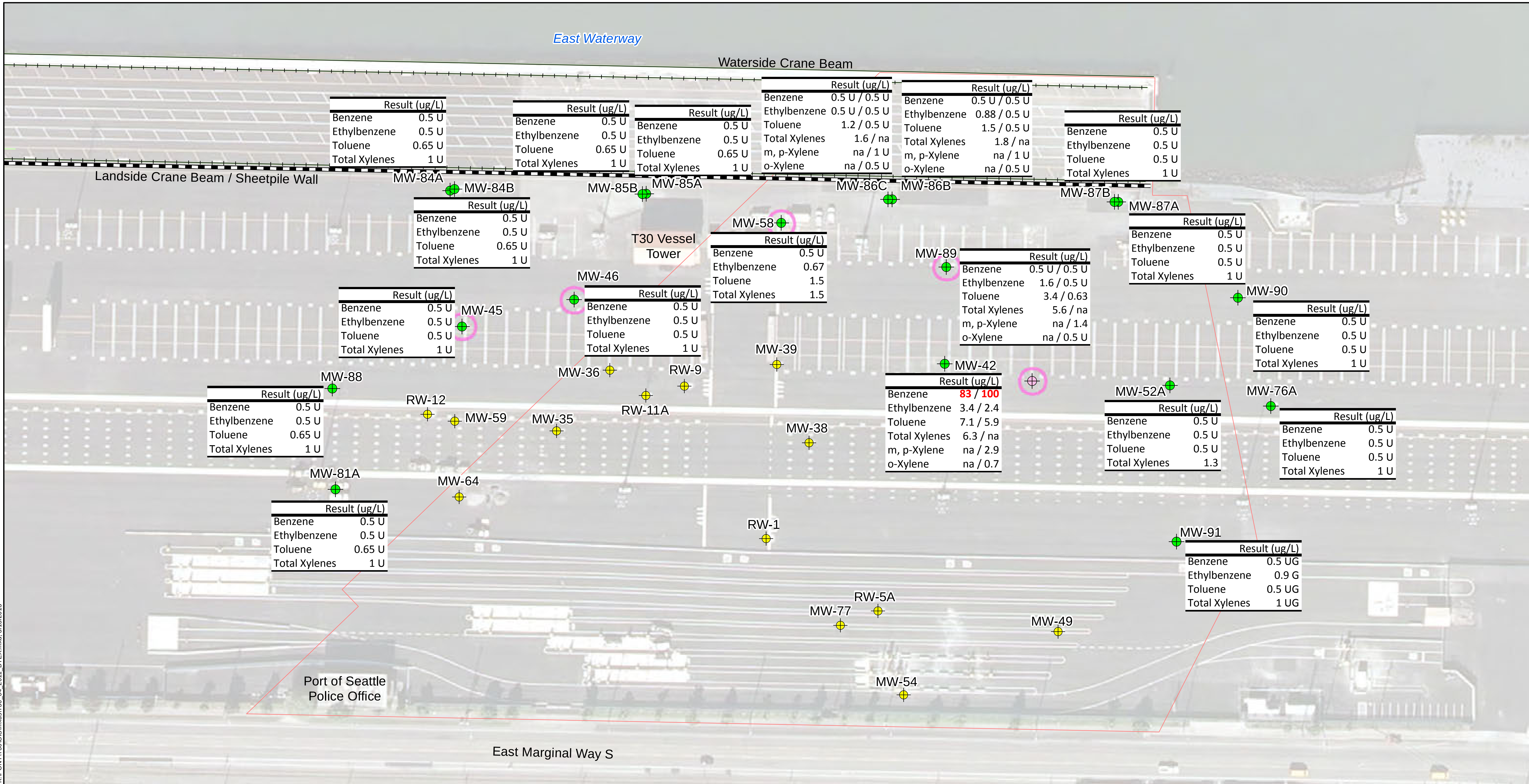
2009 USGS Orthophoto

Figure 2-13

Groundwater Petroleum Hydrocarbon Results, April 2011

Terminal 30
Port of Seattle

PgG



Water Quality Monitoring Well

Gaging/Recovery Well

Conditional Point of Compliance (CPOC) Wells

Proposed New CPOC Well

1991 AO Site Boundary

Terminal 30 Action Levels

	Action Level (ug/L)
Benzene	23
Ethylbenzene	6,910
Toluene	48,500
Total Xylenes	1,000

See Table 2-4

83: result exceeds site action level
U: parameter not detected; associated number is lab reporting limit
na: not analyzed
G: sample container inconsistent with method
83 / 100 : First number is BTEX result from method EPA 8021 / second number is result from method SW8260C

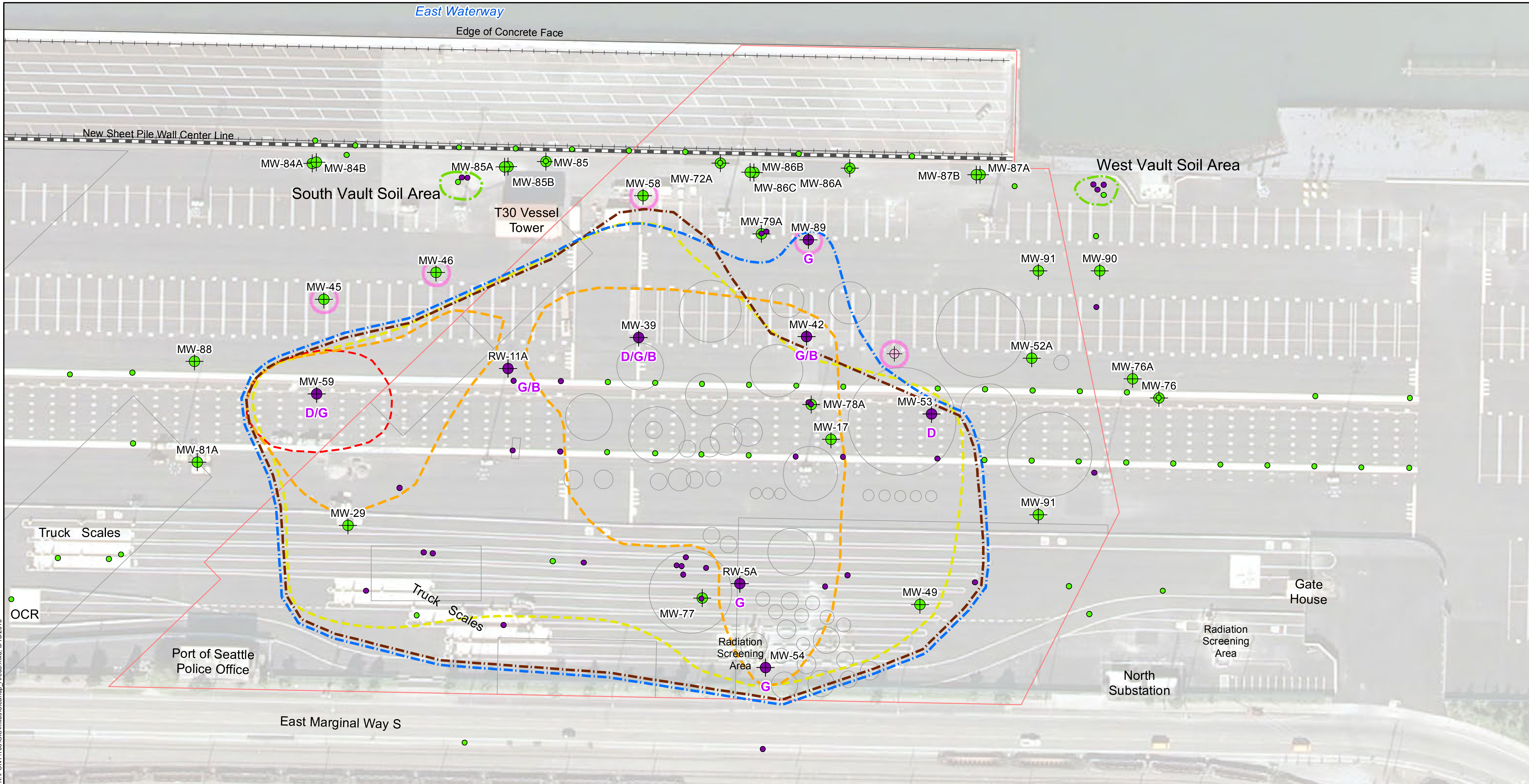
0 Feet 100

2009 USGS Orthophoto

Figure 2-14
Groundwater BTEX Results, April 2011

Terminal 30
Port of Seattle

PGG



Maximum Extent of Product Plume 1984-1991 (GeoEngineers, 1998)
LNAPL > 0.1 Feet - April 2011
Sheen Area - April 2011

Preliminary Extent of Contamination
Groundwater TPH/BTEX Extent
Soil TPH/BTEX Extent
Extents based on a combination of the historic extent of LNAPL, historic and recent data, and distribution of exceedances. Isolated "hot spots" may exist beyond the outlined soil and groundwater extent.

Soil Sample Below Cleanup Level
Soil Sample Above Cleanup Level
Groundwater Sample Below Cleanup Level for DRO, GRO, Benzene (Based on most recent sample collected)
Groundwater Sample Above Cleanup Level for DRO, GRO, Benzene (Based on most recent sample collected)
D - DRO Exceedance in Groundwater
G - GRO Exceedance in Groundwater
B - Benzene Exceedance in Groundwater
(See Tables 2-5 to 2-7 and Figures 2-9 to 2-12 for Soil & Groundwater Data)
Soil Extent (non-T30)

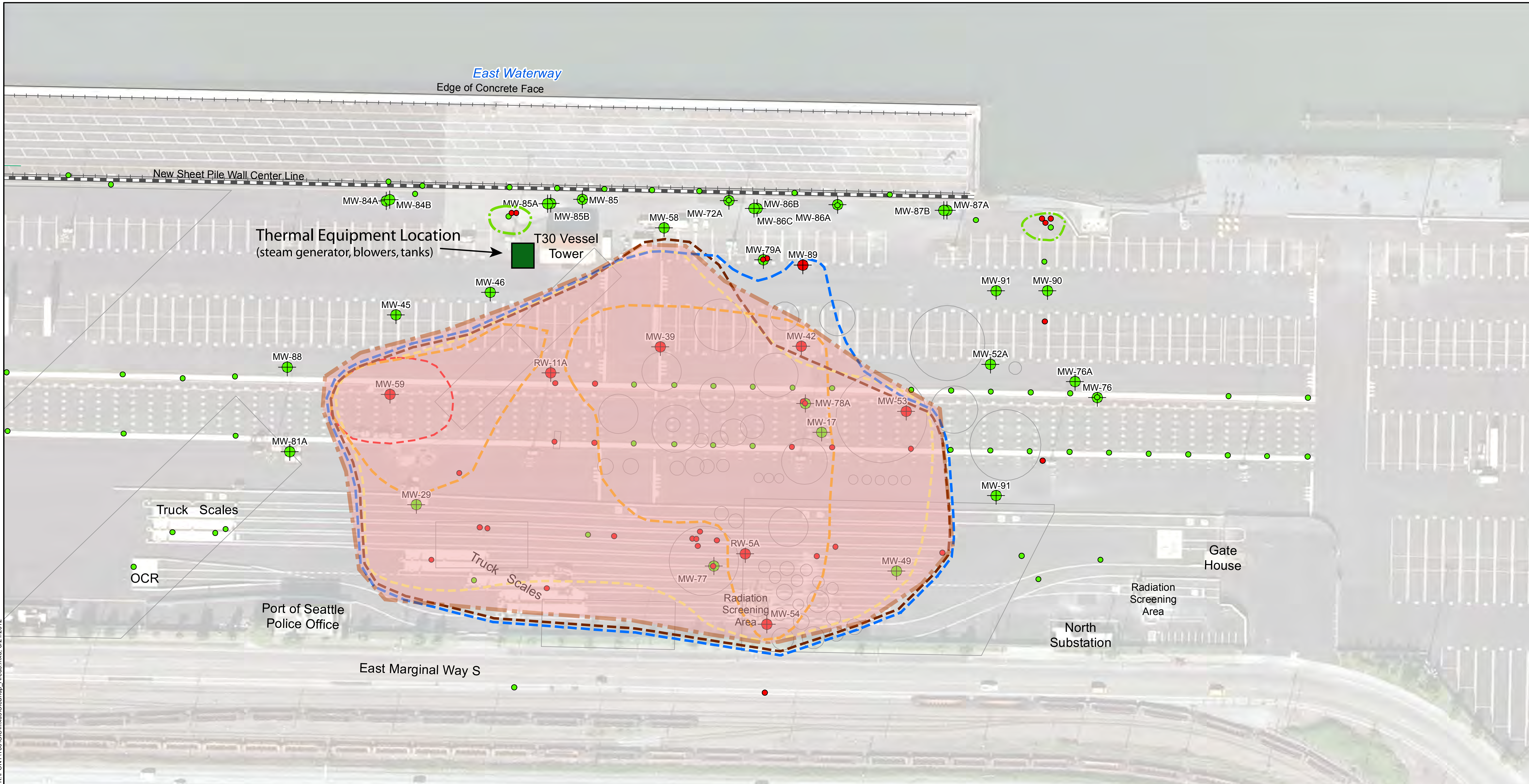
Historical Structures
1991 AO Site Boundary
Proposed New CPOC Well
Conditional Point of Compliance (CPOC) Wells

0 Feet 100
2009 USGS Orthophoto

Figure 2-15
Cleanup Areas

Port of Seattle
Terminal 30

PGG



- Maximum Extent of Product Plume 1984-1991 (GeoEngineers, 1998)
- LNAPL > 0.1 Feet April 2011
- Sheen Area April 2011

Preliminary Extent of Contamination

- Groundwater TPH/BTEX Extent
- Soil TPH/BTEX Extent
- Soil Extent (non-T30)
- Soil Sample Above Screening Level
- Soil Sample Below Screening Level
- Groundwater Sample Above Screening Level for DRO, GRO or Benzene
- Groundwater Sample Below Screening Level for DRO, GRO or Benzene
- Thermal Desorption Treatment Area
- Historical Structures
- AO Site Boundary

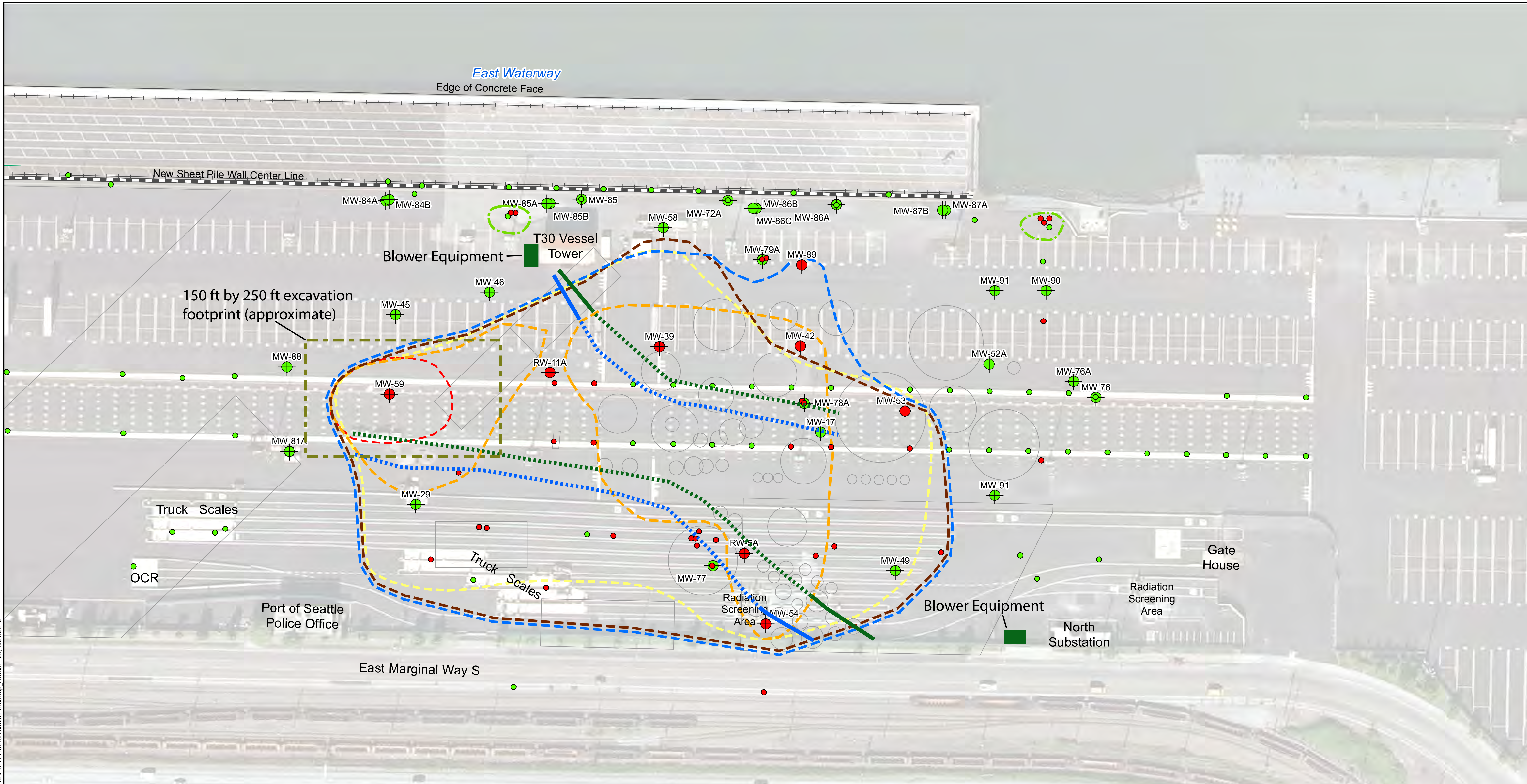
0 Feet 100

2009 USGS Orthophoto

Figure 3-1
Alternative 1: In-Situ Thermal Desorption

Port of Seattle
Terminal 30

PGG



Maximum Extent of Product Plume 1984-1991 (GeoEngineers, 1998)
LNAPL > 0.1 Feet April 2011
Sheen Area April 2011
Preliminary Extent of Contamination
Groundwater TPH/BTEX Extent
Soil TPH/BTEX Extent
Soil Extent (non-T30)

Soil Sample Above Screening Level
Soil Sample Below Screening Level
Groundwater Sample Above Screening Level for DRO, GRO or Benzene
Groundwater Sample Below Screening Level for DRO, GRO or Benzene
Approximate LNAPL Excavation Area
Air Sparge (AS) Horizontal Well (dashes indicate screen interval)
Vapor Extraction (SVE) Horizontal Well (dashes indicate screen interval)

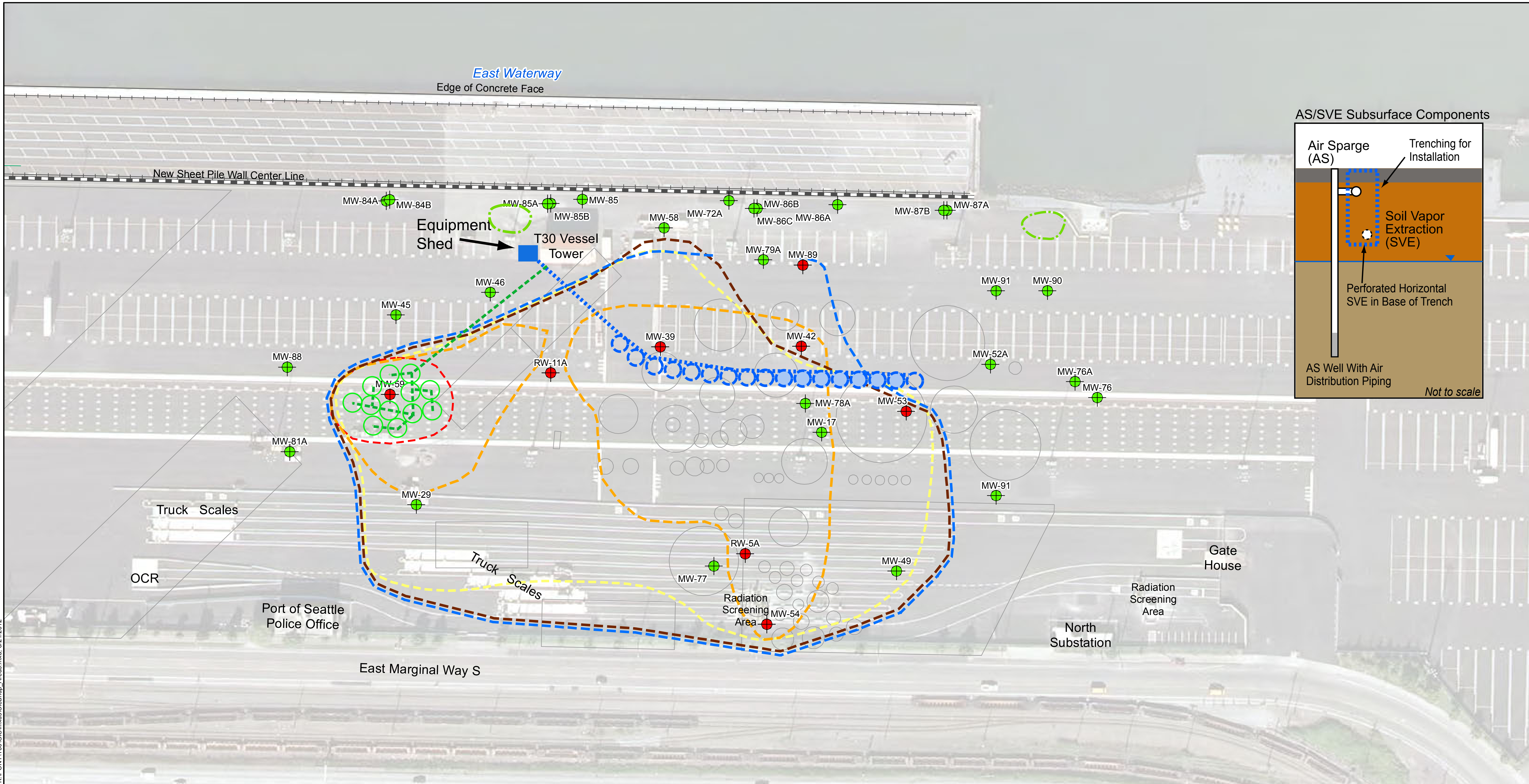
Historical Structures

0 Feet 100
2009 USGS Orthophoto

Figure 3-2
Alternative 2: Expanded Sheen Area AS/SVE with Targeted Excavation

Port of Seattle
Terminal 30

PgG



Maximum Extent of Product Plume 1984-1991 (GeoEngineers, 1998)
LNAPL > 0.1 Feet April 2011
Source Area Based on Sheen April 2011

Preliminary Extent of Contamination
Groundwater TPH/BTEX Extent
Soil TPH/BTEX Extent
Soil Extent (non-T30)

Groundwater Sample Above Screening Level for DRO, GRO or Benzene
Groundwater Sample Below Screening Level for DRO, GRO or Benzene
LNAPL Recovery Well and Trenching
Air Sparge (AS) Well; Blue Shading Indicates Primary AS for CPOC Compliance

Historical Structures
AO Site Boundary

0 Feet 100

2009 USGS Orthophoto

Figure 3-3
Alternative 3a: Targeted Sheen Area AS/SVE with LNAPL Recovery

Port of Seattle
Terminal 30

PGG

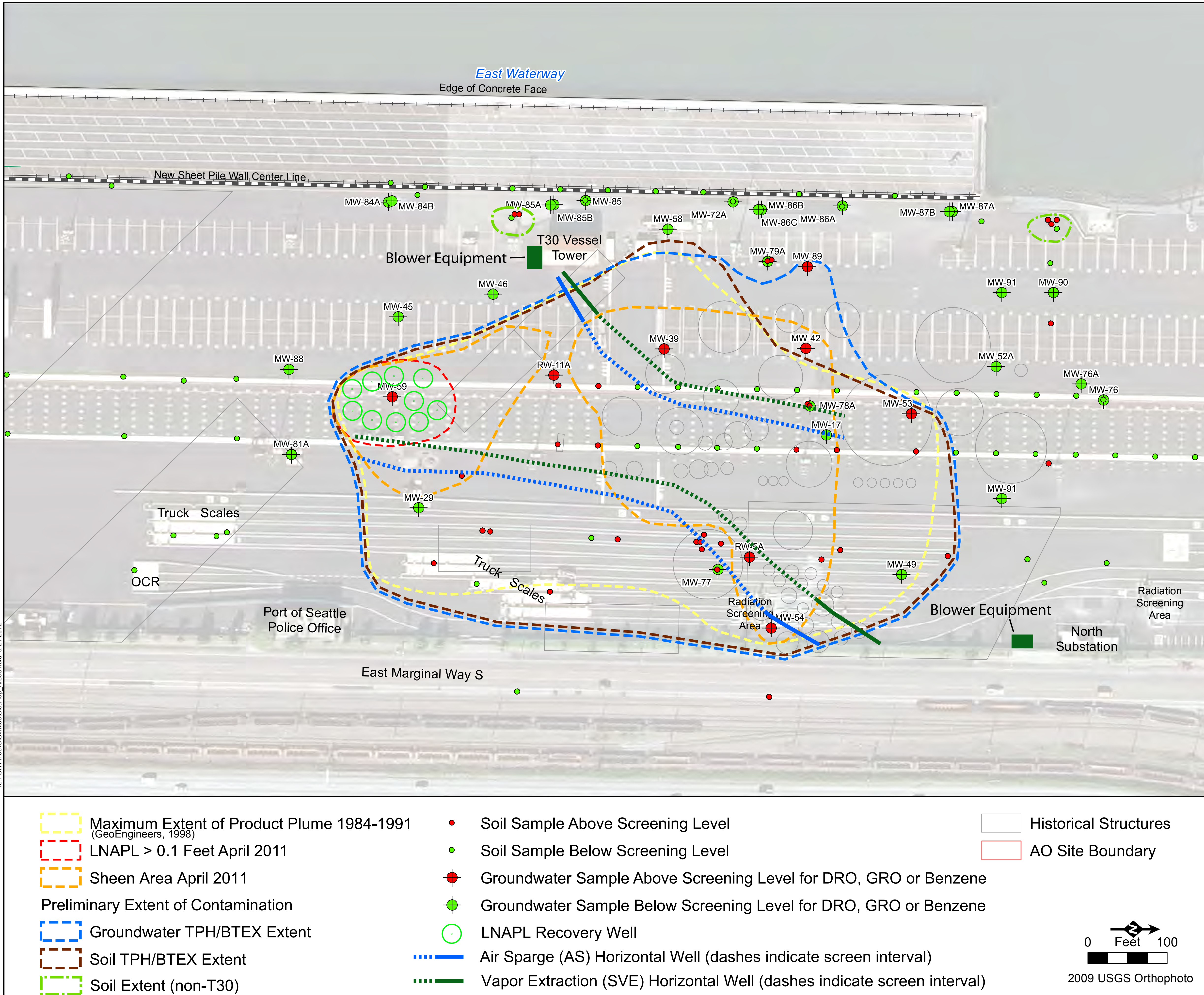


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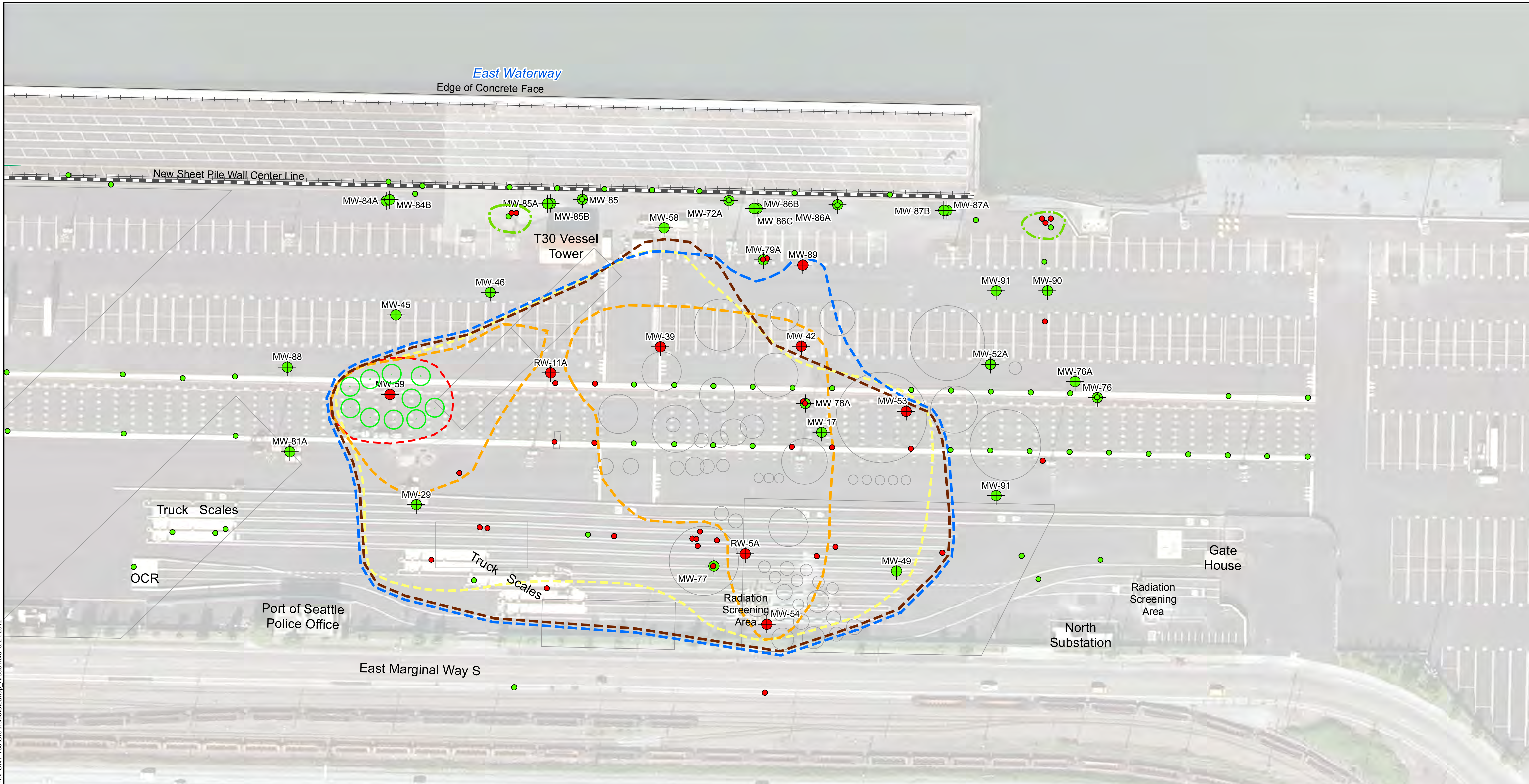
Figure 3-4
Alternative 3b: Expanded Sheen Area AS/SVE with LNAPL Recovery

Port of Seattle
Terminal 30

PgG



- Maximum Extent of Product Plume 1984-1991 (GeoEngineers, 1998)
- LNAPL > 0.1 Feet April 2011
- Sheen Area April 2011

Preliminary Extent of Contamination

- Groundwater TPH/BTEX Extent
- Soil TPH/BTEX Extent
- Soil Extent (non-T30)
- Soil Sample Above Screening Level
- Soil Sample Below Screening Level
- Groundwater Sample Above Screening Level for DRO, GRO or Benzene
- Groundwater Sample Below Screening Level for DRO, GRO or Benzene
- LNAPL Recovery Well
- Historical Structures

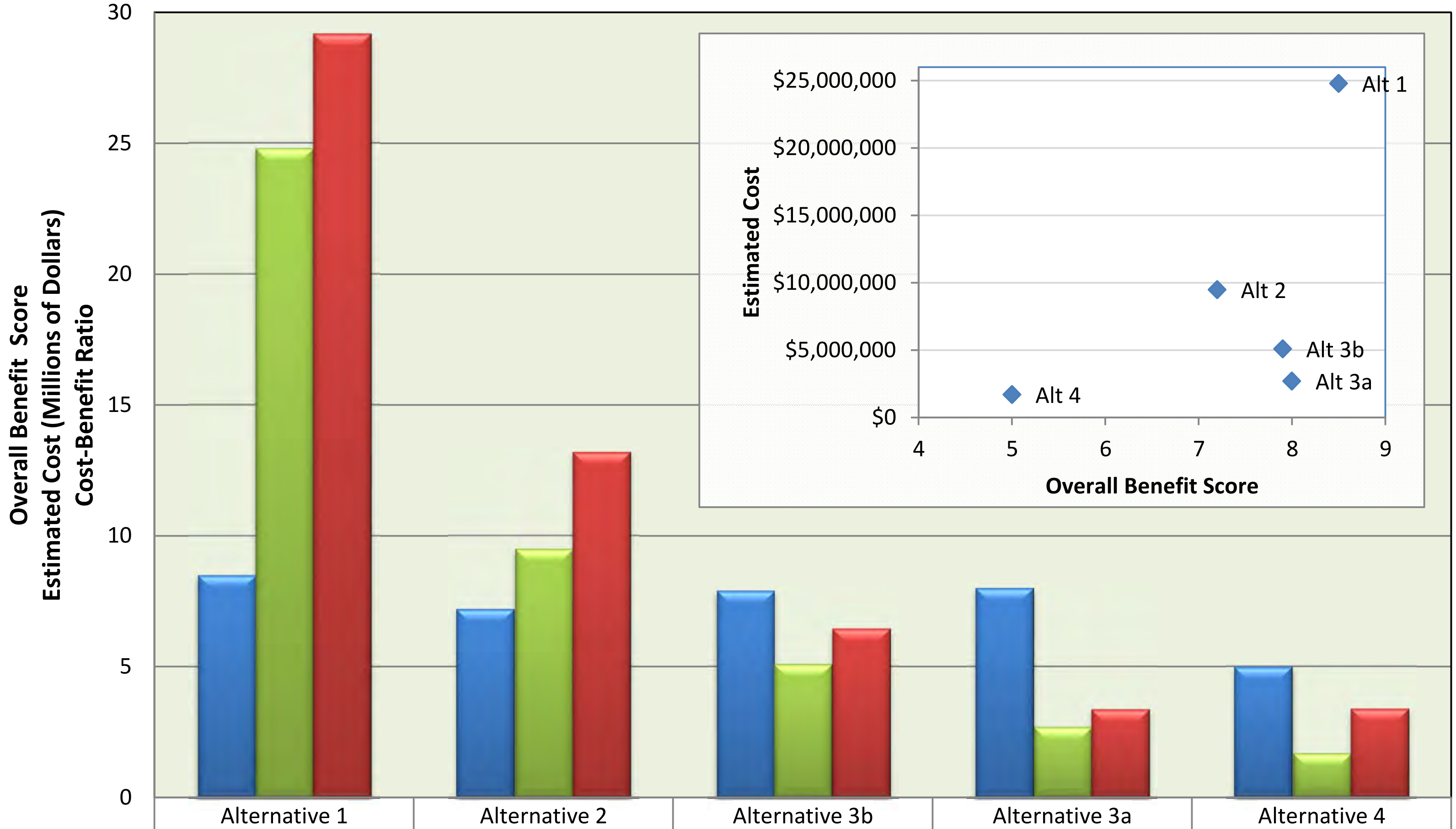
0 Feet 100

2009 USGS Orthophoto

Figure 3-5
Alternative 4: Compliance Monitoring with LNAPL Recovery

Port of Seattle
Terminal 30

PgG



	Alternative 1	Alternative 2	Alternative 3b	Alternative 3a	Alternative 4
Overall Benefit Score	8.5	7.2	7.9	8.0	5.0
Estimated Cost ($ Millions)	$24.8	$9.5	$5.1	$2.7	$1.7
Cost-Benefit Ratio	29.2	13.2	6.5	3.4	3.4

Figure 3-6. MTCA Cost-Benefit Chart
Port of Seattle Terminal 30

PgG

APPENDIX A: SITE HISTORY, ENVIRONMENTAL INVESTIGATIONS, AND INTERIM ACTIONS

This Appendix includes brief summaries of soil, groundwater, and LNAPL gauging studies conducted to date for the T30 Site and annotated historic air photos of the T30 Site and surroundings; a legal description of the property is also included.

Note: use of RETEC, ENSR, ENSR|AECOM, and AECOM reflect changes in company name over time; these are all referred to as ENSR|AECOM in references for simplicity.

1.0 SOIL INVESTIGATIONS

Soil investigations listed include those that involved soil borings where soil was sampled and described. Many of the studies only described soil observations such as sheen and odor. Many of the studies listed are also listed in the Groundwater Investigation section when monitoring wells were installed in the soil borings.

- Chevron, 1983 to 1984- As reported by GeoEngineers (1998), Chevron completed 26 shallow soil borings to 5 to 10 feet below ground surface. Monitoring wells were installed in four of the borings. The investigation indicated the presence of soil contamination in all but one of the borings, and free product was detected in all of the wells.
- GeoEngineers, 1984 and 1985- As reported by GeoEngineers (Progress Report Nos. 1 to 14; 1998) a total of 34 borings were completed during several phases between 1983 and 1984 to delineate the extent of the LNAPL. Monitoring wells were installed in each of the borings.
- Hart Crowser, 1984- As reported by GeoEngineers (1998), Hart Crowser completed a subsurface exploration and geotechnical engineering study in 1984 for the construction of Terminal 30 facilities that included 6 soil borings on-site and 10 offshore (10 to 160 feet deep) and 20 shallow borings to 3 feet below ground surface. Soil samples were variously composited and analyzed for priority pollutants. Arsenic, cadmium and mercury were detected in one or more of the composite samples at concentrations greater than (MTCA) Method A cleanup levels in use at the time.
- Groundwater Technology Inc. (GTI) 1986- As reported by GeoEngineers (1998), GTI drilled 15 soil borings and installed 15 monitoring wells (MW-46A through MW-60) to further define the extent of the free product plume in 1986. One of the soil samples obtained from MW-59 was submitted for laboratory analysis of permeability and total porosity. Soil samples obtained from the monitoring well borings were not submitted for chemical analysis.
- GeoEngineers, 1992- As reported by GeoEngineers (1998), GeoEngineers completed a total of 15 soil borings to depths of 21.5 to 41.5 feet below ground surface in January 1992. Monitoring wells were installed in all 15 borings. A total of 19 soil samples were collected for chemical and physical analyses. Concentrations of gasoline range, diesel range, and lube oil range organics were detected in a number of samples at concentrations above MTCA Method A cleanup levels in use at the time.
- AECOM, 2008- AECOM (2008) installed 3 new and 6 replacement monitoring wells and one new and one replacement recovery wells in April 2008. Soil observations were recorded on well logs. Chemical analyses were completed on soil cuttings for disposal purposes.
- AECOM, 2007 to 2009- AECOM (2010) collected soil samples for disposal characterization and excavation confirmation during redevelopment from a cruise terminal to the current shipping terminal configuration. Soil samples were collected at depths from 0.5 to 10 feet.

2.0 GROUNDWATER INVESTIGATIONS

This section lists and summarizes groundwater investigations including monitoring well installation and groundwater monitoring completed at the site. Many of the studies listed are also in the Soil Investigation section when monitoring wells were installed in the soil borings.

- Chevron, 1983 to 1984- As reported by GeoEngineers (1998), Chevron completed 26 shallow soil borings to 5 to 10 feet below ground surface. Monitoring wells were also installed. The investigation indicated the presence of soil contamination in all but one of the borings, and free product was detected in all of the wells.
- GeoEngineers, 1984 and 1985- As reported by GeoEngineers (Progress Report Nos. 1 to 14) and GeoEngineers (1998), GeoEngineers completed a total of 34 monitoring wells during several phases from 1983 to 1984 to delineate the extent of the LNAPL. Many of the monitoring wells were destroyed, abandoned and/or reinstalled during site demolition activities prior to 1986.
- Groundwater Technology Inc. (GTI) 1986- As reported by GeoEngineers (1998), GTI drilled 15 soil borings and installed 15 monitoring wells (MW-46A through MW-60) to further define the extent of the free product plume in 1986.
- GeoEngineers, 1987 to 1991- GeoEngineers (1998) completed 10 rounds of Pre-RI quarterly monitoring between November 1987 and April 1991.
- GeoEngineers, 1991 to 1992- GeoEngineers (1998) completed 3 rounds of RI period quarterly monitoring from November 1991 to July 1992; samples were analyzed for BTEX, TPH, and TEPH.
- GeoEngineers, 1993 to 1994- GeoEngineers (1998) completed two rounds of RI period semi-annual monitoring June 1993 and January 1994; samples were analyzed for VOCs, SVOCs and PAHs, TEPH, chlorinated pesticides, PCBs, metals, cyanides, and general chemistry.
- GeoEngineers, 1999 & 2003- GeoEngineers (1999 and 2003) completed Pre-Monitoring Plan Addendum (pre-MPA) investigation consisting of two rounds to collect supplemental RI groundwater data to evaluate natural attenuation. The scope was developed during discussions between Port, GeoEngineers, and Ecology (GeoEngineers, 1999). The investigation included groundwater sampling at 2-hour intervals for 25 hours along a transect through near-shore, plume attenuation, and former LNAPL areas and one surface water sample. Samples were analyzed for petroleum, SVOCs, PAHs, BTEX, metals plus natural attenuation parameters.
- RETEC, 2004 to 2005- In October 2004, May and August 2005, the Port elected periodic monitoring of wells to supplement previous data and assess potential changes in site conditions (ENSR|AECOM, 2006).
- RETEC/ENSR/AECOM, 2005 to 2009- In December 2005, quarterly in 2006 through 2009, RETEC/ENSR/AECOM collected groundwater samples. Generally, samples were collected per the Compliance Monitoring Plan (CMP) (ENSR|AECOM, 2008) and analyzed for TPH, BTEX, SVOCs, and PAHs. Natural attenuation parameters were collected in the field. The results of the sample events over the last 5 years are summarized in Section 2.7, older data can be found in the Supplemental Data Report Revision 2 (ENSR|AECOM, 2008).

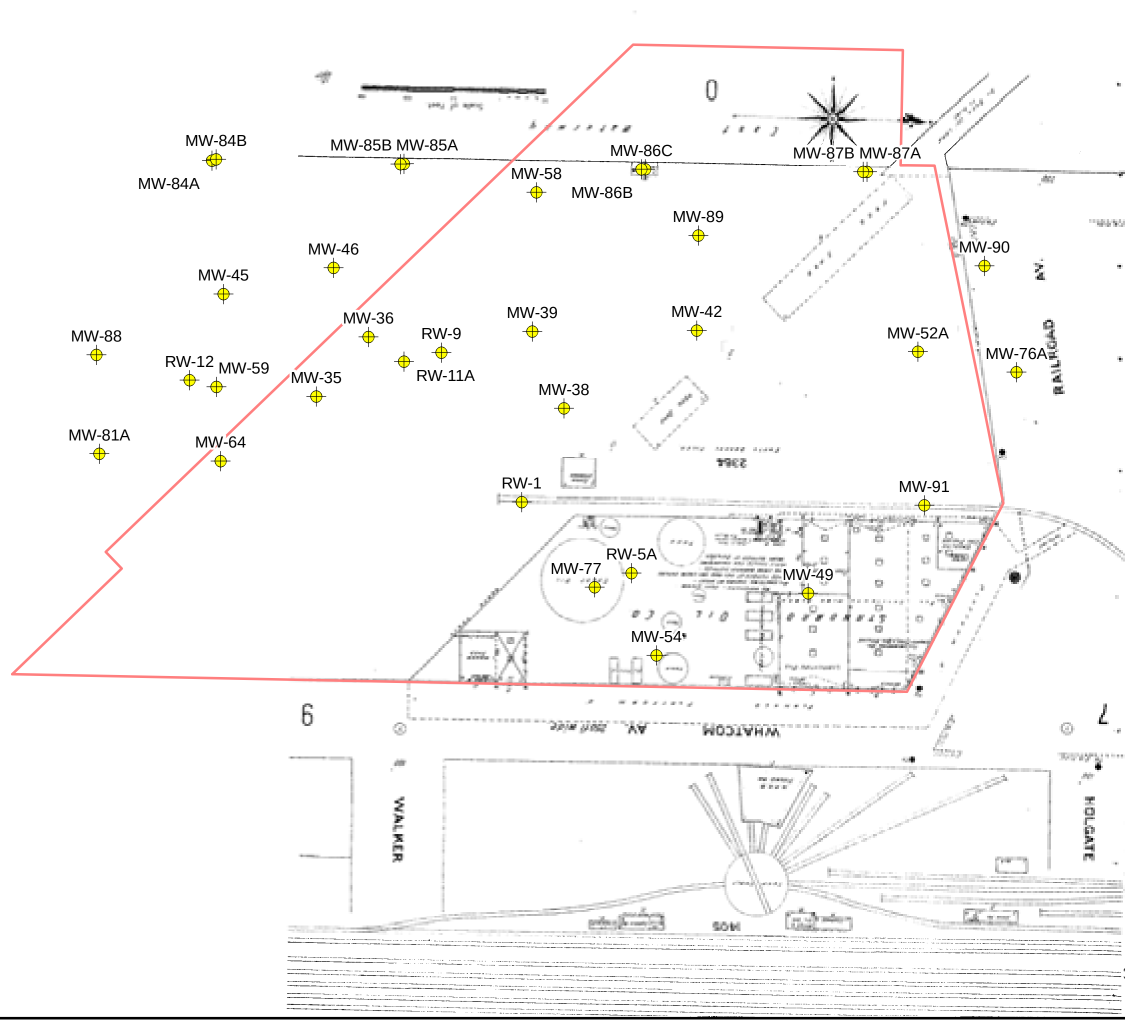
- April 2011- PGG collected groundwater samples from 19 wells in April 2011 (PGG, 2011) following the 2008 CMP and SAP. Samples were analyzed for TPH, BTEX, SVOCs and PAHs, and natural attenuation parameters were collected in the field.
- November 2011- PGG collected groundwater samples from 9 wells in November 2011 following the SAP. Samples were analyzed for PAHs. Duplicate samples were collected and centrifuged prior to analysis.
- April 2012- PGG collected groundwater samples from 2 wells in April 2012 following the SAP. Samples were analyzed for PAHs. Sample splits were field-filtered using 0.45-micron filters and lab-filtered using 0.70-micron glass filters.

3.0 LNAPL GAGING

- GeoEngineers, 1984 through 1998- GeoEngineers measured depth to water and product thickness in monitoring wells and recovery wells from 1984 through the RI/FS period. Monthly measurements were made between August 1991 and January, 1994. Limited results are included in the 1998 RI/FS Figure 7.10 (GeoEngineers, 1998).
- ENSR, 1999 through 2005- ENSR measured depth to water and product thickness in monitoring wells and recovery wells from 1999 through 2005. Data are summarized in the SDR Revision 2 Table 5-2 (ENSR, 2008).
- AECOM, 2006 through 2009- AECOM measured depth to water and product thickness in monitoring wells and recovery wells from 1999 through 2005
- PGG, 2011- PGG measured depth to water and product thickness in monitoring wells and recovery wells in April 2011 (PGG, 2011).

4.0 HISTORIC AIR PHOTOS

The following pages include annotated photos of T30 and surrounding areas.



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Current Monitoring Well Locations

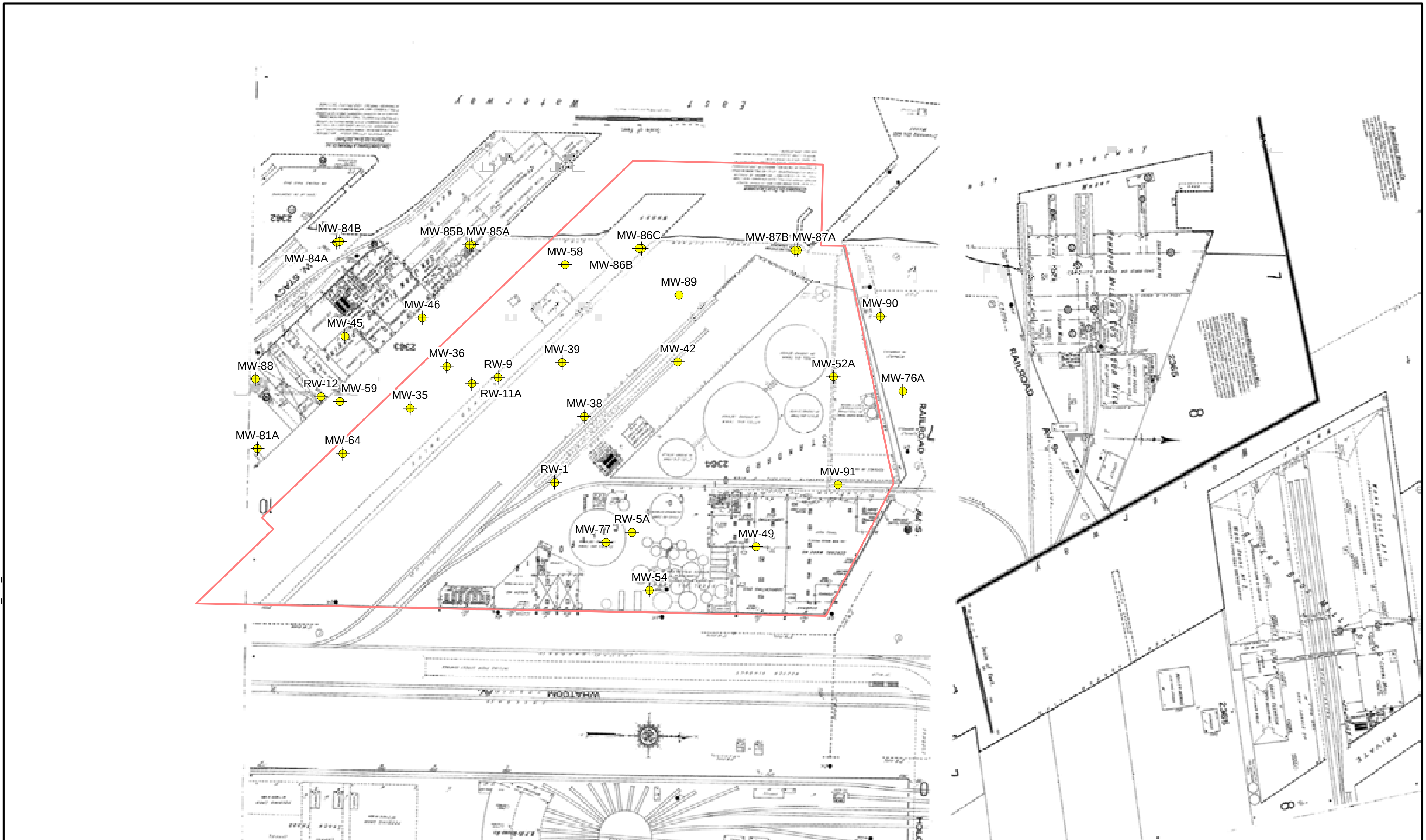
1991 AO Site Boundary

0 Feet 200

Appendix A: 1905 Sanborn Map

Port of Seattle
Terminal 30

PgG



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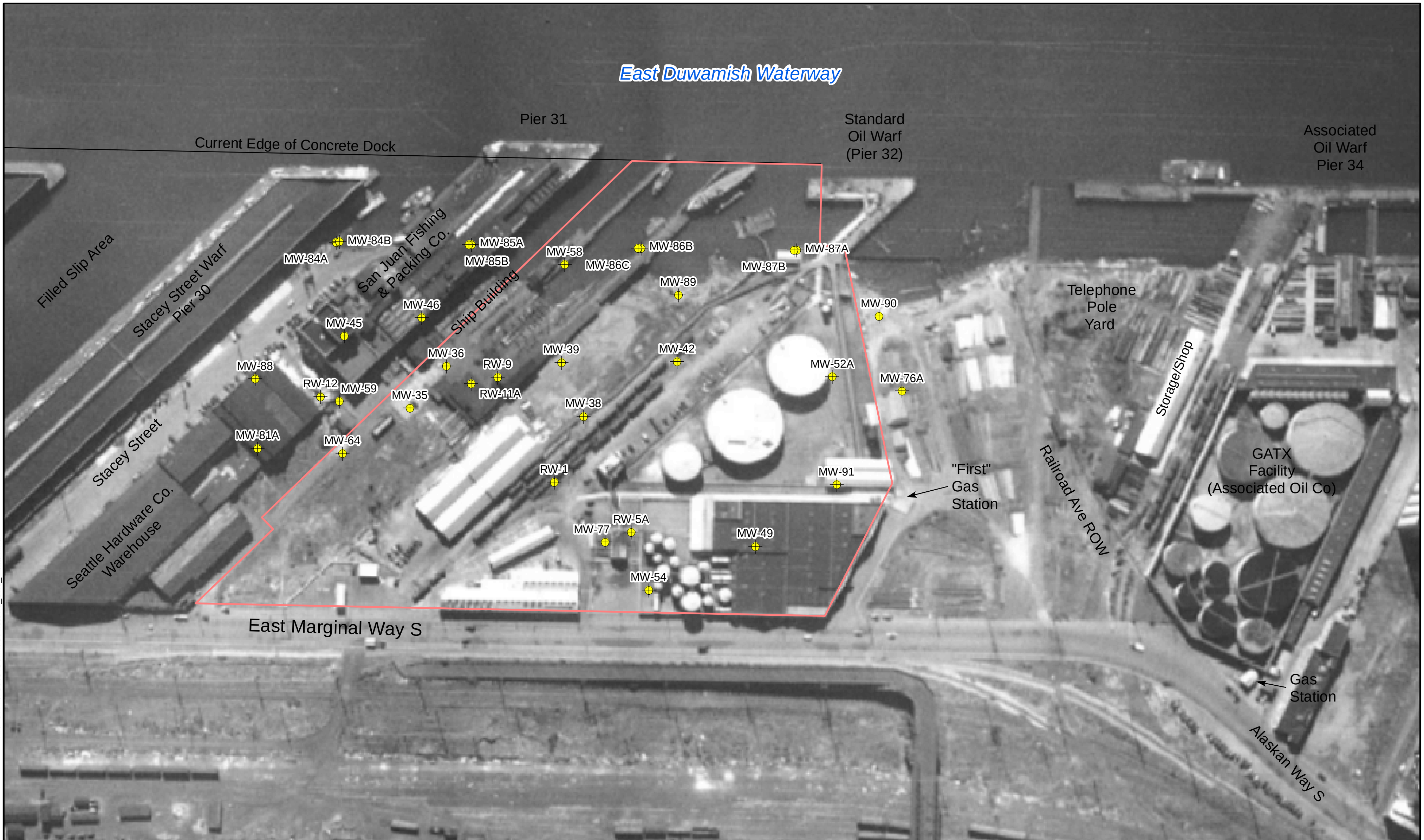
Current Monitoring Well Locations

1991 AO Site Boundary

0 Feet 200

Appendix A: 1916 Sanborn Map

Port of Seattle
Terminal 30



Current Monitoring Well Locations

1991 AO Site Boundary

0 Feet 200

Aerial photo has been georeferenced and not orthorectified.
For reference purposes only.

Appendix A: 1936 Aerial Photo

Port of Seattle
Terminal 30

PgG

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Current Monitoring Well Locations

RIFS Boundary

N

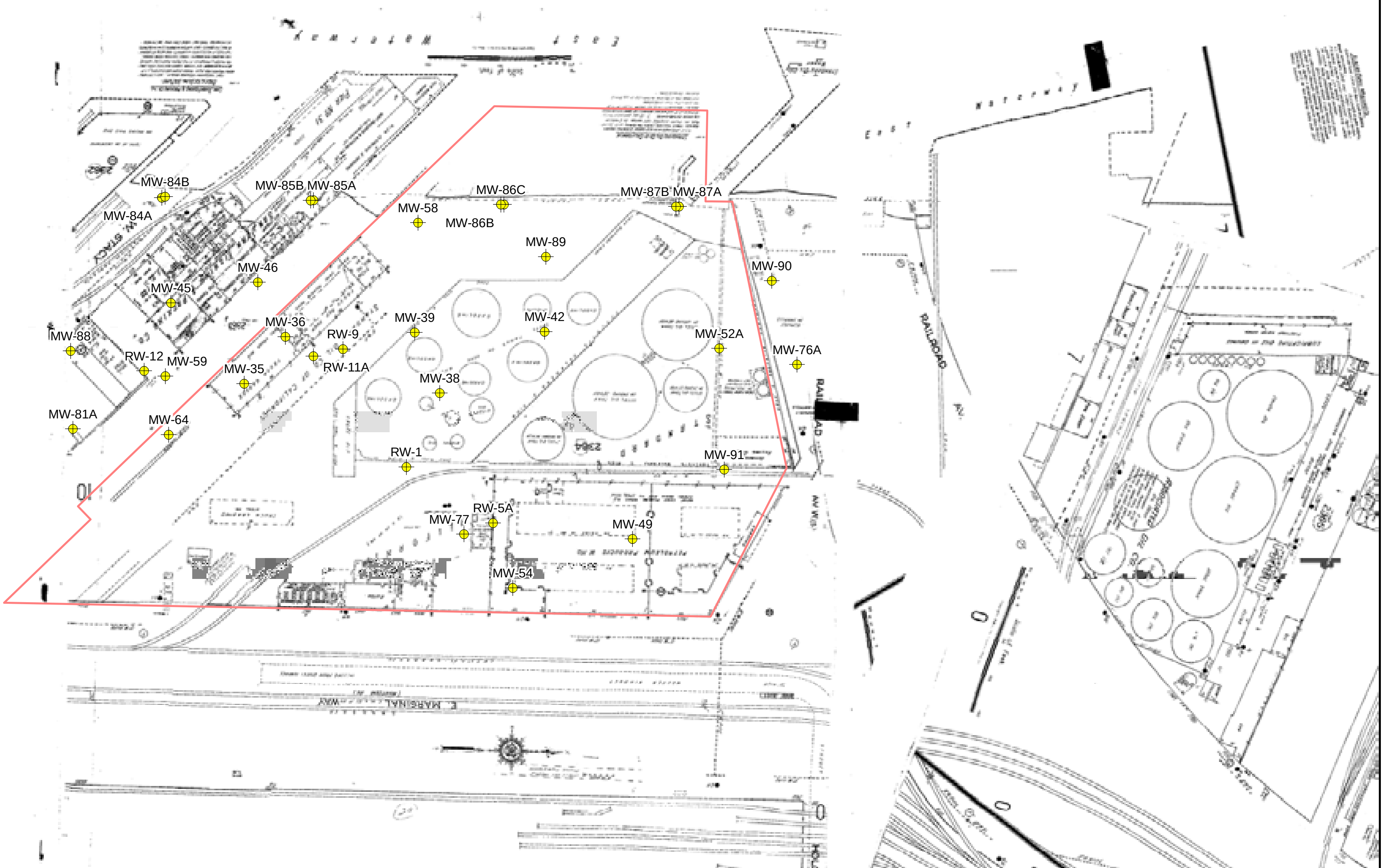
0 Feet 200

Aerial photo has been georeferenced and not orthorectified.
For reference purposes only.

Appendix A:
1946 Aerial Photo

Port of Seattle
Terminal 30

PgG



Current Monitoring Well Locations

1991 AO Site Boundary

0 Feet 200

Appendix A:
1950 Sanborn Map

Port of Seattle
Terminal 30

PGG

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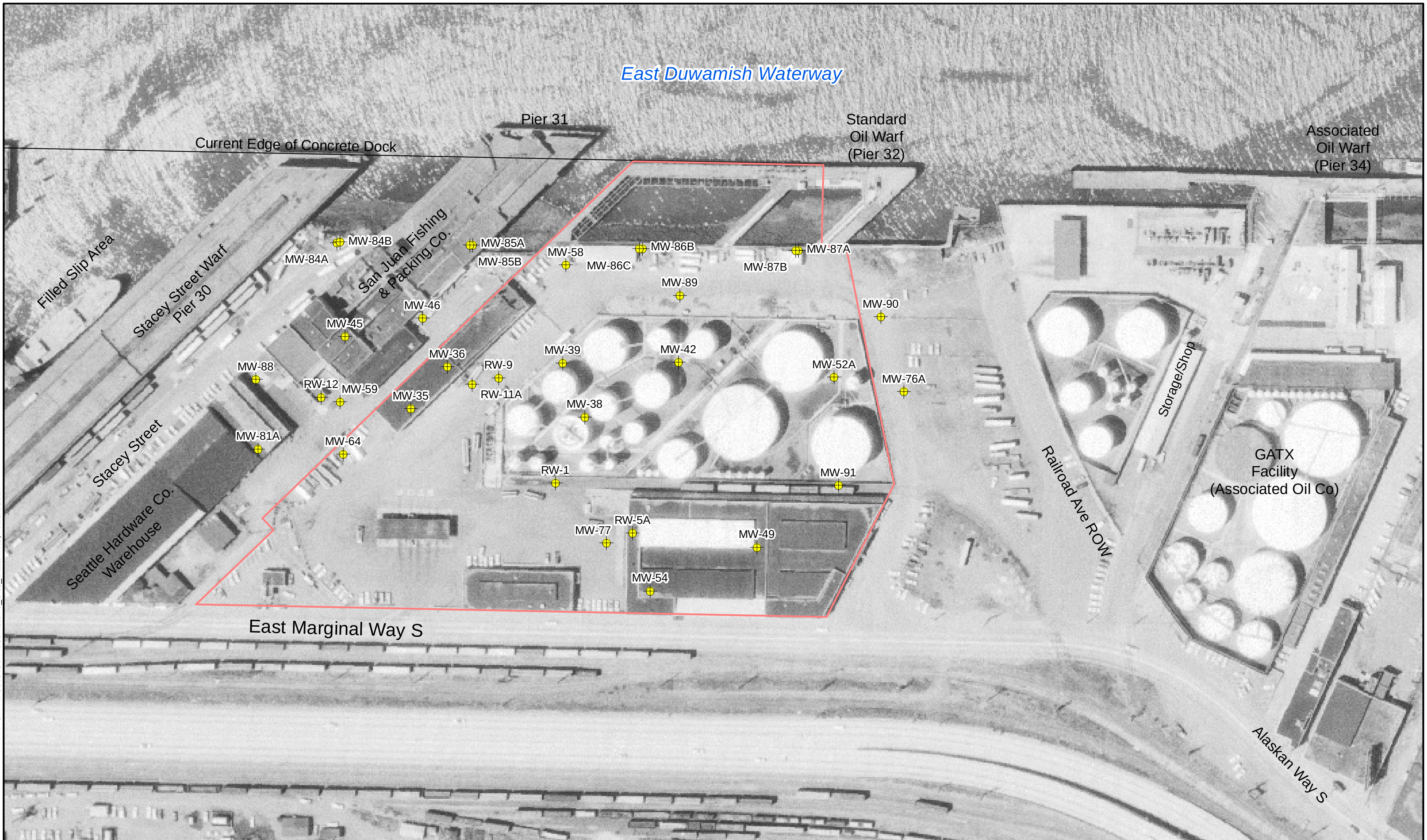

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Current Monitoring Well Locations

RIFS Boundary

N

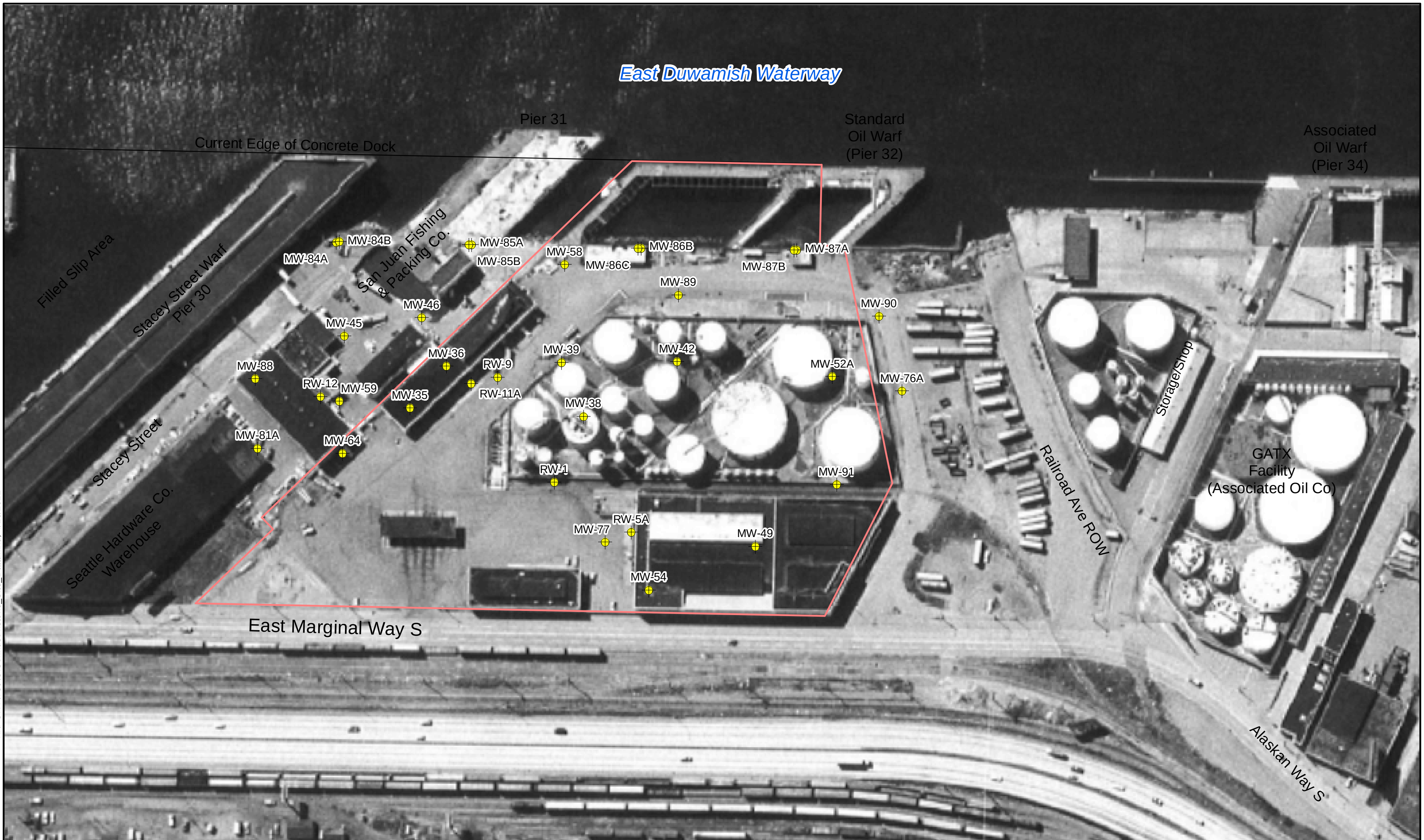
0 Feet 200

Aerial photo has been georeferenced and not orthorectified.
For reference purposes only.

Appendix A:
1969 Aerial Photo

Port of Seattle
Terminal 30

PgG



Current Monitoring Well Locations

RIFS Boundary

0 Feet 200

Aerial photo has been georeferenced and not orthorectified.
For reference purposes only.

Appendix A:
1977 Aerial Photo

Port of Seattle
Terminal 30

PGG

Current Monitoring Well Locations

RIFS Boundary

N

0 Feet 200

Aerial photo has been georeferenced and not orthorectified.
For reference purposes only.

Appendix A:
1980 Aerial Photo

Port of Seattle
Terminal 30

PgG

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Current Monitoring Well Locations

RIFS Boundary

N

0 Feet 200

Aerial photo has been georeferenced and not orthorectified.
For reference purposes only.

Appendix A: 1985 Aerial Photo

Port of Seattle
Terminal 30

PgG

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Current Monitoring Well Locations

RIFS Boundary

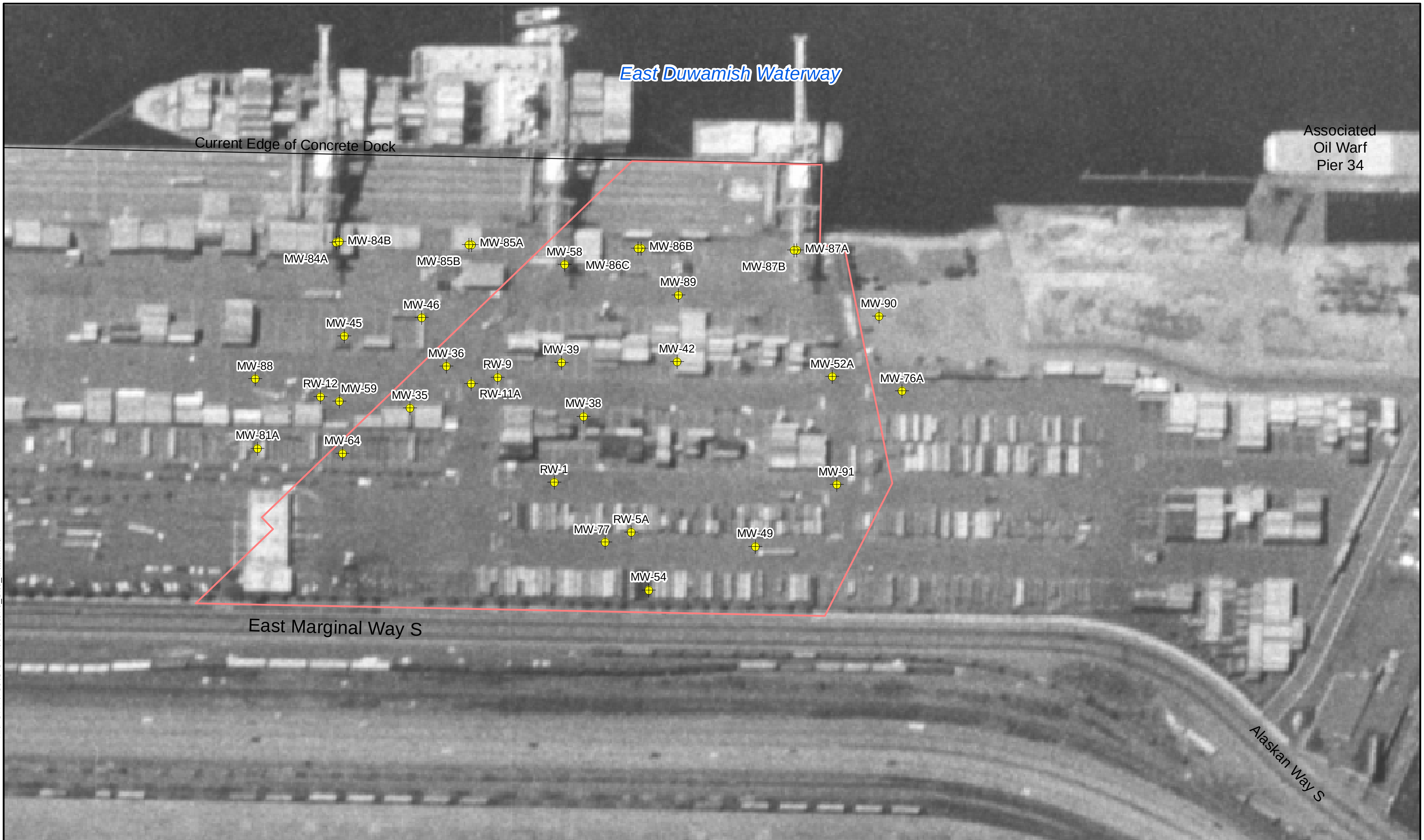
N

0 Feet 200

Appendix A:
1990 Aerial Photo

Port of Seattle
Terminal 30

PgG



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Current Monitoring Well Locations

RIFS Boundary

N

0 Feet 200

Appendix A:
1998 Aerial Photo

Port of Seattle
Terminal 30

PgG

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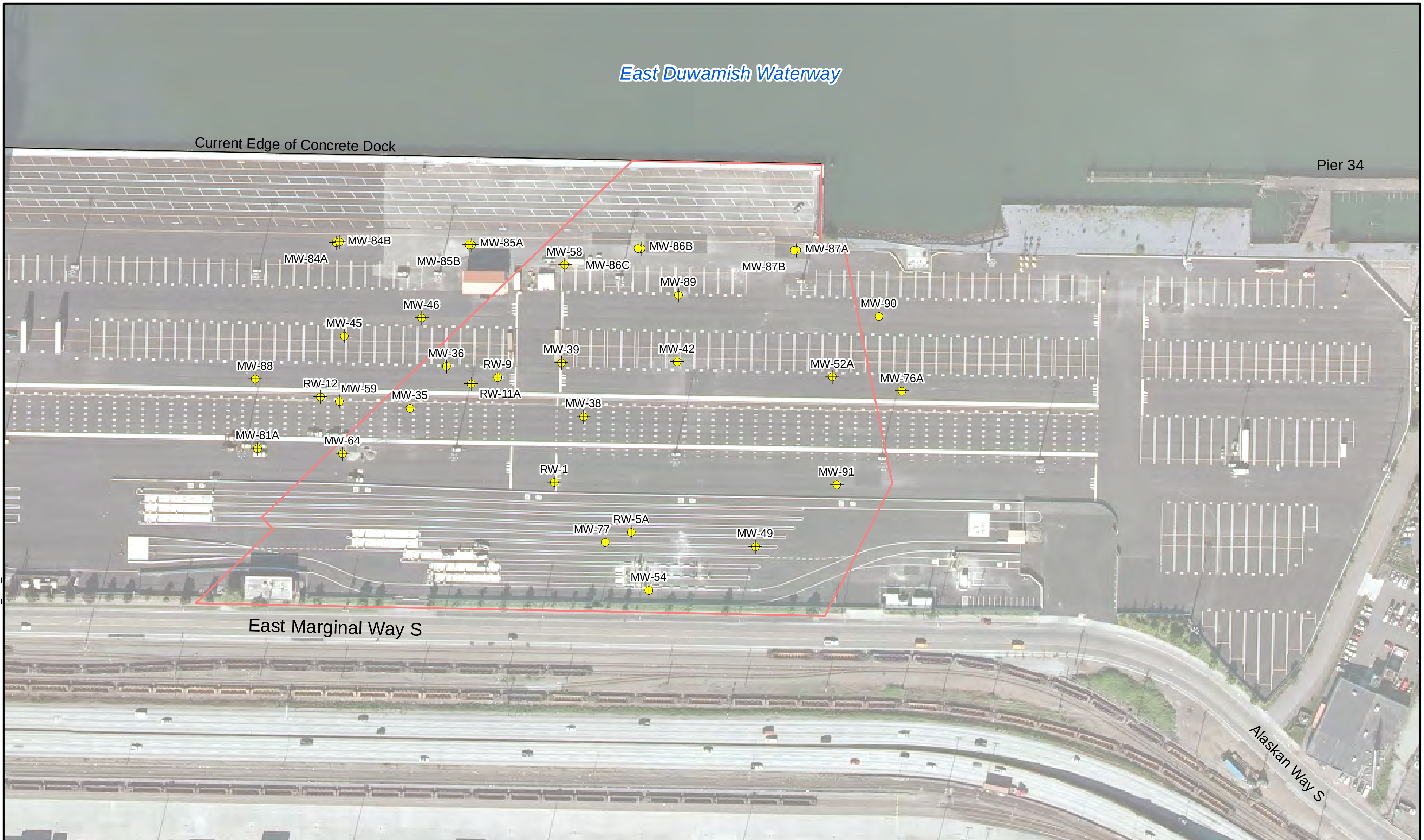
Current Monitoring Well Locations

RIFS Boundary

0 Feet 200

Appendix A: 2005 Aerial Photo

Port of Seattle
Terminal 30



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Current Monitoring Well Locations

RIFS Boundary

0 Feet 200

Appendix A:
2009 Aerial Photo

Port of Seattle
Terminal 30

PgG

APPENDIX B: TIDAL STUDY

Technical Memorandum

To: Sunny Becker, Department of Ecology

Cc: Jerome Cruz, Department of Ecology

From: Glen Wallace, Ph.D., and Pony Ellingson, Pacific Groundwater Group

Re: Tidal Study Results

Date: February 1, 2012

This appendix to the Terminal 30 Remedial Investigation/Feasibility Study (RI/FS) describes water-level measurements at the Port of Seattle's Terminal 30 (T-30) obtained and analyzed to assess groundwater flow direction and gradient across the site including flow near the sheetpile wall. The sheetpile wall was installed subsequent to earlier water level studies. At the T-30 site, tidal action in the East Waterway induces fluctuations in groundwater elevations in nearshore areas. In these areas of fluctuating groundwater, water-level "snapshots" cannot be used to accurately characterize time-averaged (net) flow direction and gradient. For this study, water-level measurements collected over a 95-hour period[1] were used to calculate mean flow direction and gradient.

The purpose of this study was to test the 2008 site conceptual model and the sufficiency of the current well network for compliance monitoring purposes now that the sheetpile wall is installed. Key findings include:

- Average water level elevations in the deeper wells of well-pairs near the sheetpile wall are higher than elevations in the shallower wells by 0.03 to 0.29 feet, indicating slight net upward groundwater flow at a time-averaged head gradient ranging from 0.0012 to 0.0145.
- Tidal variation is generally less, and decreases more quickly with increased distance east of the shore compared to the pre-wall condition.
- Net movement of shallow groundwater from the contaminant source area is likely similar to or slower than prior to sheetpile wall construction. A pathline trends west from the source area then around the north end of the sheetpile wall. Some lateral flow to the south may also occur but is less than the northerly component. Lateral flow through the wall appears likely[2]. Contrary to the prior conceptual model, vertical downward flow near the wall is not indicated; however, vertical downward flow outside the areas monitored with well pairs for this study is not ruled out. The RI/FS and monitoring plan will be reviewed in light of this additional data.

---

[1] The tidal study was originally intended to span 72-hours. Transducers were in wells for longer due to scheduling around SSA operations.

[2] PGG observed significant leakage through a sheetpile wall excavated in the Port of Tacoma.

The work was performed using generally accepted hydrogeologic practices at this time and in this vicinity, for exclusive application to the Port of Seattle Terminal 30 site. This statement is in lieu of other warranties, express or implied.

BACKGROUND

Two water-level studies were completed during the initial T-30 Remedial Investigation/Feasibility Study (GeoEngineers, 1998). Both studies occurred before the sheetpile wall was installed in the winters of 2007-2008 and 2008-2009 (two phases). The first study occurred over a 36-hour period in May 1993 and included water-level measurements at 18 monitoring wells every 15-minutes using pressure transducers. The second study occurred over a 40-hour period in January 1994 at 14 monitoring wells using the same methodology. These data were reportedly re-analyzed and incorporated into a tidal mixing model (AECOM, 2008). AECOM indicates that the findings of the mixing model remain valid following construction of the sheetpile wall. AECOM reports that the sheetpile wall will reduce, but not eliminate tidal fluctuations upgradient of the wall, but that groundwater flow direction and gradient will remain the same (AECOM, 2008; page 6-2) and that dissolved and free-phase transport would not change significantly. Water-level observations recorded during the installation of the sheetpile wall reportedly confirmed their conclusions.

DATA COLLECTION

Water-level measurements were collected at 11 water table monitoring wells, 3 deep zone nearshore monitoring wells, and one marine water stilling well for an 95-hour period (Figure 1 and Table 1). Wells were equipped with pressure transducers and programmed to record measurements at synchronized15-minute intervals. Monitoring wells for this study were selected using the following criteria:

- completed in shallow aquifer with well screen spanning the water table
- wells are distributed along the sheetpile wall and across the site
- wells do not contain LNAPL
- wells (or their replacement) were used in one or both of the previous studies and provided usable data for those studies

A marine stilling well was installed at the north end of the concrete apron to record tidal fluctuations in the East Waterway. The stilling well was constructed of 1-inch metal conduit suspended from the concrete apron and extending to below the expected low-low tide during the study period (Figure 2). A 3-foot length of rebar was attached to the bottom of the conduit to anchor the base of the stilling well against currents and prop wash while leaving an open interval for water level equilibration.

Transducers were suspended using stainless steel cable secured to the well plug in monitoring wells; a PVC cap was used at the stilling well. Hand water-level measurements were recorded at the start and end of the measurement period, and at any time the well was accessed during the water level monitoring period[3]. The elevation of the stilling well measuring point was included in the survey of selected monitoring wells conducted by the Port of Seattle survey crew in December 2011. A Solinst Barologger was deployed in the on-site equipment shed to record barometric pressure changes during the test period. All loggers were set to record on a synchronized 15-minute time interval.

WATER-LEVEL DATA ANALYSIS

Transducer data was corrected for water density variation using existing specific conductivity data, and corrected for barometric pressure changes using the data from the barometric logger. Hand water-level measurements were collected at the installation and removal of each transducer within five minutes of the transducer measurement interval, and within 1 minute at strongly tidally influenced wells close to the sheetpile wall. Manual water level measurements were used to calculate the transducer depths in the wells at the start and end of test, and to correct for instrument drift, which was negligible. Transducer data was used to calculate mean water levels and to investigate the range of tidal influence. Water level hydrographs are shown in Figures 3 and 4.

Mean water level elevations were calculated using the Serfes method over a 4-day interval (Serfes, 1991). The Serfes method uses moving averages to produce a filtered mean water-level elevation; water-table mean elevations are contoured in Figure 1. Groundwater flow is generally east to west with gradients increasing in the near-shore region. Curvature in water level contours suggests a northerly component near the north end of the sheetpile wall. Horizontal gradient is calculated between the 9.3 and 8.3 foot elevation contour at 0.0026 ft/ft, which is at the low end of the range calculated in previous tidal studies (0.0025 and 0.0035 ft/ft).

Water-level elevations in water table and deep near-shore well pairs indicate that time-averaged heads in the deeper wells are greater than those in the shallow wells. Although the net vertical gradient was upward, ranging from 0.0145 to 0.0012, it varied through the tidal cycle (Table 1; Figures 3 and 5). Vertical gradients are upwards during high tide and downwards at low tides with good correlation between vertical gradient and tide stage. The upward gradient in near-shore well pairs along the sheetpile wall likely reflects a classic discharge zone at the East Waterway (Figure 2). The upward vertical gradient in nearshore wells suggests that shallow groundwater near the wall does not flow downward and discharge beneath the sheetpile wall.

Tidal efficiency and time lag were estimated by curve fitting tide and well water level elevations to the tide cycle between low-low tide on November 4, 2011 to high tide approximately 7 hours later (Table 1). Tidal efficiency is calculated as the ratio of water-level elevation change in monitoring wells to that of the stilling well. Tidal efficiencies were generally higher closer to the East Waterway and ranged from less than 1% at MW-

[3] Wells MW-58, MW-85A, MW-87A, and MW-87B were accessed for redevelopment 4-days into the monitoring period.

91 in the eastern portion of the site up to 56% in MW-87B along the sheetpile wall (Figure 6). Well pairs along the sheetpile wall showed greater efficiencies in the deeper well completion (51 to 56%) than the shallow completion (11% to 22%).

The time lag is calculated as the difference in time between high or low tides at the stilling well and corresponding peaks and troughs in each monitoring well. Time lag increased with distance from the waterway ranging from 30 minutes at MW-84A to more than 3 hours; time lag was not estimated for wells with tidal efficiencies less than 5% where peaks could not be identified with confidence against background variation. Well pairs along the sheetpile wall again showed a consistent relationship with longer time lags in shallow wells than the deeper wells.

Water level profiles are plotted along a composite west to east transect at high-high tide, falling tide, low-low tide and the following rising tide (Figure 6). No head data are available seaward of the sheetpile wall so water level elevations from the stilling well are plotted at the sheetpile wall; this simplification increases the plotted gradients between the sheetpile and adjacent well pairs.

Groundwater flow directions and gradients shift in nearshore wells from generally westerly flow to easterly flow during tidal cycles (Figures 7a and 7b). Groundwater flow direction and gradient was calculated from sets of three water table wells at the north (MW-87A, MW-89, MW-90) and south (MW-84B[4], MW-85A, MW-46) using density-corrected transducer data. Flow at the north well cluster shifts from west-north-west over most of the tidal cycle to almost due east at high-high tide and then back (Figure 7a). Similarly, flow near MW-84B shifts from a nearly westerly flow to almost due north at high-high tide before returning to westerly flow (Figure 7b). Gradients calculated from the well clusters indicate that gradients calculated during flow reversals are generally less than a third of the magnitude of gradients calculated during flow to the west. The lower magnitude of the flow gradient coupled with the relatively short portion of the tidal cycle in which flow is reversed indicates that the tidal flow reversals are a small component of the net groundwater flow path (Figure 8).

REFERENCES

AECOM, 2008. Final Supplemental Data Report, Revision 2, Terminal 30, Port of Seattle. Consultant's report prepared for the Port of Seattle. May 2008.

GeoEngineers, Inc., 1998. Terminal 30 Final Report Remedial Investigation/ Feasibility Study. Consultant's report prepared for the Port of Seattle. December 1998.

Serfes, M.E.,1991. Determining the Mean Hydraulic Gradient of Ground Water Affected by Tidal Fluctuations. Groundwater, Vol. 29, No. 4, July-August 1991, pgs 549 to 555.

[4] MW-84B is the shallow well in this pair.

TABLES AND FIGURES

Attachments:

tidestudyappendix_v3.doc
JE1005.02

Table 1. Tidal Efficiency and Time Lag

Port of Seattle Terminal 30

Location	Well Completion	Uncorrected Mean Water Level Elevation (ft MLLW)	Tidal Lag (minutes)	Tidal Efficiency	Distance East of Sheetpile Wall (ft)	Screen Top (ft bgs)	Screen Bottom (ft bgs)	November 2011 EC (umhos/cm)	April 2011 EC (umhos/cm)	Density Corrected Mean Water Level Elevation (ft)	Well Pair Vertical Gradient (ft/ft)
MW-38 [1]	Water Table	8.57	nr	nr	281	nr	12.25	--	500	**8.57**	--
MW-46	Water Table	8.38	nr	<1 %	135	8.5	17.5	--	1,960	**8.39**	--
MW-54 [1]	Water Table	9.32	nr	nr	537	4	29	--	500	**9.33**	--
MW-58	Water Table	7.99	90	20%	56	5	30	846	900	**8.00**	--
MW-81A	Water Table	8.85	180	1%	339	5	20	--	900	**8.86**	--
MW-84A	Deep Zone	7.99	30	53%	29	30	40	1,040	961	**8.00**	0.0145
MW-84B	Water Table	7.71	70	22%	29	5	20	983	1,180	**7.71**	
MW-85A	Water Table	7.78	160	12%	29	5	20	6,370	4,890	**7.80**	0.0012
MW-85B	Deep Zone	7.75	35	52%	29	30	40	3,700	5,310	**7.83**	
MW-87A	Water Table	7.7	160	20%	29	5	20	4,051	2,460	**7.71**	0.0076
MW-87B	Deep Zone	7.85	30	56%	29	30	40	797	869	**7.86**	
MW-89	Water Table	8.16	150	6%	99	5	20	--	3,450	**8.17**	--
MW-90	Water Table	7.76	115	12%	121	5	20	--	1,410	**7.77**	--
MW-91	Water Table	8.66	nr	< 1%	373	5	20	--	1,020	**8.66**	--
Stilling Well	--	6.85	0	100%	--	30	30	--	30,000	**7.07**	--

[1] Specific Conductivity (EC) values are estimated at 500 umhos/cm. Sensitivity testing between 100 and 1000 umhos indicated uncertainty of 0.01 ft or less.

"nr" indicates that the value is not available from existing data.

MW-45 was inaccessible due to shipping container placement, and was not included in the tidal study.

Tidal efficiency too low at MW-91 to estimate tide lag.

A transducer error at MW-54 prevented calculation of time lag and tidal efficiency.

Positive vertical gradients indicate upward head gradient; gradient calculated assuming 20 foot vertical separation between head measurements.

Water level density correction is the difference in height of a column of freshwater relative to the measured water level/density in well.

Density was estimated from specific conductivity data.

K:\PONY\T30\GIS\mxds\WaterLevelElevations.mxd

Average Water Level Elevation Contours

Gaging/Recovery Well

Water Quality Monitoring Well

Stilling Well

7.71 Time-Averaged / Density Corrected Water Level Elevations

Vertical Datum: MLLW

N

2009 USGS Orthophoto

See Table 1 for Well Completion Information

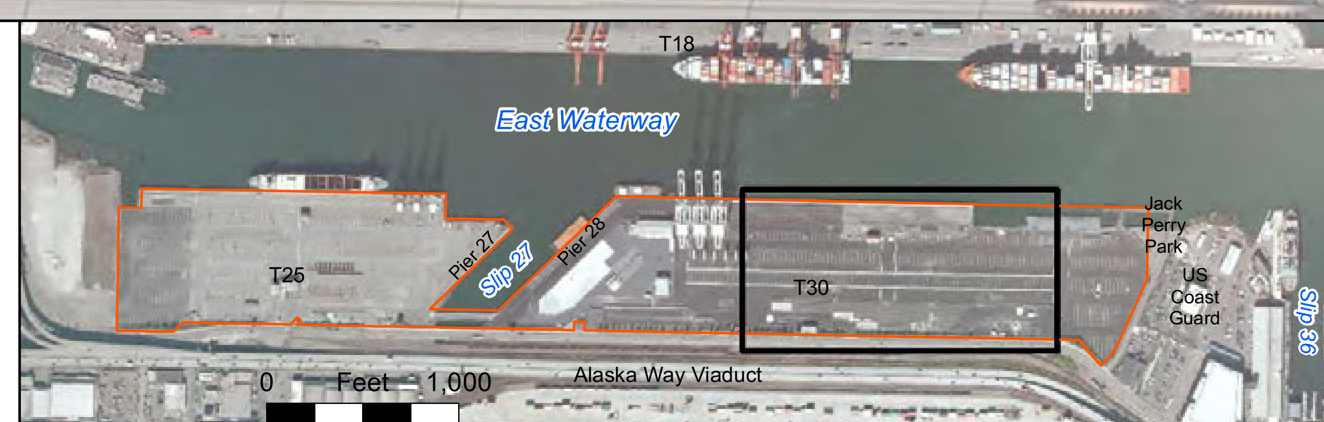
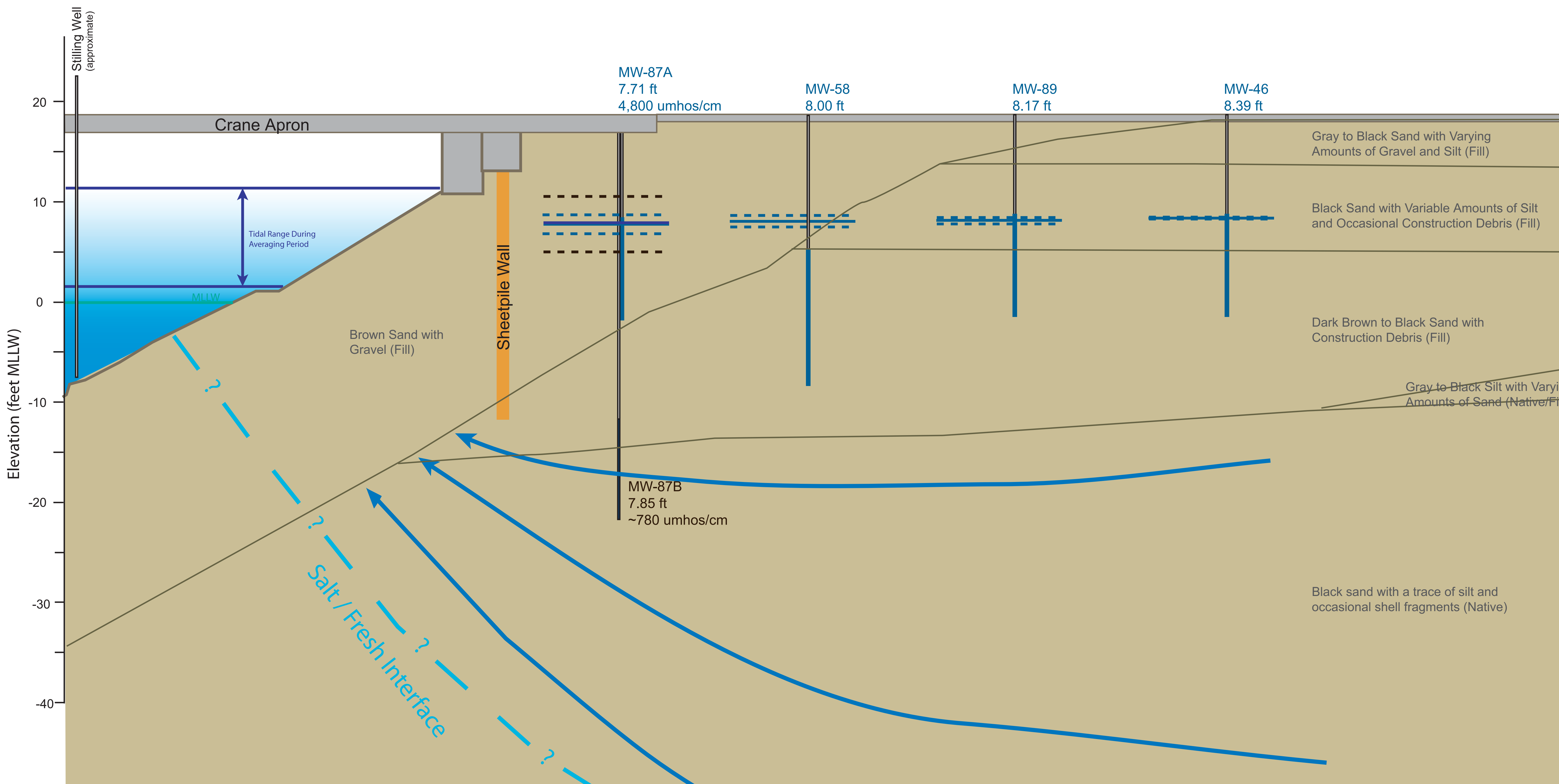


Figure 1

Site Map and Average Water Level Elevations

Terminal 30
Port of Seattle
JE1005

PgG

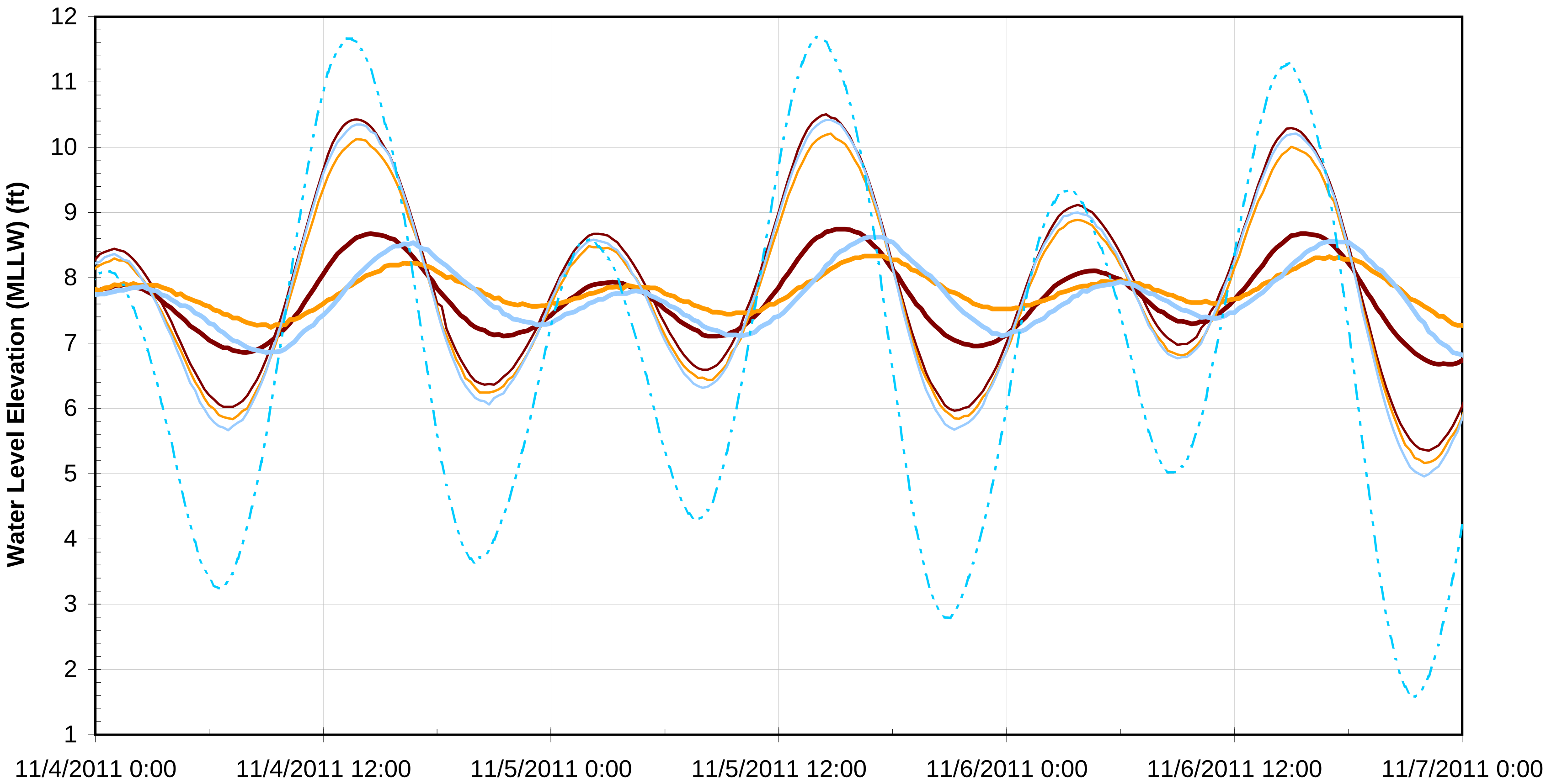


Notes:
No Vertical Exaggeration.
Geology modified from GeoEngineers (1998) Figure 6.5.
Dashed lines at each well indicate maximum and minimum water level during 2011 tidal study.
Solid lines at each well indicate average water level during 2011 tidal study.
Features such as pilings and cranes omitted for clarity.
MLLW stands for Mean Low Low Water.

Conceptualized Deep Groundwater Flow Path

Figure 2. Schematic Cross Section
Port of Seattle Terminal 30

PgG 25 years



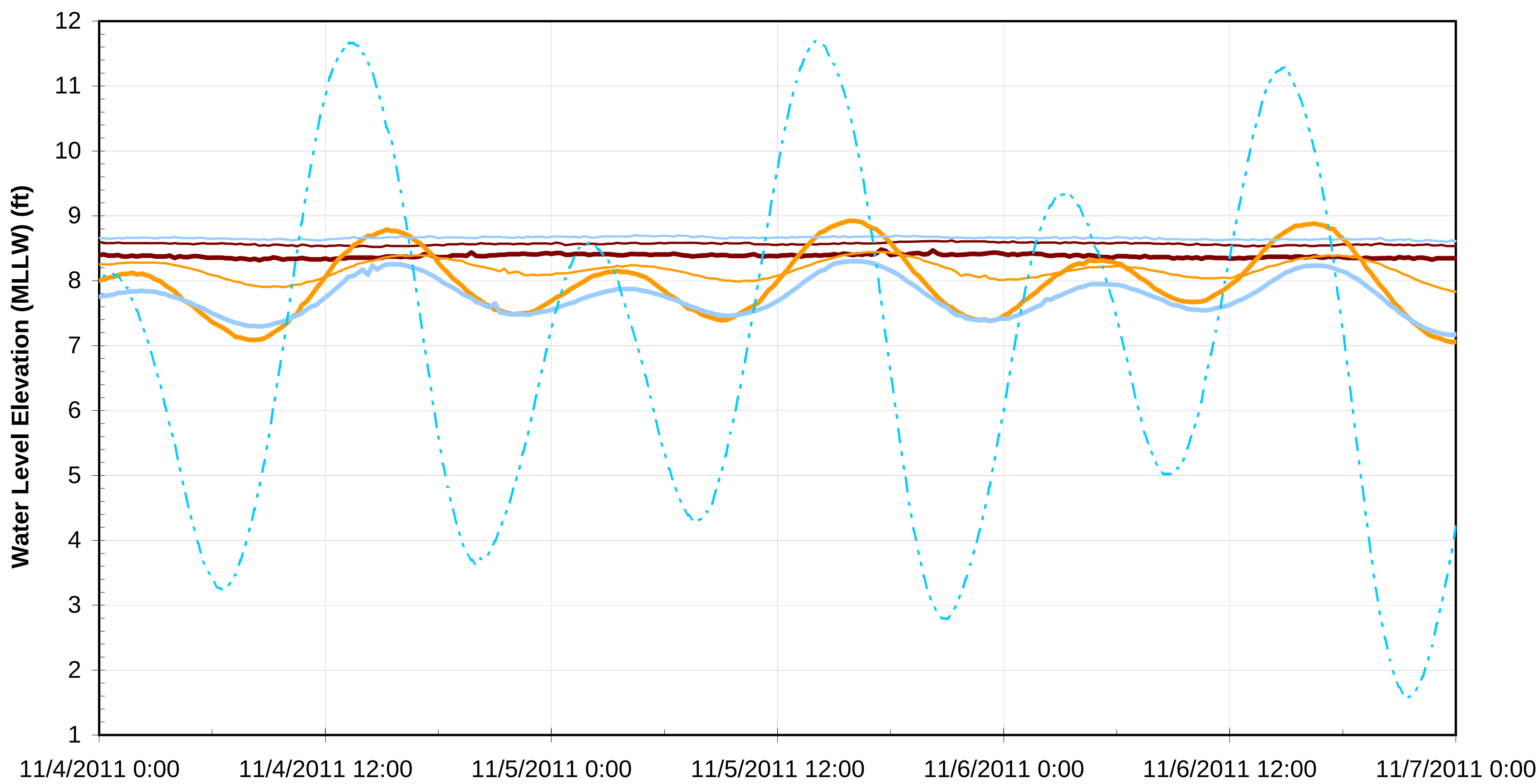
Well Depths:
MW-84A : 40
MW-84B : 20
MW-85A : 20
MW-85B : 40
MW-87A : 20
MW-87B : 40
Thin Line= 40 ft

MW-84A
MW-84B
MW-85A
MW-85B
MW-87A
MW-87B
Stilling Well

Water level elevations corrected for density. Thick lines are shallow well completions.

Figure 3. Nearshore Well Pair Hydrographs
Port of Seattle Terminal 30

PGG 25 years

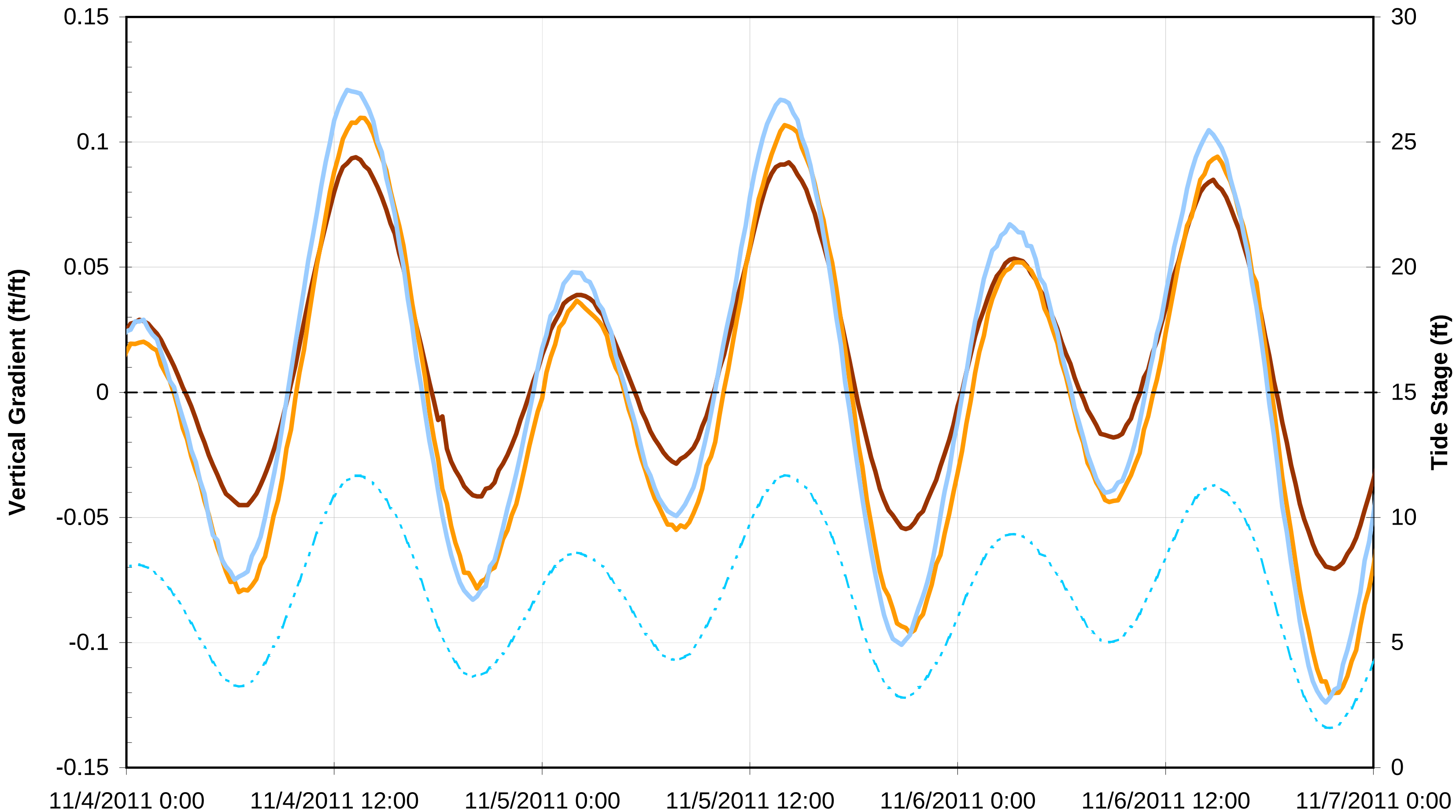


Water level elevations corrected for density.

Figure 4. Not-Nearshore Well Hydrographs

Port of Seattle Terminal 30

PgG 25 years

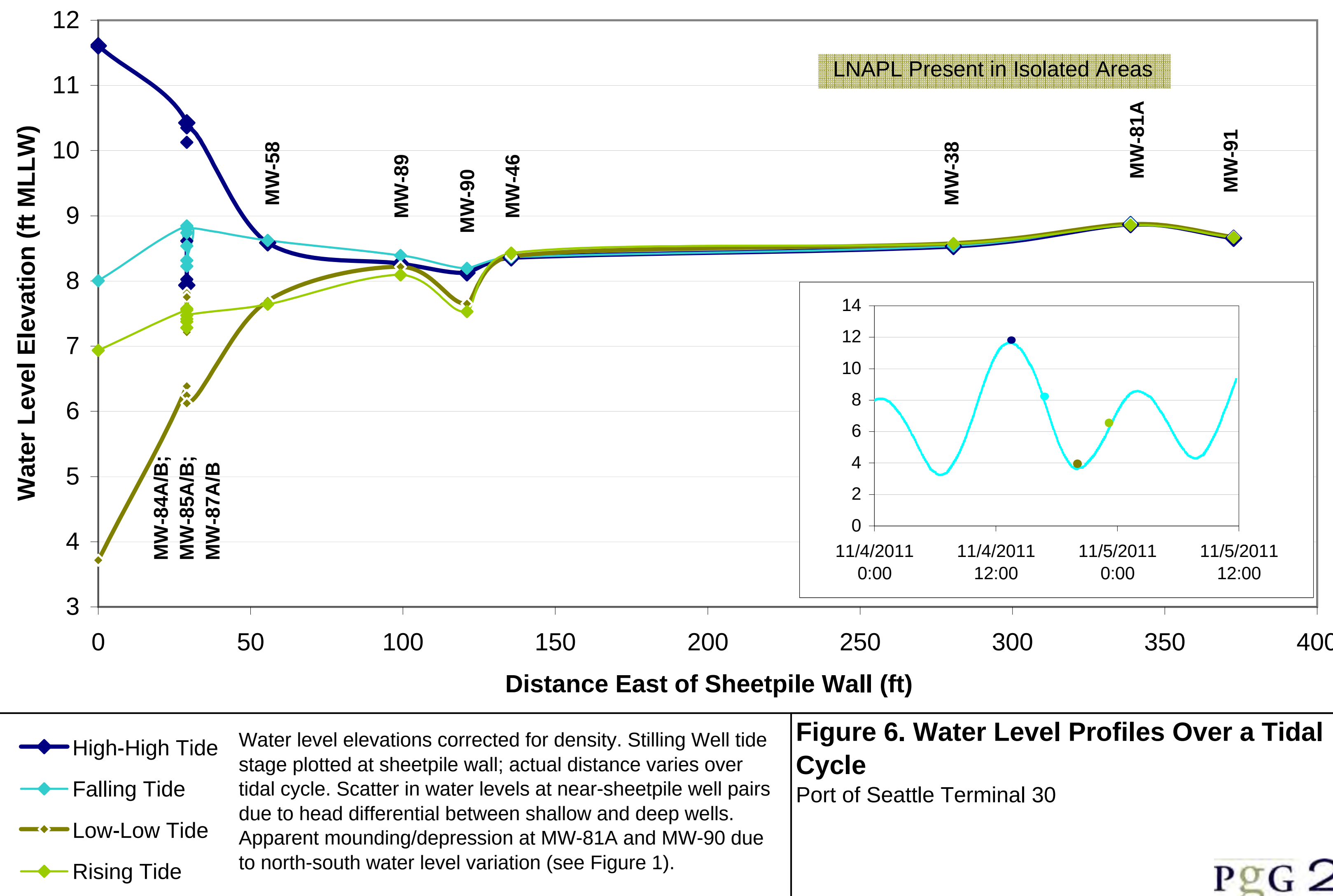


MW-84A/B (Avgerage = 0.0145)
MW-85A/B (Avgerage = 0.0012)
MW-87A/B (Avgerage = 0.0076)
Tide Stage

Positive values indicate upward gradient. Vertical gradient calculated as deep minus shallow density-corrected water level over assumed 20ft separation based on well construction. Tide stage shown for reference.

Figure 5. Nearshore Well Pair Vertical Gradient

Port of Seattle Terminal 30

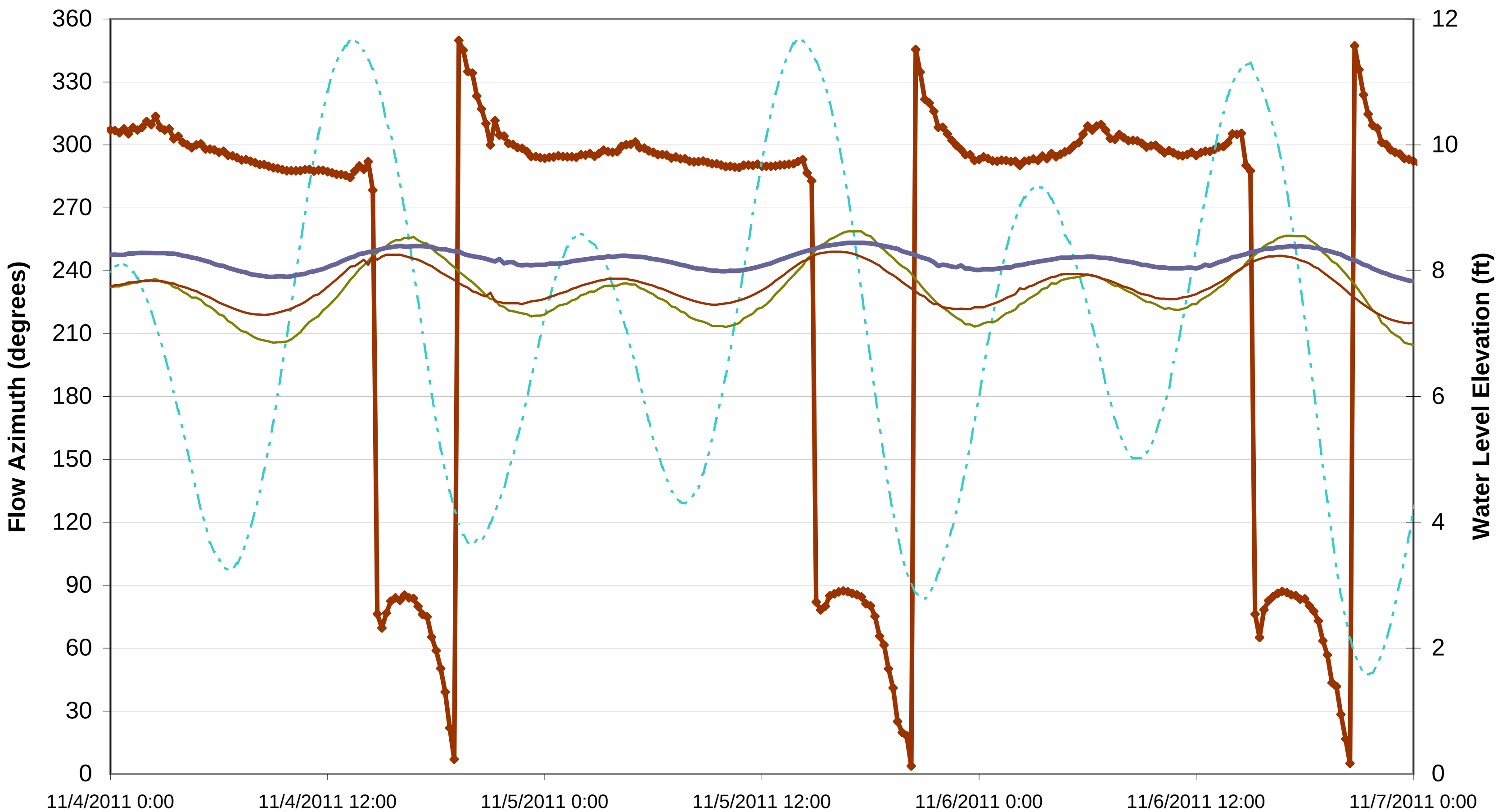


Water level elevations corrected for density. Stilling Well tide stage plotted at sheetpile wall; actual distance varies over tidal cycle. Scatter in water levels at near-sheetpile well pairs due to head differential between shallow and deep wells. Apparent mounding/depression at MW-81A and MW-90 due to north-south water level variation (see Figure 1).

Figure 6. Water Level Profiles Over a Tidal Cycle

Port of Seattle Terminal 30

PGG 25

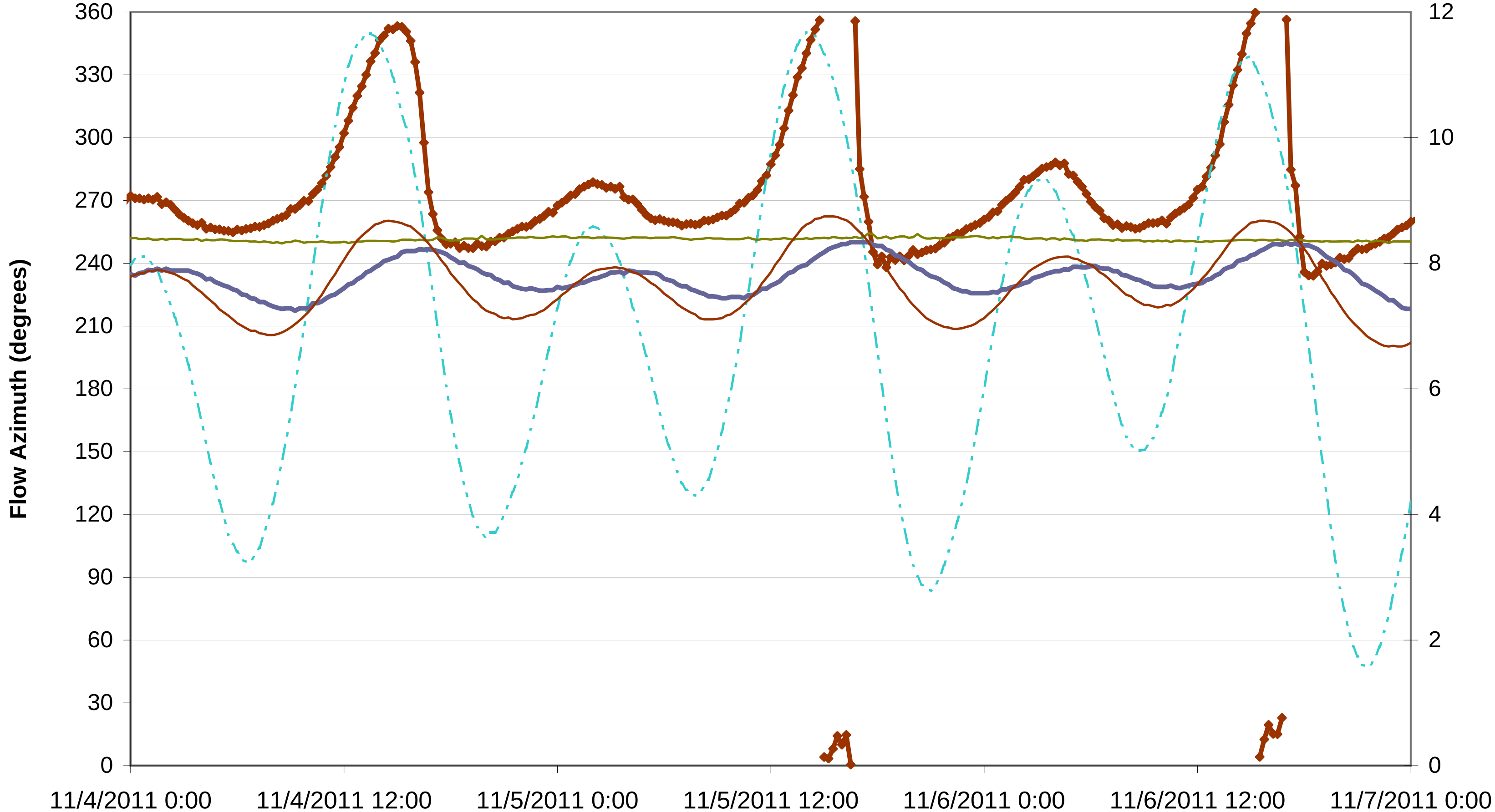


Flow Direction
Stilling Well
MW-87A
MW-89
MW-90

Water level elevations corrected for density. Flow directon calculated from MW-87A, MW-89 and MW-90.
Average flow azimuth 302 degrees (32 degrees north

Figure 7a. Groundwater Flow Direction at North End of Sheetpile Wall

Port of Seattle Terminal 30



- Flow Direction
- Stilling Well
- MW-46
- MW-85A
- MW-84B

Water level elevations corrected for density. Flow directon calculated from MW-46, MW-84B and MW-85A. Average flow azimuth 261 degrees (9 degrees south of due west).

Figure 7b. Groundwater Flow Direction at MW-84B, MW-85A, MW-46

Port of Seattle Terminal 30

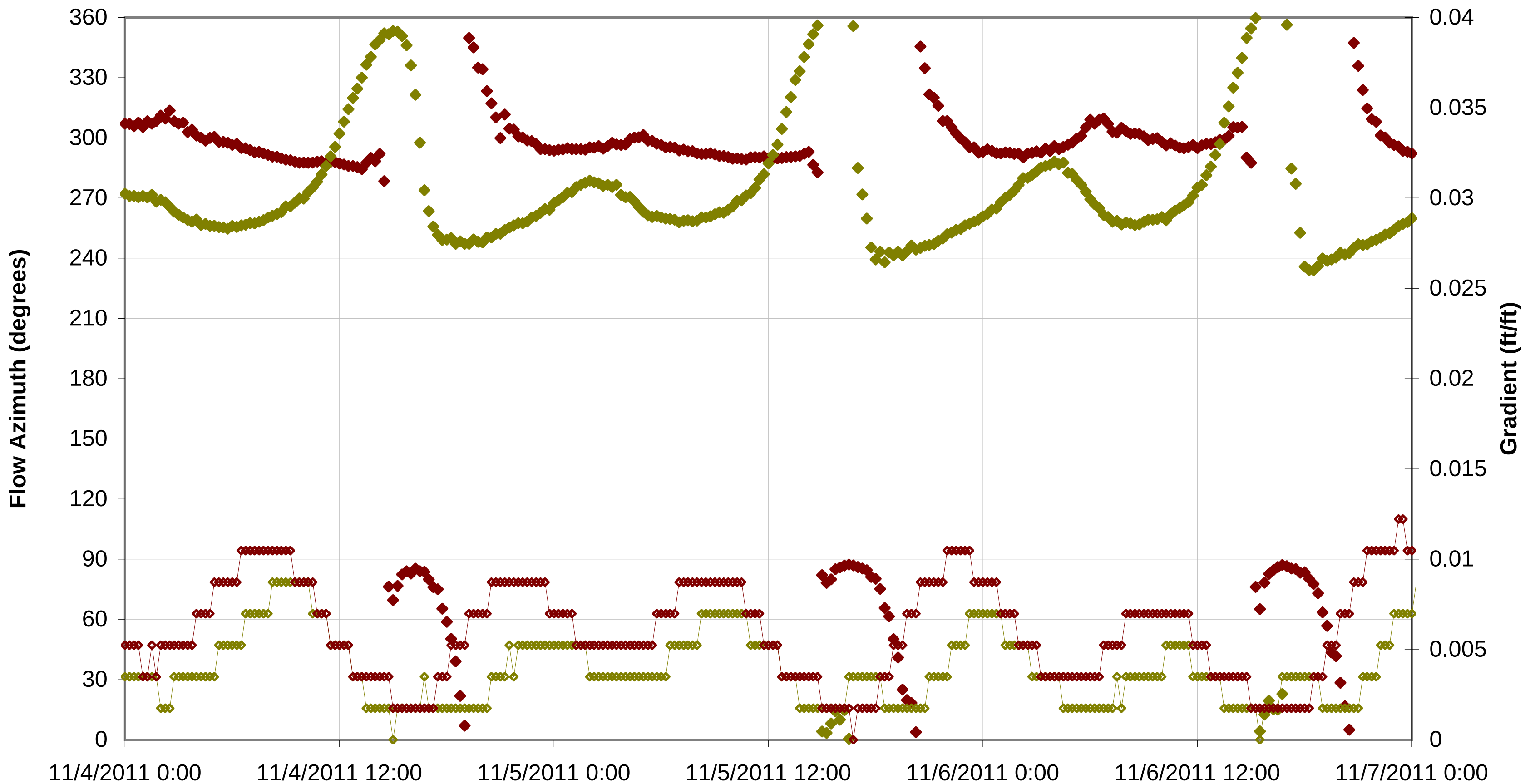
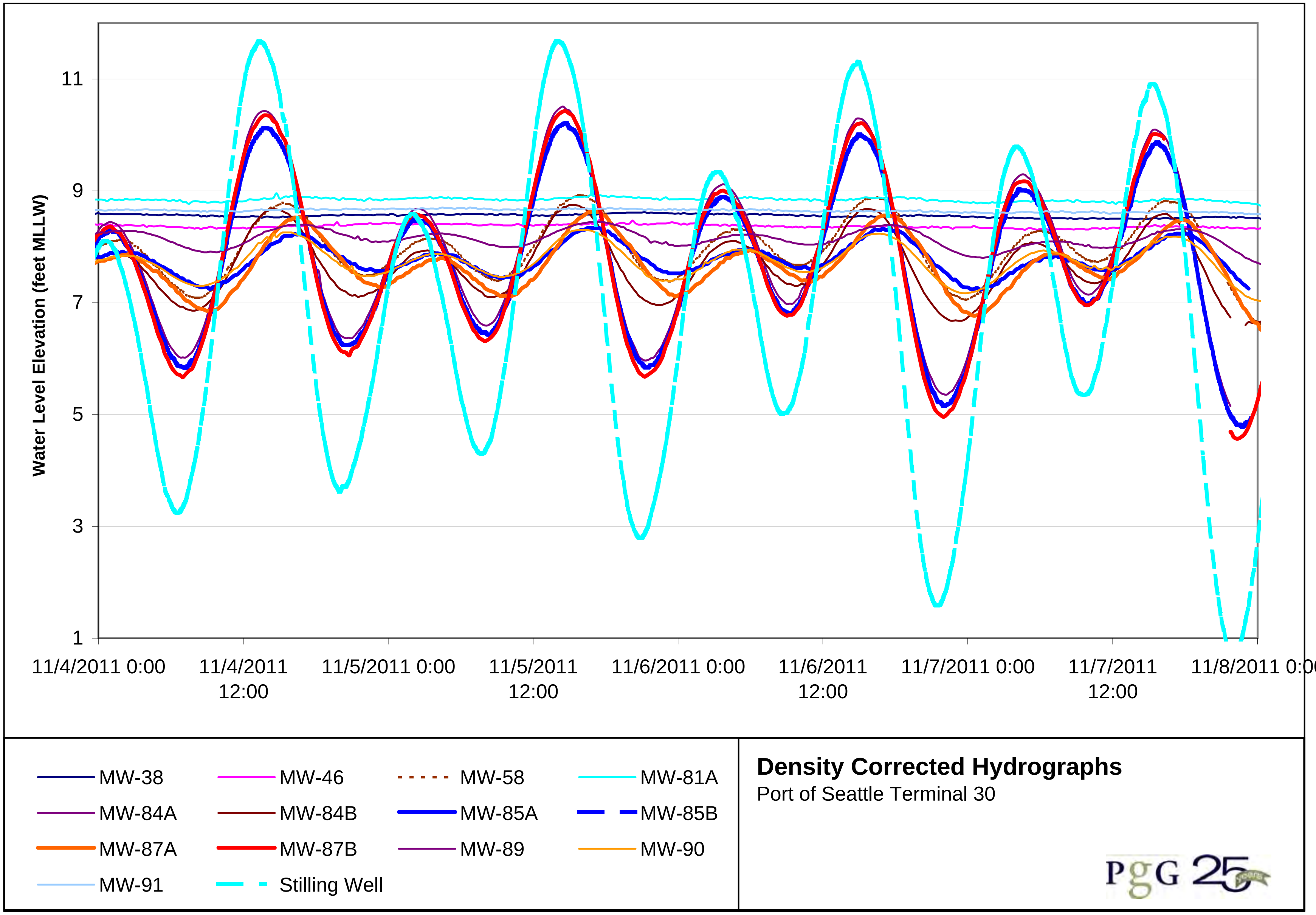


Figure 8. Groundwater Flow Direction and Gradient

Port of Seattle Terminal 30

PgG 25



Density Corrected Hydrographs

Port of Seattle Terminal 30

APPENDIX C: MW-42 OXYGEN RELEASE COMPOUND APPLICATION

Application

AECOM applied Oxygen Release Compound (ORC) in a row of 5 borings located 10 feet upgradient from MW-42 on June 4, 2007. Forty pounds of ORC were applied at each boring between 8 and 18 feet below ground surface for a total application of 200 pounds. The ORC manufacturer’s literature reports that approximately 10-percent of applied ORC mass is released as oxygen. Therefore, the application in the MW-42 area yielded up to 20 pounds of oxygen available for bioremediation and other aquifer oxygen demand.

Trend Plots

Time trends of total petroleum concentrations in groundwater samples collected at MW-42 were plotted to evaluate the effects of the 2007 ORC application.

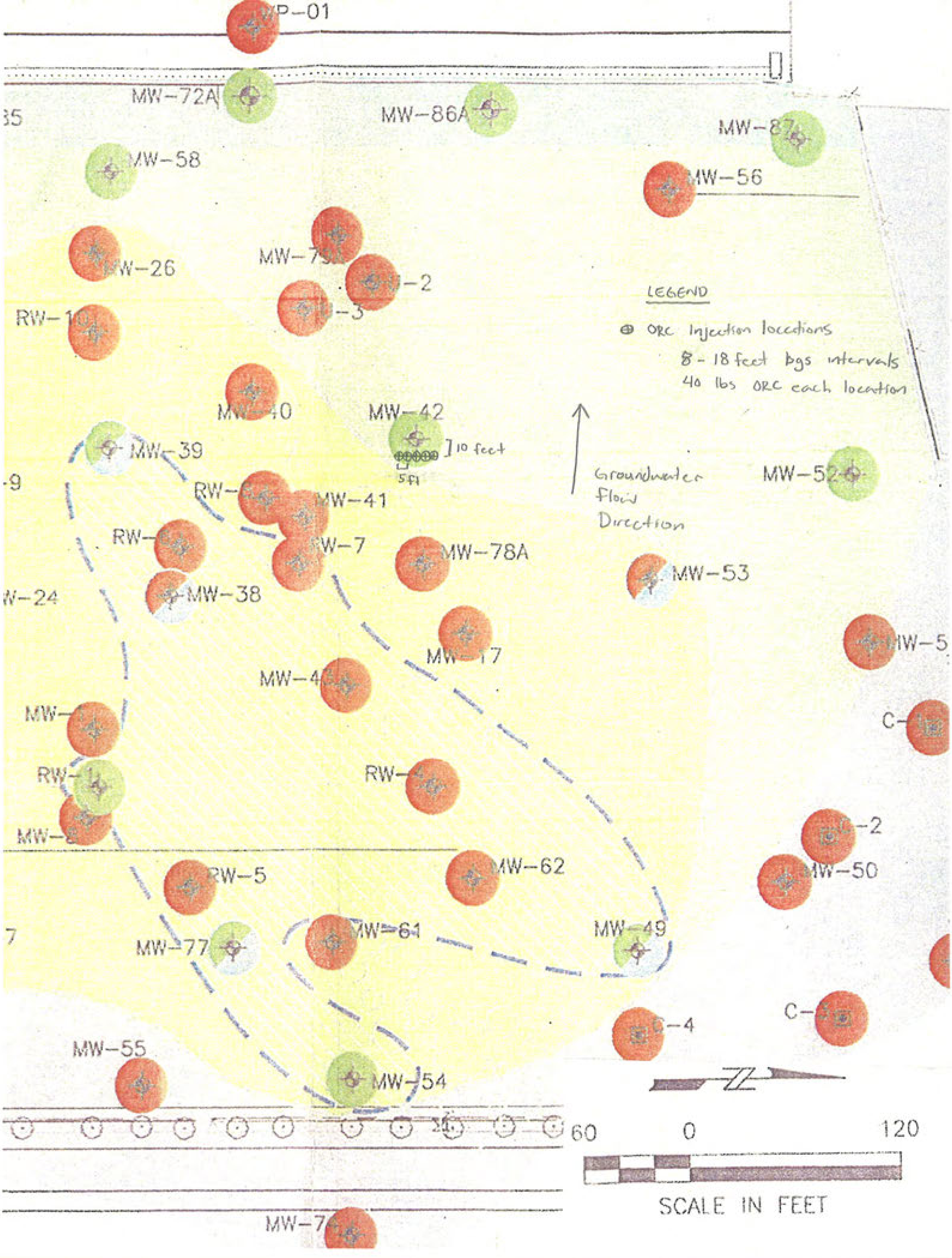
Total petroleum concentrations in MW-42 groundwater samples collected between 2004 and 2011 were plotted. The total petroleum concentrations represent the sum of TPH-G or GRO, BTEX, and naphthalene concentrations. The plot indicates that total petroleum concentrations are lower after the application of ORC in 2007. However, the decreasing linear trend over the entire 2004-2011 data set is generally parallel to the decreasing linear trend over the pre-ORC application (2001-2007) data set. This suggests that the ORC application was not the primary driver for the reduction in total petroleum concentrations at MW-42.

TPH-D or DRO concentrations in MW-42 groundwater samples were not included in the total petroleum concentration trend analysis. Diesel concentrations in MW-42 peaked in 2005 followed by non-detects from 2006 to 2011, which may have biased the trend analysis.

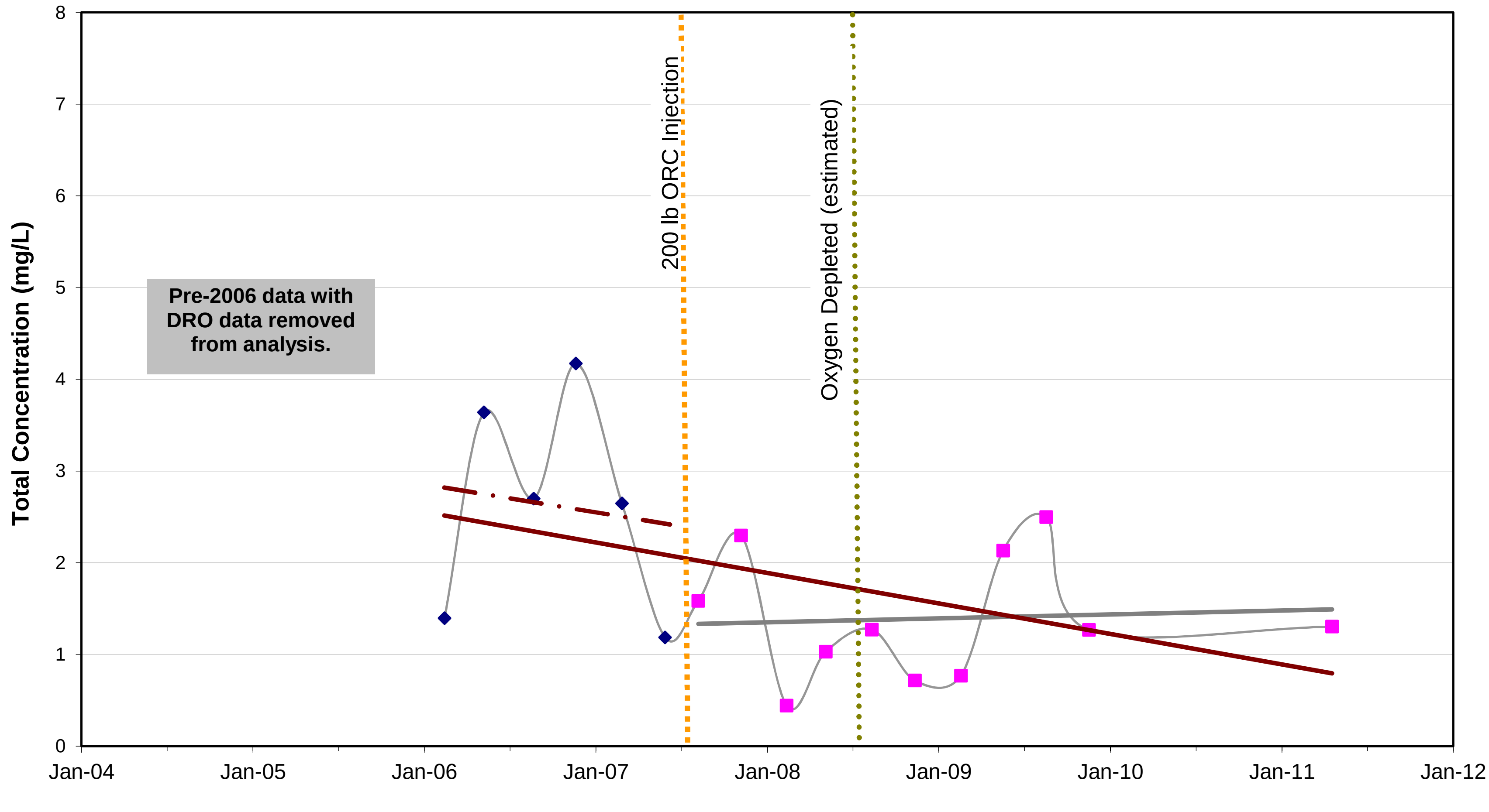
Total TPH and BTEX concentrations in MW-42 groundwater samples collected for two years prior to the ORC application were compared to total concentrations in samples collected for two years following the application. The averaged total concentration decreased from 3.4 mg/L to 1.9 mg/L. Again, the trend analysis indicates the concentrations were declining regardless of ORC application.

Conclusion

The 200 pound ORC loading (20 pounds of oxygen) appears to have been insufficient to meet the total chemical and biological oxygen demand in the application area. Decreasing trends are more likely due to a combination biodegradation and dispersion mechanisms in the source area and dissolved phase plume.



MW-72A
MW-86A
MW-87
MW-58
MW-56
MW-26
RW-10
MW-40
MW-42
10 feet
5 ft
MW-39
RW-6
MW-41
RW-7
MW-78A
MW-38
MW-53
MW-52
MW-17
MW-24
RW-4
MW-62
RW-5
MW-50
MW-61
MW-77
MW-49
MW-55
MW-54
C-2
C-4
LEGEND
ORC Injection locations
8 - 18 feet bgs intervals
40 lbs ORC each location
Groundwater Flow Direction
60
0
120
SCALE IN FEET

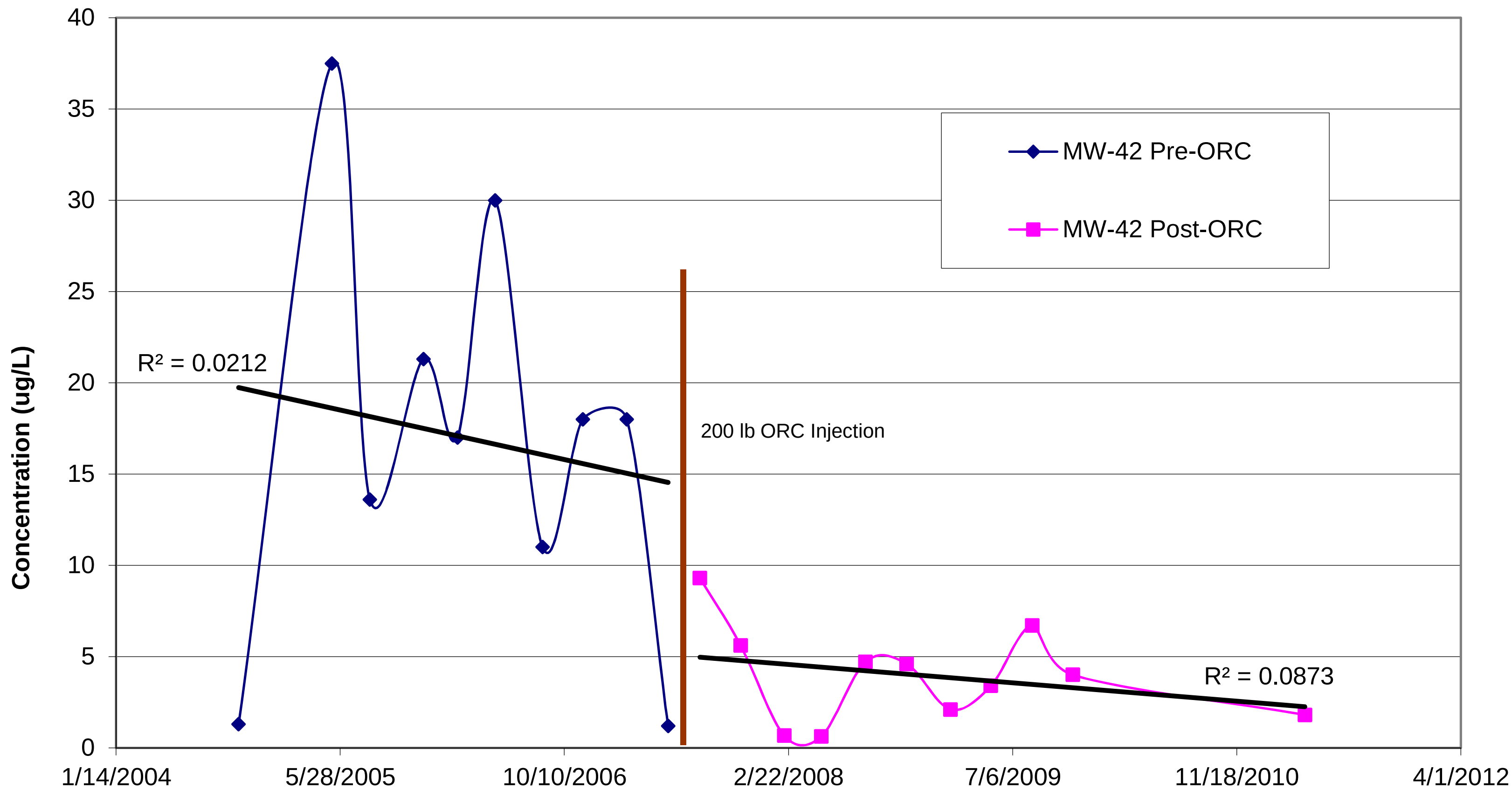


Total concentration is calculated as the sum of GRO, BTEX, and napthalene concentrations at MW-42 for each groundwater sampling event.

MW-42 Groundwater Concentrations Pre- and Post-ORC Application (No TPH-D)

Port of Seattle Terminal 30

PGG



MW-42 Napthalene Concentrations
Pre- and Post-ORC Application

Port of Seattle Terminal 30

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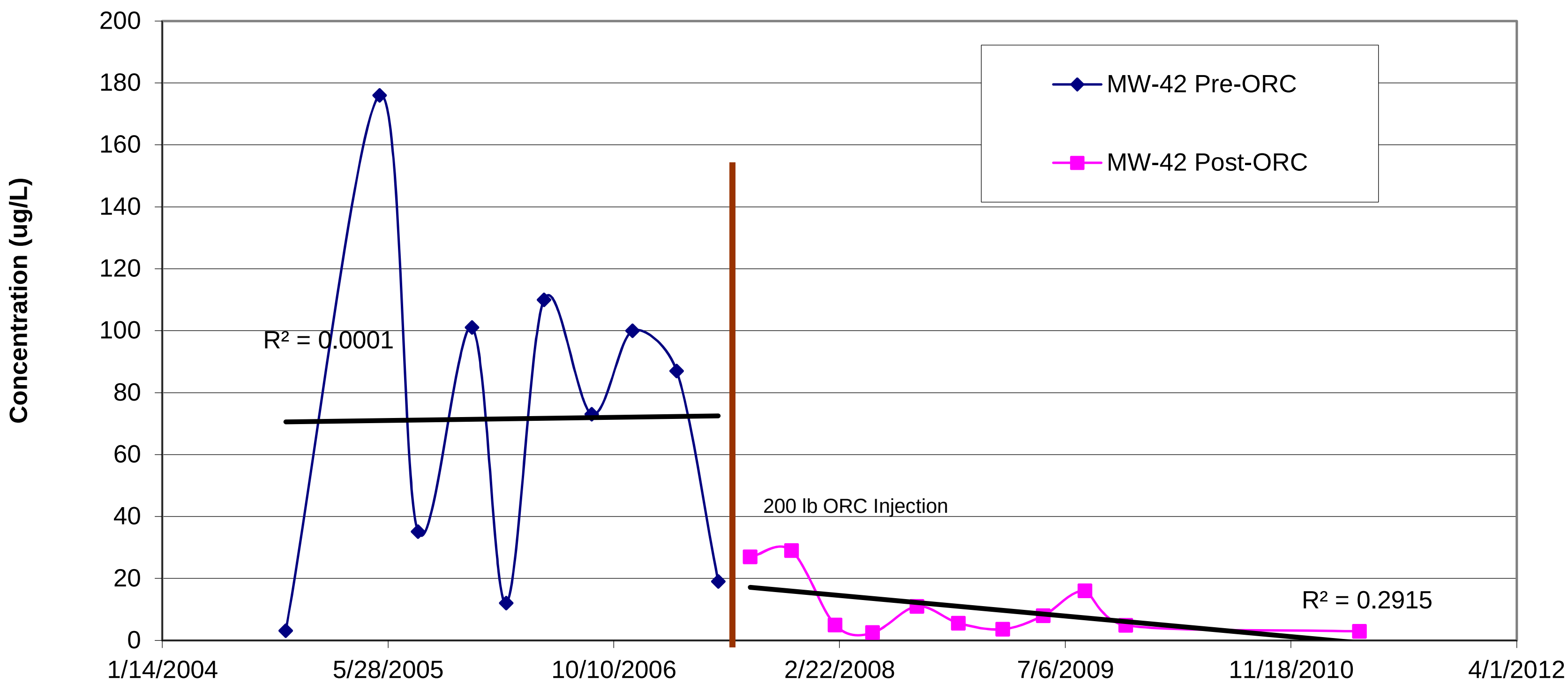
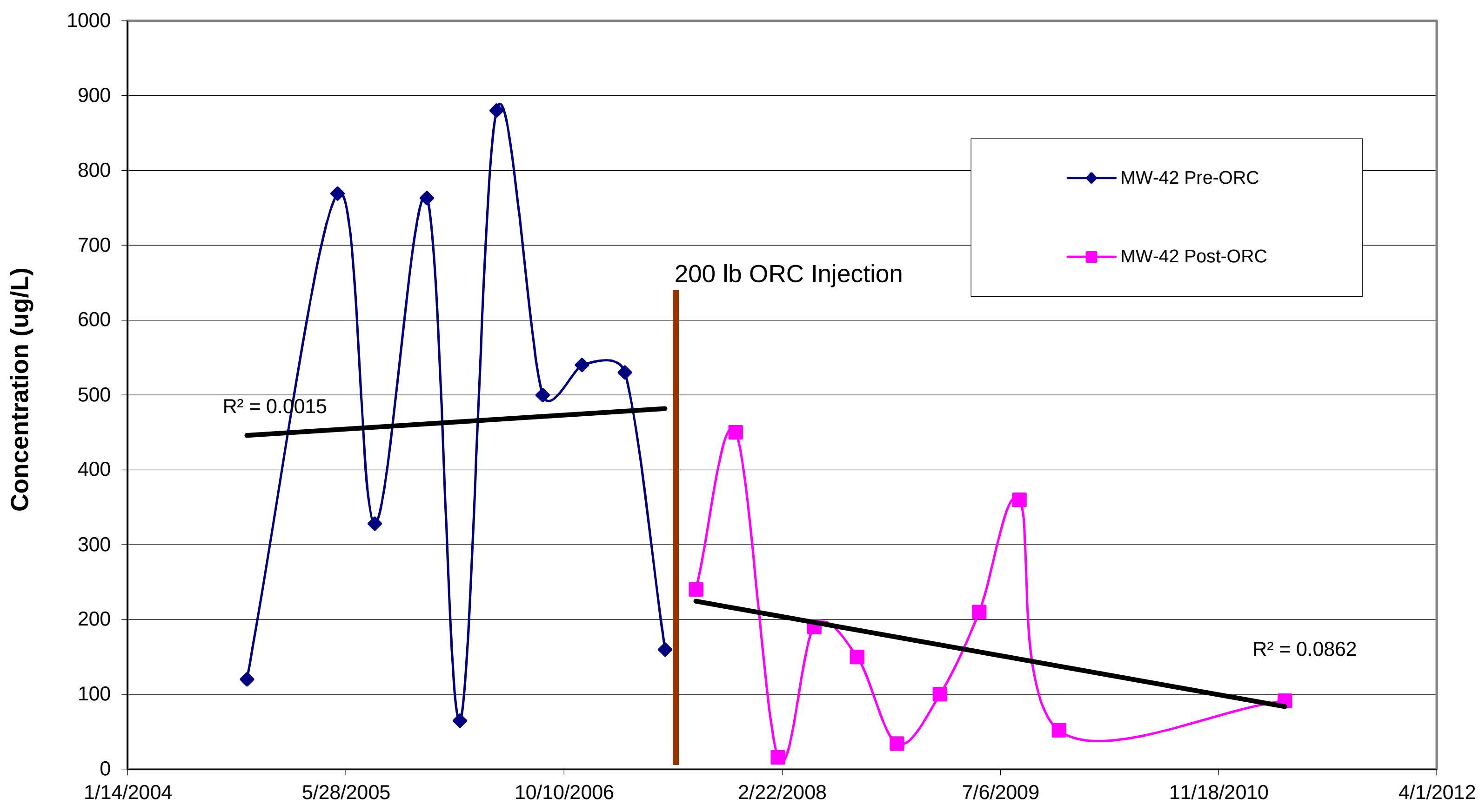


MW-42 Eythlbenzene Concentrations
Pre- and Post-ORC Application

Port of Seattle Terminal 30

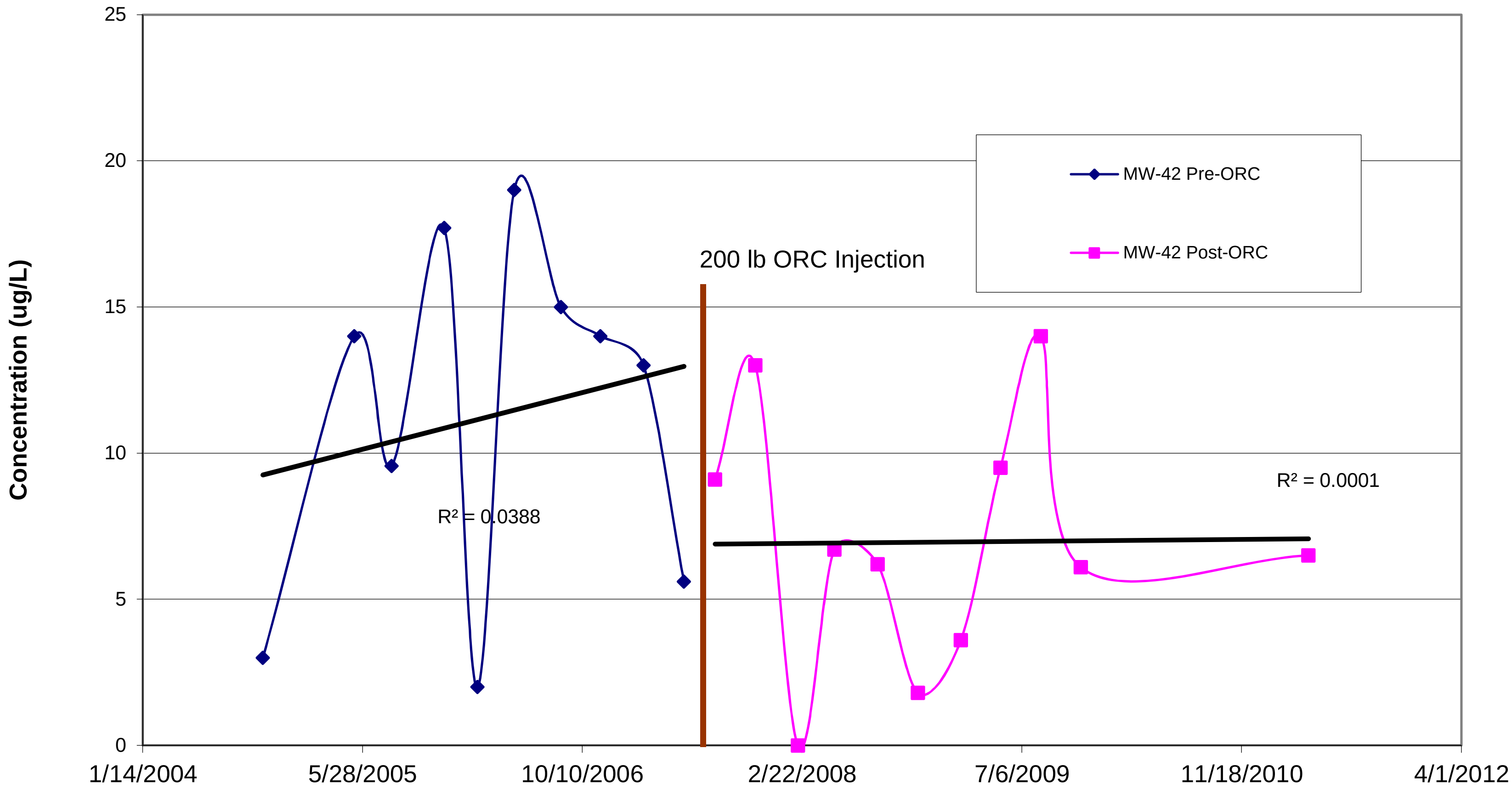
PgG



MW-42 Benzene Concentrations Pre- and Post-ORC Application

Port of Seattle Terminal 30

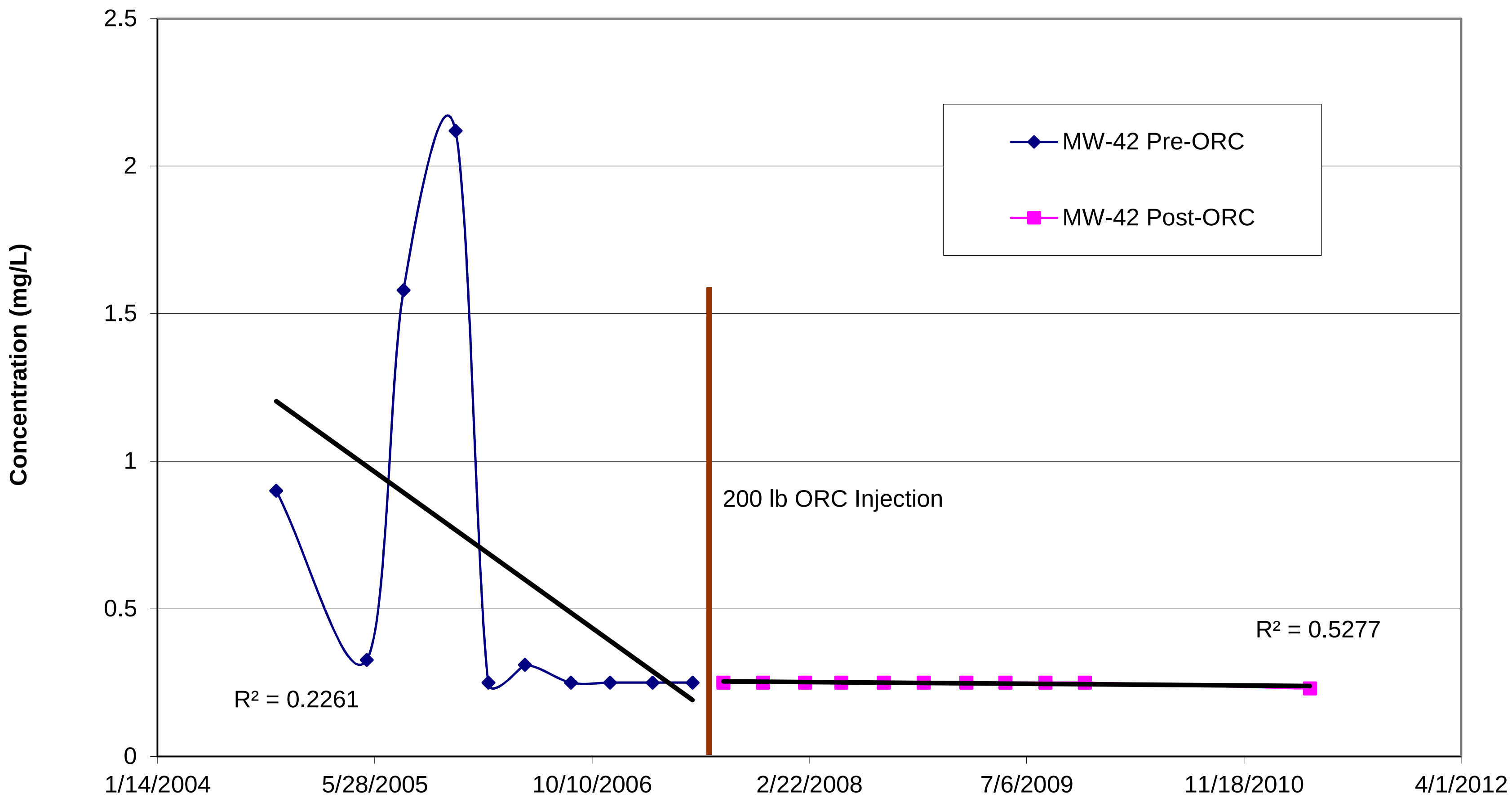
PGG



MW-42 Toluene Concentrations Pre- and Post-ORC Application

Port of Seattle Terminal 30

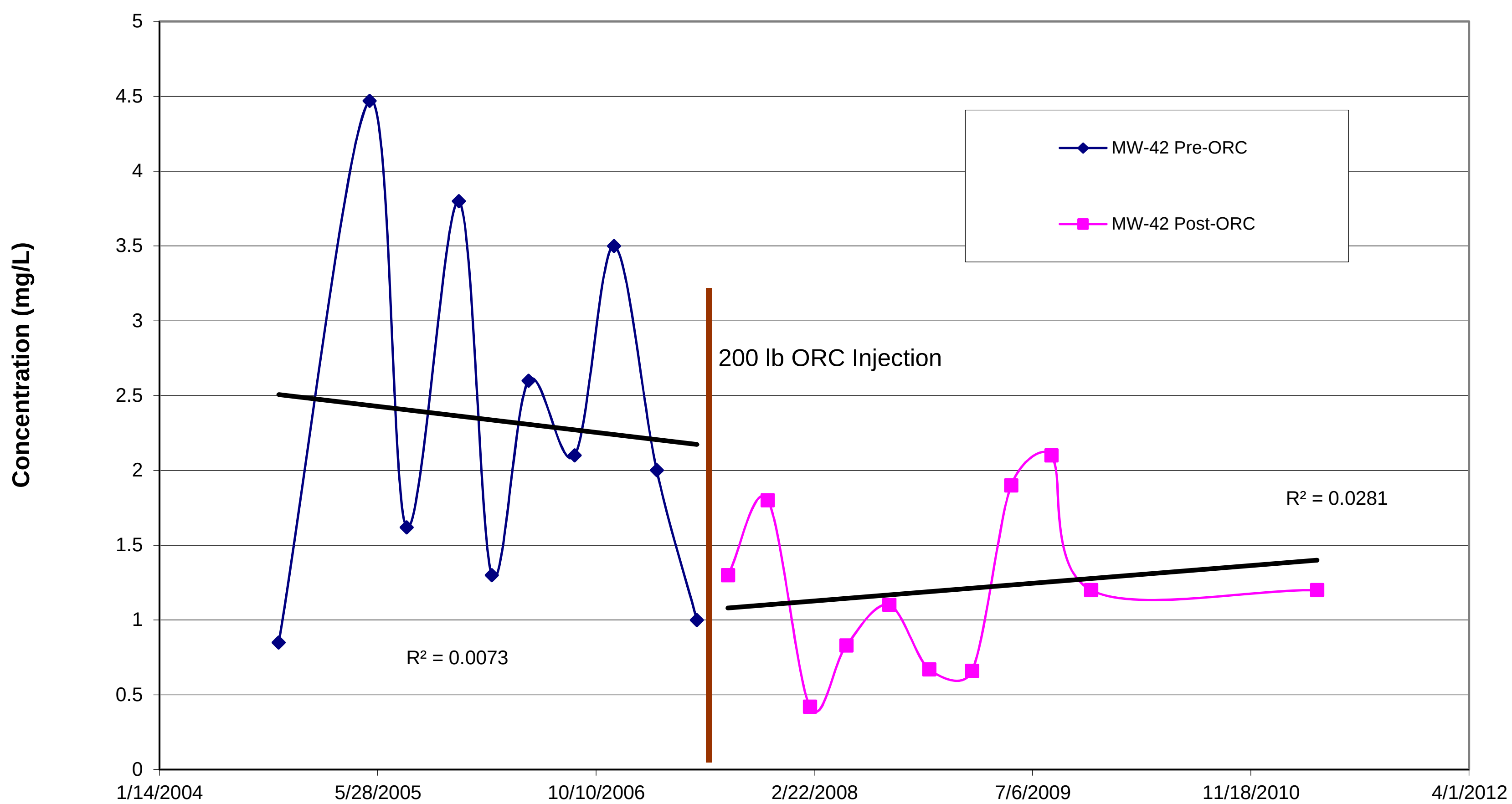
PGG



MW-42 DRO Concentrations Pre- and Post-ORC Application

Port of Seattle Terminal 30

PgG



MW-42 GRO Concentrations Pre- and Post-ORC Application

Port of Seattle Terminal 30

PGG

APPENDIX D: LNAPL EVALUATION

Technical Memorandum

To: Sunny Becker, Department of Ecology

Cc: Jerome Cruz, Department of Ecology

From: Glen Wallace, Ph.D. and Pony Ellingson, Pacific Groundwater Group

Re: Terminal 30 LNAPL Mobility Estimation

Date: Revised[1] May 1, 2012

This appendix to the Terminal 30 Remedial Investigation/Feasibility Study (RI/FS) provides an analysis of light nonaqueous phase liquid (LNAPL) mobility. The mobility analysis includes field tests of LNAPL transmissivity using baildown tests in addition to simulation of LNAPL saturation curves and transmissivity using the API *LNAPL Distribution and Recovery Model* (LDRM) (Charbeneau, 2007a). The simulations were also used to qualitatively estimate recoverable LNAPL fraction relative to the non-recoverable residual fraction. Key findings of the LNAPL mobility evaluation are:

- Where LNAPL thickness in wells is greatest, LNAPL transmissivity values range from near zero to slightly above standard thresholds indicating mobility/migration and feasible recovery of source mass by pumping. The qualitative finding is that LNAPL in the center of the plume ranges from immobile to slightly mobile, and at the margins of the plume it is immobile.
- Modeled LNAPL saturation values indicate that most source mass contributing to the dissolved groundwater plume is not mobile. Therefore recovery of measureable LNAPL will have little impact on groundwater concentrations in the near term.
- The fraction of LNAPL that is recoverable by pumping is a small fraction of the remaining source mass.

OCCURRENCE OF LNAPL AT TERMINAL 30

Please refer to Section 2.7.1 of the *Terminal 30 Remedial Investigation/Feasibility Study* for a discussion of the extent of LNAPL (PGG, 2012). Figure 1 shows the site layout, including historic and current LNAPL distribution.

[1] Calculations and text were revised in response to Ecology comments and publication of ASTM standards for estimation of LNAPL transmissivity.

CONCEPTUAL FRAMEWORK

This section discusses the conceptual framework for mobility of free product in the capillary and saturated zones. The technical understanding of LNAPL mobility has been refined over the last decade as knowledge of relationships between LNAPL saturation[2] (percent of pore space filled with LNAPL), LNAPL physical characteristics (density, viscosity), distribution of LNAPL (pore scale and vertical/lateral extent), and hydrogeologic environment have been studied in the field and laboratory (Adamski, 2011). The central measure of LNAPL mobility is LNAPL transmissivity, which describes the ability of NAPL to migrate through a porous medium. Two key concepts are:

- LNAPL saturation varies with pore-size distribution of the aquifer, LNAPL fluid characteristics, and capillary pressure in the LNAPL phase (usually through increased LNAPL thickness).
- As LNAPL saturation decreases, the effective conductivity/transmissivity decreases and thus so does mobility.

Pore spaces at petroleum-contaminated sites are occupied by a combination of air, water, and NAPL. Because NAPL is not miscible in water, to migrate it must displace air from soil pores in the vadose zone or displace water from soil pores in the saturated zone. NAPL migrates more easily through the vadose zone than saturated zone because less force is required to displace air than water.

NAPL migration through the vadose zone is generally downwards and is driven primarily by gravity. Volatile components, where present, separate into soil gas and can form vapor plumes. The migrating NAPL leaves residual product in its path wherever NAPL has been in contact with soil. The residual NAPL is effectively trapped by capillary forces and does not flow under the influence of gravity.

If sufficient NAPL is present, it can migrate through the vadose zone and reach the water table. At the water table, the fate of the NAPL is a function of solubility, capillary pressures, and density. The soluble fractions of the petroleum NAPL will dissolve in groundwater and be transported as a groundwater plume.

It is important to consider the transport of NAPL in the saturated zone at both the pore-scale and the site-scale. If NAPL reaches the saturated zone, NAPL and water can co-exist in a soil pore. Water has a greater tendency to spread on or adhere to soil particles than NAPL (i.e. water is the wetting fluid in a NAPL-water system). Therefore, NAPL within a pore is surrounded by a continuous coating of water covering the soil particles. Water is able to easily enter new pore spaces, but NAPL must overcome capillary forces to migrate (NRC, 2005). Pressure is therefore required for NAPL to move from one pore to the next. The critical pressure differential that must be achieved for NAPL to displace water from a pore is known as the displacement entry pressure (head). In that regard, water acts as a capillary barrier against NAPL spreading from pore to pore (Barkau et. al.,

[2] NAPL saturation is expressed as the fraction of the pore space. For example, in a formation with a porosity of 0.3 a NAPL saturation of 0.1 would indicate that 0.03 (3%) of the formation is occupied by NAPL.

2011). The displacement entry pressure or head is related to the thickness and physical properties of LNAPL in the formation. Below the minimum thickness, no LNAPL movement into water-wet pores occurs.

NAPL saturation is the percentage of a pore occupied by NAPL. Previously held conceptual models were that LNAPL saturation approached 100-percent in a layer near the water table; however, recent studies have found that LNAPL saturation is typically much lower. Over 300 samples collected from the most heavily LNAPL impacted portions of 11 sites (refineries, chemical plants, bulk fuel terminal, pipeline) had an average LNAPL saturation of 5.6-percent and maximum of 56.6-percent (Adamski, 2011). On a site-scale, LNAPL saturation is greater in the core of the LNAPL body than at the lateral margins of the body.

Relative permeability is a measure of a fluid's ability to flow in porous media when other immiscible fluids (phases) are present. It is directly proportionate to the saturation level of the subject fluid. The saturation level below which migration essentially ceases is called "residual saturation". Therefore, at the lateral margins of a LNAPL body where saturation is minimal, there may be little to no LNAPL migration. Potential LNAPL mobility within the core of the plume does not necessarily equate to spreading of LNAPL or an expanding LNAPL footprint (Barkau et. al., 2011).

At the site-scale, an earlier conceptual model of LNAPL migration was that LNAPL would spread out and float on the water table like a pancake of uniform saturation. This model is no longer considered accurate. Instead, LNAPL is distributed at and below the water table at saturations that vary vertically (Barkau et. al, 2011). LNAPL can penetrate up to 15 feet below the water table due to pressure head developed by LNAPL in the pore network in the vadose zone (Adamski, 2011).

If a release is sufficient to migrate through the vadose zone and reach the water table, during early periods after the release LNAPL will mound at the water table beneath the release point. This creates an LNAPL gradient or head and at this stage, the LNAPL body can expand horizontally and vertically. Mounding of LNAPL and radial spreading can cause LNAPL to migrate in directions opposite to groundwater flow direction.

If the release is stopped, the LNAPL gradient dissipates over time until there is no longer sufficient head for the LNAPL to overcome displacement entry pressures. LNAPL bodies tend to come to stable configurations relatively soon after sources are stopped (Barkau et. al., 2011). At that time, LNAPL may still be present in monitoring wells, but the LNAPL body is no longer migrating, even though LNAPL in the soil near the former release may be at high saturations. An LNAPL plume or body may be stable even if there is redistribution within the LNAPL core and varying thickness of LNAPL observed in wells. Removal of LNAPL at this point will shorten the life of the dissolved and vapor plumes.

As sites mature, they can reach a point where there is no longer LNAPL present in monitoring wells. The fraction of pore space occupied by LNAPL decreases over time as the volume of LNAPL is depleted by dissolution, volatilization, and biodegradation. With depletion, LNAPL flow paths become smaller and more tortuous. This reduces the ease with which LNAPL can move. Ultimately, the LNAPL breaks into isolated globules or ganglia that are discontinuous and immobile as a separate residual liquid phase. The residual is held in soil pores by capillary pressures and will not flow.

MTCA defines residual saturation in WAC 173-340-747(10)(b) as the “concentration of hazardous substances in the soil at equilibrium conditions. At concentrations above residual saturation, the NAPL will continue to migrate due to gravimetric and capillary forces and may eventually reach the groundwater, provided a sufficient volume of NAPL is released.” This implies that residual saturation is applicable to the vadose zone only. However, seminars hosted by the US EPA and literature sources apply “residual saturation” to saturated zones and define it as the fraction of pore space occupied by LNAPL that cannot be mobilized under an applied gradient (Barkau et. al, 2011).

Residual NAPL is immobile and not “free product” but may remain a source of dissolved contaminants in groundwater. Soluble fractions of petroleum are dissolved and mobilized from the residual product until an insoluble residue remains.

LNAPL TRANSMISSIVITY

Similar to the transmissivity of an aquifer, LNAPL transmissivity is a metric of the ability of a fluid with a given viscosity and density to move through a medium with a given permeability. The two primary differences between the transmissivity of the aquifer as normally determined and LNAPL transmissivity are that the viscosity of the LNAPL is generally greater than water, and the relative permeability of the aquifer is lower for NAPL than for water. This is because the LNAPL is generally more viscous and, due to miscibility and surface tension effects, is preferentially partitioned into only a portion of the larger soil pores, limiting the mobility of the LNAPL relative to water. The equation for LNAPL transmissivity has the same form as the familiar equation for aquifer transmissivity:

$$\mathbf{T_n = K_n * b_n}$$

Where:

$\mathbf{T_n}$ LNAPL Transmissivity

$\mathbf{K_n}$ Average LNAPL Conductivity

$\mathbf{b_n}$ Mobile LNAPL Thickness

The LNAPL conductivity is a function of aquifer characteristics and LNAPL characteristics with the following relationships:

$$\overline{K}_n = \frac{\rho_n g k \overline{k}_{rn}}{\mu_n}$$

Where:

ρ_n = LNAPL density
g = Gravitational constant
k = Formation intrinsic permeability
$\bar{k}_{rn}$ = Average LNAPL relative permeability
μ_n = LNAPL dynamic viscosity

From these relationships, it is clear that increasing aquifer conductivity and LNAPL thickness increase LNAPL transmissivity. It also demonstrates the end-member cases where low conductivity and thick LNAPL can result in a similar LNAPL transmissivity to a site with high conductivity and thin LNAPL. Note in the foregoing discussion $\mathbf{b_n}$ is generalized as a distinct thickness whereas in reality it is a function of the sum of connected pore spaces through which LNAPL moves, and is typically not a distinct layer.

Calculation From Baildown Tests

LNAPL transmissivity can be calculated from a modified version of the Bouwer-Rice slug test method (Huntley, 2000; ASTM, 2012). The calculation is modified so that rather than tracking the rise of water in a well after a slug of water is removed, the equation uses the increasing thickness of product in the well. The rise is corrected to the depth to the top of product using the density of the product relative to water ($\boldsymbol{\rho_r}$ = LNAPL density/water density). The resulting equation is:

$$T = \frac{2.3 r_c^2 \left(\frac{1}{1-\rho_r}\right)}{2t} \ln\left(\frac{r_0}{r_w}\right) \mathrm{Log}\left(\frac{s_0}{s}\right)$$

Where:

$\mathbf{r_o}$	Radius of Influence
$\mathbf{r_w}$	Radius of Well (includes sand pack)
$\mathbf{r_c}$	Radius of Casing
$\boldsymbol{\rho_r}$	Relative Density of Hydrocarbon (density of LNAPL/density of water)
t	Elapsed Time (minutes)
$\mathbf{s_o}$	Initial Drawdown (taken from linear fit to recovery plot at **t** = 0)
s	Drawdown at **t** (above)
$\mathbf{T_n}$	LNAPL Transmissivity

LNAPL MOBILITY AT TERMINAL 30

PGG conducted baildown tests (one form of NAPL slug test) at two wells in November 2011 to define constraints on NAPL transmissivity and mobility (Huntley, 2000). PGG also collected samples of the withdrawn NAPL for laboratory analysis of density and viscosity.

BAILDOWN TESTS

PGG conducted baildown tests at MW-59 on April 19, 2011, and MW-59 and RW-12 on November 2 and 3, 2011. These wells were selected because they currently have the greatest observed thickness of measured product. The baildown tests were conducted by removing LNAPL from the well using a peristaltic pump without purging water, until no measureable LNAPL remained in the well. LNAPL thickness recovery was recorded. LNAPL thickness was checked using a Heron Instruments interface probe by measuring depth to the base and then the top of LNAPL (Tables 1, 2 and 3).

LNAPL recovery data generally indicate low LNAPL transmissivity. LNAPL samples were collected for viscosity and density measurements and delivered to Friedman and Bruya for analysis; analytical lab reports are attached.

The November baildown tests at MW-59 and RW-12 were conducted during a rising tide, which shifts direct measurements of LNAPL top and bottom elevation during the test (see Figures 1 and 2) and potentially compresses the capillary zone. Tidal influence can both offset the direct measurements of NAPL air-water interfaces in the well bore and also could influence NAPL transmissivity due to changes in the water table relative to NAPL saturation in the surrounding aquifer. Tidal offsets were compensated by calculating a synthetic upper LNAPL interface (**s**-synthetic) based on the measured thickness of the NAPL in the well and NAPL elevations at the start of the recovery phase ($\mathbf{s_o}$).

MW-59

MW-59 is a 2 inch diameter monitoring well installed in an 8-inch borehole. The screen interval extends from 5 to 20 feet bgs[3]. Three baildown tests were conducted at MW-59 (Table 1). In the April event 0.75 gallons of product were removed with an initial LNAPL thickness of 1.55 ft. Once all LNAPL was removed, recovery was monitored for 34 minutes. Two consecutive baildown tests were conducted during the November event. The first test was allowed to recover until LNAPL thickness had stabilized over an interval of a few minutes (Table 1b). Remaining LNAPL was then removed and the well was allowed to recover again (Table 1c). LNAPL thickness was monitored for 108 minutes. Recovery was considerably slower in the second November test and ASTM standards for

[3] This is the typical monitoring well construction at the site, as reported in the RI/FS report prepared by GeoEngineers (1998). Well construction diagrams specific to MW-59 and RW-12 were not available.

data acceptability were not met. Therefore LNAPL transmissivity was not calculated from the second November baildown test..

- MW-59 had an initial product thickness of 1.55 feet in the April test and recovered from less than 0.01ft to 1.02 ft of LNAPL thickness in 34 minutes.
- MW-59 had an initial product thickness of 0.6 feet in the first November test and recovered from less than 0.01ft to 0.37 ft in 23 minutes.

RW-12

RW-12 is a 6-inch diameter recovery well that was retrofitted from a 36-inch diameter recovery chamber. Because of this unique construction history the well currently has a filter pack that is larger than typical. One baildown test was conducted at RW-12 concurrent with testing at MW-59. The initial product thickness was 0.41 feet. 3.8 gallons of product were purged from RW-12 prior to beginning the recovery phase. The well was pumped down to a product thickness of approximately 0.05 ft and pumped at that level for approximately 30 minutes. Product recovery was monitored for 28 minutes until product thickness was stable between successive measurements. Because of the slow recovery rate an additional measurement was collected the following day (Table 2). Previous LNAPL thickness monitoring at RW-12 reports recovery to initial product thickness at RW-12 takes approximately 12 months (ENSR|AECOM, 2008).

- RW-12 had an initial product thickness of 0.41 ft and recovered from 0.05 ft to 0.11 ft in 25 hours.

Results

Baildown tests at the two wells with the maximum LNAPL thicknesses indicate that LNAPL transmissivity ranges from 1.1 to 0.3 ft^2/day in the vicinity of MW-59 and is less than 0.01 ft^2/day in the vicinity of RW-12 (Table 3). Those maximum on-site values are near zero to slightly above the ITRC-recommended mobility threshold range of 0.1 to 0.8 ft^2/day[4] (ITRC, 2009). The LNAPL transmissivity values at MW-59 indicate that product is marginally mobile at the observed thicknesses in 2011. RW-12 had thinner observed LNAPL thickness and correspondingly lower LNAPL transmissivity values which are below the ITRC mobility threshold. Because the LNAPL thickness observed in wells decreases away from MW-59, the LNAPL transmissivity estimates indicate that the currently observed LNAPL is not likely to migrate. The LNAPL transmissivity values are consistent with monitoring results at T30 over the last decade. LNAPL has not been observed migrating laterally beyond the historic extent of LNAPL.

The slow recovery after LNAPL withdrawal and decreasing LNAPL transmissivity with product thickness indicate that while some LNAPL is recoverable through direct extrac-

[4] The initial threshold for LNAPL transmissivity was estimated by Beckett and Lundegaard (1997) at 0.015 ft^2/day. The ITRC working group later revised that threshold to between 0.1 and 0.8 ft^2/day on the basis of expanded site experience.

tion (e.g., pumping), direct extraction of LNAPL from wells will be very slow now, and will have progressively decreasing recovery rates with decreasing product thickness.

LNAPL SIMULATIONS

LNAPL saturation curves and recoverability in the vicinity of RW-12 and MW-59 were modeled using the API *LNAPL Distribution and Recovery Model* (LDRM) (Charbeneau, 2007a). Simulated maximum, current and residual LNAPL and water saturation curves provide information on how contaminants are distributed in the subsurface, and how observations in wells relate to the distribution of contaminant mass.

INPUT PARAMETERS

Simulation input parameters were selected based on site-specific viscosity, density and product thickness data. Van Genuchten parameters were selected using Rosetta (Schaap, 2001) based on an assumed generic lithology of 90% sand and 10% silt (SM-SW) (Figure 2); this grain size distribution likely biases towards larger pore size distribution than actually exists at the site and will overestimate $\mathbf{T}_n$ and recoverability. Samples collected from the eastern portion of the site closer to RW-12 and MW-59 had 20 to 50% fines while samples collected closer to the seawall (now a sheetpile wall) had <1% to 10% fines[5]. Other parameters were selected using values from the model supporting documentation (Charbeneau, 2007b). Simulation model inputs[6] using a variable residual saturation and current LNAPL thickness are shown in Figure 3.

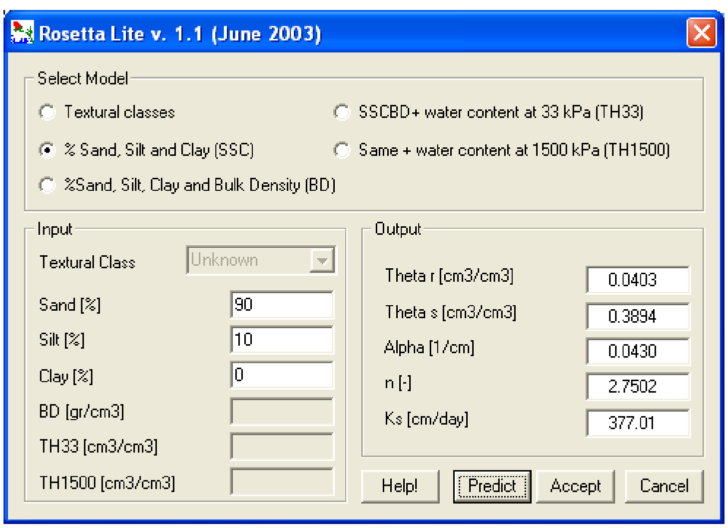


Figure 2. Rosetta van Genuchten Parameter Estimates

[5] Table 6-1 of the GeoEngineers RI/FS (GeoEngineers, 1998) includes grain size data for samples collected at Terminal 30.

[6] API simulations were completed using metric units, consistent with the van Genuchten parameters estimted with Rosetta. LNAPL transmissivity values were converted from m^2/day to ft^2/day units of feet for consistency with other portions of this study.

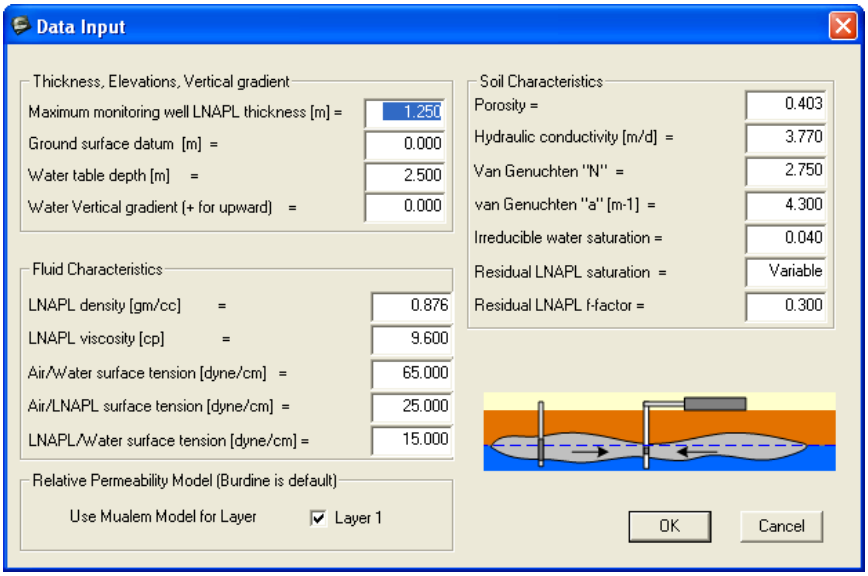


Figure 3. Example API Model Inputs

SIMULATION RESULTS

PGG conducted LNAPL simulations at MW-59 based on the maximum historic LNAPL thickness coupled with observed LNAPL thickness in April and November 2011. Simulated saturation curves shown in Figures 4a and 4b are:

- Water saturation
- NAPL saturation
- Residual NAPL saturation
- NAPL relative permeability

Estimates of current LNAPL saturation curves are obtained from a combination of historical maximum LNAPL thickness and the current observed thickness in wells because the current distribution is a function of the LNAPL occurrence history. The maximum observed LNAPL thickness between 1984 and 1991 at MW-59 was 3.9 ft (1.28 m)(GeoEngineers, 1998). The LNAPL saturation curves in Figures 4a and 4b use the maximum thickness as a baseline and then LNAPL thicknesses of 1.55 feet (0.5 m; April 2011) and 0.6 feet (0.2 m; November, 2011); (0) indicates saturation curves at the initial condition with maximum historic LNAPL thickness and (t) indicates simulated saturation curves under current conditions.

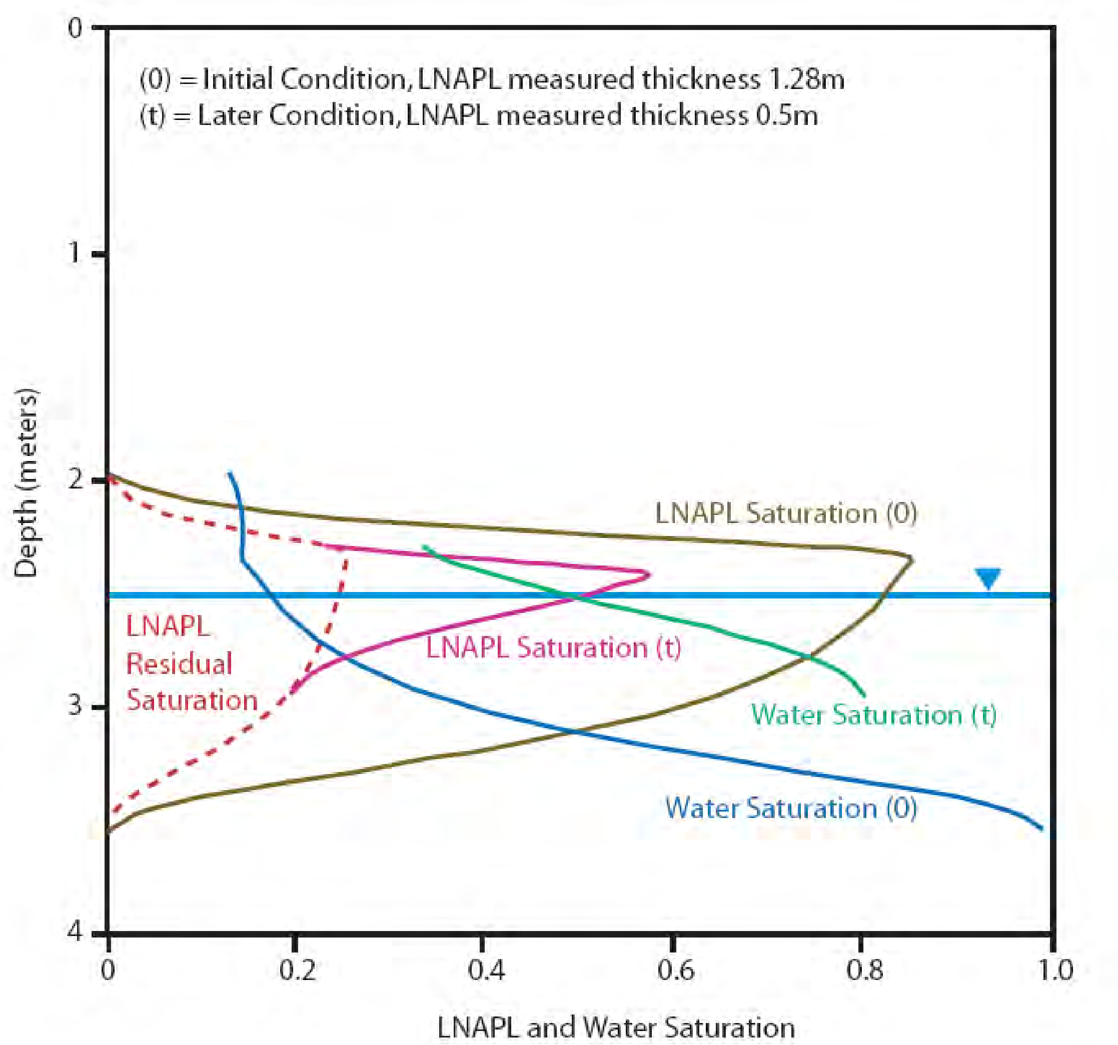


Figure 4a. Simulated MW-59 LNAPL Saturation Curve (1.28 m initial, 0.5 m current)

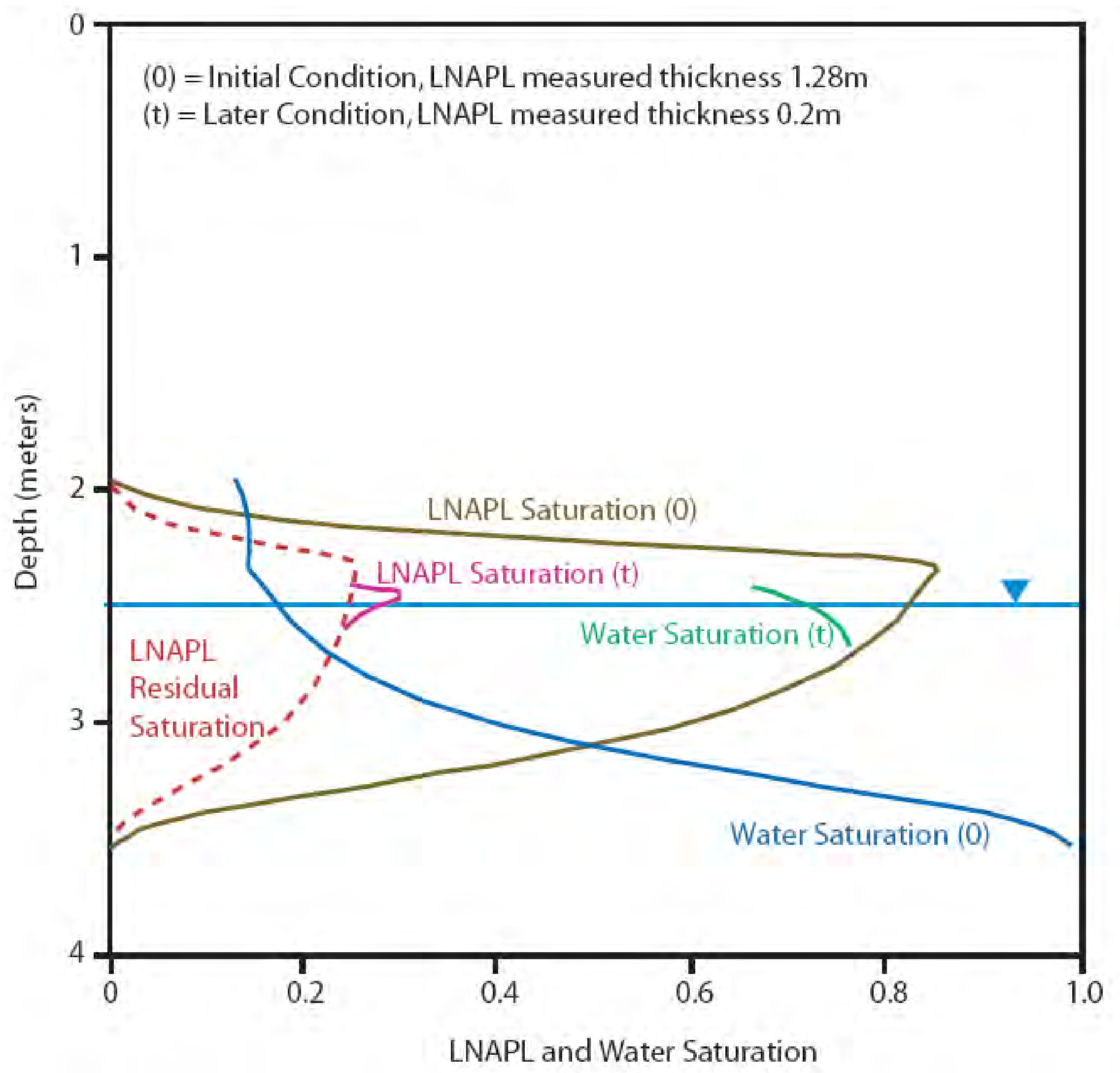


Figure 4b. Simulated MW-59 LNAPL Saturation Curve (1.28 m initial, 0.2 m current)

Figures 4a and 4b illustrate that saturation was higher at the time of maximum LNAPL thickness, and residual saturation therefore currently occurs over a thicker portion of the aquifer than would otherwise be the case. The area left of the residual LNAPL saturation curve represents LNAPL that is not mobile under natural conditions and during application of standard remedial techniques. The small area between the LNAPL and residual saturation curves represents the mobile/recoverable fraction. Although these analyses predict some LNAPL will enter wells near the center of the plume (which is confirmed by field data), the estimated Tn values (0.0 to 1.1 ft2/day) at the center of the plume are at or below the values where migration risk exists and hydraulic recovery of LNAPL is feasible. LNAPL transmissivity at the plume margins is much lower, and thus plume migration is not a significant risk

Preliminary calculations indicate that using skimmers to recover product entering a well would recover about 10% of the total LNAPL mass over 5 years assuming a 60 foot well spacing and an initial uniform 1.5 foot in-well LNAPL thickness.

PREVIOUS LNAPL SIMULATIONS

ENSR|AECOM also used the API LNAPL model to estimate the recoverable volume in the vicinity of MW-59 and RW-12 (Charbeneau, 2007a; ENSR|AECOM, 2008). That analysis used van Genuchten parameters for sand, an assumed literature value for viscosity (2.5 cP) that was lower than the sample results from samples at MW-59 and RW-12, and did not include simulations of LNAPL saturation curves because they used a single 5% value for residual saturation. The residual saturation used in the ENSR|AECOM analysis is lower than the simulated residual saturation in Figures 4a and 4b.

The input parameters and assumptions used in the ENSR|AECOM analysis will predict greater LNAPL recovery than would be calculated using the van Genuchten parameters and product viscosity used in the 2011 analysis. The 2011 analysis incorporated assumptions about silt content based on soil grain size analyses and measurements of LNAPL viscosity. The 2008 ENSR|AECOM analysis likely overestimate product recoverability.

CONCLUSIONS

LNAPL thickness measurements, baildown tests at MW-59 and RW-12, and the API LNAPL simulation model, indicate that LNAPL migration is not a risk and LNAPL recovery by hydraulic means is not effective. Also, where LNAPL thicknesses are greatest near the center of the source area, LNAPL mobility and recoverability is very low but not zero.

Simulated LNAPL saturation curves also indicate that little of the current LNAPL mass is recoverable and that the bulk of the recoverable LNAPL mass was removed. This is consistent with observed declines in recovery efficiency from the trench and recovery systems that recovered more than 171,000 gallons of LNAPL (GeoEngineers, 1998; see Figures 3-7 and 3-8).

REFERENCES

Adamski, Mark. May 2, 2011. *LNAPL in Fine Grained Soil Webinar*. Hosted by Midwest Geosciences Group.

ASTM, 2012. *Standard Guide for Estimation of LNAPL Transmissivity*. Designation E2856-11e. January, 2012.

Barkau, L., Adamski, M., and Hers, I. May 27, 2011. *LNAPL Training Part 1: An Improved Understanding of LNAPL Behavior in the Subsurface*. ITRC Internet-based Training Program. Sponsored by Interstate Technology and Regulatory

Council (www.itrcweb.org) and hosted by US EPA Clean Up Information Network (www.cluin.org).

Beckett, G. and Lundegaard, P., 1997. *Practically Impractical- The Limits of LNAPL Recovery and Relationship to Risk.* Proceedings of the Petroleum Hydrocarbons an Organic Chemicals in Groundwater, NGWA, Houston, Texas.

Charbeneau, R., 2007a. LNAPL *Distribution and Recovery Model (LDRM) Volume 1: Distribution and Recovery of Petroleum Liquids in Porous Media*. API Publication 4760. January, 2007.

Charbeneau, R., and Beckett, G., 2007b. *LNAPL Distribution and Recovery Model (LDRM) Volume 2: User and Parameter Selection Guide*. API Publication 4760. January, 2007.

ENSR|AECOM, May 2008b. *Final Supplemental Data Report, Revision 2 Terminal 30, Port of Seattle*. Document No. 05482-014-400. Consultant's report prepared for the Port of Seattle.

GeoEngineers, Inc. December 21, 1998. *Final Report Remedial Investigation/Focused Feasibility Study Chevron/Port of Seattle T-30 Seattle, Washington. GEI File: 0303-037-00*. Consultant's report prepared for the Port of Seattle.

Huntley, D., 2000. *Analytic Determination of Hydrocarbon Transmissivity from Baildown Tests.* Groundwater, v. 38, no 1. Jan-Feb 2000.

Interstate Technology & Regulatory Council, 2009. *Evaluating LNAPL Remedial Technologies for Achieving Project Goals.* December, 2009.

National Research Council. 2005. *Contaminants in the Subsurface Source Zone Assessment and Remediation.* The National Academies Press, Washington, D.C.

Schaap, M.G., F.J. Leij, and M. Th. van Genuchten, 2001. *Rosetta: a computer program for estimating soil hydraulic parameters with hierarchical pedotransfer functions*. Journal of Hydrology, 251:163-176.

Attachments

Table 1a.	MW-59 Baildown Test, April 2011 (attached)
Table 1b.	MW-59 Baildown Test, November 2011 #1 (attached)
Table 1c.	MW-59 Baildown Test, November 2011 #2 (attached)
Table 2.	RW-12 Baildown Test, November 2011 (attached)
Table 3.	Bouwer-Rice LNAPL Transmissivity Calculation Summary (attached)
Figure 1.	Site Map and Extent of LNAPL (attached)
Figure 2.	Rosetta van Genuchten Parameter Estimates (embedded)
Figure 3.	Example API Model Inputs (embedded)

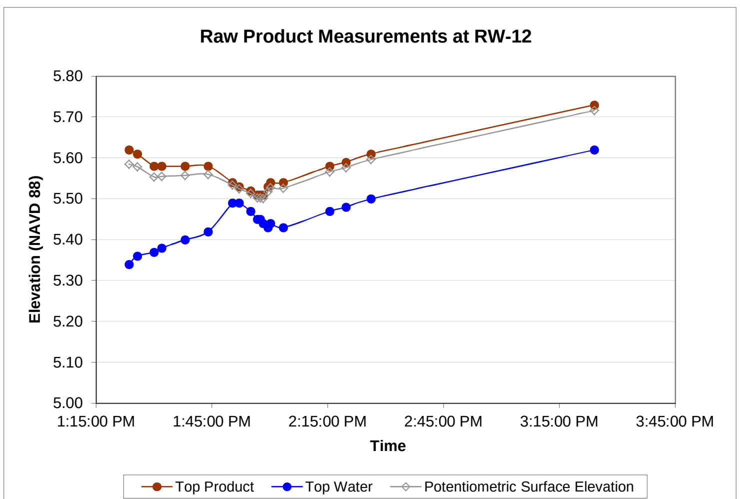
Friedman and Bruya Analytical Report

Table 2. RW-12 Baildown Test, November 2011

Port of Seattle Terminal 30

Well	RW-12	
Date	11/2/2011	
MP Elevation	15.5	ft
LNAPL Density	0.8756	g/ml
Water Density	1.00	g/ml
Initial Product Thicl	0.41	ft
Notes: rising tide during test.		

				Depth to...		Elevation of...				Product Drawdown	
Pumping Notes	Date	Time	Elapsed Minutes (t)	Top Product	Top Water	Top Product	Top Water	Product Thickness	Potentiometric Surface Elevation	s	s (synthetic)
Initial Condition	*11/02/11*	*1:09:10 PM*		*9.80*	*10.21*	*5.70*	*5.29*	*0.41*	*5.65*	*0.00*	*0.00*
	11/02/11	1:23:30 PM		9.88	10.16	5.62	5.34	0.28	*5.59*	0.08	*0.02*
	11/02/11	1:25:40 PM		9.89	10.14	5.61	5.36	0.25	*5.58*	0.09	*0.02*
	11/02/11	1:30:00 PM		9.92	10.13	5.58	5.37	0.21	*5.55*	0.12	*0.02*
	11/02/11	1:32:00 PM		9.92	10.12	5.58	5.38	0.20	*5.56*	0.12	*0.03*
	11/02/11	1:38:00 PM		9.92	10.10	5.58	5.40	0.18	*5.56*	0.12	*0.03*
	11/02/11	1:44:00 PM		9.92	10.08	5.58	5.42	0.16	*5.56*	0.12	*0.03*
	11/02/11	1:50:20 PM		9.96	10.01	5.54	5.49	0.05	*5.53*	0.16	*0.04*
Stop Pump	11/02/11	1:52:00 PM		9.97	10.01	5.53	5.49	0.04	*5.53*	0.17	*0.05*
	11/02/11	1:55:00 PM		9.98	10.03	5.52	5.47	0.05	*5.51*	0.18	*0.04*
	11/02/11	1:56:43 PM		9.99	10.05	5.51	5.45	0.06	*5.50*	0.19	*0.04*
	11/02/11	1:57:30 PM	0.00	9.99	10.05	5.51	5.45	0.06	*5.50*	0.19	*0.04*
	11/02/11	1:58:13 PM	0.72	9.99	10.06	5.51	5.44	0.07	*5.50*	0.19	*0.04*
	11/02/11	1:59:30 PM	2.00	9.97	10.07	5.53	5.43	0.10	*5.52*	0.17	*0.04*
	11/02/11	2:00:10 PM	2.67	9.96	10.06	5.54	5.44	0.10	*5.53*	0.16	*0.04*
	11/02/11	2:03:30 PM	6.00	9.96	10.07	5.54	5.43	0.11	*5.53*	0.16	*0.04*
	11/02/11	2:15:30 PM	18.00	9.92	10.03	5.58	5.47	0.11	*5.57*	0.12	*0.04*
	11/02/11	2:19:45 PM	22.25	9.91	10.02	5.59	5.48	0.11	*5.58*	0.11	*0.04*
	11/02/11	2:26:10 PM	28.67	9.89	10.00	5.61	5.50	0.11	*5.60*	0.09	*0.04*
	11/03/11	3:24:00 PM	1526.50	9.77	9.88	5.73	5.62	0.11	*5.72*	-0.03	*0.04*
									Intercept (s_o)	**0.15**	**0.04**
									Slope	0.00	0.00



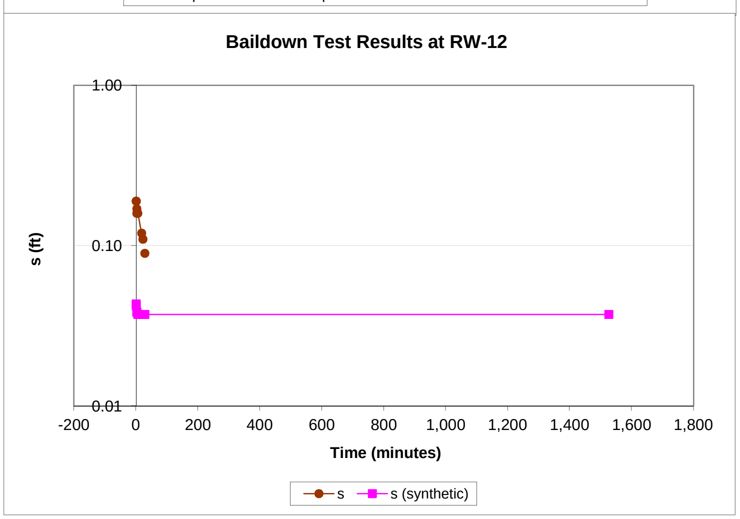
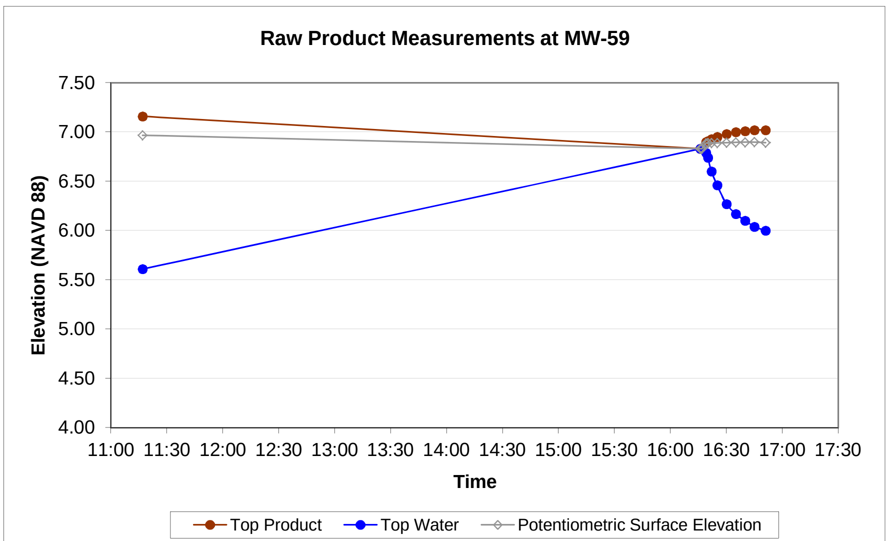


Table 1a. MW-59 Baildown Test, April 2011
Port of Seattle Terminal 30

Well	MW-59	
Date	4/19/2011	
MP Elevation	15.5	ft
LNAPL Density	0.8756	g/ml
Water Density	1.00	g/ml
Initial Product Thickness	1.55	ft
Notes: rising tide during test.		

				Depth to...		Elevation of...				Product Drawdown	
Pumping Notes	Date	Time	Elapsed Minutes (t)	Top Product	Top Water	Top Product	Top Water	Product Thickness	Potentiometric Surface Elevation	s	s (synthetic)
Calculated Initial Condition	*04/19/11*	*16:16*		*8.40*	*9.95*	*7.10*	*5.55*	*1.55*	*6.91*	*0.00*	*0.00*
No Pumping	04/19/11	11:17		8.34	9.89	7.16	5.61	1.55	6.97	-0.06	*0.00*
Remove Product	04/19/11	16:16		8.67	8.67	6.83	6.83	0.00	6.83	0.27	*0.19*
Stop Pump	04/19/11	16:16	0:00	8.67	8.67	6.83	6.83	0.00	6.83	0.27	*0.19*
	04/19/11	16:19	0:02	8.60	8.71	6.90	6.79	0.11	6.89	0.20	*0.18*
	04/19/11	16:20	0:03	8.59	8.76	6.91	6.74	0.17	6.89	0.19	*0.17*
	04/19/11	16:22	0:05	8.57	8.90	6.93	6.60	0.33	6.89	0.17	*0.15*
	04/19/11	16:25	0:08	8.55	9.04	6.95	6.46	0.49	6.89	0.15	*0.13*
	04/19/11	16:30	0:13	8.52	9.23	6.98	6.27	0.71	6.89	0.12	*0.10*
	04/19/11	16:35	0:18	8.50	9.33	7.00	6.17	0.83	6.90	0.10	*0.09*
	04/19/11	16:40	0:23	8.49	9.40	7.01	6.10	0.91	6.90	0.09	*0.08*
	04/19/11	16:45	0:28	8.48	9.46	7.02	6.04	0.98	6.90	0.08	*0.07*
End of test	04/19/11	16:51	0:34	8.48	9.50	7.02	6.00	1.02	6.89	0.08	*0.07*
									Intercept (s_o)	**0.20**	**0.18**
									Slope	-6.70	-6.05



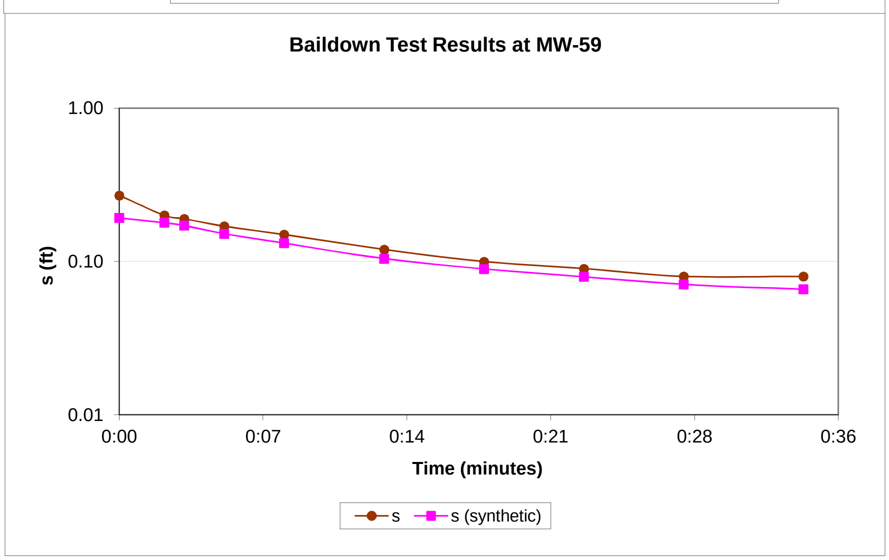
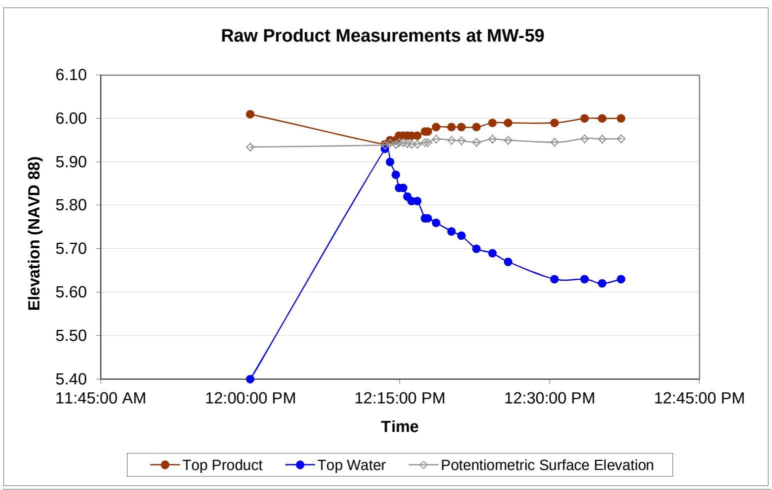


Table 1b. MW-59 Baildown Test, November 2011 #1
Port of Seattle Terminal 30

Well	MW-59	
Date	11/2/2011	
MP Elevation	15.5	
LNAPL Density	0.8756	g/ml
Water Density	1.00	g/ml
Initial Product Thickn	0.60	ft
Notes: rising tide during test.		

				Depth to...		Elevation of...				Product Drawdown	
Pumping Notes	**Date**	**Time**	**Elapsed Minutes (t)**	**Top Product**	**Top Water**	**Top Product**	**Top Water**	**Product Thickness**	**Potentiometric Surface Elevation**	**s**	**s (synthetic)**
Initial Condition	11/02/11	*11:46:00 AM*		*9.49*	*10.09*	*6.01*	*5.41*	*0.60*	*5.94*	*0.00*	*0.00*
No Pumping	11/02/11	12:00:00 PM		9.49	10.10	6.01	5.40	0.61	5.93	0.00	*0.00*
Remove Product	11/02/11	12:13:30 PM		9.56	9.57	5.94	5.93	0.01	5.94	0.07	*0.07*
Stop Pump	11/02/11	12:14:00 PM	0:00	9.55	9.60	5.95	5.90	0.05	5.94	0.06	*0.07*
	11/02/11	12:14:34 PM	0:00	9.55	9.63	5.95	5.87	0.08	5.94	0.06	*0.06*
	11/02/11	12:14:55 PM	0:00	9.54	9.66	5.96	5.84	0.12	5.95	0.05	*0.06*
	11/02/11	12:15:20 PM	0:01	9.54	9.66	5.96	5.84	0.12	5.95	0.05	*0.06*
	11/02/11	12:15:45 PM	0:01	9.54	9.68	5.96	5.82	0.14	5.94	0.05	*0.06*
	11/02/11	12:16:10 PM	0:02	9.54	9.69	5.96	5.81	0.15	5.94	0.05	*0.06*
	11/02/11	12:16:44 PM	0:02	9.54	9.69	5.96	5.81	0.15	5.94	0.05	*0.06*
	11/02/11	12:17:30 PM	0:03	9.53	9.73	5.97	5.77	0.20	5.95	0.04	*0.05*
	11/02/11	12:17:47 PM	0:03	9.53	9.73	5.97	5.77	0.20	5.95	0.04	*0.05*
	11/02/11	12:18:37 PM	0:04	9.52	9.74	5.98	5.76	0.22	5.95	0.03	*0.05*
	11/02/11	12:20:10 PM	0:06	9.52	9.76	5.98	5.74	0.24	5.95	0.03	*0.04*
	11/02/11	12:21:10 PM	0:07	9.52	9.77	5.98	5.73	0.25	5.95	0.03	*0.04*
	11/02/11	12:22:40 PM	0:08	9.52	9.80	5.98	5.70	0.28	5.95	0.03	*0.04*
	11/02/11	12:24:15 PM	0:10	9.51	9.81	5.99	5.69	0.30	5.95	0.02	*0.04*
	11/02/11	12:25:50 PM	0:11	9.51	9.83	5.99	5.67	0.32	5.95	0.02	*0.03*
	11/02/11	12:30:30 PM	0:16	9.51	9.87	5.99	5.63	0.36	5.95	0.02	*0.03*
	11/02/11	12:33:30 PM	0:19	9.50	9.87	6.00	5.63	0.37	5.95	0.01	*0.03*
	11/02/11	12:35:15 PM	0:21	9.50	9.88	6.00	5.62	0.38	5.95	0.01	*0.03*
	11/02/11	12:37:10 PM	0:23	9.50	9.87	6.00	5.63	0.37	5.95	0.01	*0.03*
									Intercept (s_o)	**0.05**	**0.06**
									Slope	-2.90	-2.24



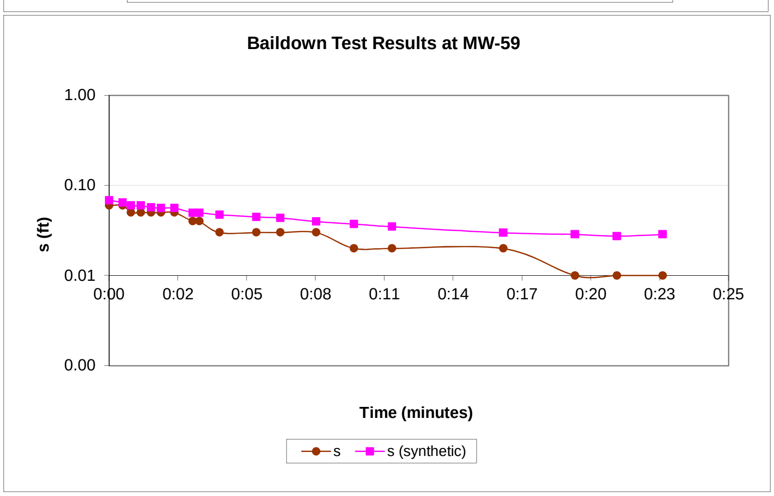
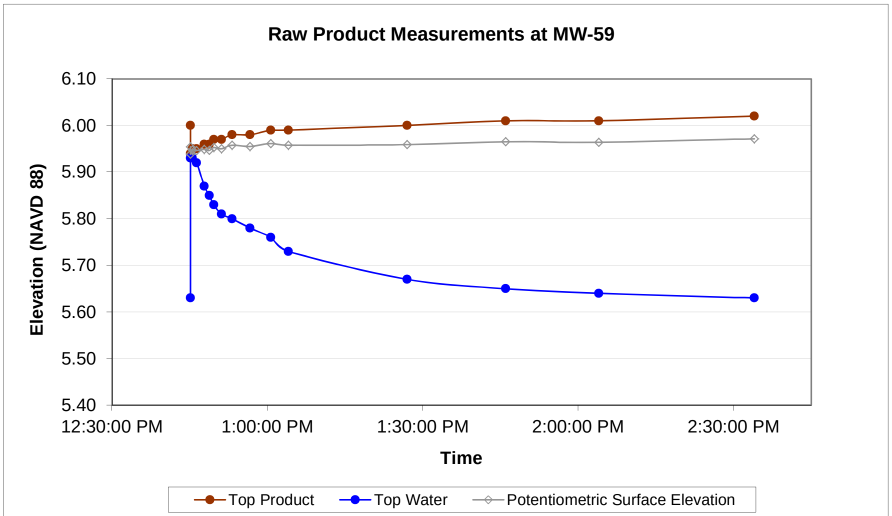


Table 1c. MW-59 Baildown Test, November 2011 #2
Port of Seattle Terminal 30

Well	MW-59
Date	11/2/2011
MP Elevation	15.5
LNAPL Density	0.8756 g/ml
Water Density	1.00
Initial Product Thickness	0.6 ft
Notes: rising tide during test.	

				Depth to...		Elevation of...				Product Drawdown	
Pumping Notes	Date	Time	Elapsed Minutes (t)	Top Product	Top Water	Top Product	Top Water	Product Thickness	Potentiometric Surface Elevation	s	s (synthetic)
Initial Condition	11/02/11	*12:45:10 PM*		*9.50*	*9.87*	*6.00*	*5.63*	*0.37*	*5.95*	*0.00*	*0.03*
No Pumping	11/02/11	*12:45:10 PM*		9.50	9.87	6.00	5.63	0.37	5.95	0.00	*0.03*
Remove Product	11/02/11	*12:45:10 PM*		9.56	9.57	5.94	5.93	0.01	5.94	0.06	*0.07*
Stop Pump	11/02/11	*12:45:30 PM*	0:00	9.55	9.57	5.95	5.93	0.02	5.95	0.05	*0.07*
	11/02/11	12:46:20 PM	0:00	9.55	9.58	5.95	5.92	0.03	5.95	0.05	*0.07*
	11/02/11	12:47:50 PM	0:02	9.54	9.63	5.96	5.87	0.09	5.95	0.04	*0.06*
	11/02/11	12:48:47 PM	0:03	9.54	9.65	5.96	5.85	0.11	5.95	0.04	*0.06*
	11/02/11	12:49:38 PM	0:04	9.53	9.67	5.97	5.83	0.14	5.95	0.03	*0.06*
	11/02/11	12:51:10 PM	0:05	9.53	9.69	5.97	5.81	0.16	5.95	0.03	*0.05*
	11/02/11	12:53:10 PM	0:07	9.52	9.70	5.98	5.80	0.18	5.96	0.02	*0.05*
	11/02/11	12:56:40 PM	0:11	9.52	9.72	5.98	5.78	0.20	5.96	0.02	*0.05*
	11/02/11	1:00:40 PM	0:15	9.51	9.74	5.99	5.76	0.23	5.96	0.01	*0.05*
	11/02/11	1:04:05 PM	0:18	9.51	9.77	5.99	5.73	0.26	5.96	0.01	*0.04*
	11/02/11	1:27:00 PM	0:41	9.50	9.83	6.00	5.67	0.33	5.96	0.00	*0.03*
	11/02/11	1:46:00 PM	1:00	9.49	9.85	6.01	5.65	0.36	5.97	-0.01	*0.03*
	11/02/11	2:04:00 PM	1:18	9.49	9.86	6.01	5.64	0.37	5.96	-0.01	*0.03*
	11/02/11	2:34:00 PM	1:48	9.48	9.87	6.02	5.63	0.39	5.97	-0.02	*0.03*
									Intercept (s_o)	**0.03**	**0.06**
									Slope	-0.81	-0.53



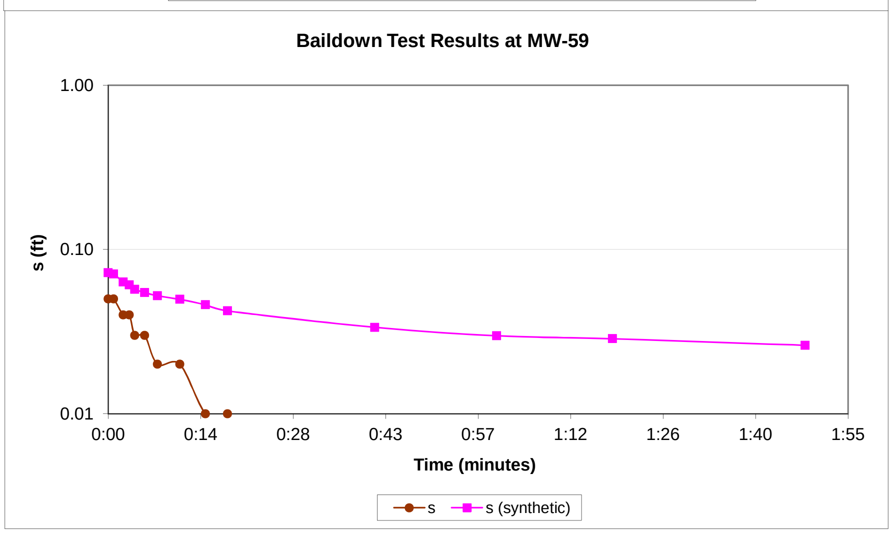


Table 3. Bouwer-Rice Slug Test Analysis for LNAPL Transmissivity

Port of Seattle Terminal 30

Parameters	
r_o	Radius of Influence
r_w	Radius of Well (includes sand pack)
r_c	Radius of Casing
P_r	Relative Density of Hydrocarbon (density of LNAPL/density of water)
t	Elapsed Time (minutes)
s_o	Initial Drawdown (taken from graph as line-intercept at t=0)
s	Drawdown at t (above)
Tn	LNAPL Transmissivity
b	Initial Gauged Product Thickness

Parameter	Units	MW-59	MW-59	RW-12
		April	November	November
r_o	*ft*	0.97	0.43	3.67
r_w	*ft*	0.33	0.33	1.5
r_c	*ft*	0.083	0.083	0.25
P_r	--	0.8756	0.8756	0.8756
t	*minutes*	34	23	1528
s_o	*ft*	0.20	0.06	0.04
s	*ft*	0.08	0.03	0.04
b	*ft*	1.55	0.6	0.41
Initial LNAPL Thickness (ft)		*0.473*	*0.183*	*0.125*
Tn	*m^2/min*	7.3 E-05	2.1 E-05	1.5 E-07
Tn	*m^2/day*	0.1	0.03	0.00
Tn	*ft^2/day*	**1.13**	**0.32**	**0.00**

ITRC indicates that LNAPL is mobile at Tn > 0.8 to 0.1 ft^2/day.

Figure 1

Site Map and Cleanup Areas

Port of Seattle
Terminal 30
JE1005

PGG

APPENDIX E: HISTORIC SOIL DATA

December 21, 1998

Port of Seattle
PO Box 1209
Seattle, Washington 98111

Attention: Mr. Doug Hotchkiss

Final Report
Remedial Investigation/Focused
Feasibility Study
Chevron/Port of Seattle T-30
Seattle, Washington
GEI File: 0303-037-00

GeoEngineers is pleased to submit this final report of the Remedial Investigation/Focused Feasibility Study for the Chevron/Port of Seattle site in Seattle, Washington. Technical memoranda related to this RI/FFS are presented in an Addendum. We appreciate the opportunity to be of continued service to the Port.

Yours very truly,

GeoEngineers, Inc.

John H. Biggane
Principal

SLF:JHB:vc
Document ID: 0303037OCTR.DOC

File No: 0303-037-00

TABLE 7.1
APPARENT PRODUCT THICKNESS (feet)
IN MONITORING WELLS (Page 1 of 2)
AUGUST 1991 - JANUARY 1994[1]

Date	Monitoring Wells										
	MW-34	MW-35	MW-36	MW-38	MW-43	MW-46A	MW-49	MW-54	MW-59	MW-62	MW-64
08/16/91	0.0	1.99	1.52	0.01	0.01	0.19	0.10	0.01	0.03	0.0	0.0
10/03/91	0.0	0.53	0.28	0.0	0.0	0.19	0.32	<0.01	0.03	0.0	0.0
10/24/91	0.22	0.72	2.53	0.51	0.02	0.0	0.84	1.29	<0.01	0.43	0.27
11/20/91	0.40	1.97	1.70	0.20	--	--	0.45	0.0	0.33	<0.01	0.09
12/04/91	<0.01	--	--	<0.01	--	0.0	0.73	<0.01	<0.01	0.0	0.01
01/08/92	--	0.88	0.21	--	--	0.0	0.0	0.0	<0.01	0.0	0.0
02/26/92	0.16	1.09	0.0	0.0	0.01	0.0	0.73	0.0	0.0	0.0	<0.01
03/12/92	0.13	0.09	0.13	0.0	--	0.0	0.0	0.0	--	--	0.0
04/29/92	0.0	1.06	0.01	0.0	0.0	0.0	0.08	0.0	0.0	0.0	0.0
05/20/92	0.0	0.96	0.15	0.0	0.15	0.15	0.15	0.0	0.0	0.0	0.0
07/02/92	0.0	1.25	0.42	0.0	--	0.0	0.31	0.0	0.0	0.0	0.0
08/14/92	0.02	1.09	2.40	--	0.0	--	0.93	0.0	0.40	0.0	--
09/18/92	0.12	2.16	1.61	0.15	0.01	--	0.20	0.0	0.78	0.0	0.10
10/29/92	0.36	1.14	2.24	9.25	--	0.0	1.71	0.0	0.88	--	0.26
11/25/92	0.38	1.14	1.11	0.26	0.0	0.0	0.74	0.0	0.27	0.0	0.12
01/27/93	0.25	0.25	0.01	0.10	--	0.0	0.31	0.0	0.61	0.0	0.02
02/26/93	0.10	1.99	0.0	0.11	0.02	0.01	0.38	0.0	0.50	0.0	0.10
03/31/93	0.18	0.09	0.01	2.66	--	--	0.31	0.0	0.65	0.0	0.01
04/15/93	0.18	0.0	0.0	<0.01	--	0.0	--	0.0	0.63	0.0	0.0
05/22/93	0.19	0.91	0.02	0.16	--	0.01	0.48	--	0.61	0.0	0.05
06/24/93	0.18	2.34	2.08	0.04	--	0.02	0.0	0.0	1.11	0.0	0.41
07/23/93	0.25	2.89	0.52	0.05	0.05	0.04	0.91	0.0	0.79	0.0	0.11
08/27/93	0.04	2.55	0.34	0.12	--	0.0	0.0	0.0	1.89	0.0	0.02
09/30/93	0.10	2.49	0.47	0.30	0.01	0.0	0.79	--	1.09	0.0	0.08
10/27/93	0.09	2.03	0.25	--	<0.01	<0.01	0.38	<0.01	1.31	0.02	0.02
11/18/93	0.25	0.76	0.26	0.40	0.06	0.01	0.53	0.02	1.30	0.08	0.03
01/07/94	0.19	0.21	0.15	0.19	<0.01	<0.01	0.40	0.0	0.55	0.0	0.05
01/08/98[3]	<0.01	0.14	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	1.82	<0.01	0.24

Notes appear on Page 2

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NOTES:

[1] Measurements were not obtained in June and December 1992 and December 1993 because of shipping traffic.

[2] Product thicknesses also were measured at most five times in monitoring wells MW-1, MW-39, MW-47, MW-53, MW-60 and MW-63; recovery wells RW-1, RW-4, RW-11 and RW-12; and water infiltration gallery cleanout CO-4 between August 15, 1991 and January 7, 1994. Product thicknesses in these wells ranged from less than 0.01 feet to 0.20 feet.

[3] Product thicknesses were also measured January 7 and 8, 1998 in monitoring wells MW-1, MW-17, MW-24, MW-29, MW-37, MW-39, MW-40, MW-42, MW-45, MW-46, MW-47, MW-48, MW-51, MW-52, MW-53, MW-55, MW-56, MW-58, MW-60, MW-63, MW-65 to MW-71, MW-73 to MW-81, and MW-83 to MW-87. Product was not detected in any of those wells.

"–" = not measured

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TABLE 8.1 (Page 1 of 2)
SUMMARY OF SOIL SAMPLE FIELD SCREENING RESULTS AND CHEMICAL ANALYTICAL DATA
TOTAL EXTRACTABLE PETROLEUM HYDROCARBONS AND VOLATILE ORGANIC COMPOUNDS
PORT OF SEATTLE - TERMINAL 30

Sample Number	Date Sampled	Depth of Sample (feet)	Field Screening Results: Headspace Vapors[1] (ppm)	Field Screening Results: Sheen	Total Extractable Petroleum Hydrocarbons (EPA Method 8015 Modified) (mg/kg): Motor Oil	Gasoline	Diesel	T-30	Volatile Organic Compounds (EPA Method 8240): Analytes Detected[2]	Concentration (µg/kg)
MW-73-2	01/27/92	5.5-6.0	5.0	SS	9.1 U	9.1 U	9.1 U	9.1 U	Methylene chloride	5 J
									Toluene	2 J
MW-74-4	01/27/92	10.5-11.0	70.0	SS	43	50	130	160	Toluene	31 J
MW-75-2	01/29/92	5.5-6.5	0	NS	9.7 U	9.7 U	9.7 U	15	Methylene chloride	1 J
									Acetone	8 J
									Toluene	430 D
MW-76-3	01/23/92	8.0-9.0	0	NS	10	8.9 U	8.9 U	16	Toluene	39
MW-77-3	01/22/92	8.0-9.0	1,012	HS	1,900 U	7,700	6,300	9,700	ND	
MW-77-9	01/22/92	23.0-24.0	226	HS	14	10 U	11	21	Benzene	8
									Toluene	5 J
									Ethylbenzene	24
									Xylenes (total)	19
MW-78-5	01/30/92	12.0-12.5	1,017	HS	1,000 U	3,500	3,800	5,300	ND	ND
MW-78-9	01/30/92	23.0-24.0	83	MS	65	15	97	130	Toluene	4 J
MW-79-2	01/25/92	5.5-6.5	1.0	SS	970 U	970 U	3,700	3,800	Methylene chloride	1 J
									Acetone	12
									Toluene	330 D
MW-79-13	01/25/92	33.0-34.0	50.0	MS	11 U	11 U	11 U	11 U	Methylene chloride	2 J
									Acetone	8 J
									Chloroform	2 J
									Toluene	120
MW-80-3	01/28/92	8.0-9.0	170	HS	4,800 U	4,800 U	30,000	28,000	Toluene	10,000
MW-80-3RE	01/28/92	8.0-9.0	--	--	--	--	--	--	Toluene	12,000
MW-80-9	01/28/92	23.0-24.0	2.0	NS	39	10 U	11	35	Toluene	120
MW-81-2	01/30/92	5.5-6.5	0	NS	67	10 U	19	57	2-Butanone	3 J
									Toluene	190

Notes appear on page 2 of 2.

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TABLE 8.1 (Page 2 of 2)

Sample Number	Date Sampled	Depth of Sample (feet)	Field Screening Results: Headspace Vapors[1] (ppm)	Field Screening Results: Sheen	Total Extractable Petroleum Hydrocarbons (EPA Method 8015 Modified) (mg/kg): Motor Oil	Gasoline	Diesel	T-30	Volatile Organic Compounds (EPA Method 8240): Analytes Detected[2]	Concentration (μg/kg)
MW-82-2	01/29/92	5.5-6.5	0	SS	43	8.8 U	15	41	Toluene	48
MW-83-2	01/23/92	5.5-6.5	0	SS	11	9.5 U	9.5 U	18	Toluene	96
MW-84-2	01/29/92	5.5-6.5	5.0	SS	120	18 U	35	100	Toluene	7
MW-85-2	01/27/92	5.5-6.5	5.0	SS	8.6 U	8.6 U	8.6 U	8.6 U	Ethylbenzene	1 J
									Toluene	510 D
MW-86-2	01/27/92	5.5-6.5	5.0	SS	8.8 U	8.8 U	8.8 U	8.8 U	Methylene chloride	1 J
									Toluene	1 J
MW-87-7	01/22/92	18.0-19.0	80.0	HS	44	12 U	23	51	Benzene	4 J
									Toluene	370 D
920127-A (MW-73)	01/27/92	7.5-8.0	0	SS	9.0 U	9.0 U	9.0 U	9.0 U	Toluene	6
920130-D (MW-78)	01/30/92	12.5-13.0	1,017	HS	18	28	30	51	Benzene	3 J
									Toluene	3 J

Notes:

[1]Headspace vapors were measured using a Photovac MicroTIP photoionization detection as described in Appendix A.

[2]Only those analytes detected are presented. See Appendix D for a complete list of analytes and detection limits.

D - Indicates compounds identified in an analysis at a secondary dilution factor.

J - Indicates an estimated value.

U - Indicates compound was analyzed for but not detected at the given detection limit. The sample quantitation limit was corrected for dilution and percent moisture, when applicable.

ppm = parts per million

mg/kg = milligrams per kilogram; μg/kg = micrograms per kilogram

ND = not detected

Chemical analyses performed by ETC/PNEL.

Document ID: 30337081

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TABLE 8.2 (Page 1 of 6)
SUMMARY OF SOIL SAMPLE CHEMICAL ANALYTICAL DATA
SEMIVOLATILE ORGANIC COMPOUNDS, PAHs, AND CHLORINATED PESTICIDES AND PCBs
PORT OF SEATTLE - TERMINAL 30

Sample Number	Date Sampled	Depth of Sample (feet)	Semivolatile Organic Compounds (EPA Method 8270) Analyte Detected[3]	Concentration (µg/kg)	PAHs[1] (EPA Method 8310) Analyte Detected[3]	Concentration (µg/kg)	Chlorinated Pesticides & PCBs[2] (EPA Method 8080) Analyte Detected[3]	Concentration (µg/kg)
MW-73-2	01/27/92	5.5-6.0	bis(2-ethylhexyl)phthalate	94 J	Fluorene	4.3	ND	
					Phenanthrene	12		
					Anthracene	1.5		
MW-74-4	01/27/92	10.5-11.0	ND		Naphthalene	18	ND	
					Acenaphthene	18		
					Fluorene	49		
					Phenanthrene	64		
					Anthracene	11		
					Fluoranthene	17		
					Pyrene	12		
					Indeno(1,2,3-cd)pyrene[C]	4.7		
MW-75-2	01/29/92	5.5-6.5	ND		Phenanthrene	5.6	ND	
					Benzo(b)fluoranthene[C]	7.6		
					Indeno(1,2,3-cd)pyrene[C]	4.3		
MW-76-3	01/23/92	8.0-9.0	ND		Phenanthrene	6.9	ND	
					Anthracene	0.7		
					Fluoranthene	8.8		
					Pyrene	8.3		
					Benzo(a)anthracene[C]	3.6		
					Chrysene[C]	3.3		
					Benzo(b)fluoranthene[C]	9.8		
					Benzo(k)fluoranthene[C]	4.3		
					Benzo(a)pyrene[C]	7.9		
					Indeno(1,2,3-cd)pyrene[C]	15		
					Benzo(g,h,i)perylene	8.8		

Notes appear on page 6 of 6.

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TABLE 8.2 (Page 2 of 6)

Sample Number	Date Sampled	Depth of Sample (feet)	Semivolatile Organic Compounds (EPA Method 8270) Analyte Detected[3]	Concentration (µg/kg)	PAHs[1] (EPA Method 8310) Analyte Detected[3]	Concentration (µg/kg)	Chlorinated Pesticides & PCBs[2] (EPA Method 8080) Analyte Detected[3]	Concentration (µg/kg)
MW-77-3	01/22/92	8.0-9.0	2-methylnaphthalene	31,000 D	Acenaphthene	320 E	ND	
			Acenaphthene	1,200	Fluorene	12,000 D		
			Dibenzofuran	860	Phenanthrene	19,000 D		
			Fluorene	2,300	Anthracene	280 D		
			Phenanthrene	3,800	Fluoranthene	720 D		
			Anthracene	710 J	Pyrene	550 D		
			Fluoranthene	780				
			Pyrene	400 J				
			Benzo(a)anthracene[C]	92 J				
			Chrysene[C]	170 J				
MW-77-9	01/22/92	23.0-24.0	bis(2-ethylhexyl)phthalate	210 J	Phenanthrene	8.7	ND	
					Anthracene	0.7		
					Benzo(b)fluoranthene[C]	8.1		
					Indeno(1,2,3-cd)pyrene[C]	4.9		
MW-78-5	01/30/92	12.0-12.5	2-methylnaphthalene	520 J	Naphthalene	39	ND	
			Fluorene	96 J	Fluorene	14		
			Phenanthrene	170 J	Phenanthrene	13		
					Anthracene	3.3		
					Benzo(b)fluoranthene[C]	4.0		
MW-78-9	01/30/92	23.0-24.0	2-methylnaphthalene	270 J	Fluorene	63	ND	
			bis(2-ethylhexyl)phthalate	190 J	Phenanthrene	106 D		
					Anthracene	7.1		
					Fluoranthene	10		
					Pyrene	13		
					Benzo(b)fluoranthene[C]	6.8		
					Indeno(1,2,3-cd)pyrene[C]	5.5		
					Benzo(g,h,i)perylene	4.8		

Notes appear on page 6 of 6.

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TABLE 8.2 (Page 3 of 6)

Sample Number	Date Sampled	Depth of Sample (feet)	Semivolatile Organic Compounds (EPA Method 8270) Analyte Detected[3]	Concentration (µg/kg)	PAHs[1] (EPA Method 8310) Analyte Detected[3]	Concentration (µg/kg)	Chlorinated Pesticides & PCBs[2] (EPA Method 8080) Analyte Detected[3]	Concentration (µg/kg)
MW-79-2	01/25/92	5.5-6.5	Fluoranthene	85 J	Phenanthrene	11	ND	
			Pyrene	86 J	Anthracene	11		
					Fluoranthene	83		
					Pyrene	100		
					Benzo(a)anthracene[C]	34		
					Chrysene[C]	30		
					Benzo(b)fluoranthene[C]	49		
					Benzo(k)fluoranthene[C]	22		
					Benzo(a)pyrene[C]	49		
					Indeno(1,2,3-cd)pyrene[C]	69		
					Dibenz(a,h)anthracene[C]	4.5		
					Benzo(g,h,I)perylene	56		
MW-79-13	01/25/92	33.0-34.0	ND		Phenanthrene	14	ND	
					Benzo(b)fluoranthene	4.8		
					Indeno(1,2,3-cd)pyrene	4.4		
MW-80-3	01/28/92	8.0-9.0	2-methylnaphthalene	91,000 D	Acenaphthylene	64 J	Heptachlor	5.7
			Fluorene	11,000	Acenaphthene	720 D,J		
			Phenanthrene	29,000 D	Fluorene	20,000 D,J		
			Anthracene	1,500	Phenanthrene	30,000 D,J		
			Pyrene	550 J	Anthracene	430 D,J		
			Chrysene	170 J	Fluoranthene	600 D,J		
					Pyrene	700 D,J		
					Benzo(a)anthracene[C]	40 D,J		
					Chrysene[C]	44 D,J		
					Benzo(b)fluoranthene[C]	29 J		
					Benzo(k)fluoranthene[C]	9 J		
					Benzo(a)pyrene[C]	28 J		
					Indeno(1,2,3-cd)pyrene[C]	23 J		
					Dibenz(a,h)anthracene[C]	5.2 J		
					Benzo(g,h,I)perylene	20 J		

Notes appear on page 6 of 6.

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TABLE 8.2 (Page 4 of 6)

Sample Number	Date Sampled	Depth of Sample (feet)	Semivolatile Organic Compounds (EPA Method 8270)		PAHs[1] (EPA Method 8310)		Chlorinated Pesticides & PCBs[2] (EPA Method 8080)	
			Analyte Detected[3]	Concentration (μg/kg)	Analyte Detected[3]	Concentration (μg/kg)	Analyte Detected[3]	Concentration (μg/kg)
MW-80-9	01/28/92	23.0-24.0	2-methylnaphthalene	350 J	ND		ND	
			Phenanthrene	92 J				
MW-81-2	01/30/92	5.5-6.5	Benzo(a)pyrene	150 J	Phenanthrene	5.9	Dieldrin	3.5
					Anthracene	1.1		
					Fluoranthene	7.5		
					Pyrene	8.2		
					Benzo(b)fluoranthene[c]	16		
					Indeno(1,2,3-cd)pyrene[c]	5.2		
MW-82-2	01/29/92	5.5-6.5	ND		Phenanthrene	11	ND	
					Anthracene	0.8		
					Fluoranthene	16		
					Pyrene	19		
					Benzo(a)anthracene[c]	6.7		
					Benzo(b)fluoranthene[c]	13		
					Benzo(k)fluoranthene[c]	5.7		
					Benzo(a)pyrene[c]	10		
					Indeno(1,2,3-cd)pyrene[c]	18		
MW-83-2	01/23/92	5.5-6.5	ND		Fluoranthene	6.4	ND	
					Pyrene	8.8		
					Benzo(b)fluoranthene[c]	5.0		
					Benzo(a)pyrene[c]	5.4		
					Indeno(1,2,3-cd)pyrene[c]	7.7		
					Benzo(g,h,i)perylene	6.4		

Notes appear on page 6 of 6.

TABLE 8.2 (Page 5 of 6)

Sample Number	Date Sampled	Depth of Sample (feet)	Semivolatile Organic Compounds (EPA Method 8270) Analyte Detected[3]	Concentration (μg/kg)	PAHs[1] (EPA Method 8310) Analyte Detected[3]	Concentration (μg/kg)	Chlorinated Pesticides & PCBs[2] (EPA Method 8080) Analyte Detected[3]	Concentration (μg/kg)
MW-84-2	01/29/92	5.5-6.5	Dibenzofuran	79 J	Naphthalene	50	ND	
			Fluorene	84 J	Acenaphthene	45		
			Phenanthrene	710	Fluorene	29		
			Anthracene	92 J	Phenanthrene	1,300 D		
			Fluoranthene	910	Anthracene	99 D		
			Pyrene	880	Fluoranthene	1,100 D		
			Benzo(a)anthracene[C]	430 J	Pyrene	830 D		
			Chrysene[C]	620 J	Benzo(a)anthracene[C]	410 D		
			Benzo(b)fluoranthene[C]	470 J	Chrysene[C]	410 D		
			Benzo(k)fluoranthene[C]	420 J	Benzo(b)fluoranthene[C]	540 D		
			Benzo(a)pyrene[C]	450 J	Benzo(k)fluoranthene[C]	270 D		
			Indeno(1,2,3-cd)pyrene[C]	270 J	Benzo(a)pyrene[C]	490 D		
			Dibenz(a,h)anthracene[C]	110 J	Indeno(1,2,3-cd)pyrene[C]	235 D		
			Benzo(g,h,i)perylene	240 J	Dibenz(a,h)anthracene[C]	50 D		
					Benzo(g,h,i)pyrene	320 D		
MW-85-2	01/27/92	5.5-6.5	ND		Phenanthrene	2.4	ND	
MW-86-2	01/24/92	5.5-6.5	ND		ND		ND	
MW-87-7	01/22/92	18.0-19.0	bis(2-ethylhexyl)phthalate	280J	Anthracene	0.7	ND	
			Benzo(a)pyrene	170J	Fluoranthene	18		
					Pyrene	14		
					Benzo(b)fluoranthene[C]	49		
					Benzo(a)pyrene[C]	9.0		
					Indeno(1,2,3-cd)pyrene[C]	7.2		
					Benzo(g,h,i)perylene	5.8		

Notes appear on page 6 of 6.

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TABLE 8.2 (Page 6 of 6)

Sample Number	Date Sampled	Depth of Sample (feet)	Semivolatile Organic Compounds (EPA Method 8270) Analyte Detected[3]	Concentration (μg/kg)	PAHs[1] (EPA Method 8310) Analyte Detected[3]	Concentration (μg/kg)	Chlorinated Pesticides & PCBs[2] (EPA Method 8080) Analyte Detected[3]	Concentration (μg/kg)
920127-A (MW-73)	01/27/92	7.5-8.0	ND		Fluorene	8.7	ND	
					Phenanthrene	26		
					Anthracene	4.4		
					Fluoranthene	12		
					Pyrene	8.7		
920130-D (MW-78)	01/30/92	12.5-13.0	2-methylnaphthalene	160	Naphthalene	44	ND	
					Fluoranthene	23		
					Phenanthrene	53		
					Anthracene	4.5		
					Pyrene	9.3		
					Benzo(b)fluoranthene	5.4		
					Indeno(1,2,3-cd)pyrene	4.3		

Notes:

[1]PAHs = polycyclic aromatic hydrocarbons

[2]PCBs = polychlorinated biphenyls

[3]Only those analytes detected are presented. See Appendix D for a complete list of analytes and detection limits.

[c]Carcinogenic PAH compound.

D - Indicates compounds identified in an analysis at a secondary dilution factor.

E - Indicates compounds whose concentrations exceed the calibration range of the instrument for that specific analysis.

J - Indicates an estimated value.

μg/kg = micrograms per kilogram

ND = not detected

Chemical analyses performed by ETC/PNEL.

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Prepared for:
Port of Seattle
Seattle, Washington

Final Supplemental Data Report, Revision 2

Terminal 30, Port of Seattle

ENSR Corporation
May 2008
Document No.: 05482-014-400

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Table 4-1 Grain Size Data

Soil Type	Estimated Hydraulic Conductivity[1] cm/sec	
Sedimentary		
Gravel	0.03	3
Coarse Sand	9.E-05	0.60
Medium Sand	9.E-05	0.05
Fine Sand	2.E-05	0.02
Silt, loess	1.E-07	0.002
Till	1.E-10	2.E-04
Clay	1.E-09	5.E-07
Unweathered marine clay	8.E-11	2.E-07
Sedimentary Rocks		
Karst and reef limestone	0.0001	2
Limestone, dolomite	1.E-07	0.0006
Sandstone	3.E-08	0.0006
Siltstone	1.E-09	1.E-06
Shale	1.E-11	2.E-07
Crystalline Rocks		
Permeable basalt	4.E-05	2.00
Fractured igneous and metamorphic rock	8.E-07	0.03
Weathered granite	3.E-04	0.01
Basalt	2.E-09	4.E-05
Unfractured igneous and metamorphic rock	3.E-12	2.E-08

Notes:

1. Hydraulic Conductivity was obtained from *Physical and Chemical Hydrogeology*, Domenico & Schwartz, 1990.

Represents soil type present at Terminal 30

Table 5-1 Measured Chemical Concentrations in Terminal 30 Soils

Location	Regional Puget Sound Background	MTCA Method A Soil Cleanup Levels for Industrial Properties	MTCA Method C Soil Criteria	Nearshore Soil Samples					Attenuation Zone Soil Samples		Former NAPL Area Soil Samples					
Sample ID				MW-82-2	MW-84-2	MW-85-2	MW-86-2	MW-87-7	MW-79-2	MW-79-13	MW-80-3	MW-80-9	MW-77-3	MW-77-9	MW-78-5	MW-78-9
Sample Depth				5.5-6.5	5.5-6.5	5.5-6.5	5.5-6.5	18.-19	5.5-6.5	33-34	8.0-9.0	23.0-24.0	8.0-9.0	23.0-24.0	12.0-12.5	23-24
Sample Date				01/29/92	01/29/92	01/27/92	01/24/92	01/22/92	01/25/92	01/25/92	01/28/92	01/28/92	01/22/92	01/22/92	01/30/92	01/30/92
Compound		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Petroleum Hydrocarbons - EPA 8015 (mg/kg)																
Gasoline Range Hydrocarbons	NV	100	NV	< 8.8	< 18	< 8.6	< 8.8	< 12	< 970	< 11	< 4,800	< 10	**7,700**	< 10	**3,500**	15
Diesel Range Hydrocarbons	NV	2,000	NV	15	35	< 8.6	< 8.8	23	**3,700**	< 11	**30,000**	11	**6,300**	11	**3,800**	97
Motor Oil Range Hydrocarbons	NV	2,000	NV	43	120	< 8.6	< 8.8	44	< 970	< 11	< 4,800	39	< 1,900	14	< 1,000	65
Chlorinated Pesticides / PCB Compounds - EPA 8080 (mg/kg)																
Dieldrin	NV	NV	8.2	< 0.0014	< 0.0014	< 0.0013	< 0.0014	< 0.0019	< 0.0015	< 0.0017	< 0.0086	< 0.0016	< 0.0015	< 0.0016	--	< 0.0016
Heptachlor	NV	NV	29	< 0.0021	< 0.0021	< 0.0021	< 0.0021	< 0.003	< 0.0023	< 0.0026	0.0057	< 0.0024	< 0.0023	< 0.0025	--	< 0.0025
Volatile Organic Compounds - EPA 8240 (mg/kg)																
2-Butanone	NV	NV	NV	< 0.011	< 0.011	< 0.010	0.003 B	0.017 B	0.006 B	< 0.013	< 15	< 0.012	< 140	< 0.013	< 1.5	< 0.013
Acetone	NV	NV	350,000	0.005 B	< 0.011	0.006 B	< 0.011	0.013 B	0.012	0.008 J	< 7.3	0.010 B	< 140	0.015 B	< 1.5	0.005 B
Benzene	NV	0.03	2,400	< 0.005	< 0.005	< 0.005	< 0.005	0.004 J	< 0.006	< 0.006	< 7.3	< 0.006	< 71	0.008	< 0.770	< 0.006
Carbon Disulfide	NV	NV	350,000	< 0.005	< 0.005	< 0.005	< 0.005	0.003 B	< 0.006	< 0.006	< 7.3	< 0.006	< 71	0.003 B	< 0.770	< 0.006
Chloroform	NV	NV	22,000	< 0.005	< 0.005	< 0.005	< 0.005	< 0.007	< 0.006	0.002 J	< 7.3	< 0.006	< 71	< 0.006	< 0.770	< 0.006
Ethylbenzene	NV	6	350,000	< 0.005	< 0.005	0.001 J	< 0.005	< 0.007	< 0.006	< 0.006	< 7.3	< 0.006	< 71	0.024	< 0.770	< 0.006
Methylene Chloride	NV	0.02	18,000	0.007 B	0.003 B	0.003 B	0.001 J	0.002 B	0.001 J	0.002 J	**1.6** B	0.007 B	< 71	0.002 B	< 0.770	0.003 B
Toluene	NV	7	280,000	0.048	0.007	0.510 J	0.001 J	0.370 J	0.330 J	0.120	**12**	0.120	< 71	0.005 J	< 0.770	0.004 J
Xylene (total)	NV	9	700,000	< 0.005	< 0.005	< 0.005	< 0.005	< 0.007	< 0.006	< 0.006	< 7.3	< 0.006	< 71	0.019	< 0.770	< 0.006
PAH Compounds - EPA 8270 (mg/kg)																
Naphthalene	NV	5[a]	70000[a]	< 0.7	< 0.7	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	< 0.77	< 0.8	< 0.75	< 0.84	< 0.81	< 0.84
Acenaphthylene	NV	NV	NV	< 0.7	< 0.7	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	< 0.77	< 0.8	< 0.75	< 0.84	< 0.81	< 0.84
Acenaphthene	NV	NV	210,000	< 0.7	< 0.7	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	< 0.77	< 0.8	1.2	< 0.84	< 0.81	< 0.84
Dibenzofuran	NV	NV	7,000	< 0.7	0.079 J	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	< 0.77	< 0.8	0.86	< 0.84	< 0.81	< 0.84
Fluorene	NV	NV	140,000	< 0.7	0.084 J	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	11	< 0.8	2.3	< 0.84	0.096 J	< 0.84
Phenanthrene	NV	NV	NV	< 0.7	0.71	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	29 J	0.092 J	3.8	< 0.84	0.17 J	< 0.84
Anthracene	NV	NV	1,100,000	< 0.7	0.092 J	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	1.5	< 0.8	0.71 J	< 0.84	< 0.81	< 0.84
Fluoranthene	NV	NV	140,000	< 0.7	0.91	< 0.68	< 0.69	< 0.97	< 0.085 J	< 0.86	< 0.77	< 0.8	0.78	< 0.84	< 0.81	< 0.84
Pyrene	NV	NV	110,000	< 0.7	0.88	< 0.68	< 0.69	< 0.97	< 0.086 J	< 0.86	0.55 J	< 0.8	0.4 J	< 0.84	< 0.81	< 0.84
Benzo(a)anthracene	NV	2[b]	18.0[b]	< 0.7	0.43 J	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	< 0.77	< 0.8	0.092 J	< 0.84	< 0.81	< 0.84
Chrysene	NV	2[b]	18.0[b]	< 0.7	0.62 J	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	0.17 J	< 0.8	0.17 J	< 0.84	< 0.81	< 0.84
Benzo(b)fluoranthene	NV	2[b]	18.0[b]	< 0.7	0.47 J	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	< 0.77	< 0.8	< 0.75	< 0.84	< 0.81	< 0.84
Benzo(k)fluoranthene	NV	2[b]	18.0[b]	< 0.7	0.42 J	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	< 0.77	< 0.8	< 0.75	< 0.84	< 0.81	< 0.84
Benzo(a)pyrene	NV	2[b]	18.0[b]	< 0.7	0.45 J	< 0.68	< 0.69	0.17 J	< 0.77	< 0.86	< 0.77	< 0.8	< 0.75	< 0.84	< 0.81	< 0.84
Indeno(1,2,3-cd)pyrene	NV	2[b]	18.0[b]	< 0.7	0.27 J	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	< 0.77	< 0.8	< 0.75	< 0.84	< 0.81	< 0.84
Dibenz(a,h)anthracene	NV	2[b]	18.0[b]	< 0.7	0.11 J	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	< 0.77	< 0.8	< 0.75	< 0.84	< 0.81	< 0.84
Benzo(g,h,i)perylene	NV	NV	NV	< 0.7	0.24 J	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	< 0.77	< 0.8	< 0.75	< 0.84	< 0.81	< 0.84
Selected Semivolatile Organics - EPA 8270 (mg/kg)																
2-Methylnaphthalene	NV	5[a]	14,000	< 0.7	< 0.7	< 0.68	< 0.69	< 0.97	< 0.77	< 0.86	**91** J	0.35 J	**31** J	< 0.84	0.52 J	0.27 J
bis(2-Ethylhexyl)phthalate	NV	NV	9,400	< 0.7	< 0.7	< 0.68	< 0.69	0.28 J	< 0.77	< 0.86	< 0.77	< 0.8	< 0.75	0.21 J	< 0.81	0.19 J
Heavy Metals - EPA 6000/7000 Series (mg/kg)																
Antimony	NV	NV	1,400	< 7.4 J	< 7.2 J	< 6.9 J	< 7.5 J	< 10.8 J	< 8.4 J	< 10.1 J	< 8.5 J	< 8 J	< 9.1 J	< 8.1 J	< 8.9 J	< 9 J
Arsenic	7	20	88	4.1 J	4	2.1 J	2.1	4.9	6.7 J	2.1 J	1.8 J	2.6 J	1.2 J	2.8	1.3 J	1.4 J
Beryllium	0.6	NV	7,000	0.5 B	0.68 J	0.39 J	0.5 J	0.73 J	0.38 J	0.27 J	0.34 J	0.33 J	0.36 J	0.44 J	0.38 J	0.39 J
Cadmium	1	2	3,500	< 0.93	< 0.9	< 0.86	< 0.94	< 1.4	**2**	< 1.3	< 1.1	< 1	< 1.1	< 1	< 1.1	< 1.1
Chromium (total)	48	NV	NV	29.7	14.2	17.9	20.8 J	16.2 J	11.9	11.5	13.5	11.5	9.1 J	11.9 J	10.2	12.8
Copper	36	NV	130,000	18.2	50	10.2	10.5	19.5	9.1	8.3	15.2	9.4	8.8	8.6	7.7	8.4
Lead	24	1,.000	NF	8.6	135	1.5	1.3	1.9	187	1.4	2.3	1.4	2.6	1.3	2.6	1.4
Mercury	0.07	2	1,100	< 0.07	< 0.1	< 0.07	< 0.1	< 0.1	4.1	< 0.1	< 0.1	< 0.08	< 0.11	< 0.11	< 0.1	< 0.08
Nickel	48	NV	70,000	33.3	16.6	22.4	26.2	11.8	15.4	6.6 B	7 J	8.6	5.9 J	7 J	7.2 J	7.5 J
Selenium	NV	NV	NV	< 0.6 J	< 0.6 J	< 0.59 J	< 0.53 J	< 0.87	< 0.67 J	< 0.76 J	< 0.62 J	< 0.63 J	< 0.62	< 0.59	< 0.68 J	< 0.68 J
Silver	NV	NV	18,000	< 1.9	1.8	< 1.7	< 1.9	< 2.7	2.3	< 2.5	< 2.1	< 2	< 2.3	< 2	< 2.2	< 2.3
Thallium	NV	NV	NV	< 0.4	< 0.4	< 0.39	< 0.35 J	< 0.58 J	< 0.44	< 0.5	< 0.41	< 0.42	< 0.41 J	< 0.39 J	< 0.45	< 0.46
Zinc	85	NV	1,100,000	33.9	87.8	45	26.2	29	150	19.4	20.8	20.7	18.6	20.5	21	20.2

Notes:

[a] Cleanup level is based on protection of groundwater for drinking water use, using procedures described in WAC 173-340-747(4). This is a total value for naphthalene, 1-methylnaphthalene and 2-methylnaphthalene.

[b] Cleanup level (for benzo(a)pyrene) based on protection of groundwater for drinking water use using the procedures described in WAC 173-340-747(4). If other carcinogenic PAHs are suspected of being present at the site, test for them and use this value as the total concentration that all carcinogenic PAHs must meet using the toxicity equivaleny methodology in WAC 173-340-708(8)

B - indicates possible/probable blank contamination. Flagged when the analyte is detected in the blank as well as the sample.

J - indicates and estimated concentration when the value is less than the calculated reporting limit.

All results presented in mg/kg.
NV indicates no value.
BOLD value indicates detection above MTCA Criteria
PAH analytical results from Method EPA 8310 are excluded due to known false positives associated with the method.

Table 5-1 Measured Chemical Concentrations in Terminal 30 Soils

Compound / Location / Sample ID / Sample Depth / Sample Date	Regional Puget Sound Background	MTCA Method A Soil Cleanup Levels for Industrial Properties (mg/kg)	MTCA Method C Soil Criteria (mg/kg)	Perimeter Soil Samples					
Sample ID				MW-83-2	MW-81-2	MW-73-2	MW-74-4	MW-75-2	MW-76-3
Sample Depth				5.5-6.5	5.5-6.5	5.5-6.0	10.5-11.0	5.5-6.5	8.0-9.0
Sample Date				01/23/92	01/30/92	01/27/92	01/27/92	01/29/92	01/23/92
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Petroleum Hydrocarbons - EPA 8015 (mg/kg)									
Gasoline Range Hydrocarbons	NV	100	NV	< 9.5	< 10	< 9.1	50	< 9.7	< 8.9
Diesel Range Hydrocarbons	NV	2,000	NV	< 9.5	19	< 9.1	130	< 9.7	< 8.9
Motor Oil Range Hydrocarbons	NV	2,000	NV	11	67	< 9.1	43	< 9.7	10
Chlorinated Pesticides / PCB Compounds - EPA 8080 (mg/kg)									
Dieldrin	NV	NV	8.2	< 0.0015	0.0035	< 0.0014	< 0.0016	< 0.0015	< 0.0014
Heptachlor	NV	NV	29	< 0.0023	< 0.0024	< 0.0022	< 0.0025	< 0.0023	< 0.0021
Volatile Organic Compounds - EPA 8240 (mg/kg)									
2-Butanone	NV	NV	NV	0.004 B	0.003 J	0.002 B	< 0.063	< 0.012	0.007 B
Acetone	NV	NV	350,000	0.018 B	0.017 B	< 0.011	0.022 B	0.008 J	0.005 B
Benzene	NV	0.03	2,400	< 0.006	< 0.006	< 0.005	< 0.032	< 0.006	< 0.005
Carbon Disulfide	NV	NV	350,000	0.002 B	< 0.006	< 0.005	< 0.032	< 0.006	0.002 B
Chloroform	NV	NV	22,000	< 0.006	< 0.006	< 0.005	< 0.032	< 0.006	< 0.005
Ethylbenzene	NV	6	350,000	< 0.006	< 0.006	< 0.005	< 0.032	< 0.006	< 0.005
Methylene Chloride	NV	0.02	18,000	< 0.006	0.002 B	0.005 J	0.013 B	0.001 J	0.001 B
Toluene	NV	7	280,000	0.096	0.190	0.002 J	0.031 J	0.430 J	0.039
Xylene (total)	NV	9	700,000	< 0.006	< 0.006	< 0.005	< 0.032	< 0.006	< 0.005
PAH Compounds - EPA 8270 (mg/kg)									
Naphthalene	NV	5[a]	70000[a]	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Acenaphthylene	NV	NV	NV	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Acenaphthene	NV	NV	210,000	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Dibenzofuran	NV	NV	7,000	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Fluorene	NV	NV	140,000	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Phenanthrene	NV	NV	NV	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Anthracene	NV	NV	1,100,000	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Fluoranthene	NV	NV	140,000	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Pyrene	NV	NV	110,000	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Benzo(a)anthracene	NV	2[b]	18.0[b]	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Chrysene	NV	2[b]	18.0[b]	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Benzo(b)fluoranthene	NV	2[b]	18.0[b]	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Benzo(k)fluoranthene	NV	2[b]	18.0[b]	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Benzo(a)pyrene	NV	2[b]	18.0[b]	< 0.75	0.15 J	< 0.72	< 0.84	< 0.77	< 0.7
Indeno(1,2,3-cd)pyrene	NV	2[b]	18.0[b]	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Dibenz(a,h)anthracene	NV	2[b]	18.0[b]	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Benzo(g,h,i)perylene	NV	NV	NV	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
Selected Semivolatile Organics - EPA 8270 (mg/kg)									
2-Methylnaphthalene	NV	5[a]	14,000	< 0.75	< 0.8	< 0.72	< 0.84	< 0.77	< 0.7
bis(2-Ethylhexyl)phthalate	NV	NV	9,400	< 0.75	< 0.8	0.094 J	< 0.84	< 0.77	< 0.7
Heavy Metals - EPA 6000/7000 Series (mg/kg)									
Antimony	NV	NV	1,400	< 7.9 J	< 9.1 J	< 8.4 J	< 9 J	< 9.2 J	< 8.3 J
Arsenic	7	20	88	1.7 J	2.4	0.93 J	2.4	1.9 J	2.5
Beryllium	0.6	NV	7,000	0.97 J	0.39 J	< 0.21	< 0.22	0.25 J	0.33 J
Cadmium	1	2	3,500	< 0.99	< 1.1	< 1	< 1.1	< 1.2	< 1
Chromium (total)	48	NV	NV	15.2 J	12.2	10.3	10.2	10.3	12.2 J
Copper	36	NV	130,000	16.4	11.1	6.4	8.9	9.9	8.2
Lead	24	1,.000	NF	9.3	4.2	0.97	1.4	1.6	2.7
Mercury	0.07	2	1,100	< 0.09	< 0.09	< 0.08	< 0.09	< 0.11	< 0.09
Nickel	48	NV	70,000	14.5	8.3 J	< 4.2	6.4 J	5.6 J	7.5 J
Selenium	NV	NV	NV	< 0.6	< 0.65 J	< 0.58 J	0.7	< 0.67 J	< 0.63
Silver	NV	NV	18,000	< 2	< 2.3	< 2.1	< 2.2 J	< 2.3	< 2.1
Thallium	NV	NV	NV	< 0.4 J	< 0.43 J	< 0.39	< 0.46	< 0.44	< 0.42 J
Zinc	85	NV	1,100,000	30.5	35	14.8	20.5	18.3	102

Notes:

[a.] Cleanup level is based on protection of groundwater for drinking water use, using procedures described in WAC 173-340-747(4). This is a total value for naphthalene, 1-methylnaphthalene and 2-methylnaphthalene.

[b.] Cleanup level (for benzo(a)pyrene) based on protection of groundwater for drinking water use using the procedures described in WAC 173-340-747(4). If other carcinogenic PAHs are suspected of being present at the site, test for them and use this value as the total concentration that all carcinogenic PAHs must meet using the toxicity equivaleny methodology in WAC 173-340-708(8)

B - indicates possible/probable blank contamination. Flagged when the analyte is detected in the blank as well as the sample.

J - indicates and estimated concentration when the value is less than the calculated reporting limit.

All results presented in mg/kg.
NV indicates no value.
BOLD value indicates detection above MTCA Criteria
PAH analytical results from Method EPA 8310 are excluded due to known false positives associated with the method.

Table 5-2 LNAPL Monitoring – 1999 to 2005

Monitoring Date	July 1999	December 2000	July 2001	February 2003	February 2004	May 2005	August 2005	October 2005	November 2005	December 2005
Well ID										
MW-35	0.05	—	0.01	0.02	—	0.10	0.24	NM	0.01	0.02
MW-36	0.06	—	—	—	—	NM	0.00	NM	0.00	0.00
MW-38	0.04	—	—	—	NM	NM	0.00	NM	0.00	0.03
MW-39	0.05	Present	0.04	—	—	NM	0.07	NM	0.04	0.05
MW-40	0.04	—	—	—	NM	NM	0.00	NM	NM	NM
MW-49	**0.32**	—	—	—	—	0.03	0.00	NM	0.00	NM
MW-54	0.02	—	—	—	—	0.00	0.00	NM	0.00	NM
MW-59	**1.34**	Present	**0.93**	**0.40**	**0.99**	1.07	0.93	NM	0.82	0.93
MW-63	< 0.01	—	—	—	NM	NM	0.00	NM	NM	NM
MW-64	0.07	—	—	—	NM	NM	0.16	NM	0.09	0.09
RW-1	0.08	Present	**0.15**	**0.10**	—	NM	NM	0.84	0.21	0.03
RW-5	0.07	—	—	—	—	NM	NM	0.02	0.01	0.00
RW-9	< 0.01	—	—	—	NM	NM	NM	0.05	0.04	0.04
RW-10	**0.18**	—	0.01	—	NM	NM	NM	0.00	0.00	0.00
RW-11	0.01	Present	**0.14**	**0.10**	**0.02**	NM	NM	0.26	0.08	0.10
RW-12	**0.15**	—	**0.26**	**0.10**	—	NM	NM	1.13	0.49	0.24

Note:

"Apparent" product thickness is reported in feet.

—: Indicates no product detected.

NM: Indicates not measured.

AECOM

Environment

Submitted to:
The Port of Seattle
Terminal 30 – Seattle, Washington

Submitted by:
AECOM
Seattle, WA
60137527-100
January 20, 2010

Terminal 30 Cargo Terminal Construction Completion Report

Table 3-2: Phase 1 Analytical Results – RTG

Lab Report No.	Sample Date	Sample ID	Sample Depth (ft. bgs)	Gasoline mg/kg	Diesel mg/kg	Lube Oil mg/kg	Port Classification (type)	Current Location
LW06	10/31/2007	RTG EAST 1	2	**740**	**4,100**	420	II	Offsite
LW75	11/6/2007	RTG EAST 2	2	93	360	180	I	Offsite
LW75	11/6/2007	RTG EAST 3	2	5	5	10	I	Offsite
LW75	11/6/2007	RTG EAST 4	2	5	6	32	I	Offsite
LW75	11/6/2007	RTG EAST 5	2	5	6	33	I	Offsite
LW75	11/6/2007	RTG EAST 6	2	5	5	22	I	Offsite
LW75	11/6/2007	RTG EAST 7	2	360	420	210	II	Offsite
LW26	11/1/2007	RTG EAST 8	2	61	46	160	I	Offsite
-	-	RTG EAST 9	-	Not sampled - access road			I	Offsite
LW26	11/1/2007	RTG EAST 10	2	**140**	510	920	II	Offsite
LW26	11/1/2007	RTG EAST 11	2	5	38	77	I	Offsite
LW48	11/2/2007	RTG EAST 12	2	6	72	220	II	Offsite
LW48	11/2/2007	RTG EAST 13	2	9	130	190	I	Offsite
LW48	11/2/2007	RTG EAST 14	2	5	5	10	I	Offsite
LW48	11/2/2007	RTG EAST 15	2	6	67	370	II	Offsite
LW48	11/2/2007	RTG EAST 16	2	6	200	850	II	Offsite
LW48	11/2/2007	RTG EAST 17	2	6	110	570	II	Offsite
LW48	11/2/2007	RTG EAST 18	2	7	67	380	II	Offsite
LW48	11/2/2007	RTG EAST 19	2	6	80	410	II	Offsite
LW48	11/2/2007	RTG EAST 20	2	6	7	48	I	Offsite
LW06	10/31/2007	RTG WEST 1	2	440	**3,600**	770	II	Offsite
LW06	10/31/2007	RTG WEST 2	2	**120**	620	580	II	Offsite
LW25	11/1/2007	RTG WEST 3	2	5	6	16	I	Offsite
LW06	10/31/2007	RTG WEST 4	2	5	6	19	I	Offsite
LW25	11/1/2007	RTG WEST 5	2	5	5	10	I	Offsite
LW25	11/1/2007	RTG WEST 6	2	18	130	120	I	Offsite
LW26	11/1/2007	RTG WEST 7	2	6	19	35	I	Offsite
LW26	11/1/2007	RTG WEST 8	2	12	44	56	I	Offsite
-	-	RTG WEST 9	-	Not sampled - access road			I	Offsite
LW26	11/1/2007	RTG WEST 10	2	16	250	620	II	Offsite
LW26	11/1/2007	RTG WEST 11	2	11	88	110	I	Offsite
LW26	11/1/2007	RTG WEST 12	2	8	74	140	I	Offsite
LW26	11/1/2007	RTG WEST 13	2	5	5	10	I	Offsite
LW26	11/1/2007	RTG WEST 14	2	5	5	10	I	Offsite
-	-	RTG WEST 15	-	Not Sampled			I	Offsite
LX21	11/8/2007	RTG WEST 16	2	8	24	170	I	Offsite
-	-	RTG WEST 17	-	Not Sampled			I	Offsite
LX21	11/8/2007	RTG WEST 18	2	6	140	700	II	Offsite
-	-	RTG WEST 19	-	Not Sampled			I	Offsite
LX21	11/8/2007	RTG WEST 20	2	19	130	580	II	Offsite

Table 3-3: Phase 1 Analytical Results – East/West Electrical Duct Bank

Lab Report No.	Sample Date	Sample ID	Sample Depth (ft. bgs)	Gasoline mg/kg	Diesel mg/kg	Lube Oil mg/kg	Port Classification (type)	Current Location
11-132	11/19/2007	E/W Duct 1 Bottom	6-7	ND	ND	ND	I	Offsite
11-132	11/19/2007	E/W Duct 1 Comp	3-3.5	ND	ND	ND	I	Offsite
LX63	11/12/2007	E/W Duct 2 Bottom	4-5.5	9	170	600	II	Offsite
LX63	11/12/2007	E/W Duct 2 Comp	1-4	31	250	760	II	Offsite
LX63	11/12/2007	E/W Duct 3 Bottom	5.5-6	**330**	**2,100**	590	II	Offsite
LX63	11/12/2007	E/W Duct 3 Comp	1-4	6	210	350	II	Offsite
01-068	1/10/2008	W. Vault-1-3-4	3-4	< 11	**6,000**	860	II	Offsite
01-068	1/10/2008	W. Vault-NWSW	4-8	< 11	**5,900**	900	II	Confirmation
01-068	1/10/2008	W. Vault-SWSW	4-8	< 11	**3,300**	750	II	Confirmation
01-068	1/10/2008	W. Vault-NESW	4-8	< 5.7	< 28	< 57	I	Confirmation

Table 3-4: Phase 1 Analytical Results – Truck Scales

Lab Report No.	Sample Date	Sample ID	Sample Depth (ft. bgs)	Gasoline mg/kg	Diesel mg/kg	Lube Oil mg/kg	Port Classification (type)	Current Location
LX99	11/13/2007	TS 1 0 TO 4	0-4	**130**	870	440	II	Offsite
0711-156	11/21/2007	TS-2 0-4	0-4	ND	95	ND	I	Offsite
0711-165	11/26/2007	TS-3-0-4	0-4	12	**3,700**	**6,500**	II	Offsite

Table 3-5: Phase 1 Analytical Results – Sanitary Sewer

Lab Report No.	Sample Date	Sample ID	Sample Depth (ft. bgs)	Gasoline mg/kg	Diesel mg/kg	Lube Oil mg/kg	Port Classification (type)	Current Location
LX22	11/8/2007	SS-0	6	**450**	**1,700**	**1,300**	II	Offsite
LX40	11/9/2007	SS-0-6	0-6	**290**	**2,100**	150	II	Offsite
LX99	11/13/2007	SS 10 8 TO 9	8-9	**1,800**	**12,000**	< 570	II	Offsite
LX22	11/8/2007	SS-137-BOTTOM	5	20	210	760	II	Offsite
LX22	11/8/2007	SS-137-SIDEWALL	3-4	27	980	**1,300**	II	Offsite
LX99	11/13/2007	SS 170 8 TO 9	8-9	**4,600**	**6,700**	**2,600**	II	Offsite
LX22	11/8/2007	SS-274	3	**1,600**	**30,000**	**36,000**	II	Offsite
LX99	11/13/2007	SS 300 0 TO 5	0-5	96	**6,800**	**11,000**	II	Offsite
LX99	11/13/2007	SS 300 8 TO 9	8-9	**980**	**2,600**	**1,700**	II	Offsite
LX99	11/13/2007	SS 450 0 TO 4	0-4	46	10	18	I	Offsite
LX99	11/13/2007	SS 450 6 TO 7	6-7	**4,800**	**4,100**	**1,200**	II	Offsite
LX99	11/13/2007	SS 585 0 TO 4	0-4	< 5.6	19	74	I	Offsite
LX99	11/13/2007	SS 585 5 TO 6	5-6	**220**	44	24	II	Offsite
LX99	11/13/2007	SS 685 0 TO 4	0-4	< 6.2	6	20	I	Offsite
LX99	11/13/2007	SS 685 4 TO 6.5	4-6.5	17	990	< 120	II	Offsite
LX99	11/13/2007	SS 785 0 TO 4	0-4	< 7.5	50	250	I	Offsite
LX99	11/13/2007	SS 785 4 TO 5	4-5	< 6.7	34	190	II	Offsite
-	11/13/2007	SS 885 0 TO 3	0-3	Not Analyzed			I	Offsite
01-040-01	1/8/2008	Over-ex-1 [1]	NA	< **10,000**	**310,000**	**500,000**	II	Offsite
01-068	1/9/2008	EX-W.Sidewall	4-8	< 11	**2,200**	**1,600**	II	Confirmation
01-068	1/9/2008	EX-E.Sidewall	4-8	< 30	**12,000**	**11,000**	II	Confirmation
01-068	1/9/2008	EX-Bottom	8-8.5	< 34	**10,000**	**3,400**	II	Confirmation
01-155	1/23/2008	EX-NWSW	4-8	< 13	940	960	II	Confirmation
01-155	1/23/2008	EX-NESW	4-7	< 11	**6,100**	**7,000**	II	Confirmation
01-155	1/23/2008	EX-SESW	4-7	< 11	**1,400**	150	II	Confirmation
0711-183	11/27/2007	Pothole 1 0-4	0-4	< **110**	**7,500**	**5,300**	II	Offsite

Notes:
Bolded values exceed MTCA Method A limit.
[1] Sample was collected from product/soil out of drum.
< - Indicates analyte was not detected above the detection limit shown

Table 4-1: Phase 2 Analytical Results – Equipment Slab

Lab Report No.	Sample Date	Sample ID	Sample Depth (ft. bgs)	Gasoline mg/kg	Diesel mg/kg	Lube Oil mg/kg	Port Classification (type)	Current Location
BRJ0251	10/16/2008	S-1-1008	6	< 4.9	< 10.5	< 26.3	I	Offsite
BRJ0251	10/16/2008	S-2-0to4-1008	0 - 4	< 4.93	< 11.0	< 27.5	I	Offsite
BRJ0251	10/16/2008	S-2-4to8-1008	4 - 8	< 5	< 11.3	< 28.3	I	Offsite
BRJ0296	10/20/2008	S-3-1008	4	< 8.03	67.7	285	II	Offsite
BRJ0296	10/20/2008	S-4-1008	4	< 4.93	14.3	69.7	I	Offsite
BRJ0296	10/20/2008	S-5-1008	4	< 5.01	42.4	171	II	Offsite
BRJ0298	10/21/2008	S-6-1008	5	< 5.18	345	763	II	Offsite

Table 4-2: Phase 2 Analytical Results – Refrigerated Cargo Racks

Lab Report No.	Sample Date	Sample ID	Sample Depth (ft.	Gasoline mg/kg	Diesel mg/kg	Lube Oil mg/kg	Port Classification	Current Location
BRJ0262	10/17/2008	RR-1-1008	5	< 4.13	< 10.7	< 26.7	I	Offsite
BRJ0298	10/21/2008	RR-2-1008	3	< 4.45	10.8	< 27.0	I	Offsite
BRJ0298	10/21/2008	RR-3-1008	4	< 4.26	< 10.6	< 26.4	I	Offsite
BRK0228	11/18/2008	RR-4-0-4	0 - 4	< 4.59	< 10.4	< 26.0	I	Offsite
BRK0228	11/18/2008	RR-4-4-8	4 - 8	< 4.83	< 10.9	< 27.3	I	Offsite

Table 4-3: Phase 2 Analytical Results – Truck Scales and Optical Character Recognition Housing

Lab Report No.	Sample Date	Sample ID	Sample Depth (ft.	Gasoline mg/kg	Diesel mg/kg	Lube Oil mg/kg	Port Classification	Current Location
BRJ0262	10/17/2008	TS-1-1008	5	11.9	16.4	41.0	I	Offsite
BRJ0262	10/17/2008	TS-2-1008	5	< 5.29	14.2	71.7	I	Offsite
BSB0042	2/5/2009	ET-1-0109	2	**3,130**	**3,790**	1,470	II	Offsite
BRJ0296	10/20/2008	OCR-1008	4	< 5.27	27.3	98.4	I	Offsite

Table 4-4: Phase 2 Analytical Results – Land Side Crane Beam

Lab Report No.	Sample Date	Sample ID	Sample Depth (ft.	Gasoline mg/kg	Diesel mg/kg	Lube Oil mg/kg	Port Classification	Current Location
BRJ0296	10/20/2008	LSCB-1-1008	4	< 4.99	44.0	110	I	Equipment Slab
BRK0228	11/18/2008	LSCB-2-1108	0 - 4	< 4.45	< 10.3	84.4	I	Equipment Slab
BRK0228	11/18/2008	LSCB-3-1108	0 - 4	< 4.90	12.7	34.9	I	Offsite

Table 4-5: Phase 2 Analytical Results – Cruise Terminal Building

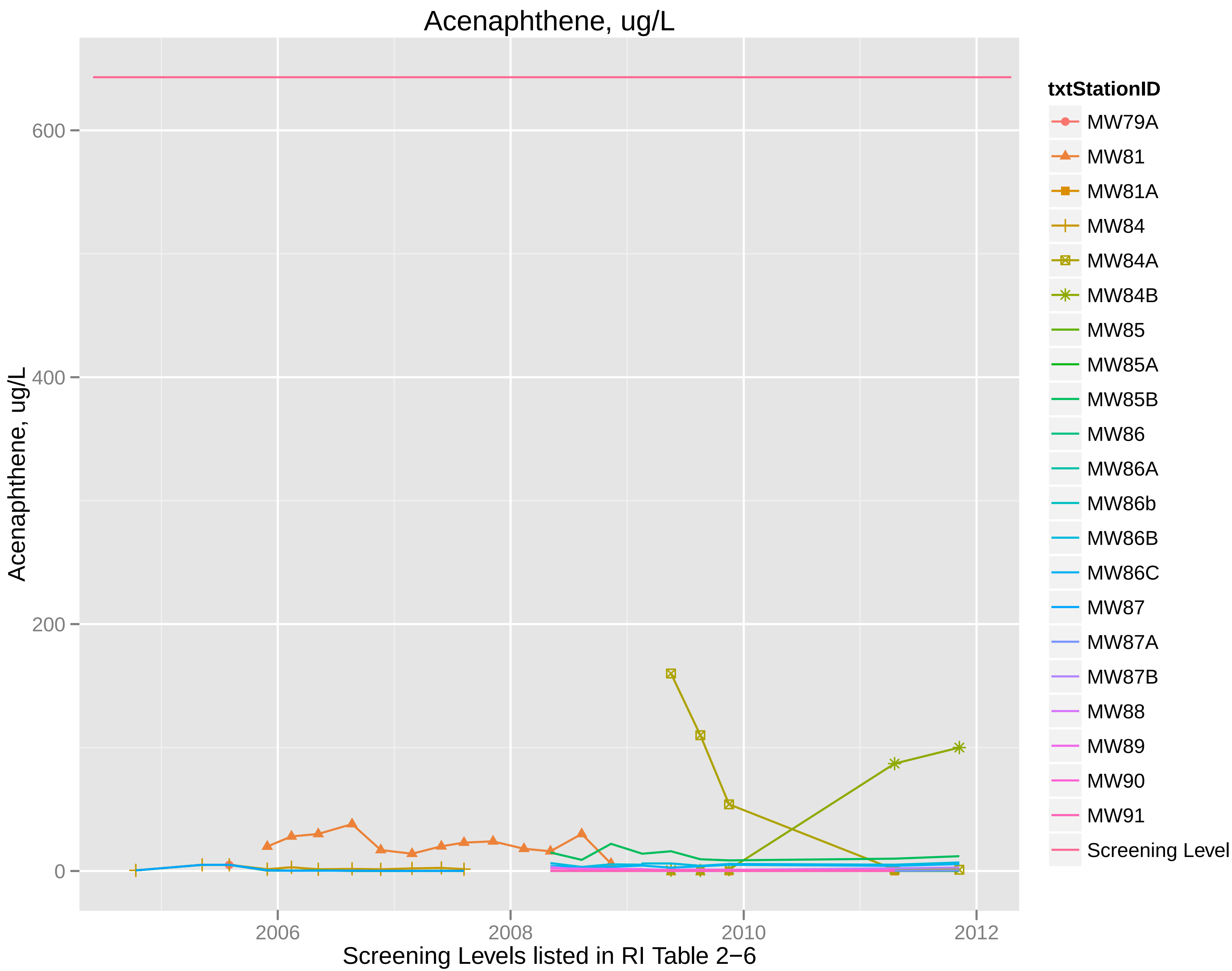
Lab Report No.	Sample Date	Sample ID	Sample Depth (ft.	Gasoline mg/kg	Diesel mg/kg	Lube Oil mg/kg	Port Classification	Current Location
BSB0070	2/9/2009	CT-1-0209	2.5	< 7.63	< 10.7	< 26.8	I	Offsite
BSB0084	2/10/2009	CT-2-0209	2.5	< 6.04	< 11.2	< 27.9	I	Offsite
BRL0132	12/11/2008	CT-1-1208	2 - 6	< 5.04	< 10.4	< 26.0	I	Offsite
BRL0132	12/11/2008	CT-2-1208	2 - 6	14.4	< 11.0	37.4	I	Offsite
BRL0132	12/11/2008	CT-3-1208	2 - 6	< 4.41	< 10.4	< 26.1	I	Offsite
BRL0132	12/11/2008	CT-4-1208	2 - 6	< 5.95	< 11.5	< 28.6	I	Offsite
BRL0132	12/11/2008	CT-5-1208	2 - 6	< 5.48	< 10.4	< 26.0	I	Offsite
BRL0132	12/11/2008	CT-6-1208	2 - 6	< 7.81	< 10.8	< 26.9	I	Offsite

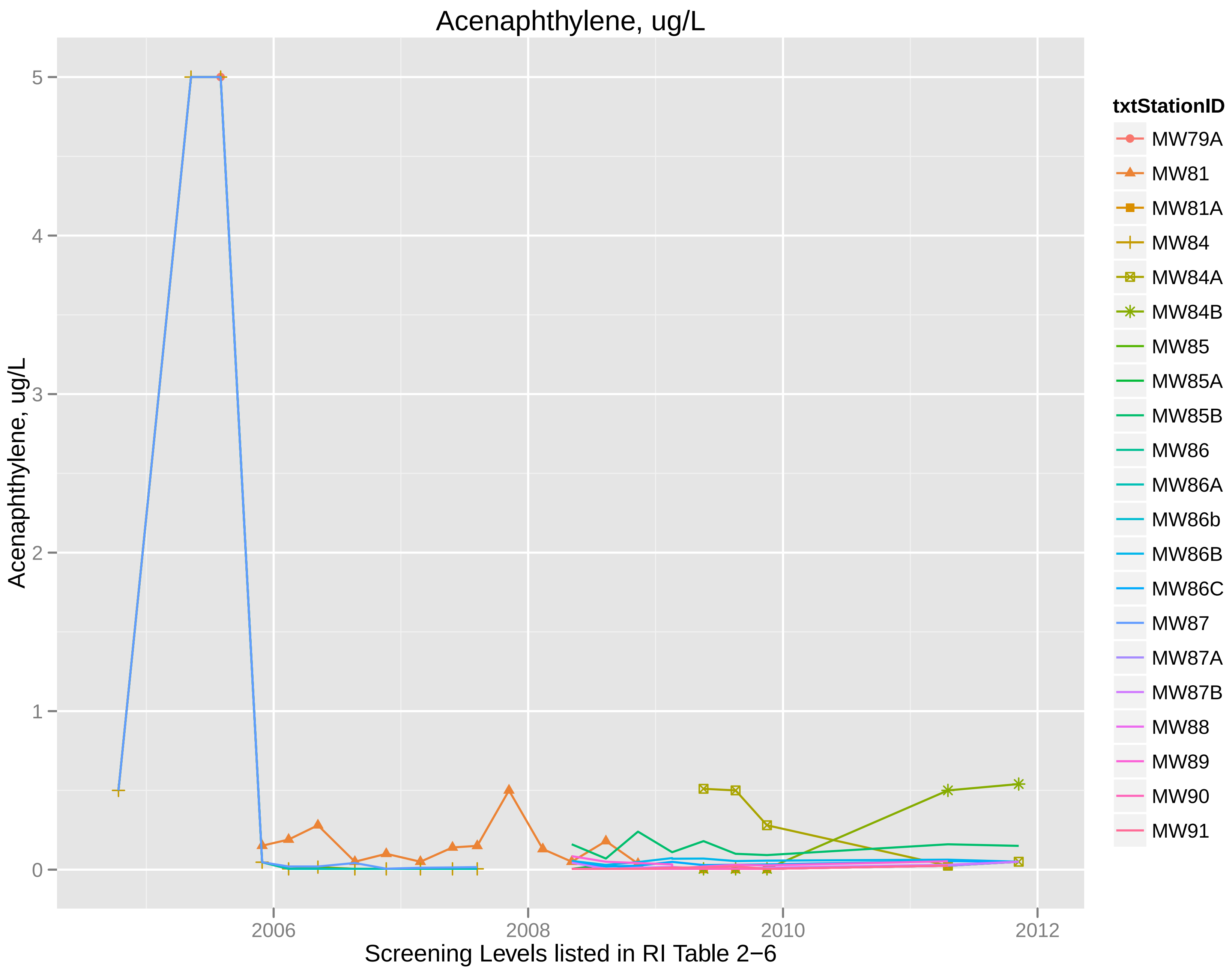
Notes:
Bolded values exceed MTCA Method A limit.
< - Indicates analyte was not detected above the detection limit shown

Table 5-1: Phase 2 Analytical Results – North/South Electrical Duct Bank

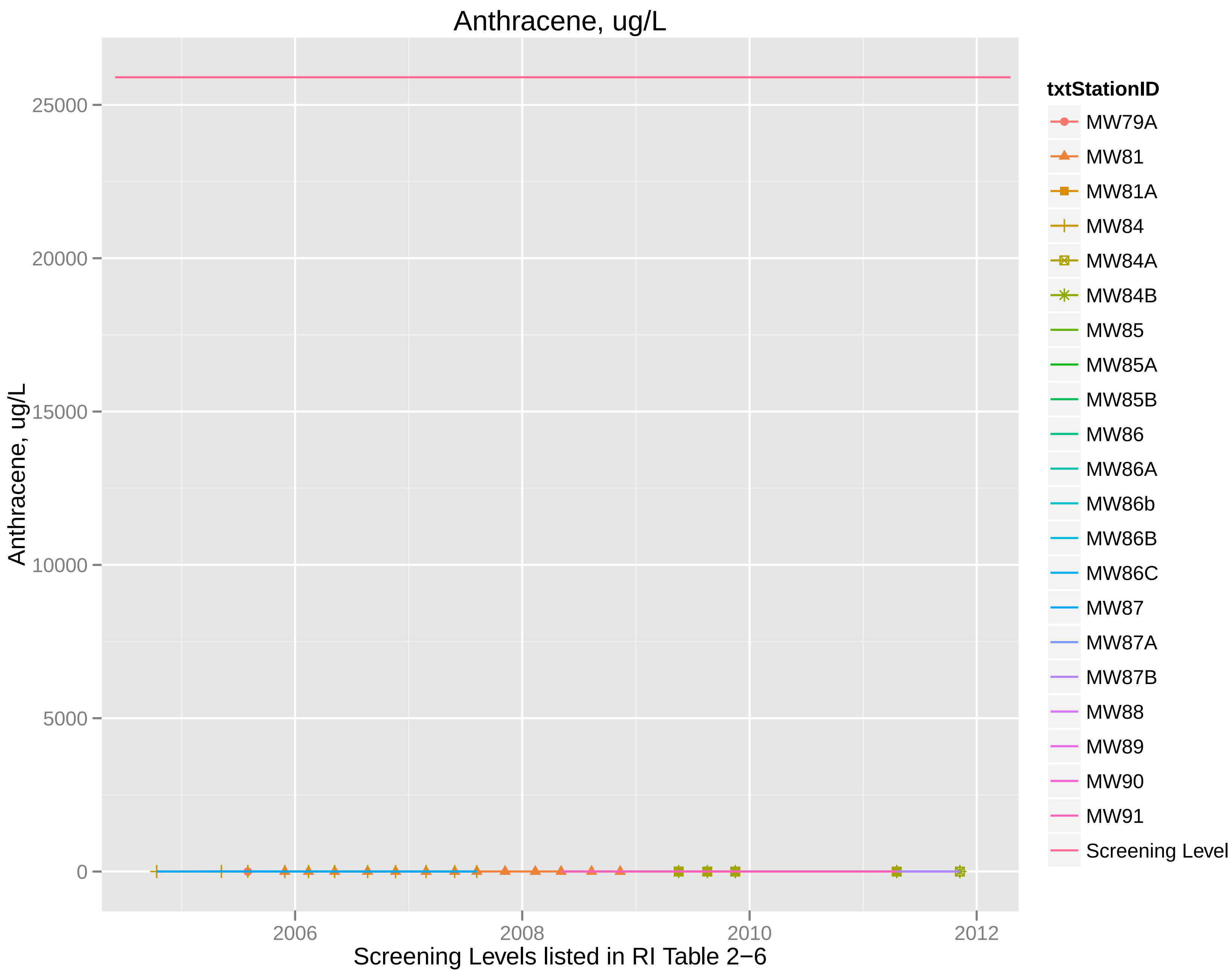
Lab Report No.	Sample Date	Sample ID	Sample Depth (ft. bgs)	Gasoline mg/kg	Diesel mg/kg	Lube Oil mg/kg	Port Classification (type)	Current Location
0802-083	2/12/2008	S. Vault-10.5-11	10.5-11	< 15	**15,000**	**14,000**	II	Confirmation
0802-083	2/12/2008	S. Vault-SESW-7.5-8.5	7.5-8.5	< 9.7	< 37	< 74	I	Confirmation
0802-083	2/12/2008	S. Vault-North-7.0-8.5	7-8.5	< 6.6	**1,900**	**3,400**	II	Confirmation

APPENDIX F: CONCENTRATION TREND PLOTS


Acenaphthene, ug/L
Acenaphthene, ug/L
600
400
200
0
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level



Acenaphthylene, ug/L
Acenaphthylene, ug/L
0
1
2
3
4
5
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91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20000
15000
10000
5000
0
Anthracene, ug/L
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
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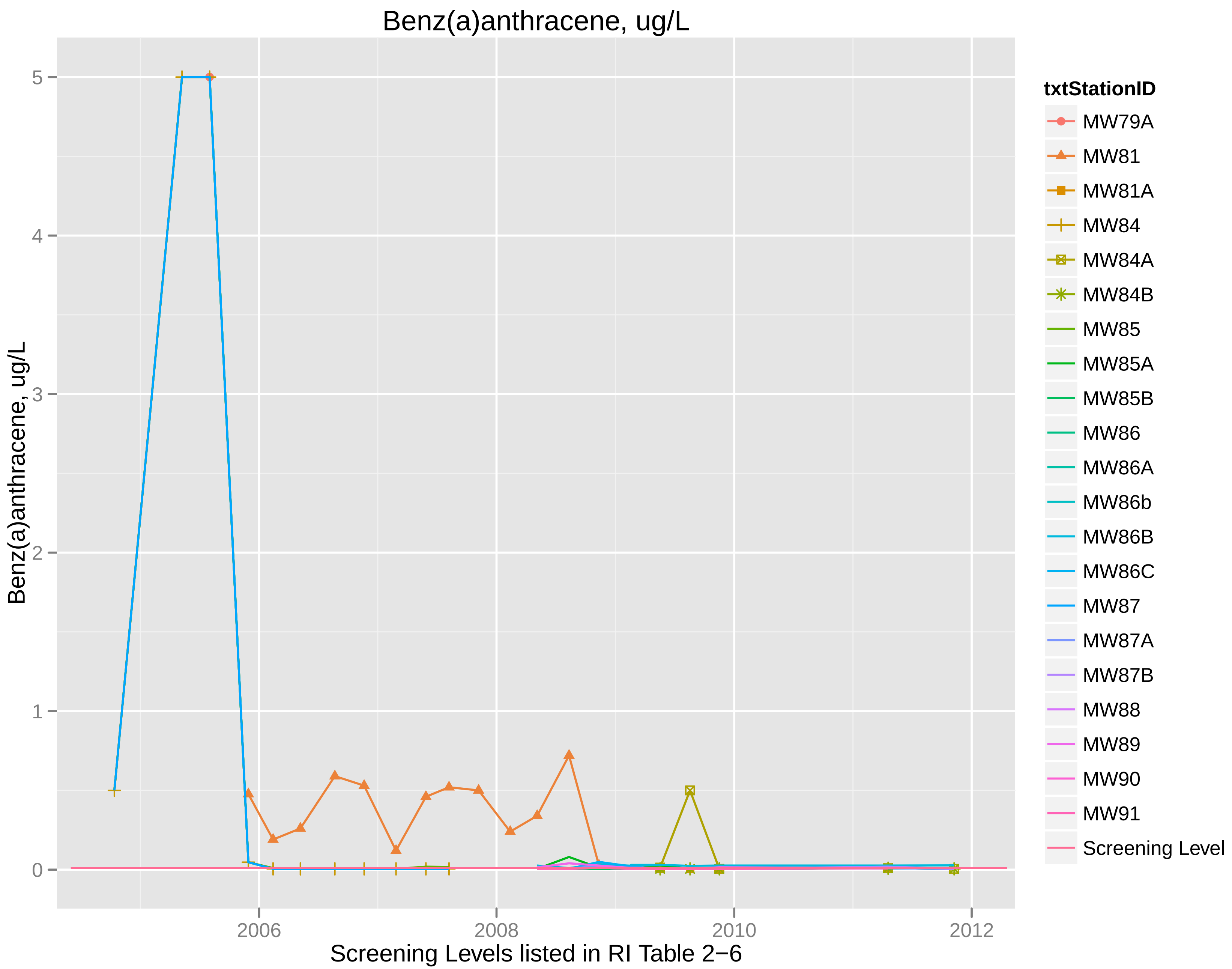
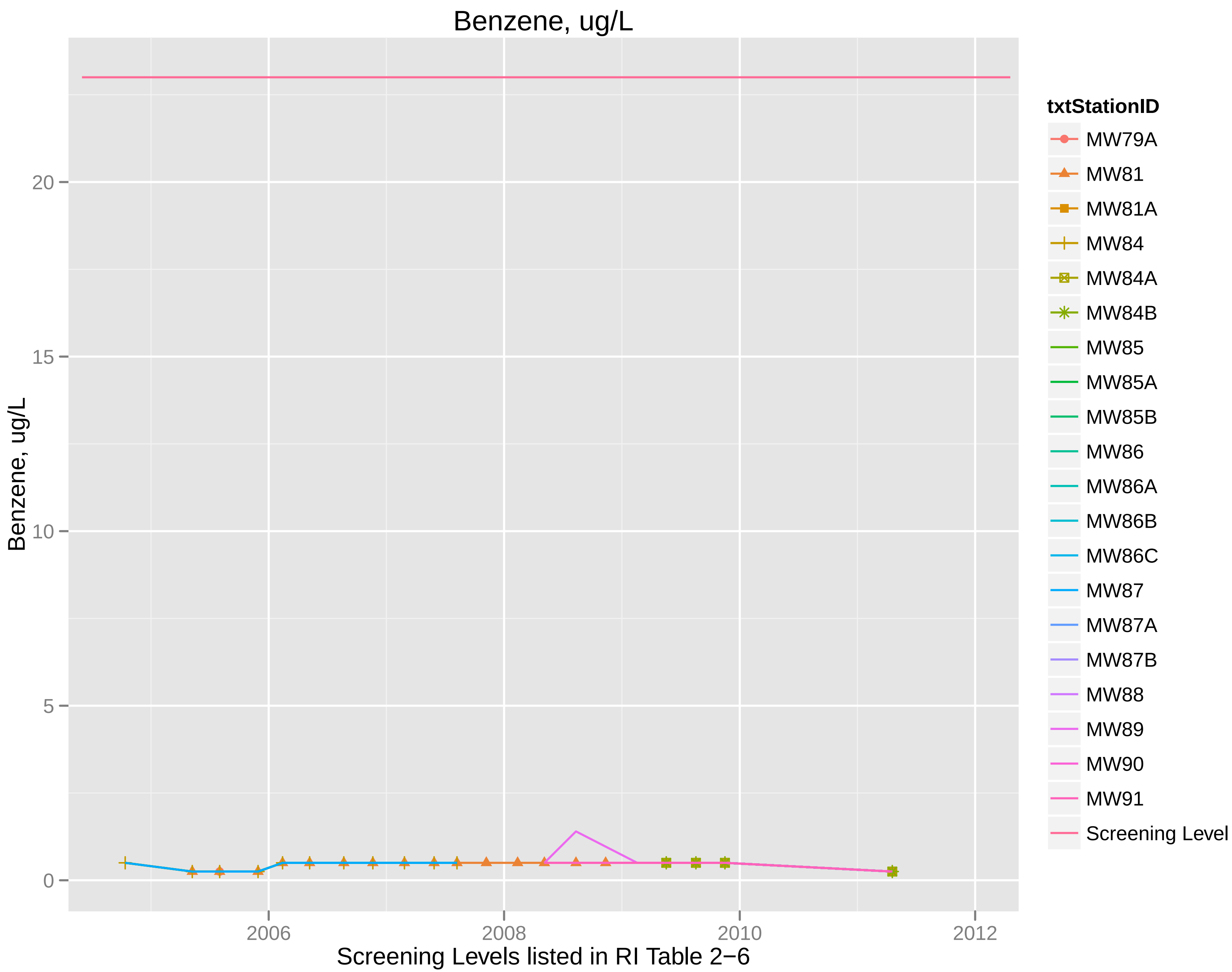
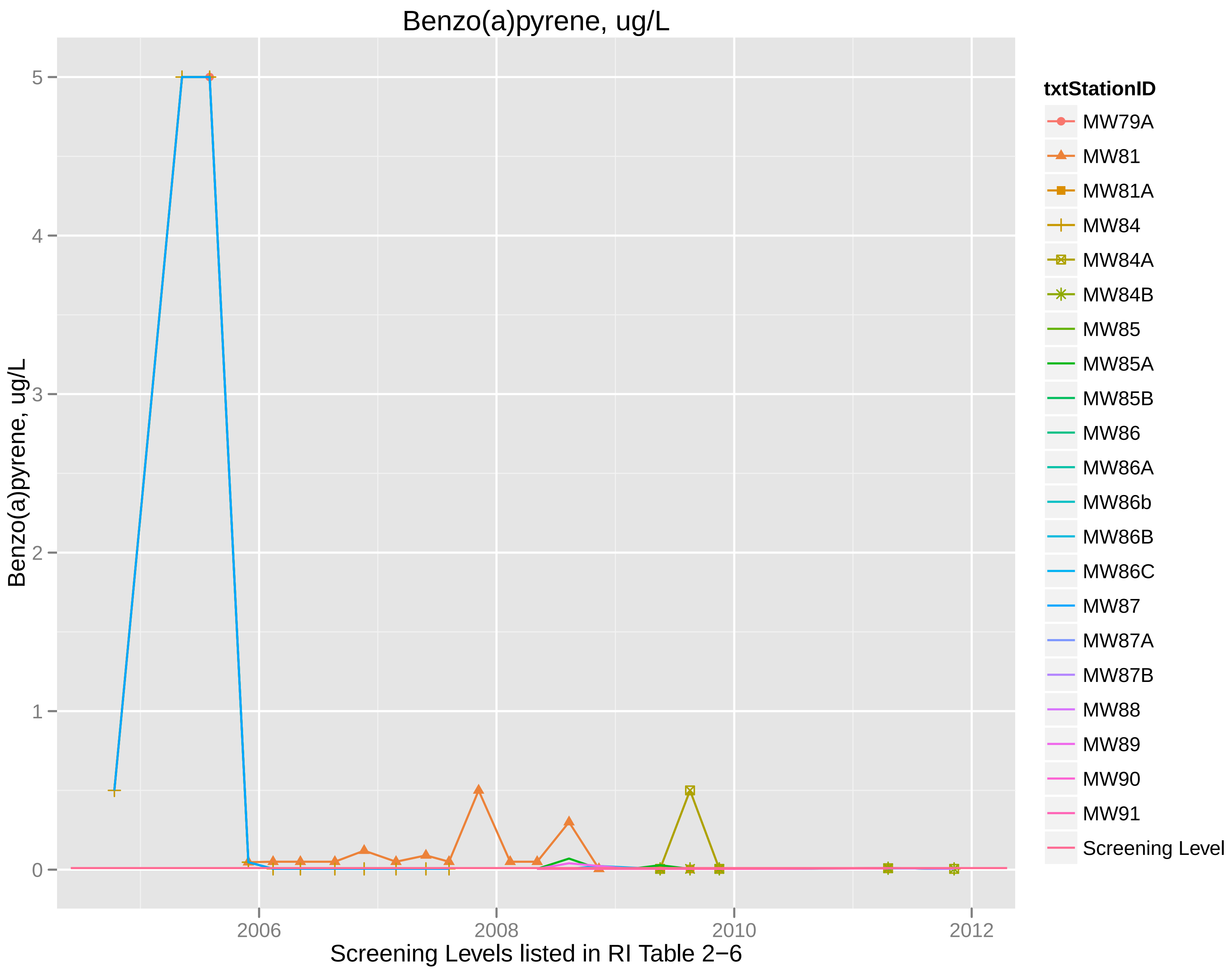
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level

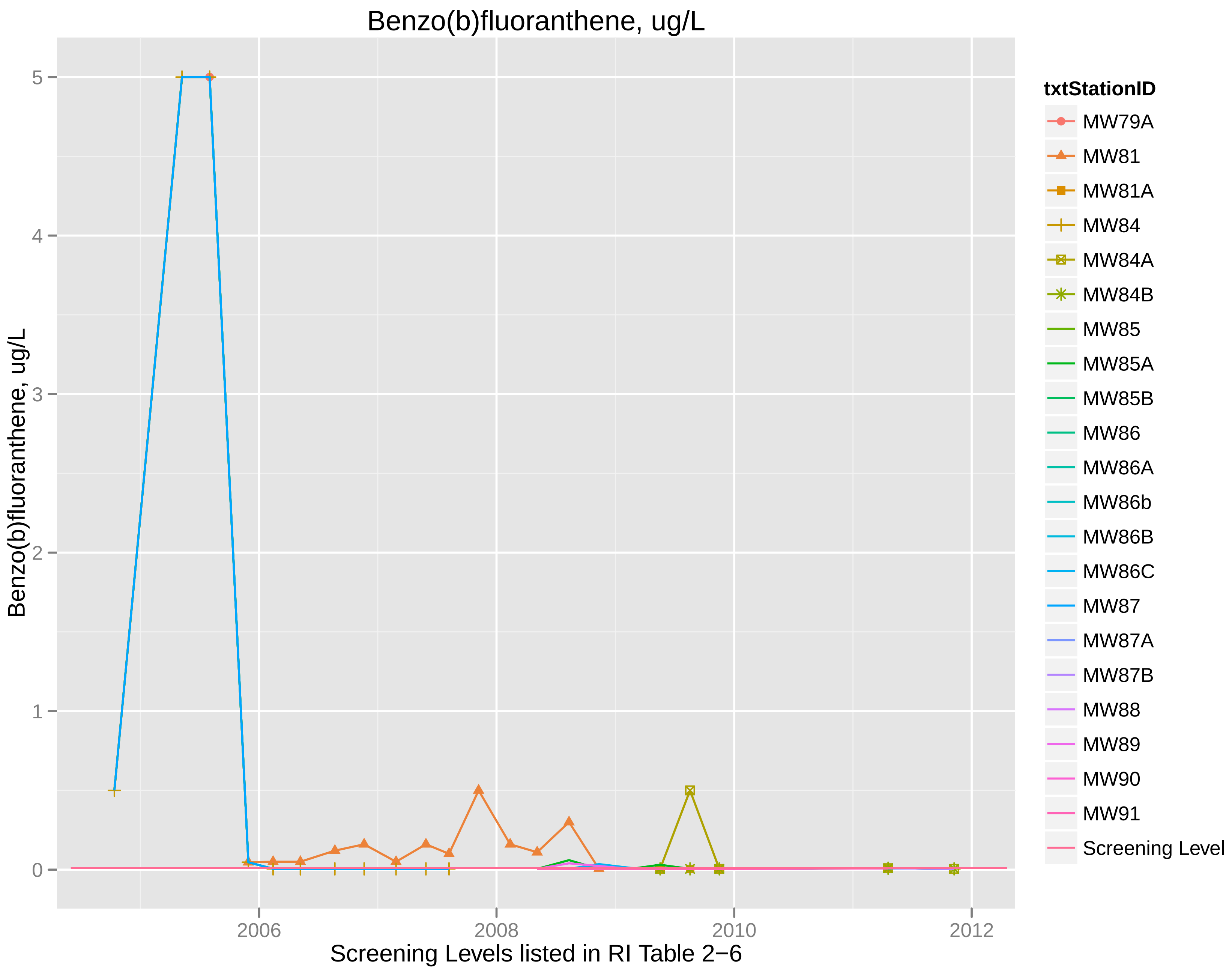

Benz(a)anthracene, ug/L
Benz(a)anthracene, ug/L
0
1
2
3
4
5
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level



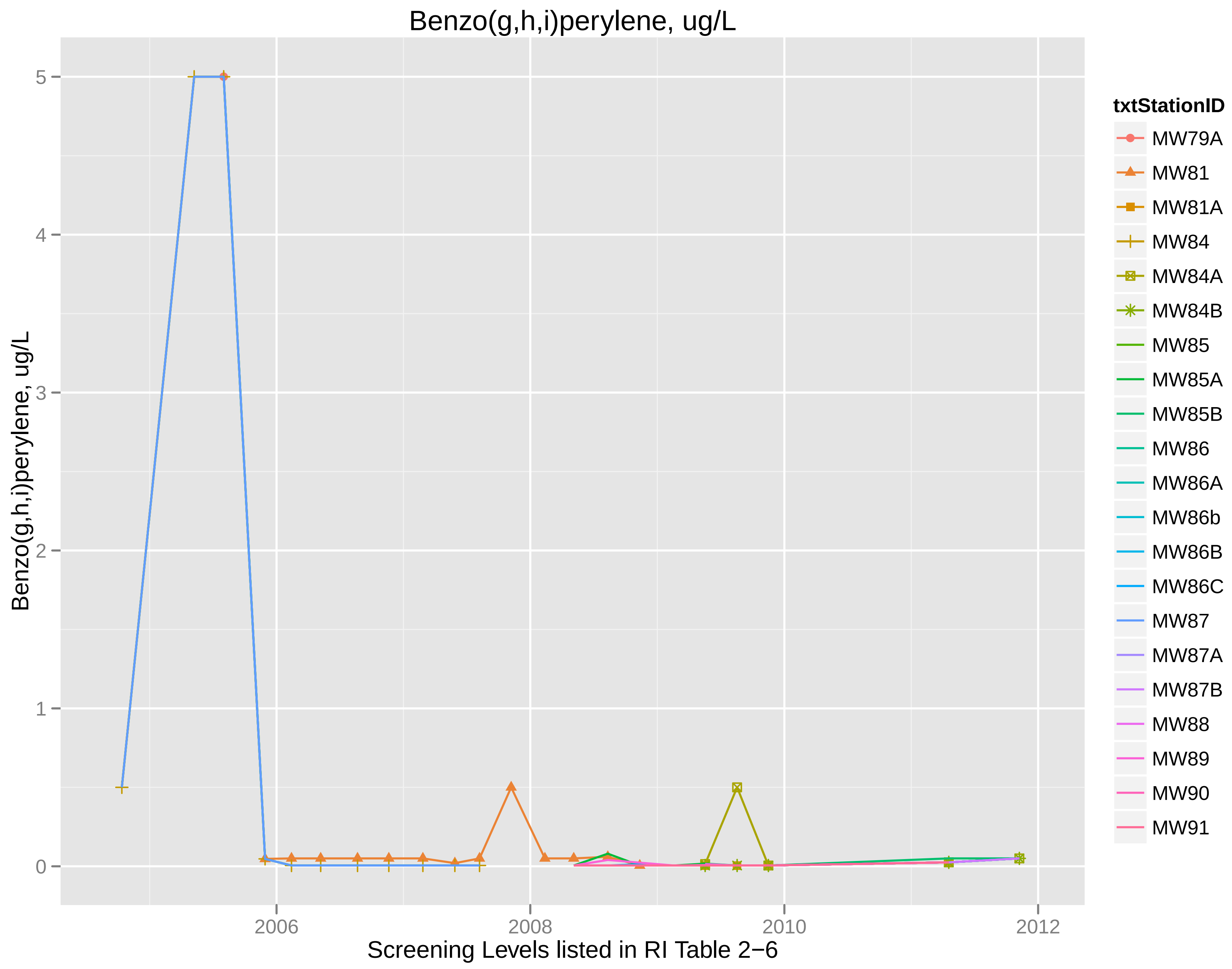
Benzene, ug/L
Benzene, ug/L
20
15
10
5
0
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level



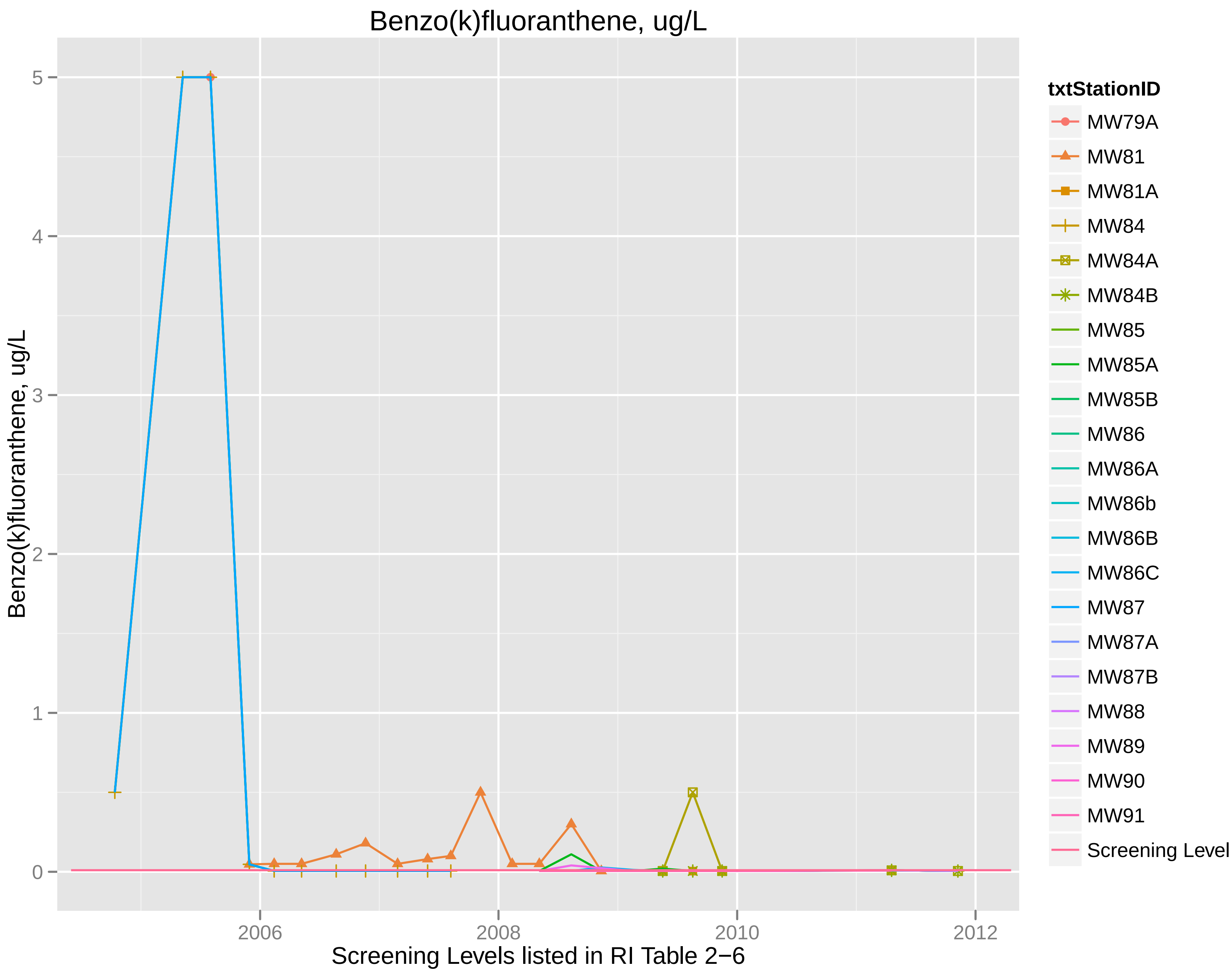
Benzo(a)pyrene, ug/L
Benzo(a)pyrene, ug/L
0
1
2
3
4
5
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level

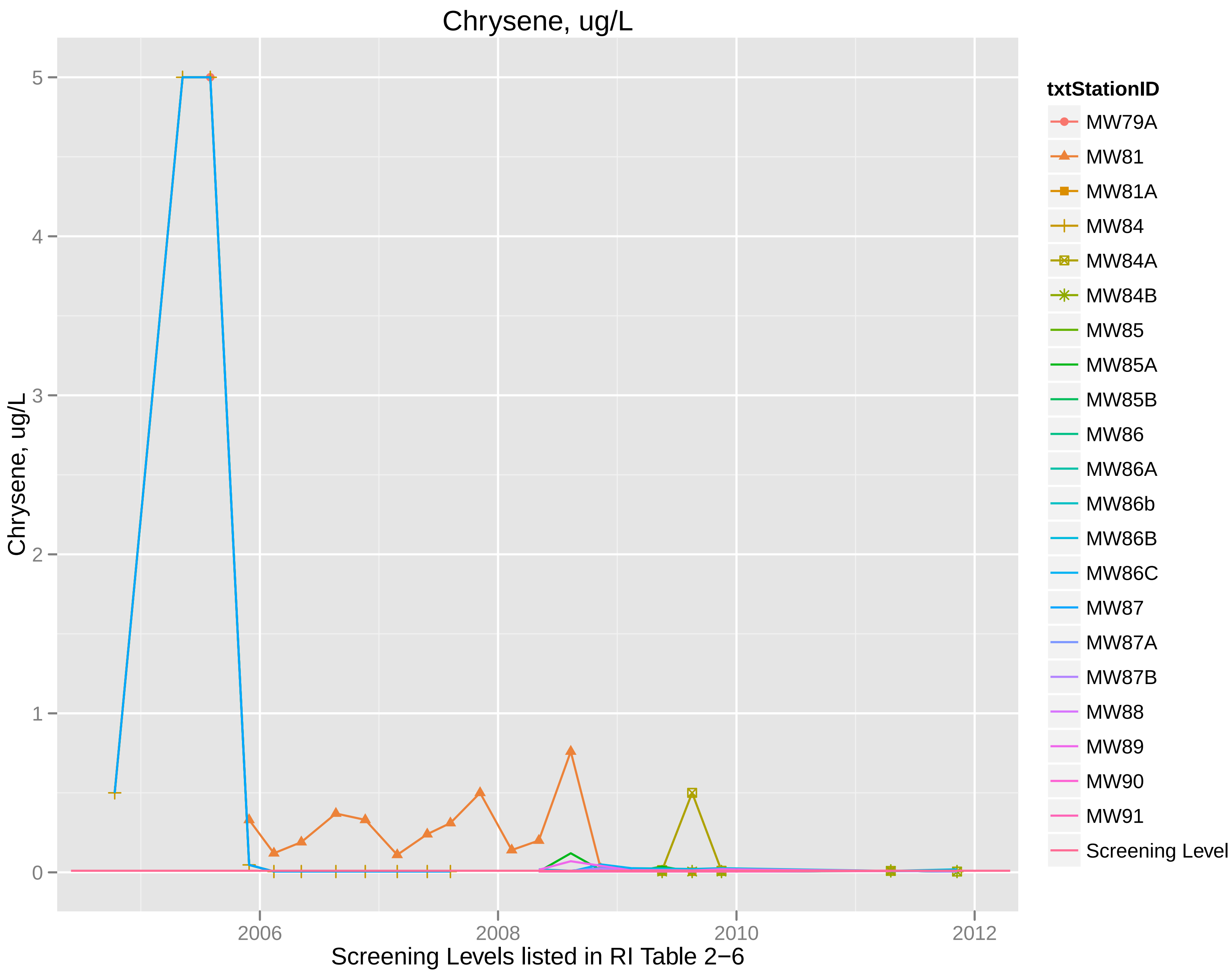


Benzo(b)fluoranthene, ug/L
Benzo(b)fluoranthene, ug/L
0
1
2
3
4
5
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level

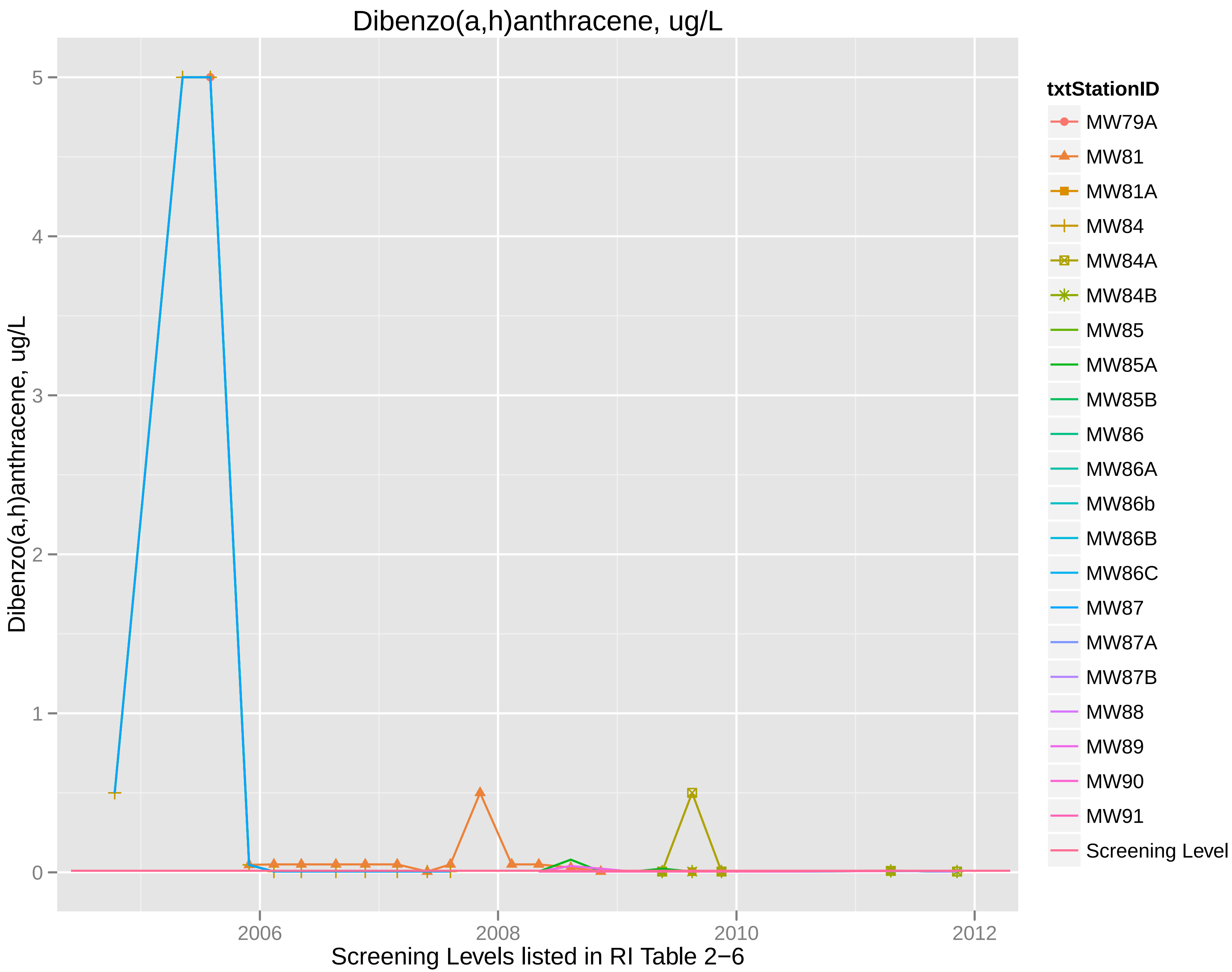


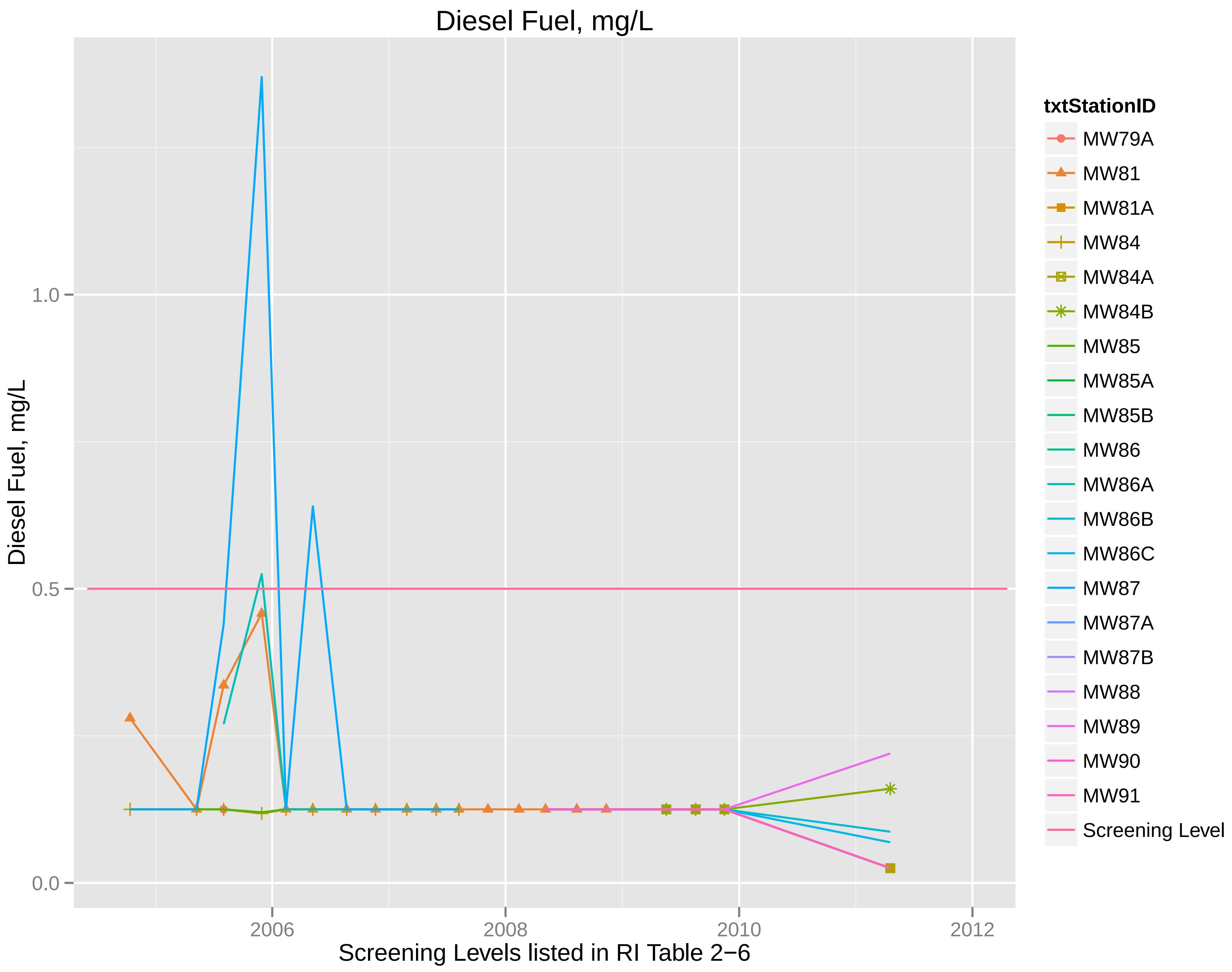
Benzo(g,h,i)perylene, ug/L
Benzo(g,h,i)perylene, ug/L
0
1
2
3
4
5
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91

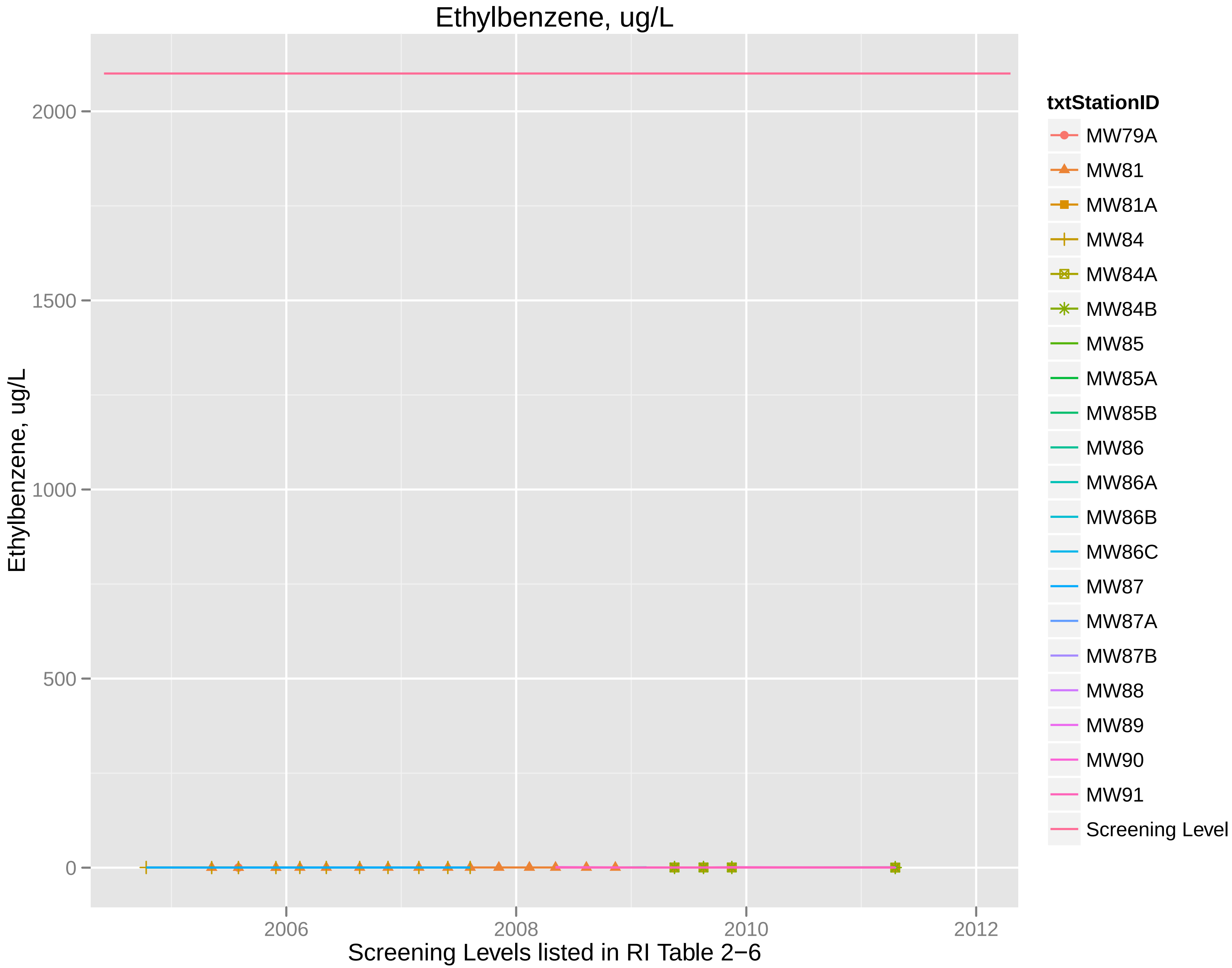

Benzo(k)fluoranthene, ug/L
Benzo(k)fluoranthene, ug/L
0
1
2
3
4
5
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level

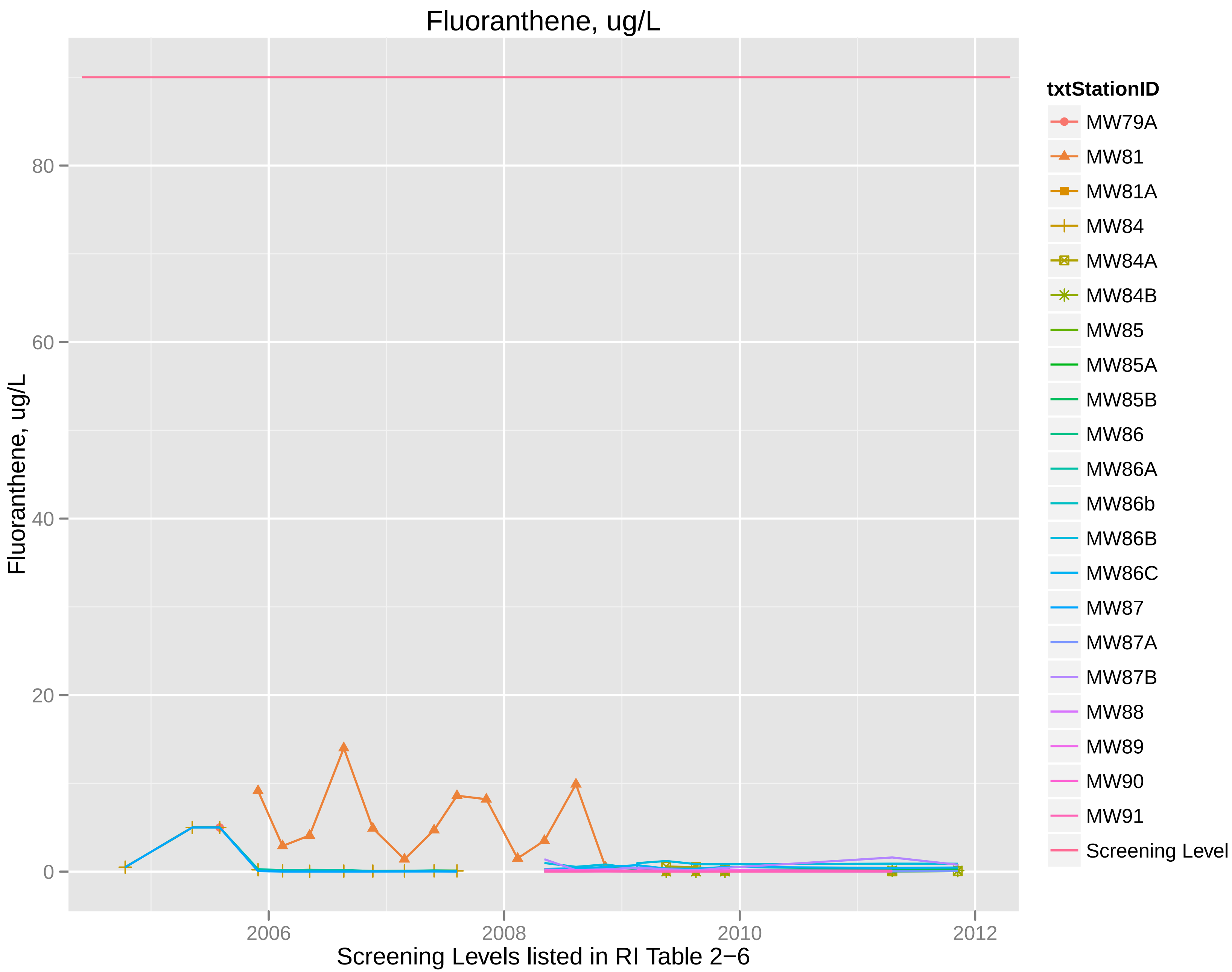


Chrysene, ug/L
Chrysene, ug/L
0
1
2
3
4
5
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level

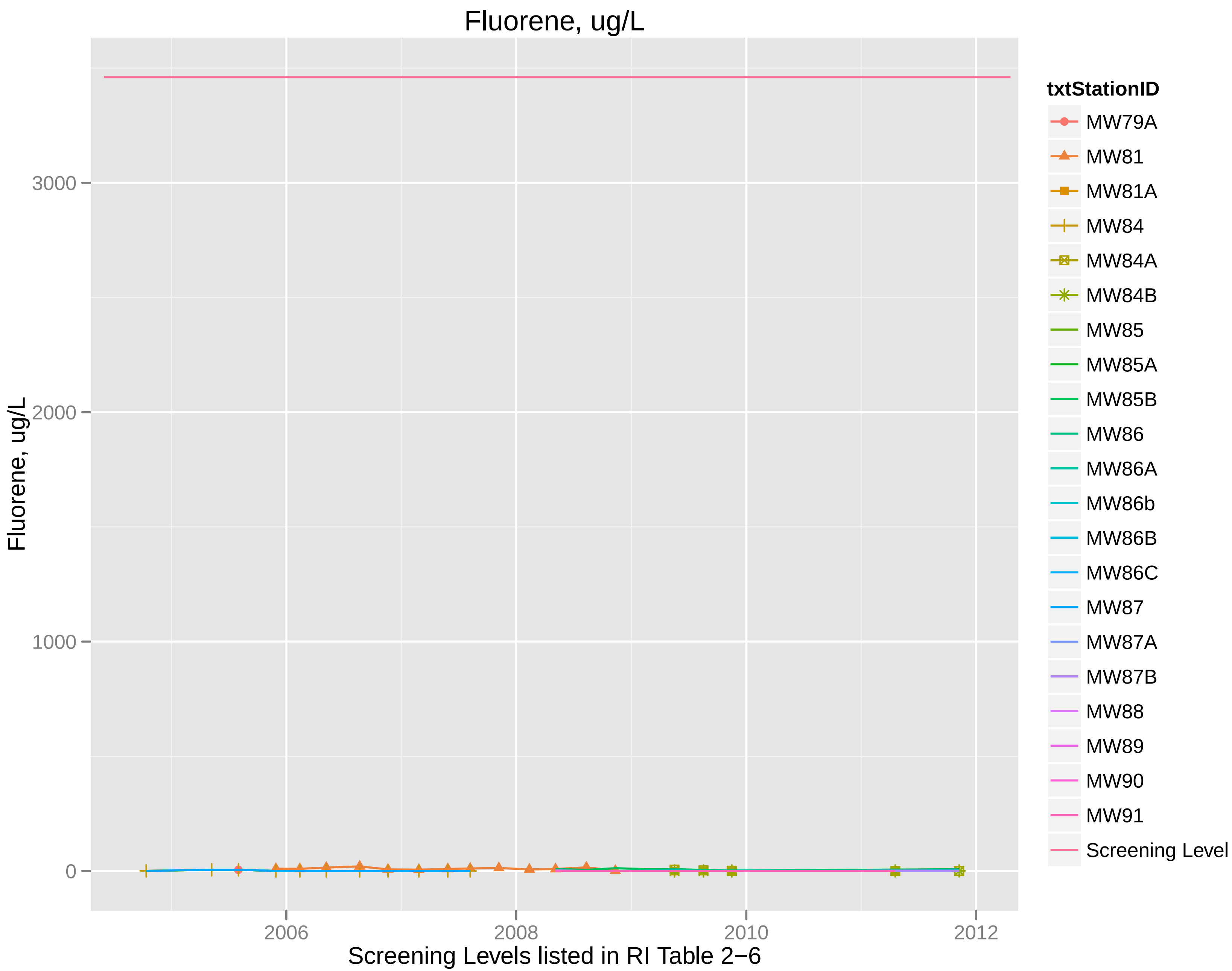

Dibenzo(a,h)anthracene, ug/L
Dibenzo(a,h)anthracene, ug/L
0
1
2
3
4
5
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level


Diesel Fuel, mg/L
Diesel Fuel, mg/L
1.0
0.5
0.0
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level

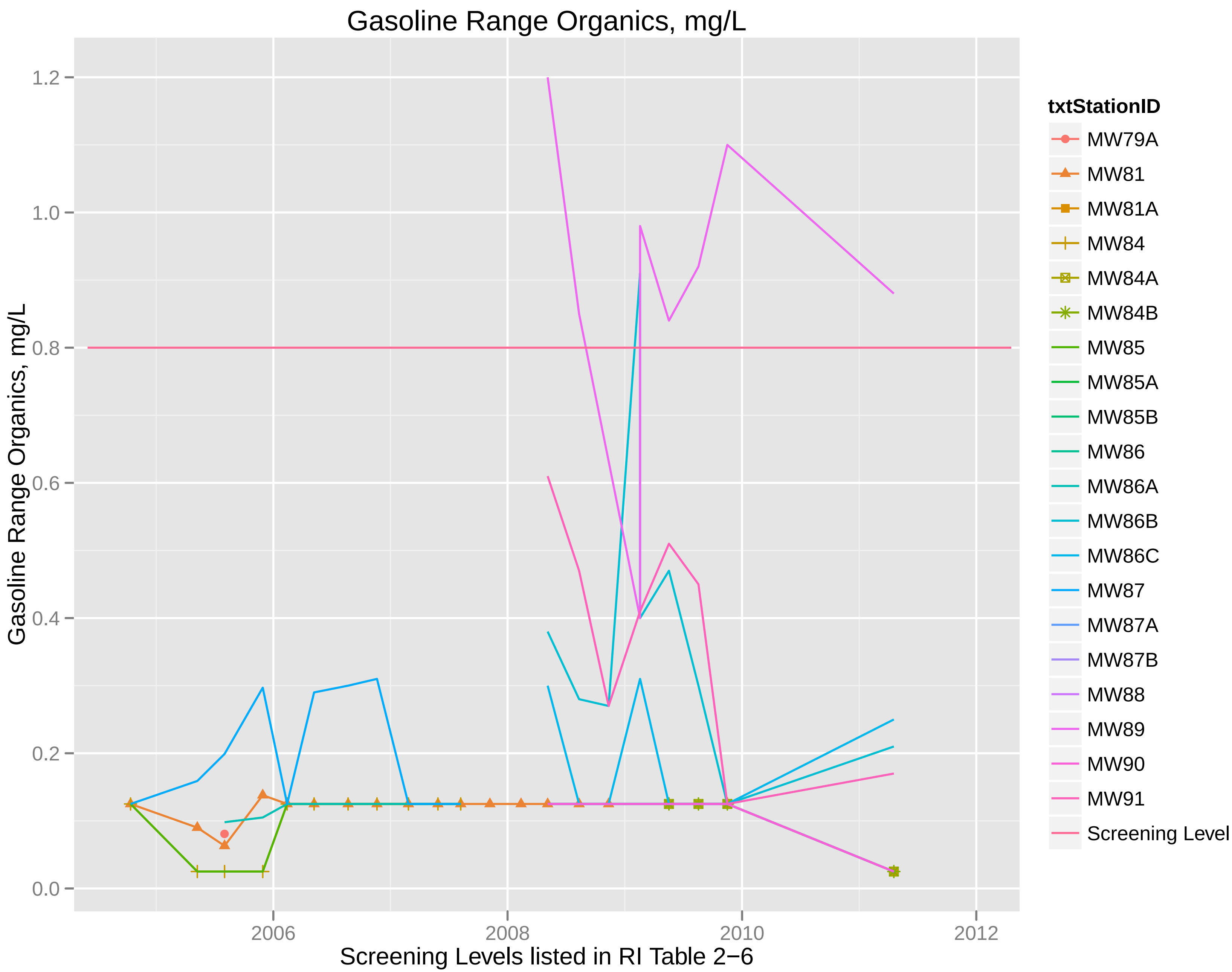

Ethylbenzene, ug/L
Ethylbenzene, ug/L
2000
1500
1000
500
0
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level



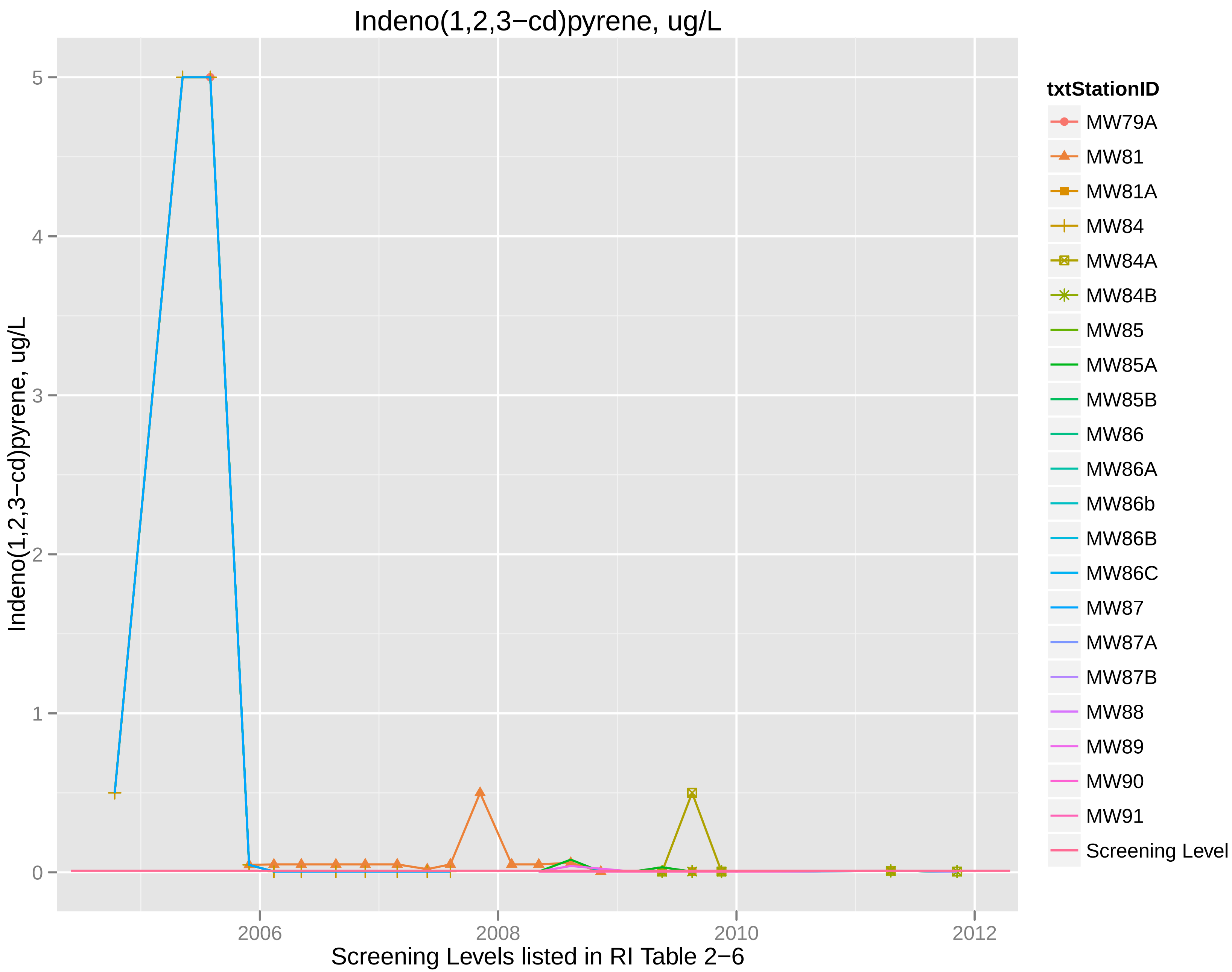
Fluoranthene, ug/L
Fluoranthene, ug/L
80
60
40
20
0
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level



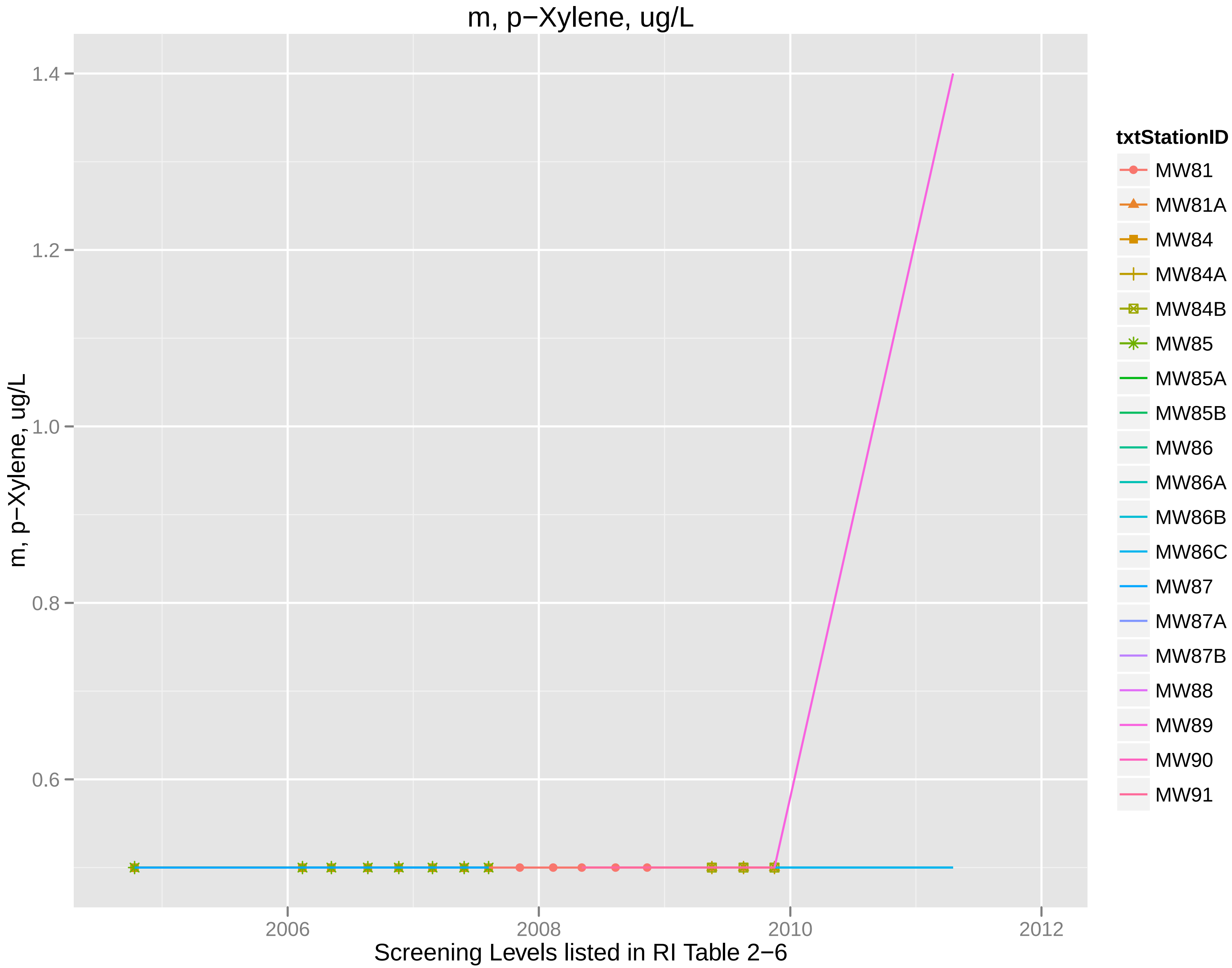
Fluorene, ug/L
Fluorene, ug/L
3000
2000
1000
0
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level

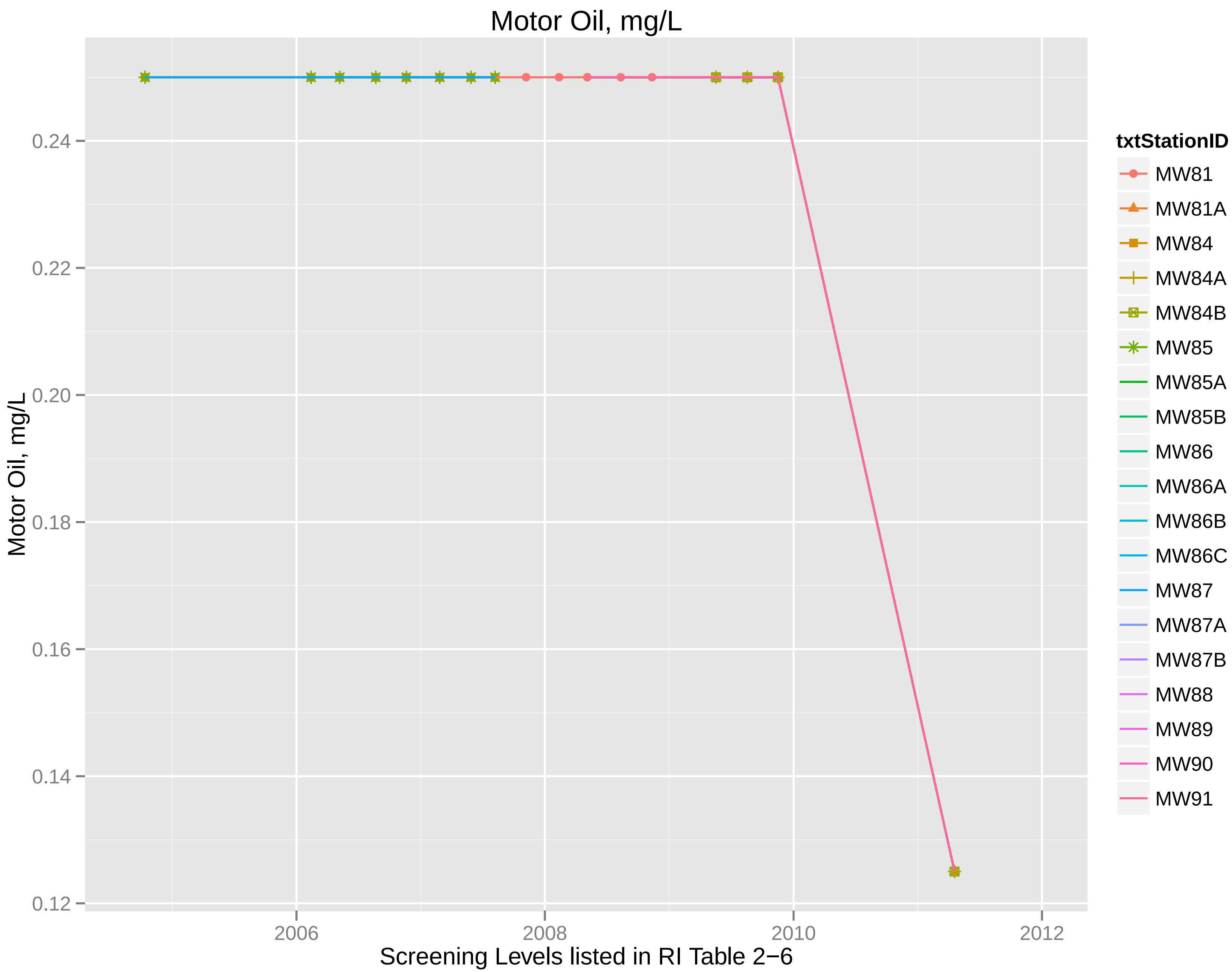


Gasoline Range Organics, mg/L
Gasoline Range Organics, mg/L
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level

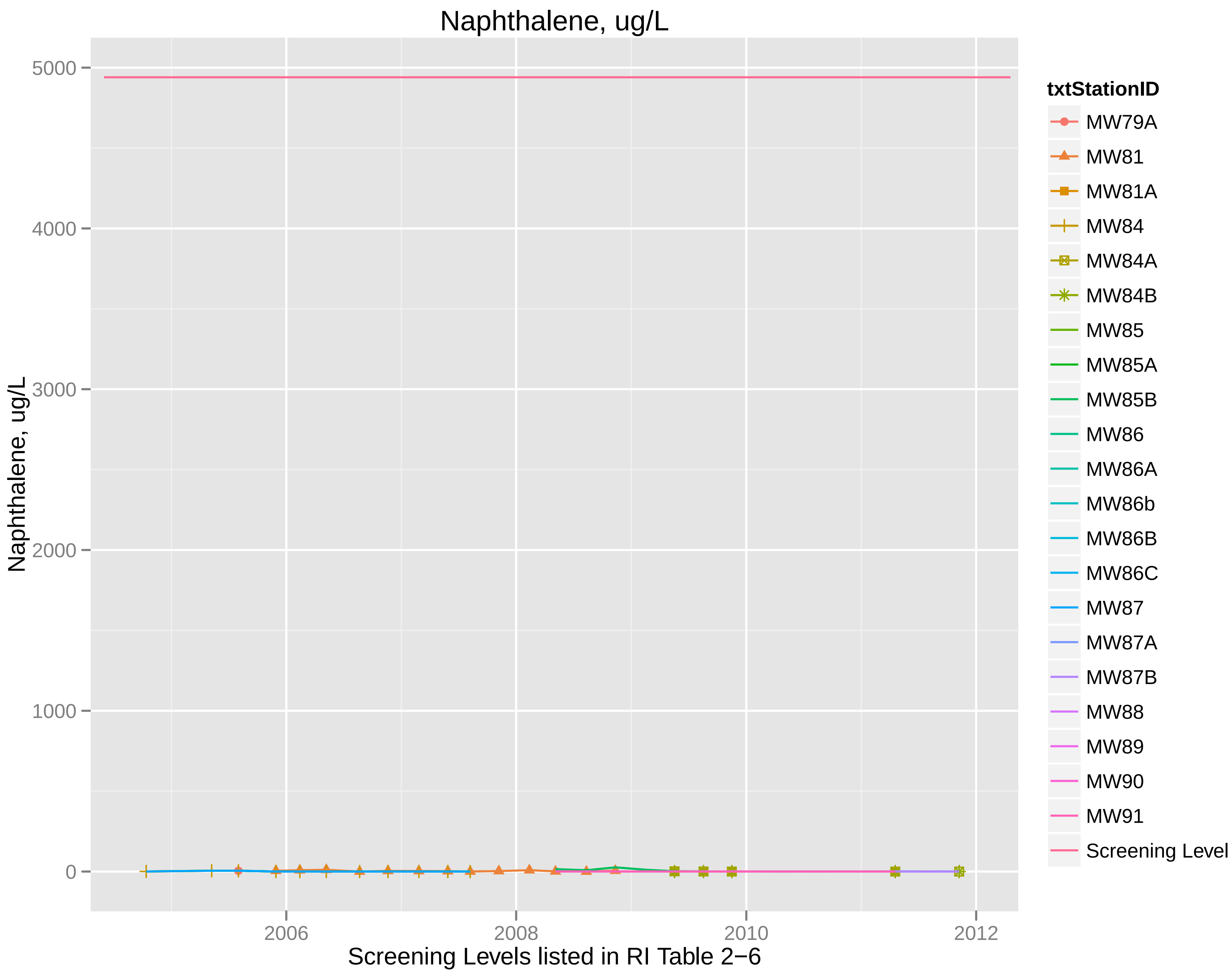


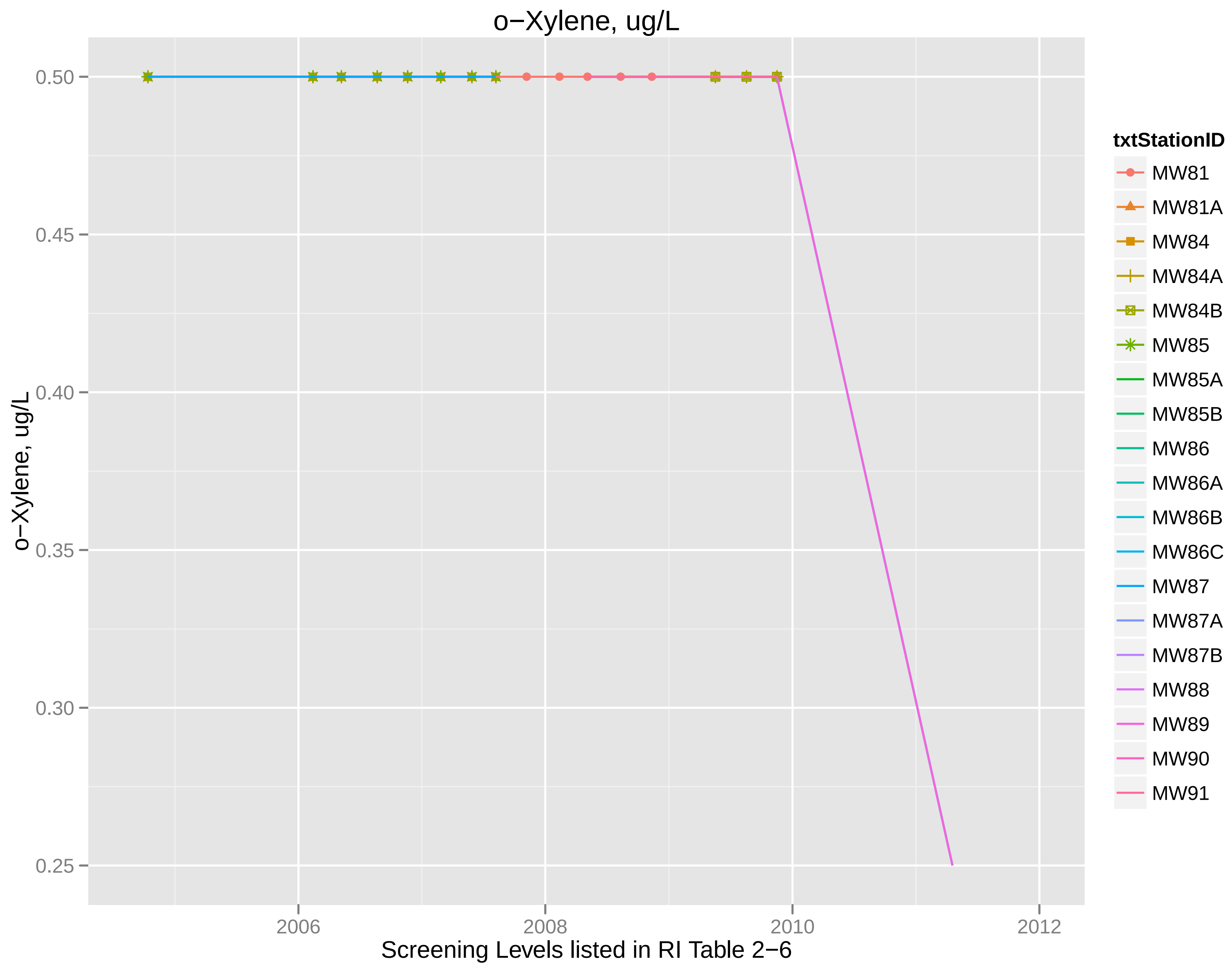
Indeno(1,2,3−cd)pyrene, ug/L
Indeno(1,2,3−cd)pyrene, ug/L
0
1
2
3
4
5
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level


m, p−Xylene, ug/L
m, p−Xylene, ug/L
1.4
1.2
1.0
0.8
0.6
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91

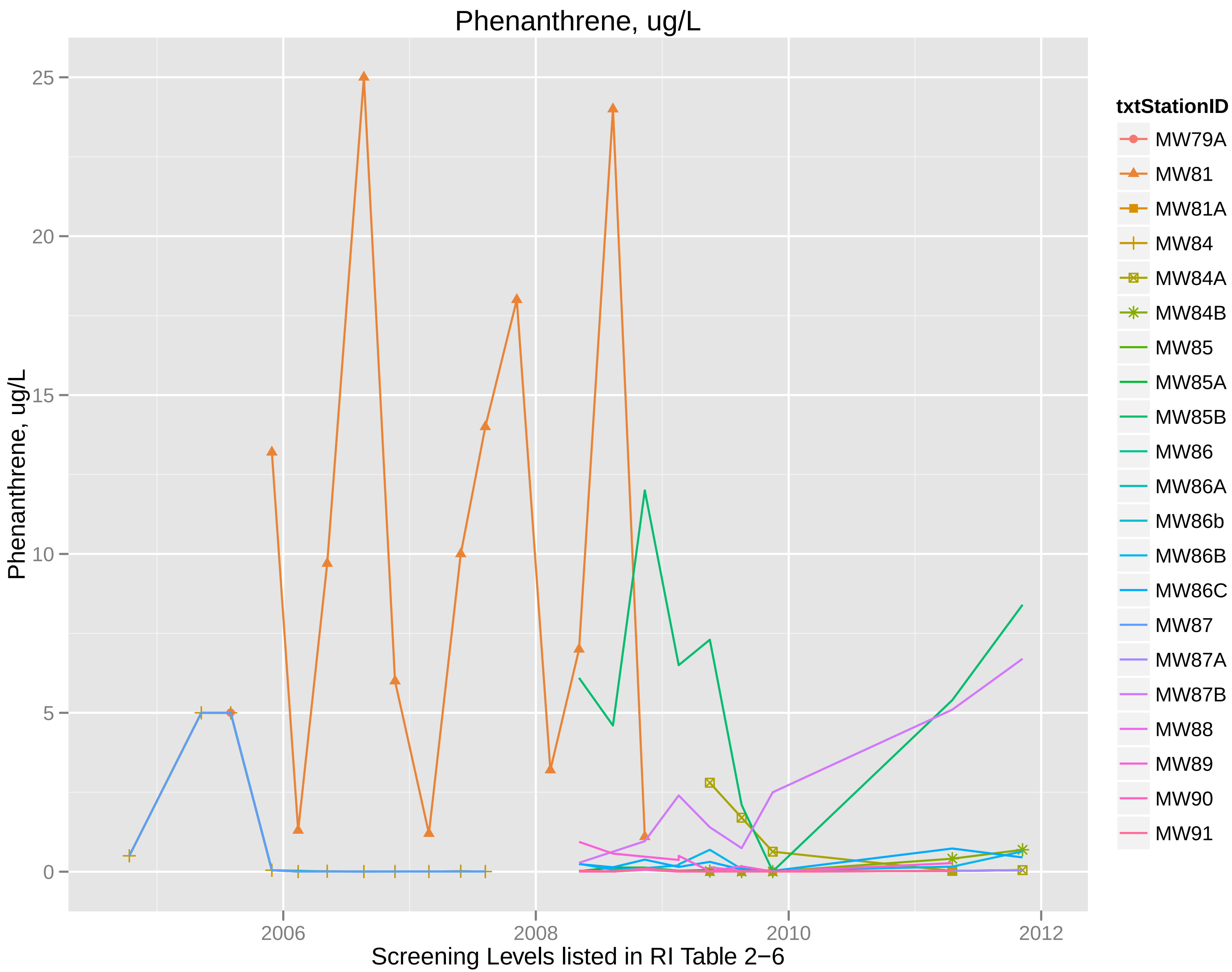


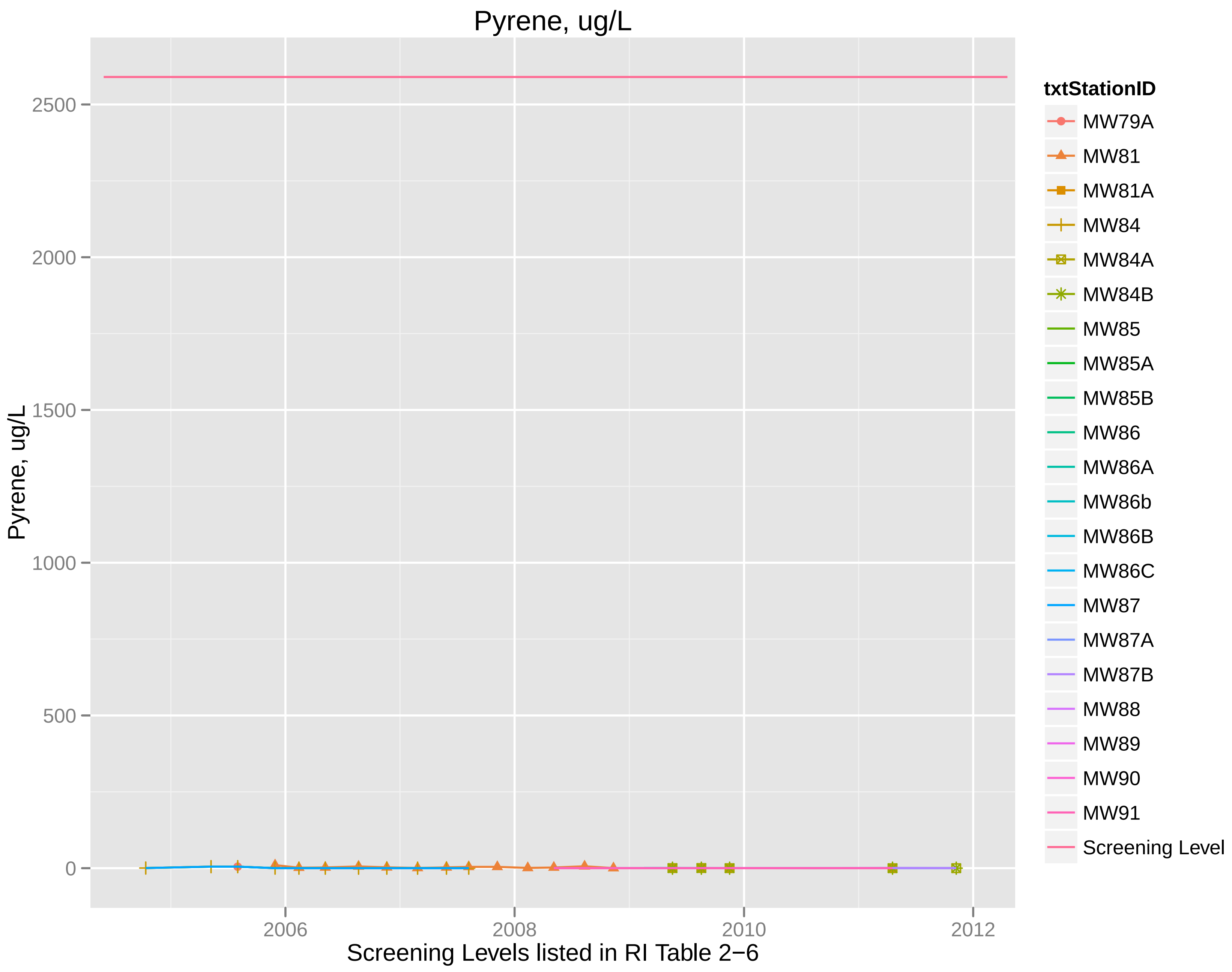
Motor Oil, mg/L
Motor Oil, mg/L
0.24
0.22
0.20
0.18
0.16
0.14
0.12
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91


Naphthalene, ug/L
Naphthalene, ug/L
5000
4000
3000
2000
1000
0
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level

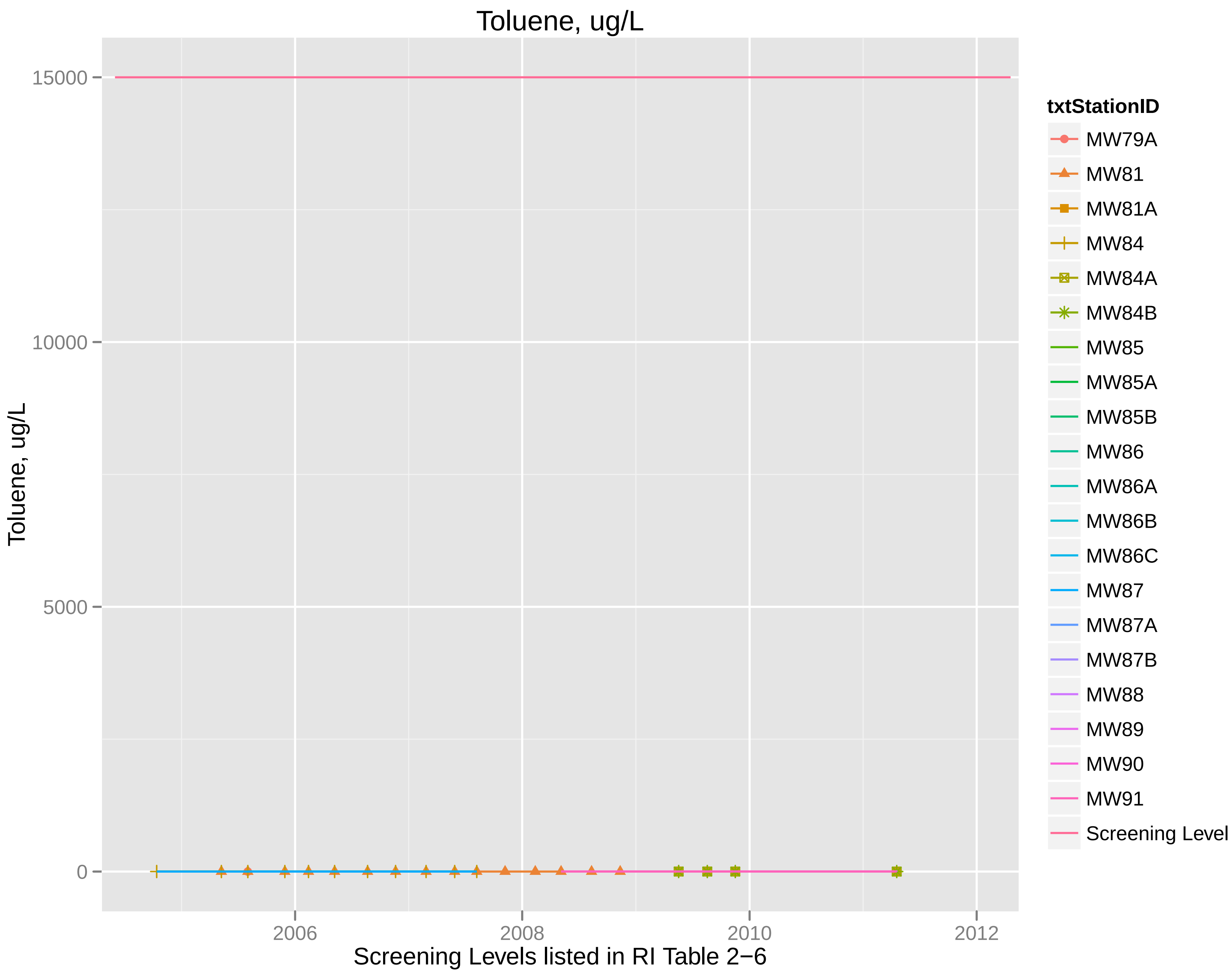


o−Xylene, ug/L
o−Xylene, ug/L
0.50
0.45
0.40
0.35
0.30
0.25
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91

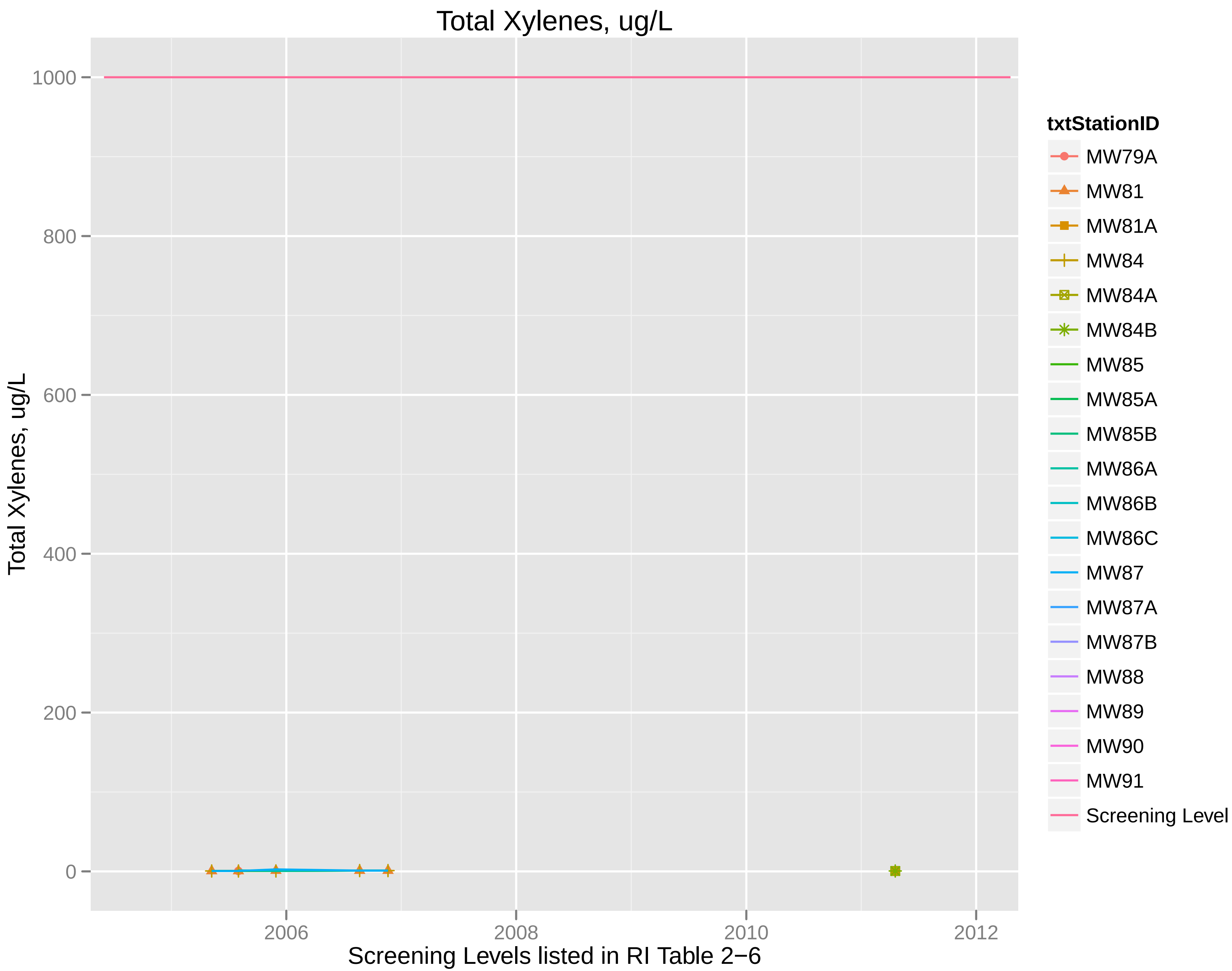

Phenanthrene, ug/L
Phenanthrene, ug/L
0
5
10
15
20
25
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91



Pyrene, ug/L
Pyrene, ug/L
0
500
1000
1500
2000
2500
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86b
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level



Toluene, ug/L
15000
10000
5000
0
Toluene, ug/L
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86
MW86A
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level



Total Xylenes, ug/L
Total Xylenes, ug/L
1000
800
600
400
200
0
2006
2008
2010
2012
Screening Levels listed in RI Table 2−6
txtStationID
MW79A
MW81
MW81A
MW84
MW84A
MW84B
MW85
MW85A
MW85B
MW86A
MW86B
MW86C
MW87
MW87A
MW87B
MW88
MW89
MW90
MW91
Screening Level

APPENDIX G: STABILITY ANALYSIS CALCULATION SHEETS

Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*South Monitoring Wells*

Analyte? **Benzene**

Level of Confidence (Decision Criteria)? **85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is ug/L)					
Sampling Event	Date Sampled	MW45	MW46	MW81A	MW88		SW ARAR = 23
#1	5/8/2006	0.5	0.5				23
#2	8/22/2006	0.5	0.5				23
#3	11/20/2006	0.5	0.5				23
#4	2/26/2007	0.5	0.5				23
#5	5/29/2007	0.5	0.5				23
#6	8/8/2007	0.5	0.5				23
#7	11/7/2007	0.5	0.5				23
#8	2/12/2008	0.5	0.5				23
#9	5/5/2008	0.5	0.5				23
#10	8/11/2008	0.5	0.5				23
#11	11/11/2008	0.5	0.5				23
#12	2/17/2009	0.5	0.5				23
#13	5/18/2009	0.5	0.5	0.5	0.5		23
#14	8/18/2009	0.5	0.5	0.5	0.5		23
#15	11/16/2009	0.5	0.5	0.5	0.5		23
#16	4/19/2011	0.25	0.25	0.25	0.25		23

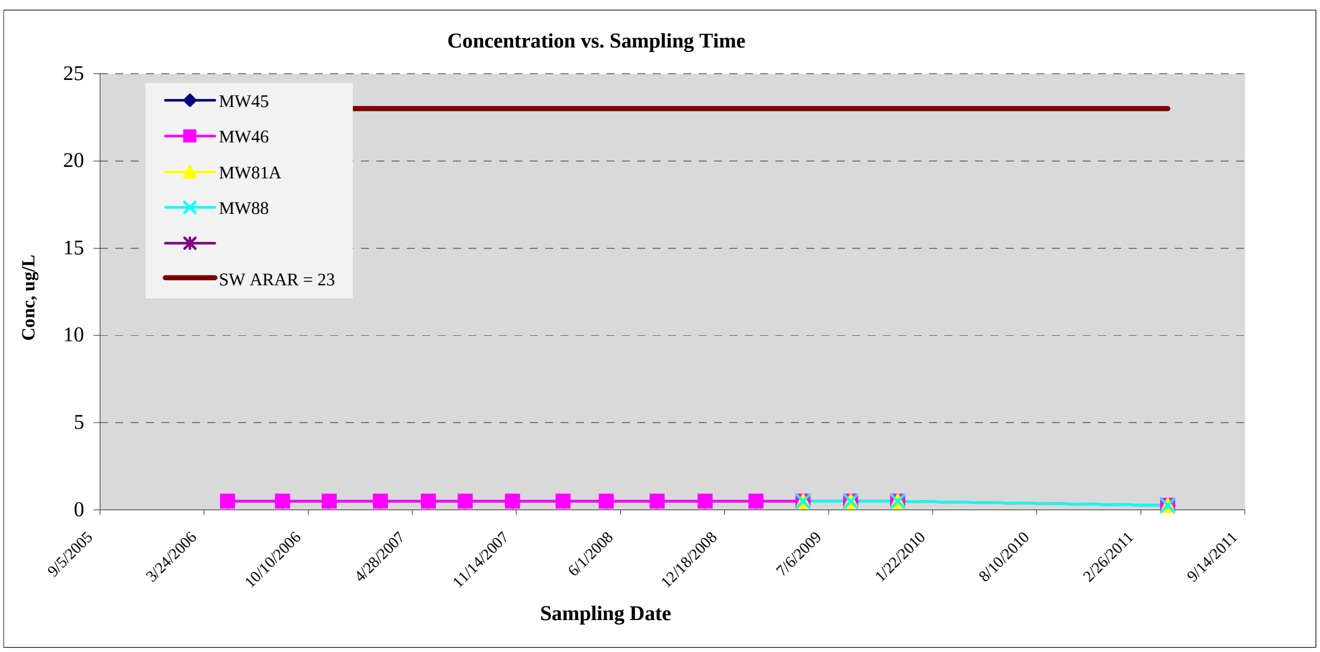
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW45**	**MW46**	**MW81A**	**MW88**		**SW ARAR = 23**
Confidence Level Calculated?	71.80%	71.80%	62.50%	62.50%		
Plume Stability?	Stable	Stable	Stable	Stable		
Coefficient of Variation?	CV <= 1	CV <= 1	CV <= 1	CV <= 1		
Mann-Kendall Statistic "S" value?	-15	-15	-3	-3		
Number of Sampling Rounds?	16	16	4	4		
Average Concentration?	0.48	0.48	0.44	0.44		
Standard Deviation?	0.06	0.06	0.13	0.13		
Coefficient of Variation?	0.13	0.13	0.29	0.29		
Blank if No Errors found						n<4

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*North Monitoring Wells*

Analyte? **Benzene**

Level of Confidence (Decision Criteria)? **85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is ug/L)					
Sampling Event	Date Sampled	MW42	MW52A	MW76A	MW90	MW91	SW ARAR = 23
#1	5/8/2006	**880**					23
#2	8/22/2006	**500**	0.5				23
#3	11/20/2006	**540**	0.5				23
#4	2/26/2007	**530**	0.5				23
#5	5/29/2007	**160**	0.5				23
#6	8/8/2007	**240**	0.5				23
#7	11/7/2007	**450**	0.5				23
#8	2/12/2008	16	0.5				23
#9	5/5/2008	**190**	0.5	0.5	0.5	0.5	23
#10	8/11/2008	**150**	0.5	0.5	0.5	0.5	23
#11	11/11/2008	**34**	0.5	0.5	0.5	0.5	23
#12	2/17/2009	**100**	0.5	0.5	0.5	0.5	23
#13	5/18/2009	**210**	0.5	0.5	0.5	0.5	23
#14	8/18/2009	**360**	0.5	0.5	0.5	0.5	23
#15	11/16/2009	**52**	0.5	0.5	0.5	0.5	23
#16	4/19/2011	**83**	0.25	0.25	0.25	0.25	23

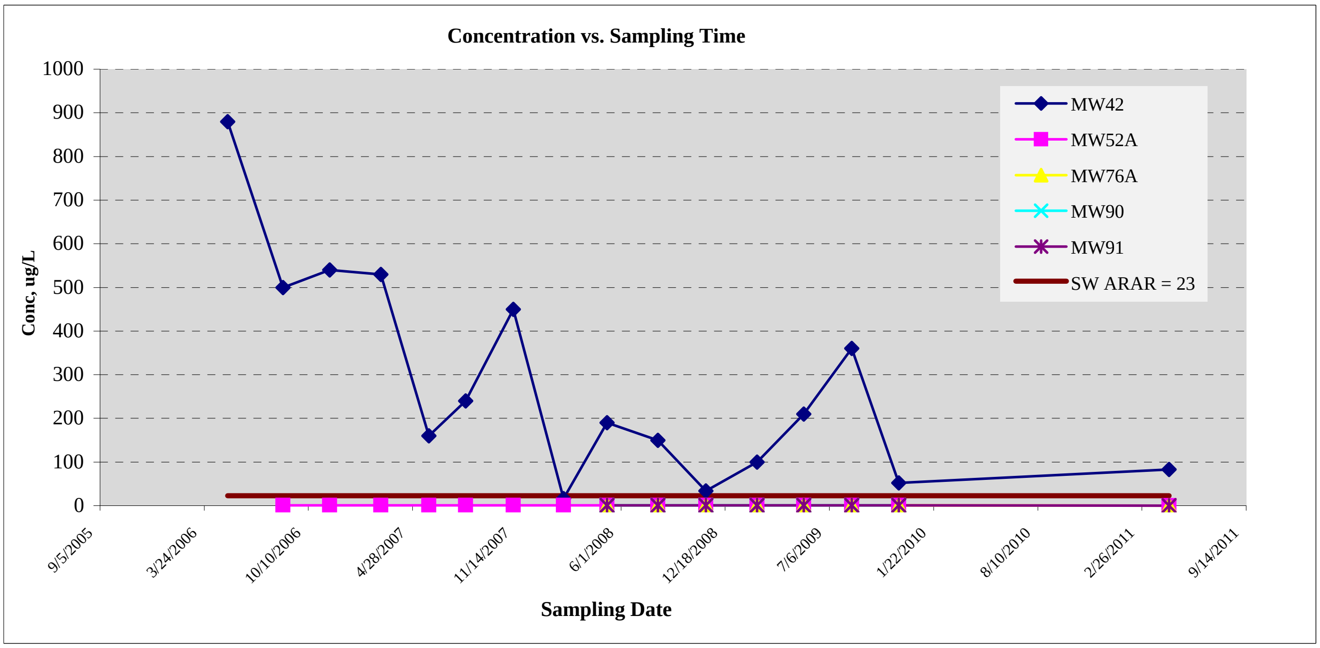
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW42**	**MW52A**	**MW76A**	**MW90**	**MW91**	**SW ARAR = 23**
Confidence Level Calculated?	99.70%	72.10%	72.60%	72.60%	72.60%	
Plume Stability?	Shrinking	Stable	Stable	Stable	Stable	
Coefficient of Variation?		CV <= 1	CV <= 1	CV <= 1	CV <= 1	
Mann-Kendall Statistic "S" value?	-60	-14	-7	-7	-7	
Number of Sampling Rounds?	16	15	8	8	8	
Average Concentration?	280.94	0.48	0.47	0.47	0.47	
Standard Deviation?	241.26	0.06	0.09	0.09	0.09	
Coefficient of Variation?	0.86	0.13	0.19	0.19	0.19	
Blank if No Errors found						n<4

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*Nearshore South Monitoring Wells*

Analyte?	**Benzene**
Level of Confidence (Decision Criteria)?	**85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is ug/L)					
Sampling Event	Date Sampled	MW58	MW84A	MW84B	MW85A	MW85B	SW ARAR = 23
#1	5/8/2006	0.5					23
#2	8/22/2006	0.5					23
#3	11/20/2006	0.5					23
#4	2/26/2007	0.5					23
#5	5/29/2007	0.5					23
#6	8/8/2007	0.5					23
#7	11/7/2007	0.5					23
#8	2/12/2008	0.5					23
#9	5/5/2008	0.5			0.5	0.5	23
#10	8/11/2008	0.5			0.5	0.5	23
#11	11/11/2008	0.5			0.5	0.5	23
#12	2/17/2009	0.5			0.5	0.5	23
#13	5/18/2009	0.5	0.5	0.5	0.5	0.5	23
#14	8/18/2009	0.5	0.5	0.5	0.5	0.5	23
#15	11/16/2009	0.5	0.5	0.5	0.5	0.5	23
#16	4/19/2011	0.25	0.25	0.25	0.25	0.25	23

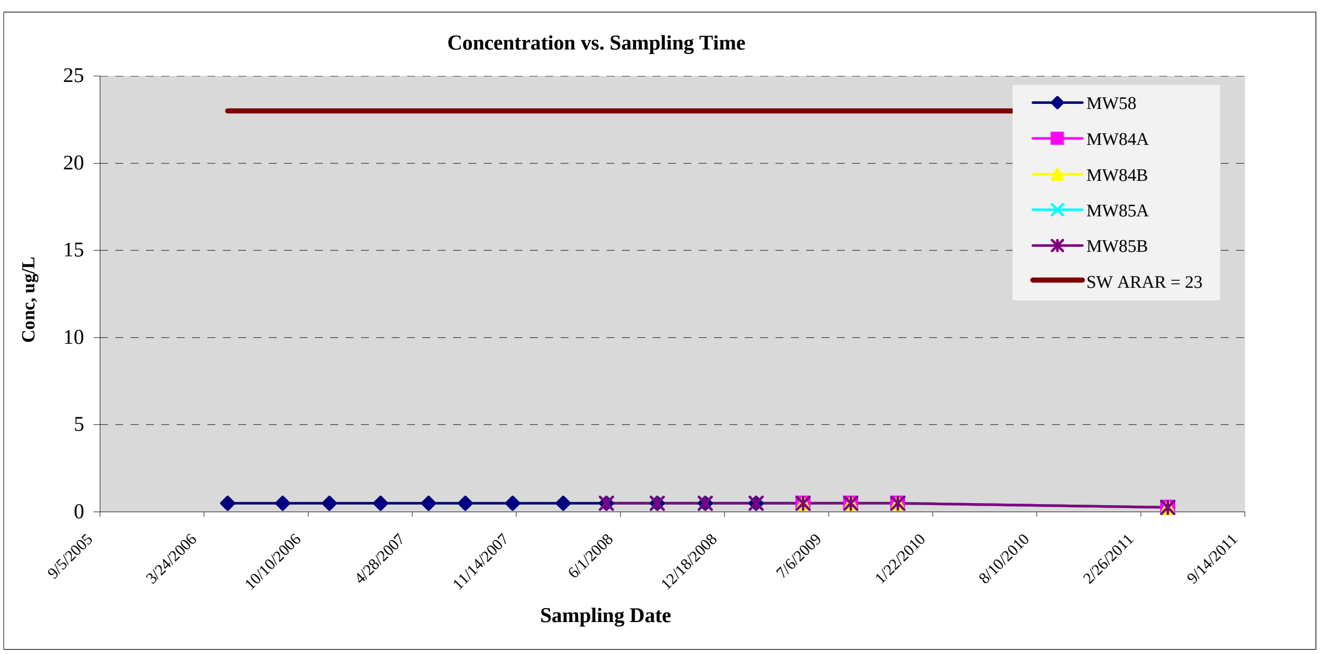
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW58**	**MW84A**	**MW84B**	**MW85A**	**MW85B**	**SW ARAR = 23**
Confidence Level Calculated?	71.80%	62.50%	62.50%	72.60%	45.20%	
Plume Stability?	Stable	Stable	Stable	Stable	Stable	
Coefficient of Variation?	CV <= 1	CV <= 1	CV <= 1	CV <= 1	CV <= 1	
Mann-Kendall Statistic "S" value?	-15	-3	-3	-7	0	
Number of Sampling Rounds?	16	4	4	8	8	
Average Concentration?	0.48	0.44	0.44	0.47	0.47	
Standard Deviation?	0.06	0.13	0.13	0.09	0.09	
Coefficient of Variation?	0.13	0.29	0.29	0.19	0.19	
Blank if No Errors found						

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*Nearshore North Monitoring Wells*

Analyte?	**Benzene**
Level of Confidence (Decision Criteria)?	**85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is ug/L)					
Sampling Event	Date Sampled	MW86B	MW86C	MW87A	MW87B	MW89	SW ARAR = 23
#1	5/8/2006						23
#2	8/22/2006						23
#3	11/20/2006						23
#4	2/26/2007						23
#5	5/29/2007						23
#6	8/8/2007						23
#7	11/7/2007						23
#8	2/12/2008						23
#9	5/5/2008	0.5	0.5	0.5	0.5	0.5	23
#10	8/11/2008	0.5	0.5	0.5	0.5	1.4	23
#11	11/11/2008	0.5	0.5	0.5	0.5		23
#12	2/17/2009	0.5	0.5	0.5	0.5	0.5	23
#13	5/18/2009	0.5	0.5	0.5	0.5	0.5	23
#14	8/18/2009	0.5	0.5	0.5	0.5	0.5	23
#15	11/16/2009	0.5	0.5	0.5	0.5	0.5	23
#16	4/19/2011	0.25	0.25	0.25	0.25	0.25	23

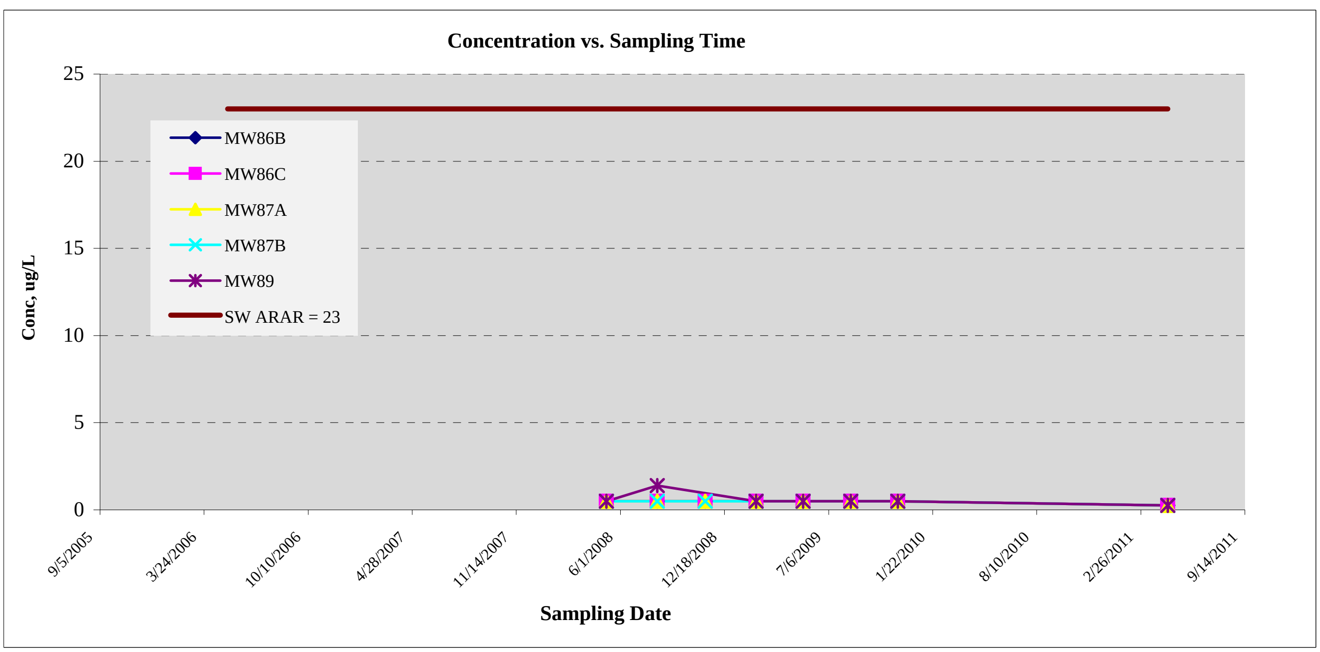
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW86B**	**MW86C**	**MW87A**	**MW87B**	**MW89**	**SW ARAR = 23**
Confidence Level Calculated?	72.60%	72.60%	72.60%	72.60%	88.10%	
Plume Stability?	Stable	Stable	Stable	Stable	Shrinking	
Coefficient of Variation?	CV <= 1	CV <= 1	CV <= 1	CV <= 1		
Mann-Kendall Statistic "S" value?	-7	-7	-7	-7	-9	
Number of Sampling Rounds?	8	8	8	8	7	
Average Concentration?	0.47	0.47	0.47	0.47	0.59	
Standard Deviation?	0.09	0.09	0.09	0.09	0.37	
Coefficient of Variation?	0.19	0.19	0.19	0.19	0.62	
Blank if No Errors found						

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*South Monitoring Wells*

Analyte? **Diesel Range Organics**

Level of Confidence (Decision Criteria)? **85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is ug/L)					
Sampling Event	Date Sampled	MW45	MW46	MW81A	MW88		SW ARAR = 0.5
#1	5/8/2006	0.125	0.125				0.5
#2	8/22/2006	0.125	0.125				0.5
#3	11/20/2006	0.125	0.125				0.5
#4	2/26/2007	0.125	0.125				0.5
#5	5/29/2007	0.125	0.125				0.5
#6	8/8/2007	0.125	0.125				0.5
#7	11/7/2007	0.125	0.125				0.5
#8	2/12/2008	0.125	0.125				0.5
#9	5/5/2008	0.125	0.125				0.5
#10	8/11/2008	0.125	0.125				0.5
#11	11/11/2008	0.125	0.125				0.5
#12	2/17/2009	0.125	0.125				0.5
#13	5/18/2009	0.125	0.125	0.125	0.125		0.5
#14	8/18/2009	0.125	0.125	0.125	0.125		0.5
#15	11/16/2009	0.125	0.125	0.125	0.125		0.5
#16	4/19/2011	0.025	0.025	0.025	0.025		0.5

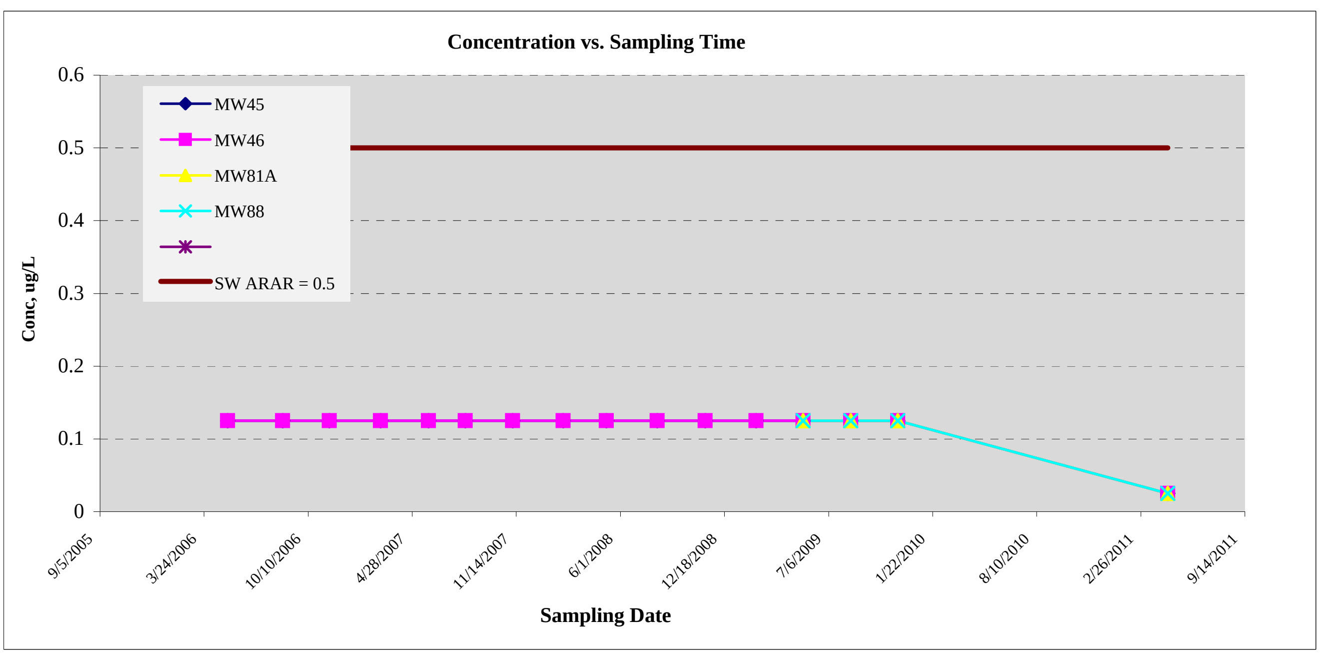
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW45**	**MW46**	**MW81A**	**MW88**		**SW ARAR = 0.5**
Confidence Level Calculated?	71.80%	71.80%	62.50%	62.50%		
Plume Stability?	Stable	Stable	Stable	Stable		
Coefficient of Variation?	CV <= 1	CV <= 1	CV <= 1	CV <= 1		
Mann-Kendall Statistic "S" value?	-15	-15	-3	-3		
Number of Sampling Rounds?	16	16	4	4		
Average Concentration?	0.12	0.12	0.10	0.10		
Standard Deviation?	0.03	0.03	0.05	0.05		
Coefficient of Variation?	0.21	0.21	0.50	0.50		
Blank if No Errors found						n<4

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*North Monitoring Wells*

Analyte? **Diesel Range Organics**

Level of Confidence (Decision Criteria)? **85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is ug/L)					
Sampling Event	Date Sampled	MW42	MW52A	MW76A	MW90	MW91	SW ARAR = 0.5
#1	5/8/2006	0.31					0.5
#2	8/22/2006	0.125	0.125				0.5
#3	11/20/2006	0.125	0.125				0.5
#4	2/26/2007	0.125	0.125				0.5
#5	5/29/2007	0.125	0.125				0.5
#6	8/8/2007	0.125	0.125				0.5
#7	11/7/2007	0.125	0.125				0.5
#8	2/12/2008	0.125	0.75				0.5
#9	5/5/2008	0.125	0.125	0.125	0.125	0.125	0.5
#10	8/11/2008	0.125	0.125	0.125	0.125	0.125	0.5
#11	11/11/2008	0.125	0.125	0.125	0.125	0.125	0.5
#12	2/17/2009	0.125	0.125	0.125	0.125	0.125	0.5
#13	5/18/2009	0.125	0.125	0.125	0.125	0.125	0.5
#14	8/18/2009	0.125	0.54	0.3	0.125	0.125	0.5
#15	11/16/2009	0.125	0.125	0.125	0.125	0.125	0.5
#16	4/19/2011	0.23	0.4	0.34	0.025	0.025	0.5

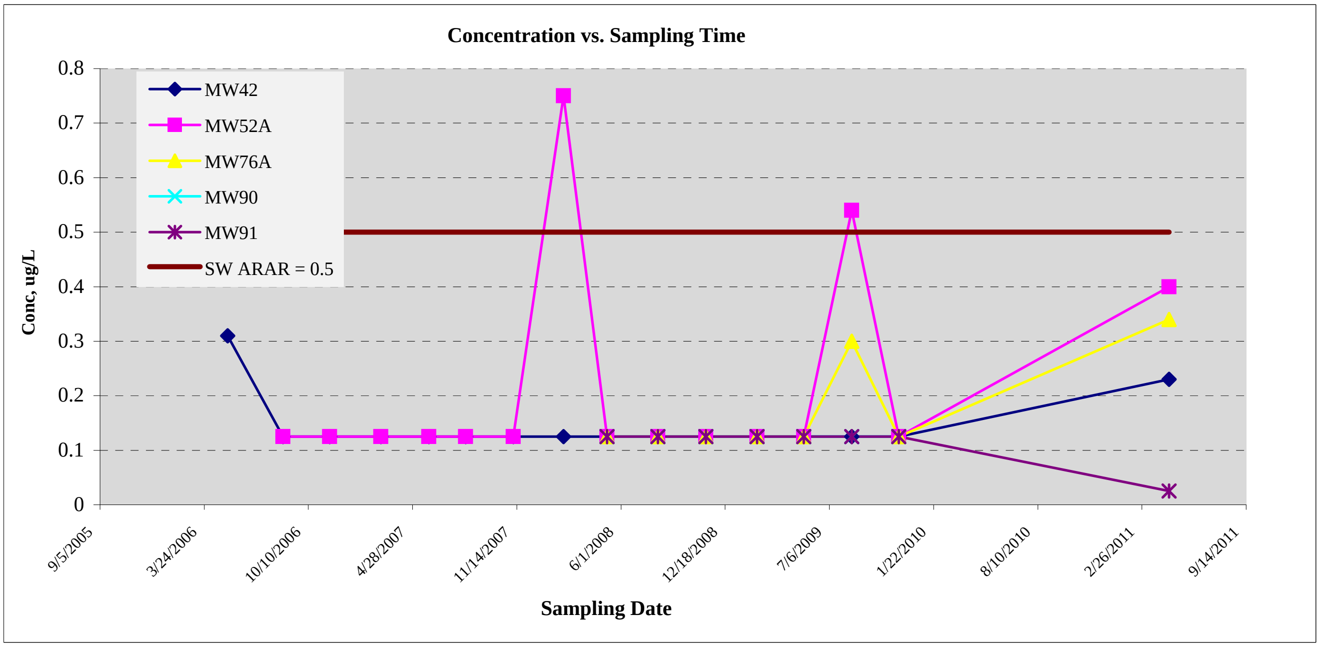
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW42**	**MW52A**	**MW76A**	**MW90**	**MW91**	**SW ARAR = 0.5**
Confidence Level Calculated?	48.20%	81.00%	86.20%	72.60%	72.60%	
Plume Stability?	Stable	Stable	***Expanding***	Stable	Stable	
Coefficient of Variation?	CV <= 1	CV <= 1		CV <= 1	CV <= 1	
Mann-Kendall Statistic "S" value?	-1	19	11	-7	-7	
Number of Sampling Rounds?	16	15	8	8	8	
Average Concentration?	0.14	0.21	0.17	0.11	0.11	
Standard Deviation?	0.05	0.19	0.09	0.04	0.04	
Coefficient of Variation?	0.36	0.91	0.52	0.31	0.31	
Blank if No Errors found						n<4

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*Nearshore South Monitoring Wells*

Analyte? **Diesel Range Organics**

Level of Confidence (Decision Criteria)? **85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is ug/L)					
Sampling Event	Date Sampled	MW58	MW84A	MW84B	MW85A	MW85B	SW ARAR = 0.5
#1	5/8/2006	0.125					0.5
#2	8/22/2006	0.125					0.5
#3	11/20/2006	0.125					0.5
#4	2/26/2007	0.125					0.5
#5	5/29/2007	0.125					0.5
#6	8/8/2007	0.125					0.5
#7	11/7/2007	0.125					0.5
#8	2/12/2008	0.125					0.5
#9	5/5/2008	0.125			0.125	0.125	0.5
#10	8/11/2008	0.125			0.125	0.125	0.5
#11	11/11/2008	0.125			0.125	0.125	0.5
#12	2/17/2009	0.125			0.125	0.125	0.5
#13	5/18/2009	0.125	0.125	0.125	0.125	0.125	0.5
#14	8/18/2009	0.125	0.125	0.125	0.125	0.125	0.5
#15	11/16/2009	0.125	0.125	0.125	0.125	0.125	0.5
#16	4/19/2011	0.19	0.16	0.025	0.025	0.025	0.5

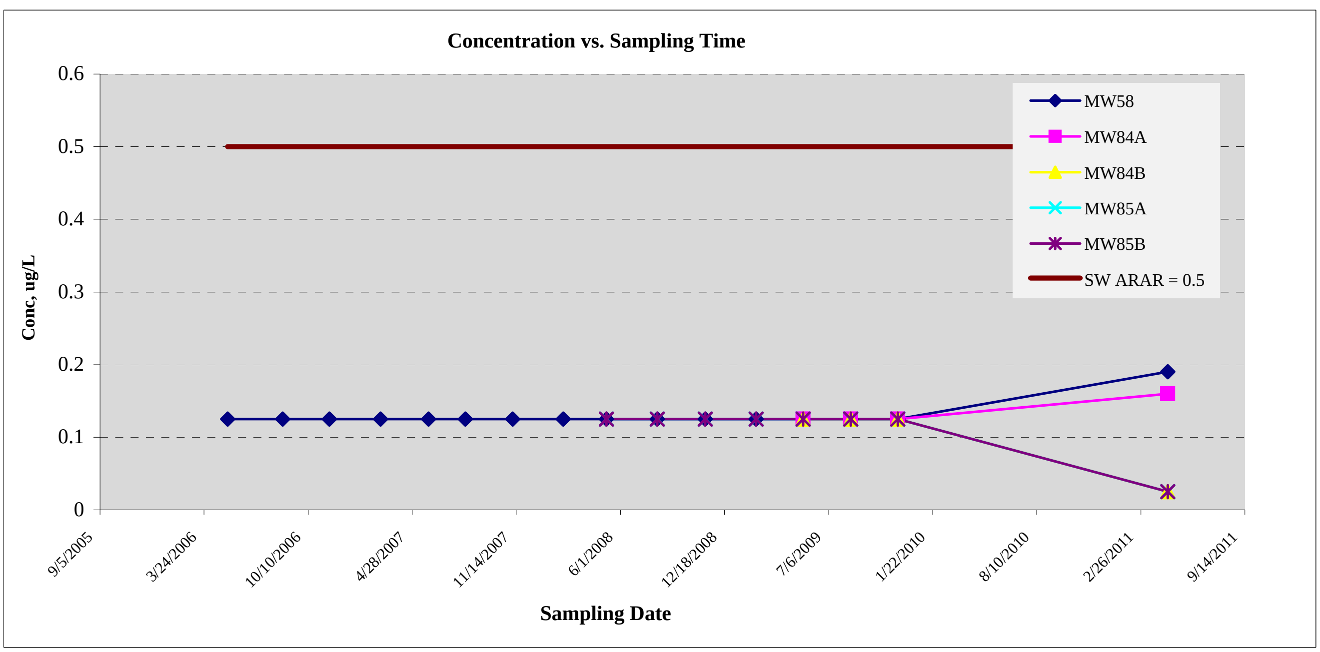
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW58**	**MW84A**	**MW84B**	**MW85A**	**MW85B**	**SW ARAR = 0.5**
Confidence Level Calculated?	71.80%	62.50%	62.50%	72.60%	45.20%	
Plume Stability?	Stable	Stable	Stable	Stable	Stable	
Coefficient of Variation?	CV <= 1	CV <= 1	CV <= 1	CV <= 1	CV <= 1	
Mann-Kendall Statistic "S" value?	15	3	-3	-7	0	
Number of Sampling Rounds?	16	4	4	8	8	
Average Concentration?	0.13	0.13	0.10	0.11	0.11	
Standard Deviation?	0.02	0.02	0.05	0.04	0.04	
Coefficient of Variation?	0.13	0.13	0.50	0.31	0.31	
Blank if No Errors found						

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*Nearshore South Monitoring Wells*

Analyte? **Diesel Range Organics**

Level of Confidence (Decision Criteria)? **85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is ug/L)					
Sampling Event	Date Sampled	MW86B	MW86C	MW87A	MW87B	MW89	SW ARAR = 0.5
#1	5/8/2006						0.5
#2	8/22/2006						0.5
#3	11/20/2006						0.5
#4	2/26/2007						0.5
#5	5/29/2007						0.5
#6	8/8/2007						0.5
#7	11/7/2007						0.5
#8	2/12/2008						0.5
#9	5/5/2008	0.125	0.125	0.125	0.125	0.125	0.5
#10	8/11/2008	0.125	0.125	0.125	0.125	0.125	0.5
#11	11/11/2008	0.125	0.125	0.125	0.125		0.5
#12	2/17/2009	0.125	0.125	0.125	0.125	0.125	0.5
#13	5/18/2009	0.125	0.125	0.125	0.125	0.125	0.5
#14	8/18/2009	0.125	0.125	0.125	0.125	0.125	0.5
#15	11/16/2009	0.125	0.125	0.125	0.125	0.125	0.5
#16	4/19/2011	0.087	0.069	0.025	0.025	0.22	0.5

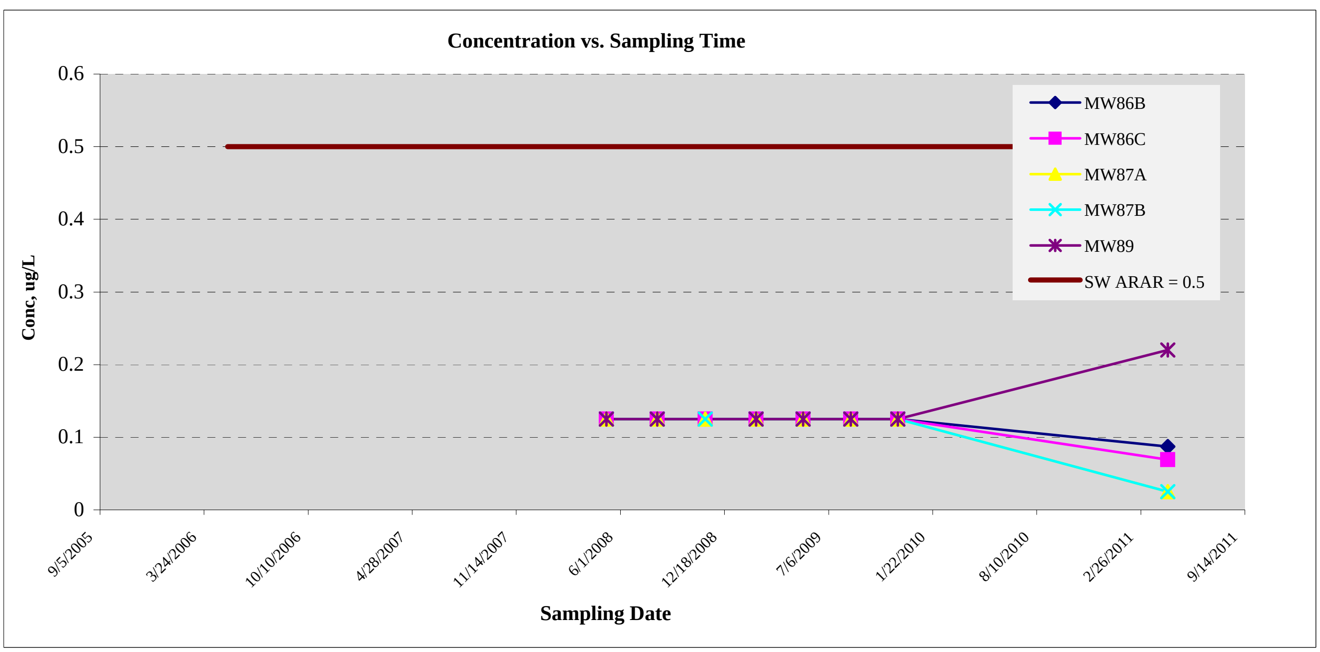
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW86B**	**MW86C**	**MW87A**	**MW87B**	**MW89**	**SW ARAR = 0.5**
Confidence Level Calculated?	72.60%	72.60%	72.60%	72.60%	71.90%	
Plume Stability?	Stable	Stable	Stable	Stable	Stable	
Coefficient of Variation?	CV <= 1	CV <= 1	CV <= 1	CV <= 1	CV <= 1	
Mann-Kendall Statistic "S" value?	-7	-7	-7	-7	6	
Number of Sampling Rounds?	8	8	8	8	7	
Average Concentration?	0.12	0.12	0.11	0.11	0.14	
Standard Deviation?	0.01	0.02	0.04	0.04	0.04	
Coefficient of Variation?	0.11	0.17	0.31	0.31	0.26	
Blank if No Errors found						

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*South Monitoring Wells*

Analyte? **Gasoline Range Organics**

Level of Confidence (Decision Criteria)? **85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is ug/L)					
Sampling Event	Date Sampled	_MW45	_MW46	MW81A	MW88		SW ARAR = 0.8
#1	5/8/2006	0.125	0.125				0.8
#2	8/22/2006	0.125	0.125				0.8
#3	11/20/2006	0.125	0.125				0.8
#4	2/26/2007	0.125	0.125				0.8
#5	5/29/2007	0.125	0.125				0.8
#6	8/8/2007	0.125	0.125				0.8
#7	11/7/2007	0.125	0.125				0.8
#8	2/12/2008	0.125	0.125				0.8
#9	5/5/2008	0.125	0.125				0.8
#10	8/11/2008	0.125	0.125				0.8
#11	11/11/2008	0.125	0.125				0.8
#12	2/17/2009	0.125	0.125				0.8
#13	5/18/2009	0.125	0.125	0.125	0.125		0.8
#14	8/18/2009	0.125	0.125	0.125	0.125		0.8
#15	11/16/2009	0.125	0.125	0.125	0.125		0.8
#16	4/19/2011	0.025	0.025	0.025	0.025		0.8

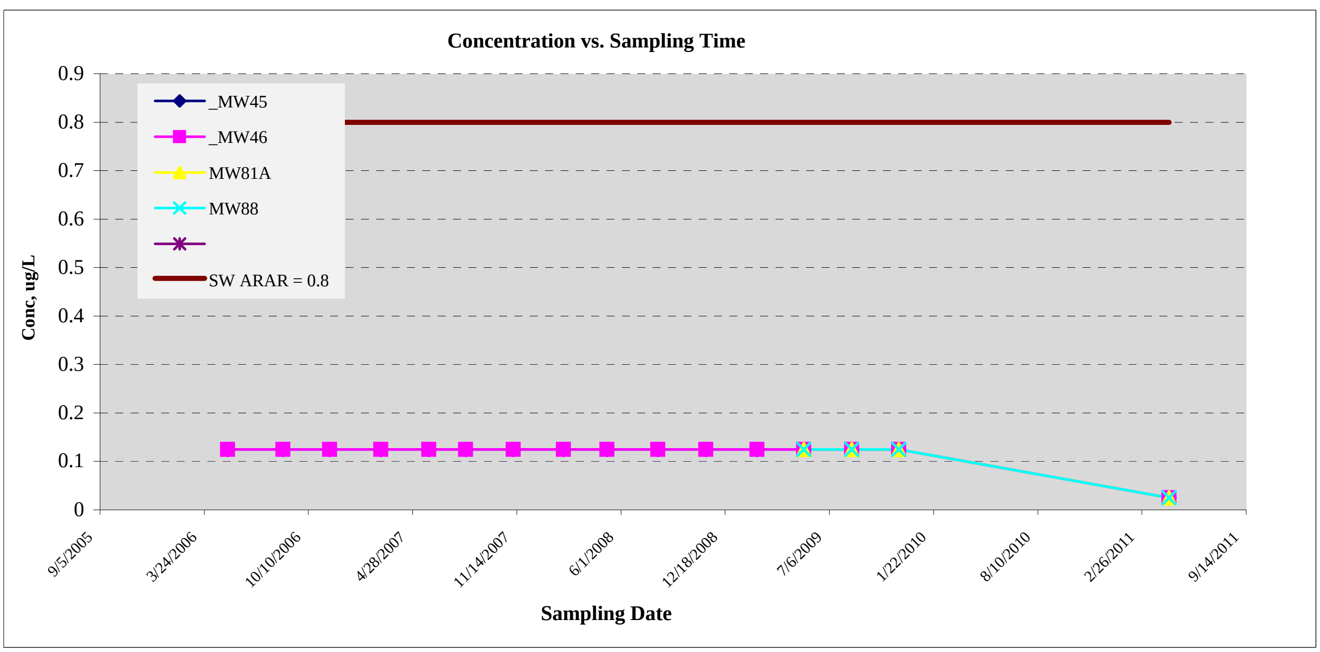
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**_MW45**	**_MW46**	**MW81A**	**MW88**		**SW ARAR = 0.8**
Confidence Level Calculated?	71.80%	71.80%	62.50%	62.50%		
Plume Stability?	Stable	Stable	Stable	Stable		
Coefficient of Variation?	CV <= 1	CV <= 1	CV <= 1	CV <= 1		
Mann-Kendall Statistic "S" value?	-15	-15	-3	-3		
Number of Sampling Rounds?	16	16	4	4		
Average Concentration?	0.12	0.12	0.10	0.10		
Standard Deviation?	0.03	0.03	0.05	0.05		
Coefficient of Variation?	0.21	0.21	0.50	0.50		
Blank if No Errors found						

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*North Monitoring Wells*

Analyte? **Gasoline Range Organics**

Level of Confidence (Decision Criteria)? **85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is ug/L)					
Sampling Event	Date Sampled	MW42	MW52A	MW76A	MW90	MW91	SW ARAR = 0.8
#1	5/8/2006	**2.6**					0.8
#2	8/22/2006	**2.1**	0.67				0.8
#3	11/20/2006	**3.5**	0.37				0.8
#4	2/26/2007	**2**	0.125				0.8
#5	5/29/2007	**1**	0.48				0.8
#6	8/8/2007	**1.3**	0.42				0.8
#7	11/7/2007	**1.8**	0.61				0.8
#8	2/12/2008	0.42	0.9				0.8
#9	5/5/2008	**0.83**	0.69	0.125	0.125	0.61	0.8
#10	8/11/2008	**1.1**	0.71	0.125	0.125	0.47	0.8
#11	11/11/2008	0.67	0.32	0.125	0.125	0.27	0.8
#12	2/17/2009	0.66	0.44	0.125	0.125	0.41	0.8
#13	5/18/2009	**1.9**	0.5	0.125	0.125	0.51	0.8
#14	8/18/2009	**2.1**	0.68	0.125	0.125	0.45	0.8
#15	11/16/2009	**1.2**	0.29	0.28	0.125	0.125	0.8
#16	4/19/2011	**1.2**	0.26	0.13	0.025	0.17	0.8

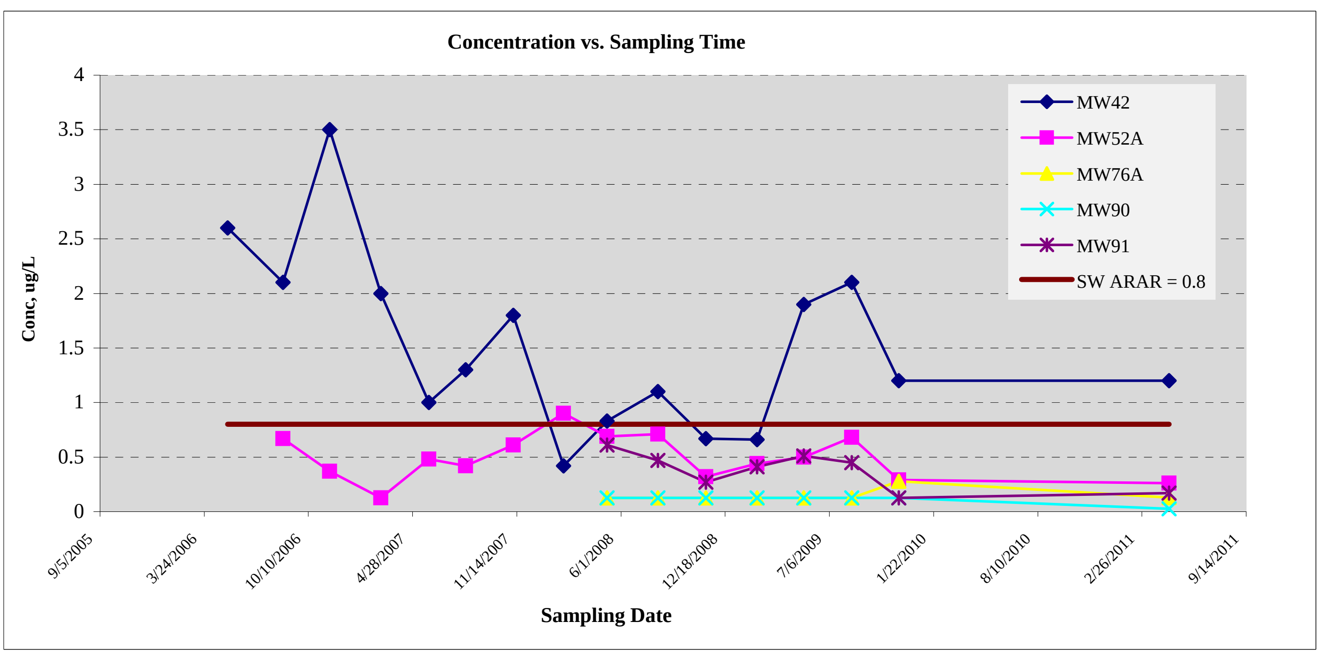
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW42**	**MW52A**	**MW76A**	**MW90**	**MW91**	**SW ARAR = 0.8**
Confidence Level Calculated?	94.20%	61.50%	86.20%	72.60%	94.60%	
Plume Stability?	Shrinking	Stable	***Expanding***	Stable	Shrinking	
Coefficient of Variation?		CV <= 1		CV <= 1		
Mann-Kendall Statistic "S" value?	-36	-7	11	-7	-14	
Number of Sampling Rounds?	16	15	8	8	8	
Average Concentration?	1.52	0.50	0.15	0.11	0.38	
Standard Deviation?	0.82	0.21	0.05	0.04	0.17	
Coefficient of Variation?	0.54	0.42	0.38	0.31	0.45	
Blank if No Errors found						

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*Nearshore South Monitoring Wells*

Analyte? **Gasoline Range Organics**

Level of Confidence (Decision Criteria)? **85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is mg/L)					
Sampling Event	Date Sampled	MW58	MW84A	MW84B	MW85A	MW85B	SW ARAR = 0.8
#1	5/8/2006	0.125					0.8
#2	8/22/2006	0.125					0.8
#3	11/20/2006	0.125					0.8
#4	2/26/2007	0.125					0.8
#5	5/29/2007	0.125					0.8
#6	8/8/2007	0.125					0.8
#7	11/7/2007	0.125					0.8
#8	2/12/2008	0.125					0.8
#9	5/5/2008	0.125			0.125	0.125	0.8
#10	8/11/2008	0.125			0.125	0.125	0.8
#11	11/11/2008	0.125			0.125	0.125	0.8
#12	2/17/2009	0.35			0.125	0.125	0.8
#13	5/18/2009	0.38	0.125	0.125	0.125	0.125	0.8
#14	8/18/2009	0.125	0.125	0.125	0.125	0.125	0.8
#15	11/16/2009	0.125	0.125	0.125	0.125	0.125	0.8
#16	4/19/2011	0.41	0.025	0.025	0.025	0.025	0.8

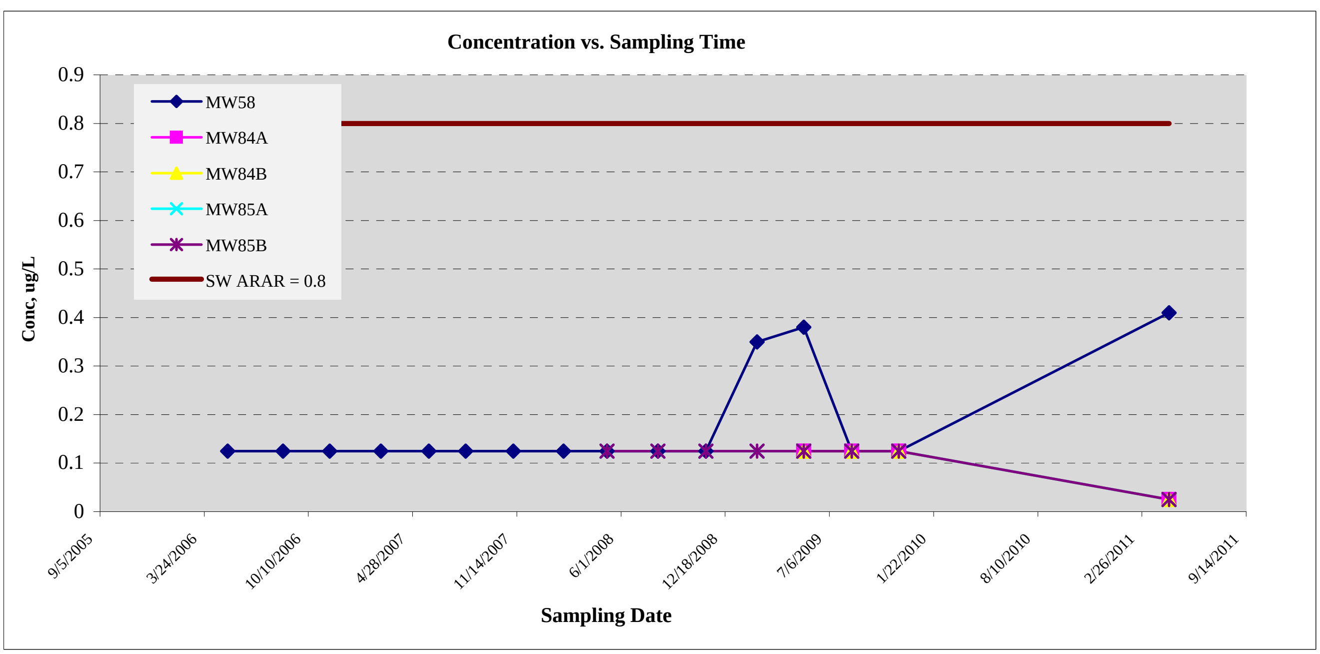
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW58**	**MW84A**	**MW84B**	**MW85A**	**MW85B**	**SW ARAR = 0.8**
Confidence Level Calculated?	93.00%	62.50%	62.50%	72.60%	45.20%	
Plume Stability?	***Expanding***	Stable	Stable	Stable	Stable	
Coefficient of Variation?		CV <= 1	CV <= 1	CV <= 1	CV <= 1	
Mann-Kendall Statistic "S" value?	34	-3	-3	-7	0	
Number of Sampling Rounds?	16	4	4	8	8	
Average Concentration?	0.17	0.10	0.10	0.11	0.11	
Standard Deviation?	0.10	0.05	0.05	0.04	0.04	
Coefficient of Variation?	0.60	0.50	0.50	0.31	0.31	
Blank if No Errors found						

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*Nearshore South Monitoring Wells*

Analyte? **Gasoline Range Organics**

Level of Confidence (Decision Criteria)? **85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is ug/L)					
Sampling Event	Date Sampled	MW86B	MW86C	MW87A	MW87B	MW89	SW ARAR = 0.8
#1	5/8/2006						0.8
#2	8/22/2006						0.8
#3	11/20/2006						0.8
#4	2/26/2007						0.8
#5	5/29/2007						0.8
#6	8/8/2007						0.8
#7	11/7/2007						0.8
#8	2/12/2008						0.8
#9	5/5/2008	0.38	0.3	0.125	0.125	**1.2**	0.8
#10	8/11/2008	0.28	0.125	0.125	0.125	**0.85**	0.8
#11	11/11/2008	0.27	0.125	0.125	0.125		0.8
#12	2/17/2009	**0.91**	0.31	0.125	0.125	0.4	0.8
#13	5/18/2009	0.47	0.125	0.125	0.125	**0.84**	0.8
#14	8/18/2009	0.3	0.125	0.125	0.125	**0.92**	0.8
#15	11/16/2009	0.125	0.125	0.125	0.125	**1.1**	0.8
#16	4/19/2011	0.21	0.25	0.025	0.025	**0.88**	0.8

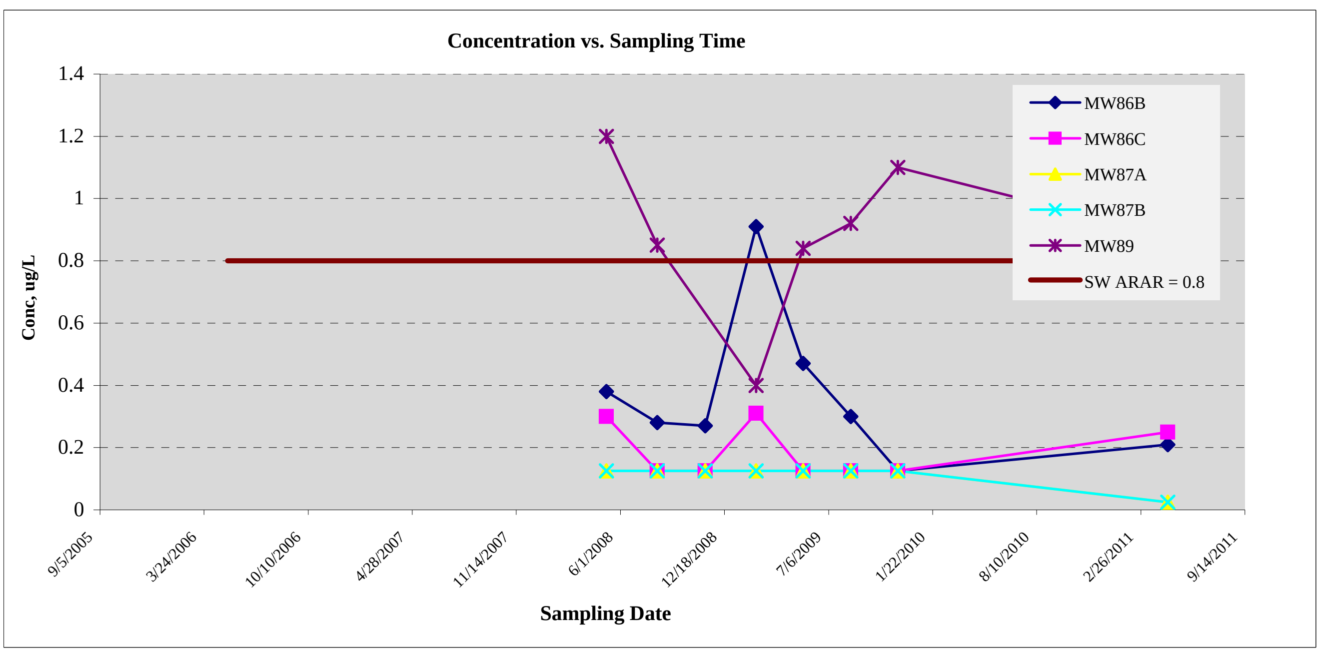
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW86B**	**MW86C**	**MW87A**	**MW87B**	**MW89**	**SW ARAR = 0.8**
Confidence Level Calculated?	86.20%	54.80%	72.60%	72.60%	50.00%	
Plume Stability?	Shrinking	Stable	Stable	Stable	Stable	
Coefficient of Variation?		CV <= 1	CV <= 1	CV <= 1	CV <= 1	
Mann-Kendall Statistic "S" value?	-10	-2	-7	-7	1	
Number of Sampling Rounds?	8	8	8	8	7	
Average Concentration?	0.37	0.19	0.11	0.11	0.88	
Standard Deviation?	0.24	0.09	0.04	0.04	0.25	
Coefficient of Variation?	0.66	0.46	0.31	0.31	0.29	
Blank if No Errors found						

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*South Monitoring Wells*

Analyte? **Lube Oil**

Level of Confidence (Decision Criteria)? **85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is mg/L)					
Sampling Event	Date Sampled	MW45	MW46	MW81A	MW88		SW ARAR = 0.5
#1	5/8/2006	0.25	0.25				0.5
#2	8/22/2006	0.25	0.25				0.5
#3	11/20/2006	0.25	0.25				0.5
#4	2/26/2007	0.25	0.25				0.5
#5	5/29/2007	0.25	0.25				0.5
#6	8/8/2007	0.25	0.25				0.5
#7	11/7/2007	0.25	0.25				0.5
#8	2/12/2008	0.25	0.25				0.5
#9	5/5/2008	0.25	0.25				0.5
#10	8/11/2008	0.25	0.25				0.5
#11	11/11/2008	0.25	0.25				0.5
#12	2/17/2009	0.25	0.25				0.5
#13	5/18/2009	0.25	0.25	0.25	0.25		0.5
#14	8/18/2009	0.25	0.25	0.25	0.25		0.5
#15	11/16/2009	0.25	0.25	0.25	0.25		0.5
#16	4/19/2011	0.125	0.125	0.125	0.125		0.5

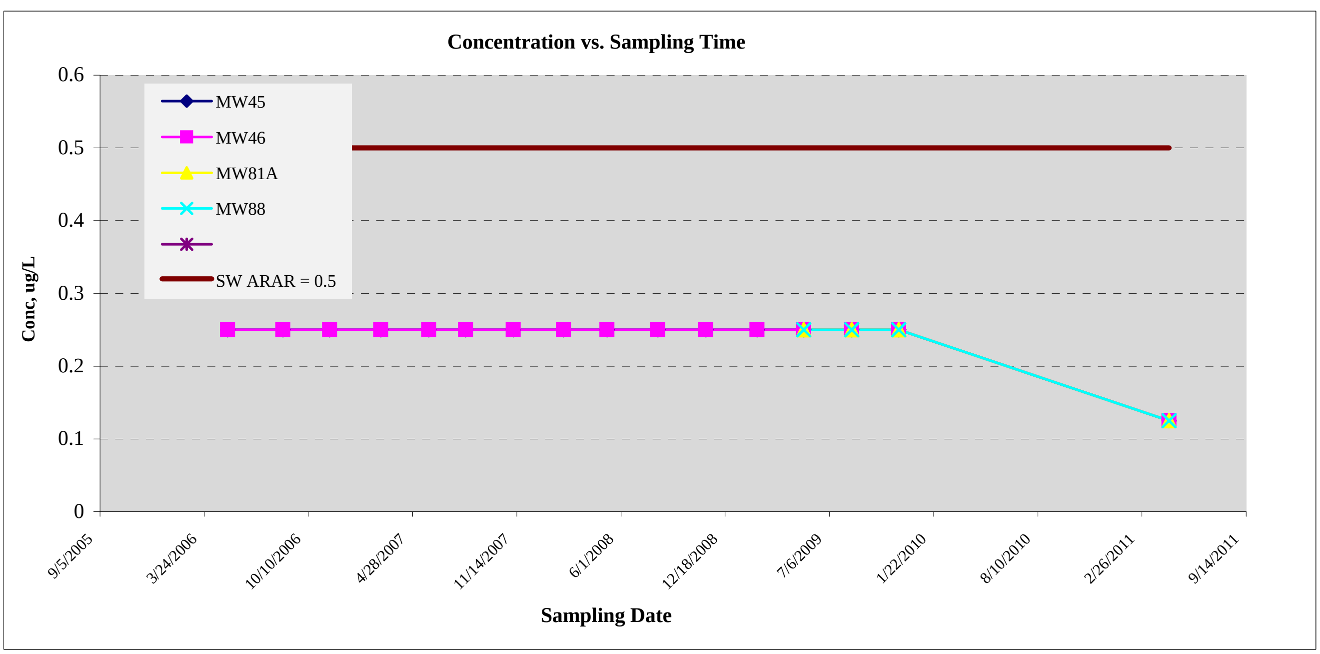
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW45**	**MW46**	**MW81A**	**MW88**		**SW ARAR = 0.5**
Confidence Level Calculated?	71.80%	71.80%	62.50%	62.50%		
Plume Stability?	Stable	Stable	Stable	Stable		
Coefficient of Variation?	CV <= 1	CV <= 1	CV <= 1	CV <= 1		
Mann-Kendall Statistic "S" value?	-15	-15	-3	-3		
Number of Sampling Rounds?	16	16	4	4		
Average Concentration?	0.24	0.24	0.22	0.22		
Standard Deviation?	0.03	0.03	0.06	0.06		
Coefficient of Variation?	0.13	0.13	0.29	0.29		
Blank if No Errors found						n<4

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*North Monitoring Wells*

Analyte?	**Lube Oil**
Level of Confidence (Decision Criteria)?	**85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is mg/L)					
Sampling Event	Date Sampled	MW42	MW52A	MW76A	MW90	MW91	SW ARAR = 0.5
#1	5/8/2006	0.25					0.5
#2	8/22/2006	0.25	0.25				0.5
#3	11/20/2006	0.25	0.25				0.5
#4	2/26/2007	0.25	0.25				0.5
#5	5/29/2007	0.25	0.25				0.5
#6	8/8/2007	0.25	0.25				0.5
#7	11/7/2007	0.25	0.25				0.5
#8	2/12/2008	0.25	0.25				0.5
#9	5/5/2008	0.25	0.25	0.25	0.25	0.25	0.5
#10	8/11/2008	0.25	0.25	0.25	0.25	0.25	0.5
#11	11/11/2008	0.25	0.25	0.25	0.25	0.25	0.5
#12	2/17/2009	0.25	0.25	0.25	0.25	0.25	0.5
#13	5/18/2009	0.25	0.25	0.25	0.25	0.25	0.5
#14	8/18/2009	0.25	0.25	0.25	0.25	0.25	0.5
#15	11/16/2009	0.25	0.25	0.25	0.25	0.25	0.5
#16	4/19/2011	0.125	0.125	0.125	0.125	0.125	0.5

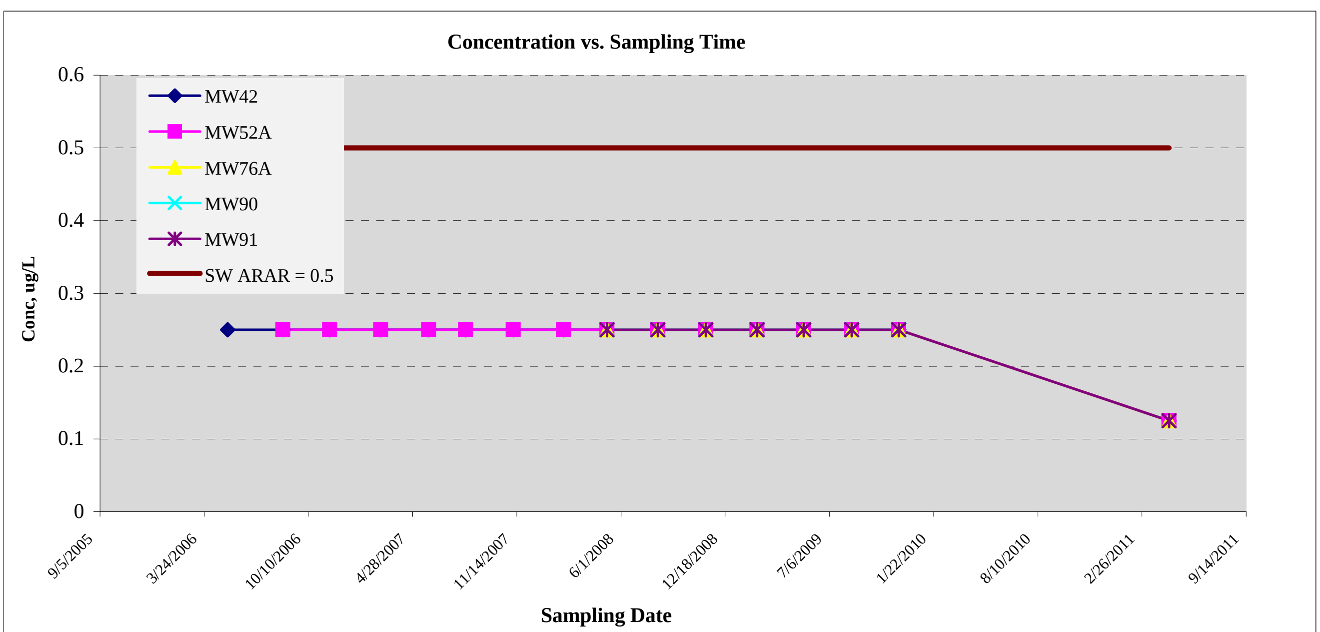
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW42**	**MW52A**	**MW76A**	**MW90**	**MW91**	**SW ARAR = 0.5**
Confidence Level Calculated?	71.80%	72.10%	72.60%	72.60%	72.60%	
Plume Stability?	Stable	Stable	Stable	Stable	Stable	
Coefficient of Variation?	CV <= 1	CV <= 1	CV <= 1	CV <= 1	CV <= 1	
Mann-Kendall Statistic "S" value?	-15	-14	-7	-7	-7	
Number of Sampling Rounds?	16	15	8	8	8	
Average Concentration?	0.24	0.24	0.23	0.23	0.23	
Standard Deviation?	0.03	0.03	0.04	0.04	0.04	
Coefficient of Variation?	0.13	0.13	0.19	0.19	0.19	
Blank if No Errors found						n<4

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*Nearshore South Monitoring Wells*

Analyte?	**Lube Oil**
Level of Confidence (Decision Criteria)?	**85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is mg/L)					
Sampling Event	Date Sampled	MW58	MW84A	MW84B	MW85A	MW85B	SW ARAR = 0.5
#1	5/8/2006	0.125					0.5
#2	8/22/2006	0.125					0.5
#3	11/20/2006	0.125					0.5
#4	2/26/2007	0.125					0.5
#5	5/29/2007	0.125					0.5
#6	8/8/2007	0.125					0.5
#7	11/7/2007	0.125					0.5
#8	2/12/2008	0.125					0.5
#9	5/5/2008	0.125			0.125	0.125	0.5
#10	8/11/2008	0.125			0.125	0.125	0.5
#11	11/11/2008	0.125			0.125	0.125	0.5
#12	2/17/2009	0.125			0.125	0.125	0.5
#13	5/18/2009	0.125	0.125	0.125	0.125	0.125	0.5
#14	8/18/2009	0.125	0.125	0.125	0.125	0.125	0.5
#15	11/16/2009	0.125	0.125	0.125	0.125	0.125	0.5
#16	4/19/2011	0.19	0.16	0.025	0.025	0.025	0.5

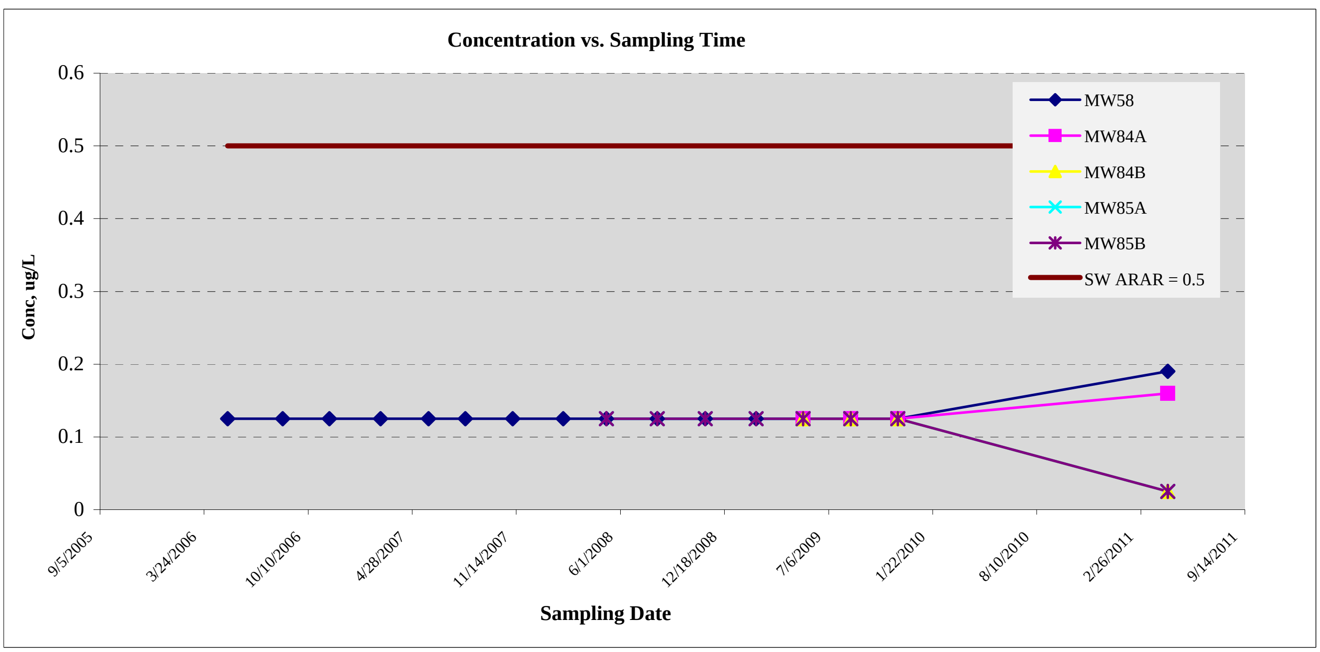
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW58**	**MW84A**	**MW84B**	**MW85A**	**MW85B**	**SW ARAR = 0.5**
Confidence Level Calculated?	71.80%	62.50%	62.50%	72.60%	45.20%	
Plume Stability?	Stable	Stable	Stable	Stable	Stable	
Coefficient of Variation?	CV <= 1	CV <= 1	CV <= 1	CV <= 1	CV <= 1	
Mann-Kendall Statistic "S" value?	15	3	-3	-7	0	
Number of Sampling Rounds?	16	4	4	8	8	
Average Concentration?	0.13	0.13	0.10	0.11	0.11	
Standard Deviation?	0.02	0.02	0.05	0.04	0.04	
Coefficient of Variation?	0.13	0.13	0.50	0.31	0.31	
Blank if No Errors found						

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



Module1: Mann-Kendall Trend Test for Plume Stability (Non-parametric Statistical Test)

Site Name:	*T30*
Site Address:	*Terminal 30 Site*
Additional Description:	*Nearshore South Monitoring Wells*

Analyte? **Lube Oil**

Level of Confidence (Decision Criteria)? **85%**

1. Monitoring Well Information: Contaminant Concentration at a well: Quarterly sampling recommended.

		Hazardous Substances (unit is mg/L)					
Sampling Event	Date Sampled	MW86B	MW86C	MW87A	MW87B	MW89	SW ARAR = 0.5
#1	5/8/2006						0.5
#2	8/22/2006						0.5
#3	11/20/2006						0.5
#4	2/26/2007						0.5
#5	5/29/2007						0.5
#6	8/8/2007						0.5
#7	11/7/2007						0.5
#8	2/12/2008						0.5
#9	5/5/2008	0.25	0.25	0.25	0.25	0.25	0.5
#10	8/11/2008	0.25	0.25	0.25	0.25	0.25	0.5
#11	11/11/2008	0.25	0.25	0.25	0.25		0.5
#12	2/17/2009	0.25	0.25	0.25	0.25	0.25	0.5
#13	5/18/2009	0.25	0.25	0.25	0.25	0.25	0.5
#14	8/18/2009	0.25	0.25	0.25	0.25	0.25	0.5
#15	11/16/2009	0.25	0.25	0.25	0.25	0.25	0.5
#16	4/19/2011	0.125	0.125	0.125	0.125	0.125	0.5

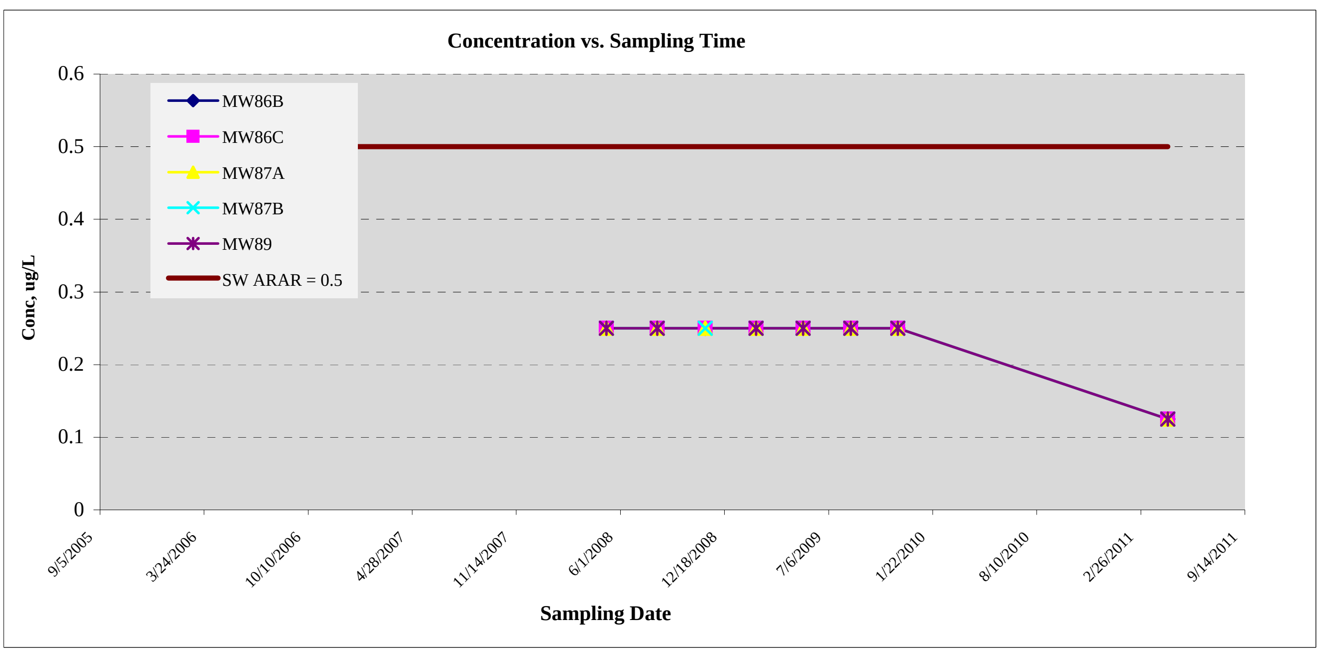
2. Mann-Kendall Non-parametric Statistical Test Results

Hazardous Substance?	**MW86B**	**MW86C**	**MW87A**	**MW87B**	**MW89**	**SW ARAR = 0.5**
Confidence Level Calculated?	72.60%	72.60%	72.60%	72.60%	71.90%	
Plume Stability?	Stable	Stable	Stable	Stable	Stable	
Coefficient of Variation?	CV <= 1	CV <= 1	CV <= 1	CV <= 1	CV <= 1	
Mann-Kendall Statistic "S" value?	-7	-7	-7	-7	-6	
Number of Sampling Rounds?	8	8	8	8	7	
Average Concentration?	0.23	0.23	0.23	0.23	0.23	
Standard Deviation?	0.04	0.04	0.04	0.04	0.05	
Coefficient of Variation?	0.19	0.19	0.19	0.19	0.20	
Blank if No Errors found						

Values shaded in grey were non-detect, orange = J

Value shown = 1/2 Method Reporting Limit

3. Temporal Trend: Plot of Concentration vs. Sampling Time



APPENDIX H: SUPPORTING TRANSPORT AND BIODEGRADATION CALCULATIONS

Table H-1: Retardation Factor Calculations

Port of Seattle Terminal 30

Constituent	Aqueous Solubility (mg/L)	Koc (L/kg)	foc	Kp (L/kg)	Bulk Density (Pb)(kg/L)	Porosity (n)	Retardation Factor (R)
PAHs							
acenaphthene	4.24	4,898	0.015	73	1.51	0.3	371
anthracene	0.0434	23,493	0.015	352	1.51	0.3	1,775
benzo[a]anthracene	0.0094	357,537	0.015	5,363	1.51	0.3	26,995
benzo[a]pyrene	0.00162	968,774	0.015	14,532	1.51	0.3	73,143
benzo[b]fluoranthene	0.0015	1,230,000	0.015	18,450	1.51	0.3	92,866
benzo[k]fluoranthene	0.0008	1,230,000	0.015	18,450	1.51	0.3	92,866
chrysene	0.0016	398,000	0.015	5,970	1.51	0.3	30,050
dibenzo[a,h]anthracene	0.00249	1,789,101	0.015	26,837	1.51	0.3	135,078
fluoranthene	0.206	49,096	0.015	736	1.51	0.3	3,708
fluorene	1.98	7,707	0.015	116	1.51	0.3	583
indeno[1,2,3-cd]pyrene	0.000022	3,470,000	0.015	52,050	1.51	0.3	261,986
naphthalene	31	1,191	0.015	17.9	1.51	0.3	91
pyrene	0.135	67,992	0.015	1,020	1.51	0.3	5,134
BTEX Compounds							
benzene	1750	62	0.015	0.9	1.51	0.3	6
toluene	526	140	0.015	2.1	1.51	0.3	12
ethylbenzene	170	200	0.015	3.0	1.51	0.3	16
xylenes	171	233	0.015	3.5	1.51	0.3	19

Aqueous Solubility and Koc values from Ecology CLARC database: https://fortress.wa.gov/ecy/clarc/Reporting/CLARCReporting.aspx
Nominal values used for bulk density, fraction organic carbon, and porosity.
Koc: Soil Organic Carbon-Water Partitioning Coefficient
foc: fraction organic carbon
Kp: Partition Coefficient; Kp = foc*Koc
R = 1+((PbKp)/n)

Table H-2: Groundwater Biodegradation Rate Calculations

Port of Seattle Terminal 30

Initial Groundwater TPH Concentration (ug/L)	150,000	75,000	30,000	15,000	10,000	5,000	150,000	75,000	30,000	15,000	10,000	5,000	150,000	75,000	30,000	15,000	10,000	5,000	150,000	75,000	30,000	15,000	10,000	5,000

First-order Biodegradation Concentration Projections

	Slow Endmember (MW-86)						Arithmetic Mean of Half-Lives						Geometric Mean of Half-Lives						Geometric Mean of Half Lives (Attenuation Zone Wells)					
half-life (years)	9.5	9.5	9.5	9.5	9.5	9.5	7.5	7.5	7.5	7.5	7.5	7.5	5.3	5.3	5.3	5.3	5.3	5.3	3.7	3.7	3.7	3.7	3.7	3.7
decay rate (r)	0.072963	0.072963	0.072963	0.072963	0.072963	0.072963	0.09242	0.09242	0.09242	0.09242	0.09242	0.09242	0.130782	0.130782	0.130782	0.130782	0.130782	0.130782	0.187337	0.187337	0.187337	0.187337	0.187337	0.187337
Concentration (C) at year (t)....	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
0	150,000	75,000	30,000	15,000	10,000	5,000	150,000	75,000	30,000	15,000	10,000	5,000	150,000	75,000	30,000	15,000	10,000	5,000	150,000	75,000	30,000	15,000	10,000	5,000
1	139,445	69,723	27,889	13,945	9,296	4,648	136,758	68,379	27,352	13,676	9,117	4,559	131,611	65,806	26,322	13,161	8,774	4,387	124,375	62,187	24,875	12,437	8,292	4,146
2	129,633	64,817	25,927	12,963	8,642	4,321	124,686	62,343	24,937	12,469	8,312	4,156	115,477	57,738	23,095	11,548	7,698	3,849	103,127	51,563	20,625	10,313	6,875	3,438
4	112,032	56,016	22,406	11,203	7,469	3,734	103,643	51,822	20,729	10,364	6,910	3,455	88,899	44,450	17,780	8,890	5,927	2,963	70,901	35,451	14,180	7,090	4,727	2,363
6	96,820	48,410	19,364	9,682	6,455	3,227	86,152	43,076	17,230	8,615	5,743	2,872	68,439	34,219	13,688	6,844	4,563	2,281	48,745	24,373	9,749	4,875	3,250	1,625
8	83,674	41,837	16,735	8,367	5,578	2,789	71,613	35,807	14,323	7,161	4,774	2,387	52,687	26,344	10,537	5,269	3,512	1,756	33,513	16,757	6,703	3,351	2,234	1,117
10	72,313	36,157	14,463	7,231	4,821	2,410	59,528	29,764	11,906	5,953	3,969	1,984	40,561	20,281	8,112	4,056	2,704	1,352	23,041	11,520	4,608	2,304	1,536	768
12	62,495	31,247	12,499	6,249	4,166	2,083	49,482	24,741	9,896	4,948	3,299	1,649	31,226	15,613	6,245	3,123	2,082	1,041	15,841	7,920	3,168	1,584	1,056	528
14	54,009	27,005	10,802	5,401	3,601	1,800	41,131	20,565	8,226	4,113	2,742	1,371	24,039	12,020	4,808	2,404	1,603	801	10,891	5,445	2,178	1,089	726	363
16	46,676	23,338	9,335	4,668	3,112	1,556	34,190	17,095	6,838	3,419	2,279	1,140	18,506	9,253	3,701	1,851	1,234	617	7,488	3,744	1,498	749	499	250
18	40,338	20,169	8,068	4,034	2,689	1,345	28,420	14,210	5,684	2,842	1,895	947	14,247	7,124	2,849	1,425	950	475	5,148	2,574	1,030	515	343	172
20	34,861	17,431	6,972	3,486	2,324	1,162	23,624	11,812	4,725	2,362	1,575	787	10,968	5,484	2,194	1,097	731	366	3,539	1,770	708	354	236	118
22	30,128	15,064	6,026	3,013	2,009	1,004	19,637	9,818	3,927	1,964	1,309	655	8,444	4,222	1,689	844	563	281	2,433	1,217	487	243	162	81
24	26,037	13,019	5,207	2,604	1,736	868	16,323	8,161	3,265	1,632	1,088	544	6,500	3,250	1,300	650	433	217	1,673	836	335	167	112	56
26	22,502	11,251	4,500	2,250	1,500	750	13,568	6,784	2,714	1,357	905	452	5,004	2,502	1,001	500	334	167	1,150	575	230	115	77	38
28	19,447	9,723	3,889	1,945	1,296	648	11,278	5,639	2,256	1,128	752	376	3,853	1,926	771	385	257	128	791	395	158	79	53	26
30	16,806	8,403	3,361	1,681	1,120	560	9,375	4,688	1,875	938	625	313	2,966	1,483	593	297	198	99	544	272	109	54	36	18
32	14,524	7,262	2,905	1,452	968	484	7,793	3,896	1,559	779	520	260	2,283	1,142	457	228	152	76	374	187	75	37	25	12
34	12,552	6,276	2,510	1,255	837	418	6,478	3,239	1,296	648	432	216	1,758	879	352	176	117	59	257	128	51	26	17	9
36	10,848	5,424	2,170	1,085	723	362	5,385	2,692	1,077	538	359	179	1,353	677	271	135	90	45	177	88	35	18	12	6
38	9,375	4,688	1,875	938	625	313	4,476	2,238	895	448	298	149	1,042	521	208	104	69	35	121	61	24	12	8	4
40	8,102	4,051	1,620	810	540	270	3,720	1,860	744	372	248	124	802	401	160	80	53	27	84	42	17	8	6	3
42	7,002	3,501	1,400	700	467	233	3,093	1,546	619	309	206	103	617	309	123	62	41	21	57	29	11	6	4	2
44	6,051	3,026	1,210	605	403	202	2,571	1,285	514	257	171	86	475	238	95	48	32	16	39	20	8	4	3	1
46	5,230	2,615	1,046	523	349	174	2,137	1,068	427	214	142	71	366	183	73	37	24	12	27	14	5	3	2	1
48	4,520	2,260	904	452	301	151	1,776	888	355	178	118	59	282	141	56	28	19	9	19	9	4	2	1	1
50	3,906	1,953	781	391	260	130	1,476	738	295	148	98	49	217	108	43	22	14	7	13	6	3	1	1	0
52	3,376	1,688	675	338	225	113	1,227	614	245	123	82	41	167	83	33	17	11	6	9	4	2	1	1	0
54	2,917	1,459	583	292	194	97	1,020	510	204	102	68	34	129	64	26	13	9	4	6	3	1	1	0	0
56	2,521	1,261	504	252	168	84	848	424	170	85	57	28	99	49	20	10	7	3	4	2	1	0	0	0
58	2,179	1,089	436	218	145	73	705	352	141	70	47	23	76	38	15	8	5	3	3	1	1	0	0	0
60	1,883	941	377	188	126	63	586	293	117	59	39	20	59	29	12	6	4	2	2	1	0	0	0	0
62	1,627	814	325	163	108	54	487	244	97	49	32	16	45	23	9	5	3	2	1	1	0	0	0	0
64	1,406	703	281	141	94	47	405	202	81	40	27	13	35	17	7	3	2	1	1	0	0	0	0	0
66	1,215	608	243	122	81	41	337	168	67	34	22	11	27	13	5	3	2	1	1	0	0	0	0	0
68	1,050	525	210	105	70	35	280	140	56	28	19	9	21	10	4	2	1	1	0	0	0	0	0	0
70	908	454	182	91	61	30	233	116	47	23	16	8	16	8	3	2	1	1	0	0	0	0	0	0
72	785	392	157	78	52	26	193	97	39	19	13	6	12	6	2	1	1	0	0	0	0	0	0	0
74	678	339	136	68	45	23	161	80	32	16	11	5	9	5	2	1	1	0	0	0	0	0	0	0
76	586	293	117	59	39	20	134	67	27	13	9	4	7	4	1	1	0	0	0	0	0	0	0	0
78	506	253	101	51	34	17	111	56	22	11	7	4	6	3	1	1	0	0	0	0	0	0	0	0
80	438	219	88	44	29	15	92	46	18	9	6	3	4	2	1	0	0	0	0	0	0	0	0	0

Groundwater concentrations cover generic range of possible initial concentrations with the upper bound above the highest observed TPH concentration at MW-38 (130,000 ug/L)

Groundwater concentrations calculated assuming exponential biodegradation: C(t) = Co e^(-r*t)

Shading plus bold indicates TPH concentration less than screening level (1000mg/kg)

Biodegradation rates as presented in *Supplemental Data Report, Revision 2* (ENSR|AECOM, 2010) Appendix I, Table I-1.

PGG

Table H-3: Soil Biodegradation Rate Calculations

Port of Seattle Terminal 30

Soil Concentrations over range of LNAPL Saturations

Cells repeat values to left

LNAPL Saturation	20.0%	15.0%	10.0%	5.0%	5.0%	1.0%	20.0%	15.0%	10.0%	5.0%	5.0%	1.0%	20.0%	15.0%	10.0%	5.0%	5.0%	1.0%	20.0%	15.0%	10.0%	5.0%	5.0%	1.0%
LNAPL Saturation	0.2	0.15	0.1	0.05	0.025	0.01	0.2	0.15	0.1	0.05	0.025	0.01	0.2	0.15	0.1	0.05	0.025	0.01	0.2	0.15	0.1	0.05	0.025	0.01
Porosity	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Vol. Fraction	0.06	0.045	0.03	0.015	0.0075	0.003	0.06	0.045	0.03	0.015	0.0075	0.003	0.06	0.045	0.03	0.015	0.0075	0.003	0.06	0.045	0.03	0.015	0.0075	0.003
TPH Concentration as ppmv	60,000	45,000	30,000	15,000	7,500	3,000	60,000	45,000	30,000	15,000	7,500	3,000	60,000	45,000	30,000	15,000	7,500	3,000	60,000	45,000	30,000	15,000	7,500	3,000
LNAPL Density (g/cm3)	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Nominal Bulk Density (g/m3)	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Approximate mg TPH per kg dry bulk soil	**34,570**	**25,927**	**17,285**	**8,642**	**4,321**	**1,728**	**34,570**	**25,927**	**17,285**	**8,642**	**4,321**	**1,728**	**34,570**	**25,927**	**17,285**	**8,642**	**4,321**	**1,728**	**34,570**	**25,927**	**17,285**	**8,642**	**4,321**	**1,728**

First-order Biodegradation Concentration Projections

	Slow Endmember																		Fast-Endmember					
half-life (years)	15	15	15	15	15	15	10	10	10	10	10	10	5	5	5	5	5	5	2.5	2.5	2.5	2.5	2.5	2.5
decay rate (r) (1/yr)	0.04621	0.04621	0.04621	0.04621	0.04621	0.04621	0.069315	0.069315	0.069315	0.069315	0.069315	0.069315	0.138629	0.138629	0.138629	0.138629	0.138629	0.138629	0.277259	0.277259	0.277259	0.277259	0.277259	0.277259
Concentration (C) at year (t)….	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
0	34,570	25,927	17,285	8,642	4,321	1,728	34,570	25,927	17,285	8,642	4,321	1,728	34,570	25,927	17,285	8,642	4,321	1,728	34,570	25,927	17,285	8,642	4,321	1,728
1	33,008	24,756	16,504	8,252	4,126	1,650	32,255	24,191	16,127	8,064	4,032	1,613	30,095	22,571	15,047	7,524	3,762	1,505	26,199	19,649	13,099	6,550	3,275	1,310
2	31,518	23,638	15,759	7,879	3,940	1,576	30,095	22,571	15,047	7,524	3,762	1,505	26,199	19,649	13,099	6,550	3,275	1,310	19,855	14,891	9,927	4,964	2,482	993
4	28,736	21,552	14,368	7,184	3,592	1,437	26,199	19,649	13,099	6,550	3,275	1,310	19,855	14,891	9,927	4,964	2,482	993	11,404	8,553	5,702	2,851	1,425	570
6	26,199	19,649	13,099	6,550	3,275	1,310	22,807	17,106	11,404	5,702	2,851	1,140	15,047	11,285	7,524	3,762	1,881	752	6,550	4,912	3,275	1,637	819	327
8	23,886	17,915	11,943	5,972	2,986	1,194	19,855	14,891	9,927	4,964	2,482	993	11,404	8,553	5,702	2,851	1,425	570	3,762	2,821	1,881	940	470	188
10	21,777	16,333	10,889	5,444	2,722	1,089	17,285	12,964	8,642	4,321	2,161	864	8,642	6,482	4,321	2,161	1,080	432	2,161	1,620	1,080	540	270	108
12	19,855	14,891	9,927	4,964	2,482	993	15,047	11,285	7,524	3,762	1,881	752	6,550	4,912	3,275	1,637	819	327	1,241	931	620	310	155	62
14	18,102	13,577	9,051	4,526	2,263	905	13,099	9,825	6,550	3,275	1,637	655	4,964	3,723	2,482	1,241	620	248	713	535	356	178	89	36
16	16,504	12,378	8,252	4,126	2,063	825	11,404	8,553	5,702	2,851	1,425	570	3,762	2,821	1,881	940	470	188	409	307	205	102	51	20
18	15,047	11,285	7,524	3,762	1,881	752	9,927	7,446	4,964	2,482	1,241	496	2,851	2,138	1,425	713	356	143	235	176	118	59	29	12
20	13,719	10,289	6,859	3,430	1,715	686	8,642	6,482	4,321	2,161	1,080	432	2,161	1,620	1,080	540	270	108	135	101	68	34	17	7
22	12,508	9,381	6,254	3,127	1,563	625	7,524	5,643	3,762	1,881	940	376	1,637	1,228	819	409	205	82	78	58	39	19	10	4
24	11,404	8,553	5,702	2,851	1,425	570	6,550	4,912	3,275	1,637	819	327	1,241	931	620	310	155	62	45	33	22	11	6	2
26	10,397	7,798	5,199	2,599	1,300	520	5,702	4,276	2,851	1,425	713	285	940	705	470	235	118	47	26	19	13	6	3	1
28	9,479	7,109	4,740	2,370	1,185	474	4,964	3,723	2,482	1,241	620	248	713	535	356	178	89	36	15	11	7	4	2	1
30	8,642	6,482	4,321	2,161	1,080	432	4,321	3,241	2,161	1,080	540	216	540	405	270	135	68	27	8	6	4	2	1	0
32	7,879	5,910	3,940	1,970	985	394	3,762	2,821	1,881	940	470	188	409	307	205	102	51	20	5	4	2	1	1	0
34	7,184	5,388	3,592	1,796	898	359	3,275	2,456	1,637	819	409	164	310	233	155	78	39	16	3	2	1	1	0	0
36	6,550	4,912	3,275	1,637	819	327	2,851	2,138	1,425	713	356	143	235	176	118	59	29	12	2	1	1	0	0	0
38	5,972	4,479	2,986	1,493	746	299	2,482	1,861	1,241	620	310	124	178	134	89	45	22	9	1	1	0	0	0	0
40	5,444	4,083	2,722	1,361	681	272	2,161	1,620	1,080	540	270	108	135	101	68	34	17	7	1	0	0	0	0	0
42	4,964	3,723	2,482	1,241	620	248	1,881	1,411	940	470	235	94	102	77	51	26	13	5	0	0	0	0	0	0
44	4,526	3,394	2,263	1,131	566	226	1,637	1,228	819	409	205	82	78	58	39	19	10	4	0	0	0	0	0	0
46	4,126	3,095	2,063	1,032	516	206	1,425	1,069	713	356	178	71	59	44	29	15	7	3	0	0	0	0	0	0
48	3,762	2,821	1,881	940	470	188	1,241	931	620	310	155	62	45	33	22	11	6	2	0	0	0	0	0	0
50	3,430	2,572	1,715	857	429	171	1,080	810	540	270	135	54	34	25	17	8	4	2	0	0	0	0	0	0
52	3,127	2,345	1,563	782	391	156	940	705	470	235	118	47	26	19	13	6	3	1	0	0	0	0	0	0
54	2,851	2,138	1,425	713	356	143	819	614	409	205	102	41	19	15	10	5	2	1	0	0	0	0	0	0
56	2,599	1,949	1,300	650	325	130	713	535	356	178	89	36	15	11	7	4	2	1	0	0	0	0	0	0
58	2,370	1,777	1,185	592	296	118	620	465	310	155	78	31	11	8	6	3	1	1	0	0	0	0	0	0
60	2,161	1,620	1,080	540	270	108	540	405	270	135	68	27	8	6	4	2	1	0	0	0	0	0	0	0
62	1,970	1,477	985	492	246	98	470	353	235	118	59	24	6	5	3	2	1	0	0	0	0	0	0	0
64	1,796	1,347	898	449	224	90	409	307	205	102	51	20	5	4	2	1	1	0	0	0	0	0	0	0
66	1,637	1,228	819	409	205	82	356	267	178	89	45	18	4	3	2	1	0	0	0	0	0	0	0	0
68	1,493	1,120	746	373	187	75	310	233	155	78	39	16	3	2	1	1	0	0	0	0	0	0	0	0
70	1,361	1,021	681	340	170	68	270	203	135	68	34	14	2	2	1	1	0	0	0	0	0	0	0	0
72	1,241	931	620	310	155	62	235	176	118	59	29	12	2	1	1	0	0	0	0	0	0	0	0	0
74	1,131	849	566	283	141	57	205	154	102	51	26	10	1	1	1	0	0	0	0	0	0	0	0	0
76	1,032	774	516	258	129	52	178	134	89	45	22	9	1	1	0	0	0	0	0	0	0	0	0	0
78	940	705	470	235	118	47	155	116	78	39	19	8	1	1	0	0	0	0	0	0	0	0	0	0
80	857	643	429	214	107	43	135	101	68	34	17	7	1	0	0	0	0	0	0	0	0	0	0	0

LNAPL saturation is fraction of pore space filled

Soil concentrations calculated assuming exponential biodegradation: C(t) = Co e^(-r*t)

20% LNAPL saturation selected as maximum expected residual saturation based on soil type and historic LNAPL thickness (Appendix D).

Shading plus bold indicates TPH concentration less than DRO screening level (2000mg/kg)

LNAPL density based on product measurement at MW-59 (See Appendix D).

APPENDIX I: DISPROPORTIONATE COST ANALYSIS BASIS

Table I-1a. Recurring Monitoring and Reporting Costs (Alternatives 1, 2, and 3)
Port of Seattle Terminal 30

2.8%	*Annual Inflation Rate*
2.0%	*Present Day Value (PDV) Discount Rate*

Groundwater Monitoring and Reporting Costs

Year	Description	Qty	Unit	Unit Cost	Total	Notes
1	Semi-Annual Monitoring	2	Event	$15,395	$30,789	Based on Monitoring at 6 wells
2	Semi-Annual Monitoring	2	Event	$15,826	$31,652	
3	Annual Monitoring	1	Event	$16,269	$16,269	
4	Annual Monitoring	1	Event	$16,724	$16,724	
5	Annual Monitoring	1	Event	$17,193	$17,193	
6	Bi-Annual Monitoring	0	Event	$17,674	$0	
7	Bi-Annual Monitoring	1	Event	$18,169	$18,169	
8	Bi-Annual Monitoring	0	Event	$18,678	$0	
9	Bi-Annual Monitoring	1	Event	$19,201	$19,201	
10	Bi-Annual Monitoring	0	Event	$19,738	$0	
11	Bi-Annual Monitoring	1	Event	$20,291	$20,291	
12	Bi-Annual Monitoring	0	Event	$20,859	$0	
13	Bi-Annual Monitoring	1	Event	$21,443	$21,443	
14	Bi-Annual Monitoring	0	Event	$22,044	$0	
15	Bi-Annual Monitoring	1	Event	$22,661	$22,661	
16	5-Year Monitoring	0	Event	$23,295	$0	
17	5-Year Monitoring	0	Event	$23,948	$0	
18	5-Year Monitoring	0	Event	$24,618	$0	
19	5-Year Monitoring	0	Event	$25,307	$0	
20	5-Year Monitoring	1	Event	$26,016	$26,016	
21	5-Year Monitoring	0	Event	$26,745	$0	
22	5-Year Monitoring	0	Event	$27,493	$0	
23	5-Year Monitoring	0	Event	$28,263	$0	
24	5-Year Monitoring	0	Event	$29,055	$0	
25	5-Year Monitoring	1	Event	$29,868	$29,868	
26	5-Year Monitoring	0	Event	$30,704	$0	
27	5-Year Monitoring	0	Event	$31,564	$0	
28	5-Year Monitoring	0	Event	$32,448	$0	
29	5-Year Monitoring	0	Event	$33,356	$0	
30	5-Year Monitoring	1	Event	$34,290	$34,290	
					Subtotal	**$304,566**
					Subtotal (PDV)	**$255,604**

Periodic Consulting Costs

Ecology Periodic Review Support

Year	Description	Qty	Unit	Unit Cost	Total	Notes
5	Lump Sum	1	LS	$10,000	$10,000	First 5-Year Ecology Review Support
10	Lump Sum	1	LS	$13,180	$13,180	Second 5-Year Ecology Review Support
15	Lump Sum	1	LS	$15,132	$15,132	Third 5-Year Ecology Review Support
20	Lump Sum	1	LS	$17,372	$17,372	Fourth 5-Year Ecology Review Support
25	Lump Sum	1	LS	$19,945	$19,945	Fifth 5-Year Ecology Review Support
30	Lump Sum	1	LS	$22,898	$22,898	Sixth 5-Year Ecology Review Support
					Subtotal	**$98,527**
					Subtotal (PDV)	**$68,955**

Soil Containment: Restrictive Environmental Covenant+Survey (by Port)

Year	Description	Qty	Unit	Unit Cost	Total	Notes
7	Admin	2	Hour	$62	$123.33	
7	Tech 1	10	Hour	$112	$1,121	
7	Sr. Tech I	40	Hour	$123	$4,933	
7	Sr Tech II	40	Hour	$135	$5,382	
7	Principal	40	Hour	$196	$7,848	
					Subtotal	**$19,408**
					Subtotal (PDV)	**$17,234**

Note: Costs detailed above are used in Tables I-2 thorugh I-5.

Table I-1b. Recurring Monitoring and Reporting Costs (Alternative 4)
Port of Seattle Terminal 30

2.8%	*Annual Inflation Rate*
2.0%	*Present Day Value (PDV) Discount Rate*

Groundwater Monitoring and Reporting Costs

Year	Description	Qty	Unit	Unit Cost	Total	Notes
1	Semi-Annual Monitoring	2	Event	$20,658	$41,316	Based on Monitoring at 10 wells
2	Semi-Annual Monitoring	2	Event	$21,236	$42,473	
3	Semi-Annual Monitoring	2	Event	$21,831	$43,662	
4	Semi-Annual Monitoring	2	Event	$22,442	$44,884	
5	Semi-Annual Monitoring	2	Event	$23,071	$46,141	
6	Annual Monitoring	1	Event	$23,717	$23,717	
7	Annual Monitoring	1	Event	$24,381	$24,381	
8	Annual Monitoring	1	Event	$25,063	$25,063	
9	Annual Monitoring	1	Event	$25,765	$25,765	
10	Annual Monitoring	1	Event	$26,486	$26,486	
11	Bi-Annual Monitoring	1	Event	$27,228	$27,228	
12	Bi-Annual Monitoring	0	Event	$27,990	$0	
13	Bi-Annual Monitoring	1	Event	$28,774	$28,774	
14	Bi-Annual Monitoring	0	Event	$29,580	$0	
15	Bi-Annual Monitoring	1	Event	$30,408	$30,408	
16	5-Year Monitoring	0	Event	$31,260	$0	
17	5-Year Monitoring	0	Event	$32,135	$0	
18	5-Year Monitoring	0	Event	$33,035	$0	
19	5-Year Monitoring	0	Event	$33,960	$0	
20	5-Year Monitoring	1	Event	$34,910	$34,910	
21	5-Year Monitoring	0	Event	$35,888	$0	
22	5-Year Monitoring	0	Event	$36,893	$0	
23	5-Year Monitoring	0	Event	$37,926	$0	
24	5-Year Monitoring	0	Event	$38,988	$0	
25	5-Year Monitoring	1	Event	$40,079	$40,079	
26	5-Year Monitoring	0	Event	$41,202	$0	
27	5-Year Monitoring	0	Event	$42,355	$0	
28	5-Year Monitoring	0	Event	$43,541	$0	
29	5-Year Monitoring	0	Event	$44,760	$0	
30	5-Year Monitoring	1	Event	$46,014	$46,014	
					Subtotal	**$551,302**
					Subtotal (PDV)	**$478,021**

Periodic Consulting Costs

Ecology Periodic Review Support

Year	Description	Qty	Unit	Unit Cost	Total	Notes
5	Lump Sum	1	LS	$10,000	$10,000	First 5-Year Ecology Review Support
10	Lump Sum	1	LS	$13,180	$13,180	Second 5-Year Ecology Review Support
15	Lump Sum	1	LS	$15,132	$15,132	Third 5-Year Ecology Review Support
20	Lump Sum	1	LS	$17,372	$17,372	Fourth 5-Year Ecology Review Support
25	Lump Sum	1	LS	$19,945	$19,945	Fifth 5-Year Ecology Review Support
30	Lump Sum	1	LS	$22,898	$22,898	Sixth 5-Year Ecology Review Support
					Subtotal	**$98,527**
					Subtotal (PDV)	**$68,955**

Soil Containment: Restrictive Environmental Covenant+Survey (by Port)

Year	Description	Qty	Unit	Unit Cost	Total	Notes
7	Admin	2	Hour	$62	$123.33	
7	Tech 1	10	Hour	$112	$1,121	
7	Sr. Tech I	40	Hour	$123	$4,933	
7	Sr Tech II	40	Hour	$135	$5,382	
7	Principal	40	Hour	$196	$7,848	
					Subtotal	**$19,408**
					Subtotal (PDV)	**$17,234**

Note: Costs detailed above are used in Table I-6.

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Table I-2. Alternative 1: In-Situ Thermal Oxidation
Port of Seattle Terminal 30

2.8%	*Annual Inflation Rate*
2.0%	*Present Day Value (PDV) Discount Rate*

Direct Costs

Groundwater Monitoring and Reporting Costs

Subtotal	**$304,566**
Subtotal (PDV)	**$255,604**

Thermal Oxidation

Year	Description	Qty	Unit	Unit Cost	Total	Notes
1	Design Procurement	1	Inclusive	$402,234	$402,234	TerraTherm Estimate
2	Construction and Operation	1	Inclusive	$9,122,000	$9,122,000	TerraTherm Estimate
2	Utilities	1	Inclusive	$2,674,000	$2,674,000	TerraTherm Estimate
					Subtotal	**$12,198,234**
					Subtotal (PDV)	**$13,103,799**

Other Consulting Costs

Ecology Periodic Review Support

See Table I-1 for details

Subtotal	**$98,527**
Subtotal (PDV)	**$68,955**

Soil Containment: Restrictive Environmental Covenant+Survey (by Port)

See Table I-1 for details

Subtotal	**$19,408**
Subtotal (PDV)	**$17,234**

Subtotal of Direct Costs (PDV)	**$13,457,376**	
Contingency of Direct Costs (PDV)	**$4,710,082**	Scope: 20% Bid: 15%
Consultant Project Management as % of Direct Costs (PDV)	**$1,345,737.60**	10% of Direct Costs
Port of Seattle Project Management as % of Direct Costs (PDV)	**$1,000,000.00**	
Agency Oversight Costs (PDV)	**$1,000,000.00**	
Sales Tax (PDV)	**$1,256,645.04**	

Terminal 30 Costs

Year	Description	Total	Notes
	Administrative Cost	$609,911.70	
	Operational Cost	$1,219,823.40	
		Subtotal	**$1,829,735**
		Subtotal (PDV)	**$2,018,606**

Estimated Total Cost (PDV)	**$ 20,100,000**	Rounded to nearest $100k
Estimated Total Cost with Contingency (PDV)	**$ 24,800,000**	Rounded to nearest $100k

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Table I-3. Alternative 2: Expanded Sheen-Area AS/SVE with Targeted Excavation
Port of Seattle Terminal 30

Direct Costs

2.8%	Annual Inflation Rate
2.0%	Present Day Value (PDV) Discount Rate

Groundwater Monitoring and Reporting Costs

See Table I-1 for details

Subtotal	$616,097
Subtotal (PDV)	$525,684

Air Sparge - Soil Vapor Extraction (AS-SVE) Install

Description	Qty	Unit	Unit Cost	Total	Notes
Mobilization	2	Event	$5,000	$10,000	Assumes mobilization per hole to conform to tenant schedule
Perforated Casing - SVE	350	Foot	$12	$4,200	Custom perforated casing based on depth/length/flow.
Blank Casing - SVE	75	Foot	$8	$600	Blank casing at ends during rise to ground surface
Drill hole - SVE	425	Foot	$110	$46,750	
Perforated Casing - AS	350	Foot	$12	$4,200	Custom perforated casing based on depth/length/flow.
Blank Casing - AS	150	Foot	$8	$1,200	Blank casing at ends during rise to ground surface
Drill hole - AS	500	Foot	$110	$55,000	
Roll Off Dumpster Rental (20 cy)	2	Unit	$500	$1,000	
Soil Volume and disposal	18.7	cy	$75	$1,404	Assume 6-inch hole for soil volume plus 4 yds per pothole
Potholing/Asphalt Repair	3	Per	$20,000	$60,000	Each end plus one location in middle as needed
Monuments, appurtances	4	Lump	$1,500	$6,000	High traffic monuments each end of horizontal boring
Subcontractor Markup	1	%	5%	$9,517.71	
Drill Second Set of Horizontal Wells (Substation to MW-59 Area)					
Mobilization	2	Event	$5,000	$10,000	Assumes mobilization per hole to conform to tenant schedule
Perforated Casing - SVE	550	Foot	$12	$6,600	Custom perforated casing based on depth/length/flow.
Blank Casing - SVE	75	Foot	$8	$600	Blank casing at ends during rise to ground surface
Drill hole - SVE	625	Foot	$110	$68,750	
Perforated Casing - AS	550	Foot	$12	$6,600	Custom perforated casing based on depth/length/flow.
Blank Casing - AS	150	Foot	$8	$1,200	Blank casing at ends during rise to ground surface
Drill hole - AS	700	Foot	$110	$77,000	
Roll Off Dumpster Rental (20 cy)	2	Unit	$500	$1,000	
Soil Volume and disposal	25.6	cy	$75	$1,922	Assume 6-inch hole for soil volume plus 4 yds per pothole
Potholing/Asphalt Repair	4	Per	$20,000	$80,000	Each end plus two locations in middle as needed
Monuments, appurtances	4	Lump	$1,500	$6,000	High traffic monuments each end of horizontal boring
Subcontractor Markup	1	%	5%	$12,983.62	
Mobilize / Setup AS-SVE Equipment to Site					
Utilities (240V, 200 amp service)	2	Install	$15,000	$30,000	Setup utilities for AS/SVE units
Mobilize/Setup AS/SVE Blower	2	Lump	$7,500.00	$15,000	Includes thermal oxidation treatment for exhaust gas
Mobilize/Setup Carbon (later stag	2	Lump	$3,200.00	$6,400	Carbon replaces thermal treatment
Demob Thermal Oxidizer	2	Lump	$3,750.00	$7,500	Demob at transition to carbon
Demob Carbon (later stage)	2	Lump	$500.00	$1,000	At conclusion of treatment
Demob AS/SVE Blower	2	Lump	$3,750.00	$7,500	At conclusion of treatment
Subcontractor Markup	1	%	5%	$3,370	
Consultant Drilling and AS-AVE Setup/Demob Hours					
Observe Drilling	192	Hour	$104.50	$20,064	
Well/System Install Report	45	Hour	$104.50	$4,703	Logs, system install documentation
Well/System Install Report	4	Hour	$166.25	$665	Logs, system install documentation
Logistics / Facilitation	60	Hour	$104.50	$6,270	
System Set Up	40	Hour	$104.50	$4,180	
Setup, Utilities	30	Hour	$104.50	$3,135	
Principal/Contact	50	Hour	$166.25	$8,313	

Subtotal	$590,627
Subtotal (PDV)	$590,627

Description	Qty	Unit	Unit Cost	Total	Notes
Routine O&M Costs - Thermal Oxidation Air Treatment Phase					
Blower Electrical	34,560	kw-hours	$0.085	*$2,938*	kw-hours per 30-day month @240V/100amp
Thermal Oxidizer Electrical	20,736	kw-hours	$0.085	*$1,763*	kw-hours per 30-day month @240V/60amp
Propane	2	Unit	$500	*$1,000*	For thermal oxidizer
Thermal/Blower Rental	2	Unit	$9,150	*$18,300*	
Subcontractor Markup	2	%	5%	*$1,200*	
Weekly System Visit	16	Hours	$104.50	*$1,672*	1 staff, 4 hours per weekly visit
Periodic System Adjustment	8	Hours	$104.50	*$836*	2 staff, 4 hours
				$27,708	Recurring Monthly Cost (Year 1)
Routine O&M Costs - Carbon Air Treatment Phase					
Blower Electrical	34,560	kw-hours	$0.085	*$2,938*	kw-hours per 30-day month @240V/100amp
Carbon/Blower Rental	2	Unit	$5,800.00	*$11,600*	
Subcontractor Markup	2	%	5%	*$727*	
Weekly System Visit	16	Hours	$104.50	*$1,672*	1 staff, 4 hours per weekly visit
Periodic System Adjustment	8	Hours	$104.50	*$836*	2 staff, 4 hours
				$17,772	Recurring Monthly Cost (Year 1)

Year	Description	Qty	Unit	Unit Cost	Total	Notes
1	Monthly AS-SVE Operation	12	Event	$27,708	$332,498	Thermal-Oxidation Air Treatment Phase
2	Monthly AS-SVE Operation	12	Event	$18,270	$219,241	Carbon Air Treatment Phase
3	Monthly AS-SVE Operation	12	Event	$18,782	$225,380	
4	Monthly AS-SVE Operation	12	Event	$19,308	$231,691	
5	Monthly AS-SVE Operation	12	Event	$19,848	$238,178	

Subtotal	$1,246,988
Subtotal (PDV)	$1,202,436

Targeted Excavation

Description	Qty	Unit	Unit Cost	Total	Notes
Excavation Costs					
Mobilization/Permitting	1	Lump	$30,000	$30,000	
Remove Asphalt	37,500	sqft	$5	$187,500	Remove/Recycle; 150 ft by 250 ft
Excavation/Disposal	13,889	cu. yards	$78	$1,083,333	AECOM DCA cost
Backfill	13,889	cu. yards	$24	$333,333	AECOM DCA cost
Replazce Paving	37,500	sqft	$15	$562,500	Scaled up from 2-inch paving costs
Replace RTG	2	Lump	$35,000	$70,000	Assumes $150/yd construction/materials plus $15k for geotech.
Confirmation Sampling	100	sample	$100	$10,000	
Disposal Sampling	34	sample	$100	$3,378	as per Ecology Petroleum Remediation Guidance Table 6.9
Utility Repair	3	Per	$20,000	$60,000	Electrical/Sanitary Sewer
Geologist Obs.	240	Hour	$95	$22,800	6 weeks @ 40 hrs/wk
	0	%	5%	$0	

Subtotal	$2,362,844
Subtotal (PDV)	$2,410,101

Other Consulting Costs

Ecology Periodic Review Support

See Table I-1 for details

Subtotal	$60,000
Subtotal (PDV)	$43,897

Soil Containment: Restrictive Environmental Covenant+Survey (by Port)

See Table I-1 for details

Subtotal	$19,408
Subtotal (PDV)	$17,234

Table I-3. Alternative 2: Expanded Sheen-Area AS/SVE with Targeted Excavation
Port of Seattle Terminal 30

Subtotal of Direct Costs (PDV)	$4,814,949	
Contingency of Direct Costs (PDV)	$1,685,232.25	Scope: 20% Bid: 15%
Consultant Project Management as % of Direct Costs (PDV)	$481,494.93	Calculated at 10% of Direct Costs
Port of Seattle Project Management as % of Direct Costs (PDV)	$962,989.86	
Agency Oversight Costs (PDV)	$481,494.93	
Sales Tax (PDV)	$396,041.47	

Terminal 30 Costs

Year	Description	Qty	Unit	Total	Notes
	Administrative Cost	1	Event	$210,022.97	
	Operational Cost	1	Event	$420,045.95	
				Subtotal	**$630,069**
				Subtotal (PDV)	**$660,793**

Estimated Total Cost (PDV)	**$ 7,800,000**	Rounded to nearest $100k
Estimated Total Cost with Contingency (PDV)	**$ 9,500,000**	Rounded to nearest $100k

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Table I-4. Alternative 3a: Targeted Sheen Area AS/SVE with LNAPL Recovery
Port of Seattle Terminal 30

Direct Costs

2.8%	*Annual Inflation Rate*
2.0%	*Present Day Value (PDV) Discount Rate*

Groundwater Monitoring and Reporting Costs

See Table I-1 for details
Two additional monitoring wells included in LNAPL recovery system mobilization

Subtotal	**$304,566**
Subtotal (PDV)	$255,604

Remediation Costs

Air Sparge - Soil Vapor Extraction (AS-SVE) Install

Year	Description	Qty	Unit	Unit Cost	Total	Notes
Trench in AS/SVE lines and Drill AS Wells (Vessel Tower to MW-42 Area)						
1	Logistics	1	Unit	$2,000	$2,000	Utilitiy locate, etc.
1	Remove Asphalt	590	ft	$20	$11,800	Approx $20/ft from Cascade Saw
1	Trench to 4ft	590	ft	$8	$4,720	Trench to 4 ft below base of asphalt based on target SVE depth
1	Replace Asphalt	590	ft	$20	$11,800	Place new asphalt with 16 inch thickness
1	Drill Air Sparge (AS) Wells	17	Unit	$4,500	$76,500	Drill, install wells with high-strength monuments
1	Soil Disposal	131	cy	$78	$10,227	Assumes disposal at Subtitle D landfill
1	Driller Mobilization	1	Unit	$2,000	$2,000	Nominal mobilization/fuel surcharge fee
1	Clean Backfill	118	cy	$30	$3,540	Backfill trench with clean, compacted structural fill (CDF)
1	SVE Extraction Piping	435	ft	$12	$5,220	Slotted PVC Extraction Pipe
1	SVE Extraction Piping	155	ft	$8	$1,240	Solid Wall PVC Extraction Pipe
1	Air Sparge distribution piping	658	ft	$8	$5,264	Assumes 4 foot offset from trunk line to well
1	PVC tees, valves, fittings	12	Unit	$40	$480	Valving and fittings to assemble AS/SVE
1	Contractor Assembly	60	Unit	$80	$4,800	Contractor piping assembly, attach AS wells
1	Potholing/Asphalt Repair	3	Unit	$20,000	$60,000	Extra excavation and work around unexpected utilities
	Note:drilling costs will increase by ~$75k if vertical SVE wells installed instead of in-trench design.					
Mobilize/Setup AS-SVE Equipment to Site						
1	Air permitting	1	Lump	$5,000	$5,000	Permits for air discharge
1	Utilities (240V, 200 amp service)	1	Install	$15,000	$15,000	Setup utilities at Vessel Tower for AS/SVE units
1	Mobilize/Setup AS/SVE Blower	1	Lump	$7,500	$7,500	Includes thermal oxidation treatment for exhaust gas
2	Mobilize/Setup Carbon (later stag	1	Lump	$3,200	$3,200	Carbon replaces thermal treatment
5	Demob Thermal Oxidizer	1	Lump	$3,750	$3,750	Demob at transition to carbon
5	Demob Carbon (later stage)	1	Lump	$500	$500	At conclusion of treatment
5	Demob AS/SVE Blower	1	Lump	$3,750	$3,750	At conclusion of treatment
1	Subcontractor Markup	1	%	5%	$1,685	Assumed Value
Consultant Drilling and AS-AVE Setup/Demob Hours						
1	Observe Drilling	96	Hour	$104.50	$10,032	
1	Well/System Install Report	40	Hour	$104.50	$4,180	Logs, system install documentation
1	Well/System Install Report	4	Hour	$166.25	$665	Logs, system install documentation
1	Logistics / Facilitation	40	Hour	$104.50	$4,180	
1	System Set Up	20	Hour	$104.50	$2,090	
1	Setup, Utilities	20	Hour	$104.50	$2,090	
1	Principal/Contact	40	Hour	$166.25	$6,650	

Subtotal	**$269,863**
Subtotal (PDV)	$264,191

Year	Description	Qty	Unit	Unit Cost	Total	Notes
Routine O&M Costs - Thermal Oxidation Air Treatment Phase						
1	Blower Electrical	17,280	kw-hours	$0.085	*$1,469*	kw-hours per 30-day month @240V/100amp
1	Thermal Oxidizer Electrical	10,368	kw-hours	$0.085	*$881*	kw-hours per 30-day month @240V/60amp
1	Propane	1	Unit	$1,000	*$1,000*	For thermal oxidizer
1	Thermal/Blower Rental	1	Unit	$9,150.00	*$9,150*	
1	Subcontractor Markup	1	%	5%	*$625*	
1	Weekly System Visit	16	Hours	$104.50	*$1,672*	1 staff, 4 hours per weekly visit
1	Periodic System Adjustment	8	Hours	$104.50	*$836*	2 staff, 4 hours
					$13,125	Recurring Monthly Cost (Year 1)
Routine O&M Costs - Carbon Air Treatment Phase						
1	Blower Electrical	17,280	kw-hours	$0.085	*$1,469*	kw-hours per 30-day month @240V/100amp
1	Carbon/Blower Rental	1	Unit	$5,800.00	*$5,800*	
1	Subcontractor Markup	1	%	5%	*$363*	
1	Weekly System Visit	16	Hours	$104.50	*$1,672*	1 staff, 4 hours per weekly visit
1	Periodic System Adjustment	8	Hours	$104.50	*$836*	2 staff, 4 hours
					$7,632	Recurring Monthly Cost (Year 1)

Year	Description	Qty	Unit	Unit Cost	Total	Notes
1	Monthly AS-SVE Operation	12	Event	$13,125	$157,501	Thermal-Oxidation Air Treatment Phase
2	Monthly AS-SVE Operation	12	Event	$7,846	$94,151	Carbon Air Treatment Phase
3	Monthly AS-SVE Operation	12	Event	$8,066	$96,788	
4	Monthly AS-SVE Operation	12	Event	$8,291	$99,498	
5	Monthly AS-SVE Operation	12	Event	$8,524	$102,284	

Subtotal	**$550,221**
Subtotal (PDV)	$531,088

LNAPL Recovery With Extended Well Network

LNAPL Recovery System Install

Year	Description	Qty	Unit	Unit Cost	Total	Notes
Skimmer Install Cost						
1	Remove Asphalt	350	ft	$20	$7,000	Approx $20/ft from Cascade Saw
1	Trench to 2 ft	350	ft	$6	$2,100	Trench to 6 inches ft below base of asphalt based on target SVE depth
1	Replace Asphalt	350	ft	$20	$7,000	Place new asphalt with 16 inch thickness
1	Drill Wells	14	Unit	$4,000	$56,000	Drill, install wells with high-strength monuments; +1 monitoring well
1	Field Oversight	60	Hours	$105	$6,270	Observe Install
1	Skimmers	12	Unit	$1,500	$18,000	Purchase Skimmers
1	Soil Disposal	19	cy	$78	$1,517	Assumes disposal at Subtitle D landfill
1	Driller Mobilization	1	Unit	$2,000	$2,000	Nominal mobilization/fuel surcharge fee
1	Distribution conduit	1400	ft	$2	$2,800	Supply install conduit for tubing, 3 wells per conduit
1	Product tubing	8400	ft	$2	$12,600	Supply install tubing: 2 lines per well
1	Compressor/Equip	1	Unit	$3,300	$5,000	Compressor, tanks, auto-shutoff valve, fittings
1	System Assembly	1	Lump	$10,000	$5,000	Contractor system assembly of piping, connections
1	System Setup, Tuning	30	hours	$104.5	$3,135	Install skimmers, optimize pumping rates and setup

Subtotal	**$128,422**
Subtotal (PDV)	$128,422

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Table I-4. Alternative 3a: Targeted Sheen Area AS/SVE with LNAPL Recovery
Port of Seattle Terminal 30

Year	Description	Qty	Unit	Unit Cost	Total	Notes
Single O&M Event Cost Breakdown						
1	PGG Oversight					
1	Field Visit	5	Hour	$104.50	*$523*	
1	Logistics	1	Hour	$104.50	*$105*	Schedule vac truck, T30 tenant, and Port; Mobilize/decon field gear
1	Recovery Record Keeping	1	Hour	$105	*$105*	
1	Vacuum Services					
1	Total Number of Gallons for Dis	100	Gallons	$0.25	*$25*	May not be required at all events
1	Contractor Labor	4	Hour	$140	*$560*	Vac truck time for disposal
1	Compressor Maintenance	1	Unit	$100	*$100*	Compressor maintenance based on run-time
1	Subcontractor Markup			5%	*$29*	
					$1,446	*LNAPL Recovery Event Unit Cost*

Year	Description	Qty	Unit	Unit Cost	Total	Notes
1	LNAPL Recovery O&M	12	Event	$1,446	$17,349	Monthly System Check
2	LNAPL Recovery O&M	12	Event	$1,486	$17,835	Monthly System Check
3	LNAPL Recovery O&M	6	Event	$1,528	$9,167	Bi-Monthly System Check
4	LNAPL Recovery O&M	6	Event	$1,571	$9,424	Bi-Monthly System Check
5	LNAPL Recovery O&M	6	Event	$1,615	$9,688	Bi-Monthly System Check
6	LNAPL Recovery O&M	6	Event	$1,660	$9,959	Bi-Monthly System Check
7	LNAPL Recovery O&M	6	Event	$1,706	$10,238	Bi-Monthly System Check
8	LNAPL Recovery O&M	6	Event	$1,754	$10,524	Bi-Monthly System Check
9	LNAPL Recovery O&M	6	Event	$1,803	$10,819	Bi-Monthly System Check
10	LNAPL Recovery O&M	6	Event	$1,854	$11,122	Bi-Monthly System Check
					Subtotal	**$116,124**
					Subtotal (PDV)	$112,118

Other Consulting Costs

Ecology Periodic Review Support

See Table I-1 for details

Subtotal	**$98,527**
Subtotal (PDV)	$68,955

Soil Containment: Restrictive Environmental Covenant+Survey (by Port)

See Table I-1 for details

Subtotal	**$19,408**
Subtotal (PDV)	$17,234

Subtotal of Direct Costs (PDV)	$1,377,611	
Contingency of Direct Costs (PDV)	$482,164	Scope: 20% Bid: 15%
Consultant Project Management as % of Direct Costs (PDV)	$137,761.12	Calculated at 10% of Direct Costs
Port of Seattle Project Management as % of Direct Costs (PDV)	$275,522.24	
Agency Oversight Costs (PDV)	$137,761.12	
Sales Tax (PDV)	$83,476.41	

Terminal 30 Costs

Year	Description	Qty	Unit	Total	Notes
1	Administrative Cost	1	Event	$53,231.48	
1	Operational Cost	1	Event	$106,462.96	
				Subtotal	**$159,694**
				Subtotal (PDV)	$159,694

Estimated Total Cost (PDV)	$ 2,200,000	Rounded to nearest $100k
Estimated Total Cost with Contingency (PDV)	$ 2,700,000	Rounded to nearest $100k

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Table I-5. Alternative 3b: Expanded Sheen Area AS/SVE with LNAPL Recovery
Port of Seattle Terminal 30

3%	*Annual Inflation Rate*
2.0%	*Present Day Value (PDV) Discount Rate*

Direct Costs

Groundwater Monitoring and Reporting Costs

See Table I-1 for details

Subtotal	**$304,566**
Subtotal (PDV)	**$255,604**

Remediation Costs

Air Sparge - Soil Vapor Extraction (AS-SVE) Install

Description	Qty	Unit	Unit Cost	Total	Notes
Drill First Set of Horizontal Wells (Vessel Tower to MW-42 Area)					
Mobilization	2	Event	$5,000	$10,000	Assumes mobilization per hole to conform to tenant schedule
Perforated Casing - SVE	350	Foot	$12	$4,200	Custom perforated casing based on depth/length/flow.
Blank Casing - SVE	75	Foot	$8	$600	Blank casing at ends during rise to ground surface
Drill hole - SVE	425	Foot	$110	$46,750	
Perforated Casing - AS	350	Foot	$12	$4,200	Custom perforated casing based on depth/length/flow.
Blank Casing - AS	150	Foot	$8	$1,200	Blank casing at ends during rise to ground surface
Drill hole - AS	500	Foot	$110	$55,000	
Roll Off Dumpster Rental (20 cy)	2	Unit	$500	$1,000	
Soil Volume and disposal	18.7	cy	$75	$1,404	Assume 6-inch hole for soil volume plus 4 yds per pothole
Potholing/Asphalt Repair	3	Per	$20,000	$60,000	Each end plus one location in middle as needed
Monuments, appurtances	4	Lump	$1,500	$6,000	High traffic monuments each end of horizontal boring
Subcontractor Markup	1	%	5%	$9,517.71	
Drill Second Set of Horizontal Wells (Substation to MW-59 Area)					
Mobilization	2	Event	$5,000	$10,000	Assumes mobilization per hole to conform to tenant schedule
Perforated Casing - SVE	550	Foot	$12	$6,600	Custom perforated casing based on depth/length/flow.
Blank Casing - SVE	75	Foot	$8	$600	Blank casing at ends during rise to ground surface
Drill hole - SVE	625	Foot	$110	$68,750	
Perforated Casing - AS	550	Foot	$12	$6,600	Custom perforated casing based on depth/length/flow.
Blank Casing - AS	150	Foot	$8	$1,200	Blank casing at ends during rise to ground surface
Drill hole - AS	700	Foot	$110	$77,000	
Roll Off Dumpster Rental (20 cy)	2	Unit	$500	$1,000	
Soil Volume and disposal	25.6	cy	$75	$1,922	Assume 6-inch hole for soil volume plus 4 yds per pothole
Potholing/Asphalt Repair	4	Per	$20,000	$80,000	Each end plus two locations in middle as needed
Monuments, appurtances	4	Lump	$1,500	$6,000	High traffic monuments each end of horizontal boring
Subcontractor Markup	1	%	5%	$12,983.62	
Mobilize / Setup AS-SVE Equipment to Site					
Utilities (240V, 200 amp service)	2	Install	$15,000	$30,000	Setup utilities for AS/SVE units
Mobilize/Setup AS/SVE Blower	2	Lump	$7,500.00	$15,000	Includes thermal oxidation treatment for exhaust gas
Mobilize/Setup Carbon (later stag	2	Lump	$3,200.00	$6,400	Carbon replaces thermal treatment
Demob Thermal Oxidizer	2	Lump	$3,750.00	$7,500	Demob at transition to carbon
Demob Carbon (later stage)	2	Lump	$500.00	$1,000	At conclusion of treatment
Demob AS/SVE Blower	2	Lump	$3,750.00	$7,500	At conclusion of treatment
Subcontractor Markup	1	%	5%	$3,370	
Consultant Drilling and AS-AVE Setup/Demob Hours					
Observe Drilling	192	Hour	$104.50	$20,064	
Well/System Install Report	45	Hour	$104.50	$4,703	Logs, system install documentation
Well/System Install Report	4	Hour	$166.25	$665	Logs, system install documentation
Logistics / Facilitation	60	Hour	$104.50	$6,270	
System Set Up	40	Hour	$104.50	$4,180	
Setup, Utilities	30	Hour	$104.50	$3,135	
Principal/Contact	50	Hour	$166.25	$8,313	
				Subtotal	**$590,627**
				Subtotal (PDV)	**$590,627**

Description	Qty	Unit	Unit Cost	Total	Notes
Routine O&M Costs - Thermal Oxidation Air Treatment Phase					
Blower Electrical	34,560	kw-hours	$0.085	*$2,938*	kw-hours per 30-day month @240V/100amp
Thermal Oxidizer Electrical	20,736	kw-hours	$0.085	*$1,763*	kw-hours per 30-day month @240V/60amp
Propane	2	Unit	$1,500	*$3,000*	For thermal oxidizer
Thermal/Blower Rental	2	Unit	$9,150	*$18,300*	
Subcontractor Markup	2	%	5%	*$1,300*	
Weekly System Visit	16	Hours	$104.50	*$1,672*	1 staff, 4 hours per weekly visit
Periodic System Adjustment	8	Hours	$104.50	*$836*	2 staff, 4 hours
				$29,808	Recurring Monthly Cost (Year 1)
Routine O&M Costs - Carbon Air Treatment Phase					
Blower Electrical	34,560	kw-hours	$0.085	*$2,938*	kw-hours per 30-day month @240V/100amp
Carbon/Blower Rental	2	Unit	$5,800.00	*$11,600*	
Subcontractor Markup	2	%	5%	*$727*	
Weekly System Visit	16	Hours	$104.50	*$1,672*	1 staff, 4 hours per weekly visit
Periodic System Adjustment	8	Hours	$104.50	*$836*	2 staff, 4 hours
				$17,772	Recurring Monthly Cost (Year 1)

Year	Description	Qty	Unit	Unit Cost	Total	Notes
1	Monthly AS-SVE Operation	12	Event	$29,808	$357,698	Thermal-Oxidation Air Treatment Phase
2	Monthly AS-SVE Operation	12	Event	$18,782	$225,380	Carbon Air Treatment Phase
3	Monthly AS-SVE Operation	12	Event	$19,308	$231,691	
4	Monthly AS-SVE Operation	12	Event	$19,848	$238,178	
5	Monthly AS-SVE Operation	12	Event	$20,404	$244,847	
					Subtotal	**$1,297,794**
					Subtotal (PDV)	**$1,251,994**

LNAPL Recovery With Extended Well Network

Description	Qty	Unit	Unit Cost	Total	Notes
Install Extended Well Network					
Field Oversight (1 staff)	50	Hour	$104.50	*$5,225*	
Driller	10	Well	$5,000	*$50,000*	Nominal 4-inch well with heavy-duty monument
Subcontractor Markup			5%	*$2,500*	
				Subtotal	**$57,725**
				Subtotal (PDV)	**$63,725**

Description	Qty	Unit	Unit Cost	Total	Notes
Single Extraction Event Cost					
PGG Oversight					
Field Oversight (2 staff)	48	Hour	$104.50	*$5,016*	
Logistics	6	Hour	$104.50	*$627*	Schedule vac truck, T30 tenant, and Port; Mobilize/decon field gear
Recovery Record Keeping	4	Hour	$105	*$418*	
Vacuum Services					
Total Number of Gallons for Dis	600	Gallons	$0.25	*$150*	
Contractor Labor	24	Hour	$140	*$3,360*	

Table I-5. Alternative 3b: Expanded Sheen Area AS/SVE with LNAPL Recovery
Port of Seattle Terminal 30

Subcontractor Markup	5%	*$176*	
		$9,747	*LNAPL Recovery Event Unit Cost*

Year	Description	Qty	Unit	Unit Cost	Total	Notes
1	Recovery Event	12	Event	$9,747	$116,958	Monthly LNAPL Recovery
2	Recovery Event	4	Event	$10,019	$40,078	Quarterly LNAPL Recovery
3	Recovery Event	4	Event	$10,300	$41,200	Quarterly LNAPL Recovery
4	Recovery Event	4	Event	$10,588	$42,353	Quarterly LNAPL Recovery
5	Recovery Event	4	Event	$10,885	$43,539	Quarterly LNAPL Recovery
6	Recovery Event	2	Event	$11,190	$22,379	Semi-Annual LNAPL Recovery
7	Recovery Event	2	Event	$11,503	$23,006	Semi-Annual LNAPL Recovery
8	Recovery Event	1	Event	$11,825	$11,825	Annual LNAPL Recovery
9	Recovery Event	1	Event	$12,156	$12,156	Annual LNAPL Recovery
10	Recovery Event	1	Event	$12,496	$12,496	Annual LNAPL Recovery
		35			**Subtotal**	**$365,991**
					Subtotal (PDV)	**$360,302**

Other Consulting Costs

Ecology Periodic Review Support

See Table I-1 for details

Subtotal	**$60,000**
Subtotal (PDV)	**$43,897**

Soil Containment: Restrictive Environmental Covenant+Survey (by Port)

See Table I-1 for details

Subtotal	**$19,408**
Subtotal (PDV)	**$17,234**

Subtotal of Direct Costs (PDV)	**$2,583,383**	
Contingency of Direct Costs (PDV)	**$904,184**	Scope: 20% Bid: 15%
Consultant Project Management as % of Direct Costs (PDV)	**$258,338**	Calculated at 10% of Direct Costs
Port of Seattle Project Management as % of Direct Costs (PDV)	**$516,677**	
Agency Oversight Costs (PDV)	**$258,338**	
Sales Tax (PDV)	**$171,356**	

Terminal 30 Costs

Year	Description	Qty	Unit	Total	Notes
	Administrative Cost	1	Event	$115,606.82	
	Operational Cost	1	Event	$231,213.63	
				Subtotal	**$346,820**
				Subtotal (PDV)	**$387,507**

Estimated Total Cost (PDV)	**$ 4,200,000**	Rounded to nearest $100k
Estimated Total Cost with Contingency (PDV)	**$ 5,100,000**	Rounded to nearest $100k

Table I-6. Alternative 4: Compliance Monitoring with LNAPL Recovery
Port of Seattle Terminal 30

Direct Costs

2.8%	*Annual Inflation Rate*
2.0%	*Present Day Value (PDV) Discount Rate*

Groundwater Monitoring and Reporting Costs

See Table I-1 for details

Subtotal	**$551,302**
Subtotal (PDV)	$478,021

LNAPL Recovery With Extended Well Network

Description	Qty	Unit	Unit Cost	Total	Notes
Install Extended Well Network					
Field Oversight (1 staff)	50	Hour	$104.50	*$5,225*	
Driller	10	Well	$5,000	*$50,000*	Nominal 4-inch well with heavy-duty monument
Subcontractor Markup			5%	*$2,500*	
				Subtotal	**$57,725**
				Subtotal (PDV)	$58,880

Description	Qty	Unit	Unit Cost	Total	Notes
Single Extraction Event Cost					
PGG Oversight					
Field Oversight (2 staff)	48	Hour	$104.50	*$5,016*	
Logistics	6	Hour	$104.50	*$627*	Schedule vac truck, T30 tenant, and Port; Mobilize/decon field gear
Recovery Record Keeping	4	Hour	$105	*$418*	
Vacuum Services					
Total Number of Gallons for Dis	600	Gallons	$0.25	*$150*	
Contractor Labor	24	Hour	$140	*$3,360*	
Subcontractor Markup			5%	*$176*	
				$9,747	*LNAPL Recovery Event Unit Cost*

Year	Description	Qty	Unit	Unit Cost	Total	Notes
1	Recovery Event	12	Event	$9,747	$116,958	Monthly LNAPL Recovery
2	Recovery Event	4	Event	$10,019	$40,078	Quarterly LNAPL Recovery
3	Recovery Event	4	Event	$10,300	$41,200	Quarterly LNAPL Recovery
4	Recovery Event	4	Event	$10,588	$42,353	Quarterly LNAPL Recovery
5	Recovery Event	4	Event	$10,885	$43,539	Quarterly LNAPL Recovery
6	Recovery Event	2	Event	$11,190	$22,379	Semi-Annual LNAPL Recovery
7	Recovery Event	2	Event	$11,503	$23,006	Semi-Annual LNAPL Recovery
8	Recovery Event	1	Event	$11,825	$11,825	Annual LNAPL Recovery
9	Recovery Event	1	Event	$12,156	$12,156	Annual LNAPL Recovery
10	Recovery Event	1	Event	$12,496	$12,496	Annual LNAPL Recovery
		35			**Subtotal**	**$365,991**
					Subtotal (PDV)	$347,808

Other Consulting Costs

Ecology Periodic Review Support

See Table I-1 for details

Subtotal	**$98,527**
Subtotal (PDV)	$68,955

Soil Containment: Restrictive Environmental Covenant+Survey (by Port)

See Table I-1 for details

Subtotal	**$19,408**
Subtotal (PDV)	$17,234

Subtotal of Direct Costs (PDV)	**$970,896**	
Contingency of Direct Costs (PDV)	**$339,814**	Scope: 20% Bid: 15%
Consultant Project Management as % of Direct Costs (PDV)	**$97,089.65**	Calculated at 10% of Direct Costs
Port of Seattle Project Management as % of Direct Costs (PDV)	**$194,179.30**	
Agency Oversight Costs (PDV)	**$97,089.65**	
Sales Tax (PDV)	**$11,784.12**	

Terminal 30 Costs

Year	Description	Qty	Unit	Unit Cost	Total	Notes
	Administrative Cost	1	Event	$21,185.78	$21,185.78	
	Operational Cost	1	Event	$0.00	$0.00	
					Subtotal	**$21,186**
					Subtotal (PDV)	$48,545

Estimated Total Cost (PDV)	**$ 1,400,000**	Rounded to nearest $100k
Estimated Total Cost with Contingency (PDV)	**$ 1,700,000**	Rounded to nearest $100k

PGG

Terminal 30, Seattle WA
Preliminary Conceptual
Design Summary

Preliminary Conceptual Design Parameters
SEE Approach

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Terminal 30, Seattle WA
Preliminary Conceptual Design Summary

Terminal 30, Seattle WA	**Pacific Groundwater Group**	
Volume and heat capacity	***Zone 1***	***Unit***
Treatment area	189,100	ft^2
Upper depth of treatment	-	ft bgs
Lower depth of treatment	8	ft bgs
Volume, TTZ	56,030	yd^3
Solids volume	36,419	yd^3
Porosity	0.35	-
Porosity volume	19,610	yd^3
Initial saturation	80	percent
Soil weight	162,623,223	lbs soil
Water weight	26,471,784	lbs water
Soil heat capacity	40,655,806	BTU/F
Water heat capacity	26,471,784	BTU/F
Total heat capacity, whole TTZ	67,127,590	BTU/F

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Terminal 30, Seattle WA
Preliminary Conceptual Design Summary, continued

Terminal 30, Seattle WA	Pacific Groundwater Group	
Energy balance	***Zone 1***	***Unit***
Steam injection rate	40,500	lbs/hr
Water extraction rate during heatup	183.8	gpm
Average extracted water temperature	190	F
Percent of injected steam extracted as steam	15	%
Steam extracted, average	6,075	lbs/hr
Energy flux into treatment volume	39,325,500	BTU/hr
Energy flux in extracted groundwater	12,889,833	BTU/hr
Energy flux in extracted steam	5,898,825	BTU/hr
Net energy flux into treatment volume	20,536,842	BTU/hr
Heating per day	7.3	F/day
Start temperature	50	F
Target temperature	212	F
Estimated heat loss, worst case	67	%
Operating time		
Shake-down	7	days
Heating to boiling point	37	days
Pressure cycling	90	days
Sampling/analysis phase	10	days
Post treatment vapor extraction	14	days
Total operating time	158	days

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Terminal 30, Seattle WA
Preliminary Conceptual Design Summary, continued

Terminal 30, Seattle WA	Pacific Groundwater Group
Numbers of wells	***Zone 1***
Multiphase extraction well, slurping	121
Horizontal SVE wells	120
Steam injection wells	405
Temperature monitoring holes	44
Pressure monitoring wells	12

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Terminal 30, Seattle WA
Preliminary Conceptual Design Summary, continued

Terminal 30, Seattle WA		**Pacific Groundwater Group**
Process equipment	***Value***	***Unit***
Treatment system power supply	300	kW
Total power need to site	380	kW
Estimated total electric load	500	kVA
Water softener feed rate	81.1	gpm
Steam generator capacity	40,500.0	lbs/hr
Vapor extraction rate, total	4,330	scfm
Non-condensable vapor	2,160	scfm
Estimated steam extraction	2,170	scfm
Liquid extraction rate	183.8	gpm
Condensed liquid rate	12.2	gpm
Water treatment rate	195.9	gpm
Vapor treatment type	Thermal Oxidizer w/ heat recovery	-
Dominant contaminant of concern	Diesel and gasoline	-
Estimated COC mass	1,430,000	lbs
Estimated COC mass treated by vapor system	715,000	lbs
Estimated maximum mass removal rate	20,530	lbs/day

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Terminal 30, Seattle WA
Preliminary Conceptual Design Summary, continued

Terminal 30, Seattle WA	**Pacific Groundwater Group**	
Utility estimates	***Value***	***Unit***
Steam usage, total	84,526,000	lbs
Power usage, total	1,092,000	kWh
Gas usage, total	141,254	MM BTU
Discharge water, total	41,836,609	gallons
Discharge vapor, total	492	mill scf
NAPL disposal, total	20,172	gallons

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Terminal 30, Seattle WA

Preliminary Turn-Key Full-Scale Price

SEE Approach

TERRATHERM®

Terminal 30, Seattle WA
Preliminary Conceptual Design Cost Summary

Pacific Groundwater Group Terminal 30, Seattle WA	
Design and Procurement	$402,234
Construction and Operation	$9,122,000
Utilities, paid by client	$2,674,000
Total	**$12,198,234**

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Terminal 30, Seattle WA

Treatability Study Cost Discussion

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Terminal 30, Seattle WA
Treatability Study Cost Range

Typical Treatability Study costs range from $15,000 to $45,000 depending on the goals of the study and the number of samples tested.

Goals would be to simulate SEE in the laboratory and determine the quantities of diesel that would be removed. Increasing the number of pore volumes of steam applied should also be evaluated to determine any additional removal rates.

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Assumptions

SEE Treatment

Terminal 30, Seattle WA

TERRATHERM®

Terminal 30, Seattle WA
Prelminary Conceptual Design
Assumptions

Confidential W. WA State Pacific Groundwater Group General Assumptions	
1	A preliminary treatment concept and price are presented for Steam Enhanced Extraction (SEE) including design to final report, conditional on assumptions presented; task sharing can occur and is typically discussed at a later time; scheduling is based on TerraTherm availability. Basis of contracting is determined at a later date.
2	SEE wells are spaced 25 ft apart and are powered by traditional utilities with a treatment temperature of 100°C. Installation rates are estimated to be 180 ft/day.
3	MPE wells and horizontal soil vapor extraction (SVE) wells are proposed for pneumatic / hydraulic site control and contaminant extraction, powered by traditional utilities. The location of the horizontal wells, i.e., near ground surface, are conducive to effectively operating an SVE system to remove vapor generated during treatment.
4	Thermal oxidation is proposed for the vapor treatment; permit application is prepared by Pacific Groundwater Group with support from TerraTherm.
5	Liquid GAC is proposed for the liquid treatment; GAC waste handled by client/Pacific Groundwater Group.
6	NAPL extracted will be containerized for client disposal where we have included the fee for disposal of 20,172 gallons of NAPL disposed at an estimated rate of $9/lb.
7	Disposal of any drill cuttings are excluded from the price.
8	Permitting fees are excluded; details to apply for permitting are included in costs.
9	All utilities are paid directly by client and are included "at cost" in the preliminary conceptual costs presented.
10	All data provided as a basis for this preliminary concept is considered a good faith representation of the current site conditions.

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Terminal 30, Seattle WA
Prelminary Conceptual Design
Assumptions, continued

Confidential W. WA State Pacific Groundwater Group General Assumptions	
11	Power and other utilities are assumed to be available to the site with service available in a reasonable timeframe.
12	It is assumed that the site is free of any existing infrastructure not compatible with treatment temperatures or which would interfere with treatment application.
13	It is assumed that sufficient space is provided for unencumbered site construction and thermal operations.
14	It is assumed that the saturated TTZ is unaffected by cooling groundwater influxes to the TTZ or that that tidal influences are not significant enough to affect the SEE approach.
15	It is assumed that there are no major site cooling effects present in the subsurface, i.e. utility or other conduits.
16	The contaminant mass in the source area, i.e., TTZ, is 1,430,000 lbs.
17	Estimated porosity is 0.35 and hydraulic conductivity is 0.05 cm/s; hydraulic gradient is estimated to be 0.01 ft/ft; it is assumed that 2 gpm will be entering the TTZ from the bottom for the SEE approach. It is assumed that the sheet pile wall does not transmit water and that water influxes would be from the bottom of the TTZ.
18	Estimated initial water saturation is 80%.
19	An insulating vapor cover is excluded and assumed to not be needed as the site is covered with thick asphalt (~12 inches) .
20	24-hr staffed site security is not included.

TERRATHERM®

Terminal 30, Seattle WA
Prelminary Conceptual Design
Assumptions, continued

Confidential W. WA State Pacific Groundwater Group General Assumptions	
21	Unit gas costs are included at $18/mm BTU.
22	Unit power costs are included at $0.12/kWh.
23	GAC costs with disposal are included at $2.50/lb.
24	NAPL disposal costs are included at $9.0/lb.
25	3 men are proposed to be on site during drilling.
26	2 drill rigs are proposed.
27	3 men are included for operations period.
28	Power drop and transformer are excluded.
29	Removal of steel wells are excluded and it is assumed that the well abandonment procedures include cutting off well head and grouting well.
30	Site restoration is excluded.

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APPENDIX J: 2013 DATA GAP MEMO

Technical Memorandum

To: Sunny Becker, Washington State Department of Ecology

From: Glen Wallace and Janet Knox, Pacific Groundwater Group

Re: Port of Seattle Terminal 30 – 2013 Well Installation and Data Gaps Sampling

Date: November 13, 2013

This technical memorandum describes updates to the monitoring well network at the Port of Seattle Terminal 30 (T30) site and targeted groundwater monitoring in support of the draft Cleanup Action Plan. The updates include decommissioning a damaged well and installing two conditional point of compliance (CPOC) wells to fill data gaps described in the *Terminal 30 Remedial Investigation / Feasibility Study* (PGG, 2013b) and *Port of Seattle Terminal 30 Data Gaps* (PGG, 2013a) memo to the Washington State Department of Ecology (Ecology).

Monitoring well updates and groundwater sampling were performed in general accordance with the scope of work described in the Port of Seattle Terminal 30 Monitoring Well Updates (PGG, 2013a). This work was performed, our findings obtained, and this memo prepared using generally accepted hydrogeologic practices used at this time and in this vicinity, for exclusive application to this study, and for the exclusive use of the Port of Seattle. This is in lieu of other warranties, express or implied.

FIELD ACTIVITIES

Field activities to fill data gaps identified in the 2013 RI/FS (PGG, 2013b) are described in the following and included well decommissioning and installation, select soil sampling, and a targeted groundwater sampling event.

MONITORING WELL UPDATES AND SELECT SOIL SAMPLING

Updates to the T30 monitoring well network include:

- Decommission damaged well MW-58
- Install replacement CPOC well MW-58A
- Install new CPOC well MW-92

Well locations are presented in Figure 1. Field work to update the monitoring well network was completed on August 29 and 30, 2013. Drilling activities were completed by a Washington State licensed well driller with Cascade Drilling, L.P. of Woodinville, Washington using a track-mounted sonic drill rig. A licensed geologist with Pacific Groundwater Group (PGG) observed drilling and well installation activities. Well logs for MW-58A and MW-92 are presented in Figures 2 and 3.

MW-58 Decommissioning

As previously documented (PGG, 2013a and 2013b), damage to the MW-58 PVC well screen and casing was observed during a down-hole camera inspection. MW-58 was therefore decommissioned in accordance with WAC 173-160-460 by over-drilling to 30 feet below ground surface (bgs) and backfilling with hydrated bentonite to 2.5 feet bgs. The former flush-mounted protective well monument was removed and the upper 2.5 feet of the hole was filled with cement and troweled smooth with surrounding asphalt.

MW-58A Drilling and Installation

Replacement well MW-58A was installed approximately 5 feet southwest of decommissioned well MW-58. This location was selected to avoid multiple utility locations in the immediate area and maintain proximity to the previous well location. MW-58A was originally attempted 6 feet north of MW-58, but a 6-inch PVC sewer line was encountered at 6 feet bgs and drilling at that location was discontinued. The storm line was repaired by the Port of Seattle. MW-58A was drilled by advancing 6-inch sonic casing to 25-feet bgs. Continuous soil core was recovered and logged in the field by a PGG geologist (Figure 2). Petroleum odor was not noted in vadose zone soils. Petroleum odor was noted in soils below the water table at 17 to 22 feet bgs. An indigo blue dye test at 20 feet bgs was negative for petroleum. Because MW-58A is a replacement well, no soil samples for lab analysis were collected during drilling.

MW-58A was constructed with 2-inch PVC 0.010-inch slotted PVC screen from 5 to 25 feet bgs and flush threaded 2-inch diameter PVC riser pipe from 0.1 to 5 feet bgs. Annular materials included 2/12 Lapis Lustre silica sand pack from 3.5 to 25 feet bgs and concrete between 0 and 3.5 feet bgs. A Sherwood high-traffic steel monument was installed flush with the ground surface. A PVC end cap was installed at the bottom of the screen and a PVC expanding well cap was installed in the top of the PVC casing. The static water level was 10.67 feet below top of casing on August 30, 2013.

Following well installation, MW-58A was developed by surging and pumping with a Q-water development tool to remove fine grained material from the surrounding aquifer and minimize turbidity during subsequent sampling. Initial turbidity was heavy with fine sand in purge water. The well was purged until turbidity stabilized at moderate to light turbidity (cloudy). Approximately 25 gallons were purged during development. Purge water was clear at the time of sampling in October 2013.

MW-92 Drilling, Installation, and Soil Sampling

MW-92 was installed approximately 375 feet north-northeast of the Vessel Tower at the preferred location indicated by Ecology. MW-92 was drilled by advancing 6-inch sonic casing to 20 feet bgs. During drilling, continuous soil core was recovered and logged in the field by a PGG geologist (Figure 3). Petroleum odor was noted in soils above, at, and below the water table during drilling. Indigo-blue dye field test kits were used to test for petroleum at two locations. The dye test was slightly positive 7 feet in a thin-interval of viscous petroleum (Figure 3). The co-location of the viscous petroleum with a discrete layer of gravel suggests a historical ground surface in the former bulk fuel facility. Dye tests are effective in gasoline through diesel petroleum, so the slightly positive dye test indicates that the observed viscous petroleum contains little gasoline- through diesel-range hydrocarbons. A dye test at 15 feet from a saturated interval with faint petroleum odor was negative for petroleum.

Soil samples for lab analyses of select site contaminants of concern were collected at 4.5, 13, and 18 feet bgs. Samples were assigned names S-92 to reflect the media and borehole number, followed by the approximate collection depth in feet (e.g. S-92-13). Samples were collected based on the following field criteria:

- S-92-4.5: sample collected in shallow fill above water table with petroleum odor
- S-92-13: sample collected from saturated soil with gasoline-like petroleum odor
- S-92-18: sample collected from saturated soil with slight petroleum odor

Clean-gloved hands and clean stainless steel spoons were used to transfer soil from cores into laboratory-provided sample jars. Fresh gloves and clean spoons were used for each sample. Samples were placed in coolers with ice and delivered to Friedman and Bruya, Inc., a Washington-certified analytical lab, for analysis on September 3, 2013.

MW-92 was constructed with 2-inch PVC 0.010-inch slotted PVC screen from 5 to 20 feet below ground surface and flush threaded 2-inch diameter PVC pipe from 0.1 to 5 feet bgs. Annular materials included 2/12 Lapis Lustre silica sand pack from 3.5 to 20 feet bgs, hydrated bentonite from 2.5 to 5 feet bgs, and concrete between 0 and 2.5 feet bgs. A Sherwood high-traffic steel monument was installed flush with the ground surface. A PVC end cap was installed at the bottom of the screen and a PVC expanding well cap was installed in the top of the PVC casing. The static water level in the well was 8.41 feet below top of casing on August 30, 2013.

Following well installation, MW-92 was developed by surging and pumping with a Q-water development tool to remove fine grained material from the surrounding aquifer and minimize turbidity during subsequent sampling. Initial turbidity was heavy with fine sand in purge water. Turbidity decreased only slightly during development and purging of approximately 30 gallons of water. Purge water was clear at the time of sampling in October 2013.

GROUNDWATER SAMPLING

Targeted groundwater sampling was conducted on October 10, 2013 consistent with the scope of work described in *Port of Seattle Terminal 30 Data Gaps* (PGG, 2013a). Monitoring wells MW-42, MW-58A, MW-89, and MW-92 were sampled following the protocols in the Terminal 30 Sampling and Analysis Plan (SAP) (ENSR|AECOM, 2008) for select site contaminants of concern and parameters related to remedial design. Enhanced monitoring parameters were not measured in the field. Measureable free product was not observed in the wells sampled. Field parameters measured with a YSI 556 and flow-through cell included: pH; specific conductivity; dissolved oxygen; turbidity; temperature; and oxidation reduction potential.

Groundwater samples were placed in coolers with ice and delivered to Friedman and Bruya, Inc. for analysis on October 11, 2013.

INVESTIGATIVE-DERIVED WASTE

Drill cuttings, development water, and purge water were contained in 55 gallon, steel drums that are temporarily being secured inside the locked environmental storage shed at T30 until they are transported for offsite disposal.

ANALYTICAL RESULTS

Soil and groundwater results are summarized in Tables 1 and 2 and discussed in the following sections.

SOIL RESULTS

Soil samples were analyzed for gasoline-, diesel-, and motor oil-range petroleum hydrocarbons; chemical oxygen demand; and biologic oxygen demand (Table 1). Key results include:

- Diesel-, gasoline-, and motor oil-range organic concentrations were below site cleanup levels protective of soil leaching to groundwater in both saturated samples (S-92-13 and S-92-18).
- Concentrations of diesel-, gasoline-, and motor oil-range organics exceeded site cleanup levels in the sample collected above the water table (S-92-4.5). The concentration of motor oil-range organics was almost twice the cleanup level and the concentration of gasoline-range organics exceeded the cleanup level by a factor of 3.6.
- Chemical oxygen demand was low in the saturated zone and highest in the unsaturated zone, consistent with the pattern of petroleum detections.

Analytical soil results from borehole MW-92 indicate residual contamination in the unsaturated zone above cleanup levels based on protection of soil-leaching to groundwater. However, the concentrations of contaminants of concern in soil samples collected below the water table and in the groundwater sample from MW-92 (see below) were less than cleanup levels indicating that the soil leaching to groundwater pathway is not complete at that location.

GROUNDWATER RESULTS

Groundwater samples collected in October 2013 were analyzed for gasoline-, diesel-, and motor oil-range petroleum hydrocarbons; benzene, toluene, ethylbenzene, total xylenes (BTEX); 2-methylnaphthalene; and polynuclear aromatic hydrocarbons (PAHs). Consistent with the SAP, diesel- and motor oil-range hydrocarbon samples had silica gel cleanup prior to analysis to remove interferences from non-petroleum compounds. PAH samples were centrifuged prior to analysis. Key results include:

- All four groundwater samples were below screening levels for site constituents of concern.
- MW-42 had the highest gasoline-range organics and benzene concentrations, consistent with the upgradient location of the well in an area with moderate sheen.
- Motor oil-range organics were not detected in the October 2013 groundwater samples.

Groundwater concentrations at MW-42 and MW-89 have occasionally been below screening levels in previous events (PGG, 2013b). The October 2013 groundwater results at MW-58A were generally consistent with recent results from decommissioned well MW-58. This was the first sampling event at MW-92 and results were consistent with the site conceptual model (PGG, 2013).

QUALITY ASSURANCE

Samples were analyzed using standard lab methods. All analyses were conducted within hold times except BOD soil samples, which were performed beyond hold time and may be biased low. All lab control samples were within acceptable recovery and relative percent difference ranges.

The data are generally acceptable for the intended purpose. BOD data are J-flagged as estimates as they may be biased low due to analysis out of hold time.

REFERENCES

Pacific Groundwater Group, 2013a. Port of Seattle Terminal Data Gaps. July 12, 2013.

Pacific Groundwater Group, 2013b. Terminal 30 Remedial Investigation / Feasibility Study. November 2013.

ATTACHMENTS

Table 1. Soil Results

Table 2. Groundwater Monitoring Results

Figure 1. Well Network
Figure 2. MW-58A Well Log
Figure 3. MW-92 Well Log

Appendix A. Analytical Lab Reports

mw replacement memo
JE1005.09

Table 1. Soil Results

Port of Seattle Terminal 30

Constituent	Units	S-92-4.5	S-92-13	S-92-18	Screening Level
Depth	*ft bgs*	*4.5*	*13*	*18*	
Diesel Range	mg/kg	**2600**	50 U	50 U	2000
Gasoline Range	mg/kg	**110**	5	23	30*
Motor Oil Range	mg/kg	**3900**	250 U	250 U	2000
COD	ug/g	10000	400 U	400 U	--
BOD	mg/g	140 J	150 J	210 J	--

Notes:

* Benzene assumed present. Screening level is 100 mg/kg if benzene not present.

J Sample analyze beyond hold time; estimated value; potentially biased low

U indicates non-detect at reporting limit shown

Table 2. Groundwater Monitoring Results

Port of Seattle Terminal 30

Constituent	Units	MW-42	MW-58A	MW-89	MW-92	Cleanup Level
Field Parameters						
Water Level (August 30, 2013)	*ft*	--	10.67	--	8.41	--
Water Level (October 11, 2013)	*ft*	10.04	9.65	9.53	9.80	--
pH	*std. units*	6.70	6.73	6.71	0.77	--
Specific Conductivity	*umhos/cm*	7572	900	4397	989	--
Temperature	*C*	15.29	15.02	16.06	16.25	--
Turbidity	*NTU*	0.59	0.12	0.35	0.35	--
Oxidation Reduction Potential	*mV*	13.8	*	*	10.4	--
Dissolved Oxygen	*mg/L*	0.47	0.22	0.18	0.36	--
Petroleum Compounds						
Diesel Fuel	*mg/L*	0.17	0.18	0.17	0.15	0.5
Gasoline Range Organics	*mg/L*	0.65	0.25	0.59	0.36	0.8 **
Motor Oil	*mg/L*	0.25 U	0.25 U	0.25 U	0.25 U	0.5
Benzene	*ug/L*	18	1 U	1 U	1 U	23
Toluene	*ug/L*	5	1.6	2.7	1 U	15000
Ethylbenzene	*ug/L*	1.1	1 U	1.6	2.4	2100
Total Xylenes	*ug/L*	5.6	3 U	4.2	3 U	1000
Semi-Volatile Organic Compounds						
2-Methylnaphthalene	*ug/L*	4.9	0.91	1.5	1.3	NV
Polynuclear Aromatic Hydrocabons (PAHs)						
Acenaphthene	*ug/L*	0.22	4.4	0.92	0.15	643
Acenaphthylene	*ug/L*	0.1	0.05 U	0.062	0.05 U	NV
Anthracene	*ug/L*	0.05 U	0.35	0.06	0.05 U	25900
Benz(a)anthracene	*ug/L*	0.01 U	0.01	0.01 U	0.01 U	0.018
Benzo(a)pyrene	*ug/L*	0.01 U	0.01 U	0.01 U	0.01 U	0.018
Benzo(b)fluoranthene	*ug/L*	0.01 U	0.01 U	0.01 U	0.01 U	0.018
Benzo(g,h,i)perylene	*ug/L*	0.05 U	0.05 U	0.05 U	0.05 U	NV
Benzo(k)fluoranthene	*ug/L*	0.01 U	0.01 U	0.01 U	0.01 U	0.018
Chrysene	*ug/L*	0.01 U	0.01 U	0.01 U	0.01 U	0.018
Dibenzo(a,h)anthracene	*ug/L*	0.01 U	0.01 U	0.01 U	0.01 U	0.018
Fluoranthene	*ug/L*	0.05 U	1.2	0.061	0.05 U	90
Fluorene	*ug/L*	0.2	1.9	0.47	0.11	3460
Indeno(1,2,3-cd)pyrene	*ug/L*	0.01 U	0.01 U	0.01 U	0.01 U	0.018
Naphthalene	*ug/L*	0.24	2.3	0.05 U	0.21	4940
Phenanthrene	*ug/L*	0.097	4.9	0.29	0.17	NV
Pyrene	*ug/L*	0.05 U	0.75	0.051	0.05 U	2590

Notes:

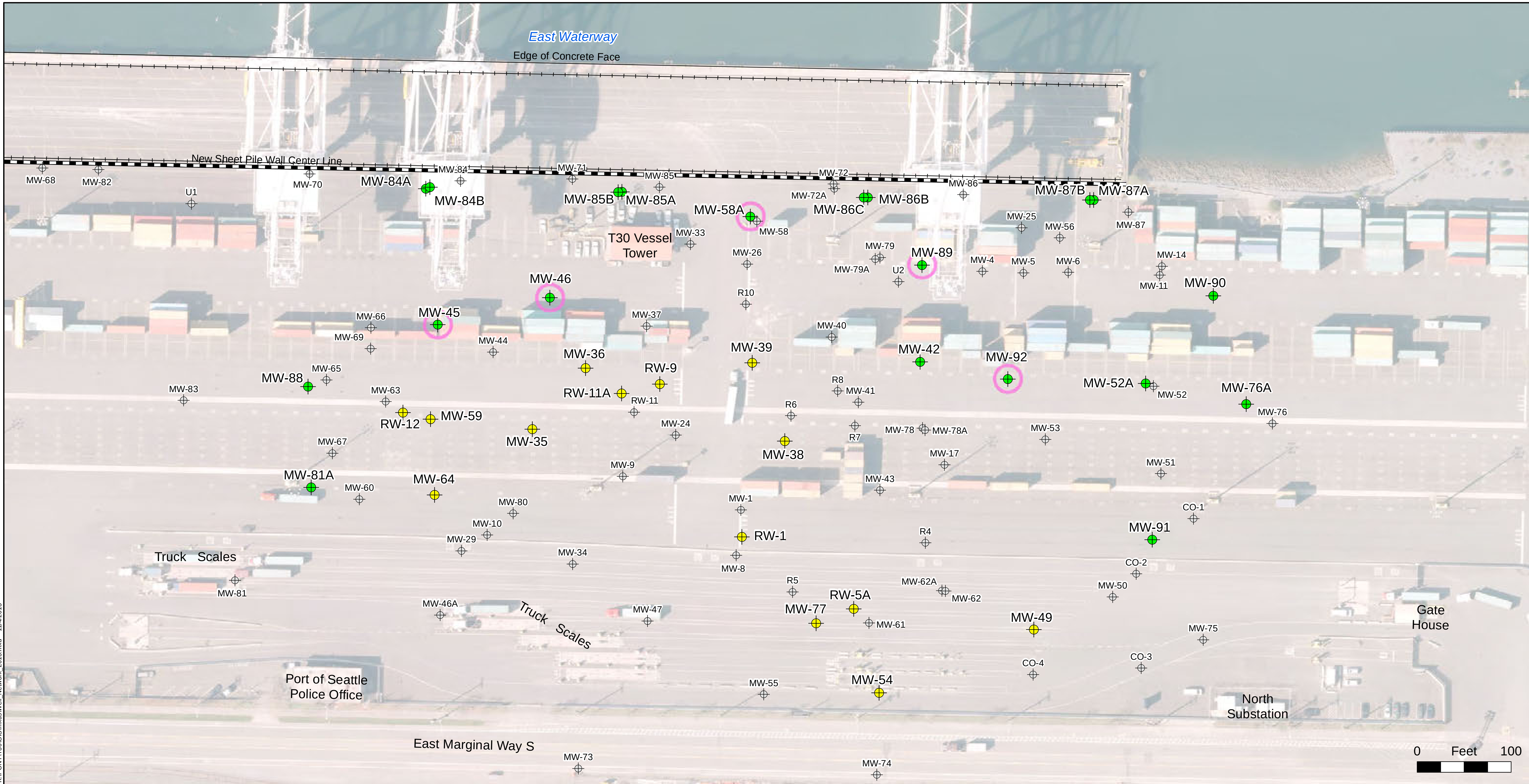
* Field meter did not measure oxidation reduction potential

** Benzene assumed present. Screening level is 1 mg/L if benzene not present.

U indicates non-detect at reporting limit shown

NV: no site cleanup level value has been established for this constituent

Silica gel cleanup was applied to diesel and motor oil sample aliquots prior to analysis



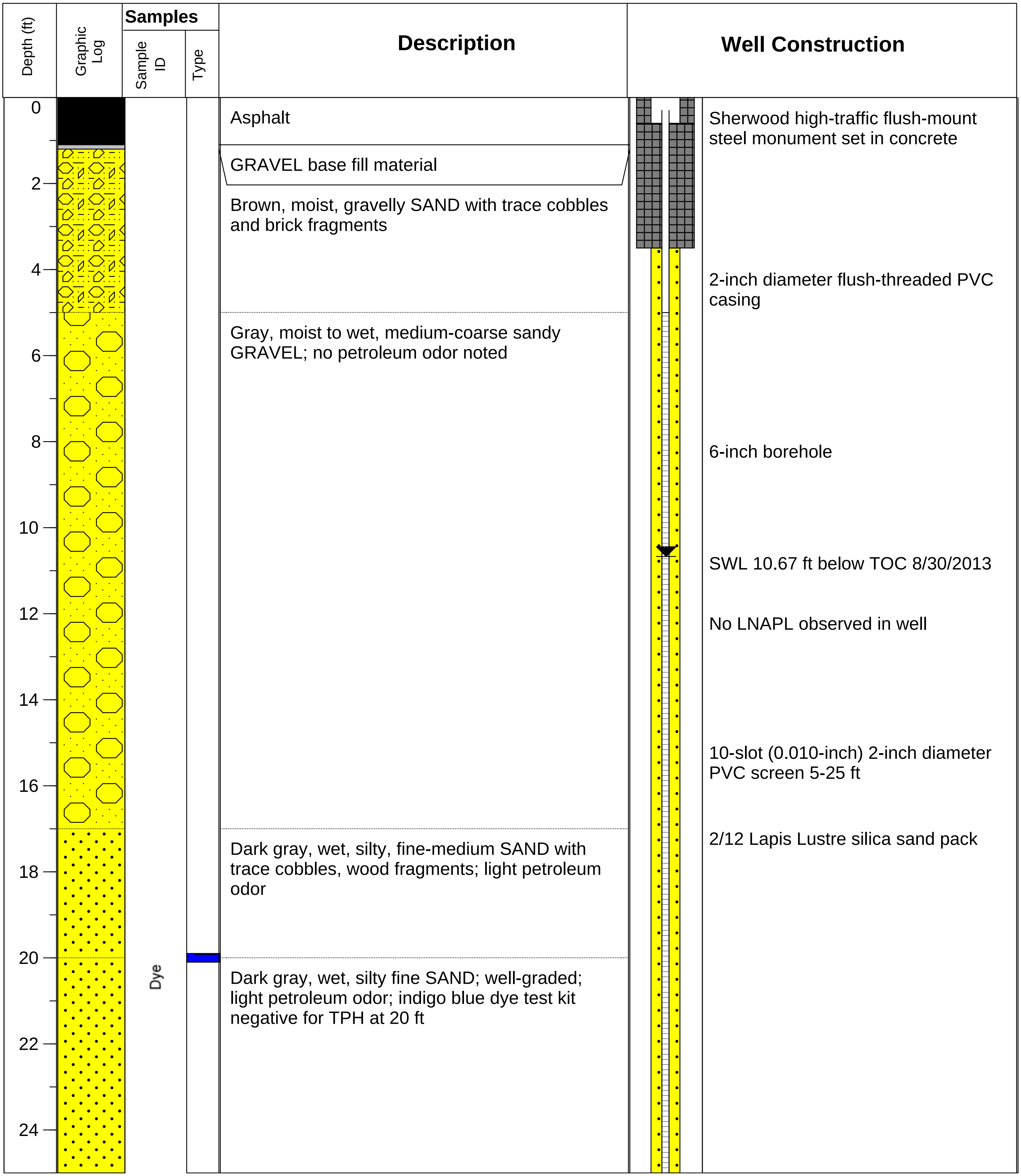
- Gaging/Recovery Well
- Water Quality Monitoring Well
- Decommissioned Wells
- Conditional Point of Compliance (CPOC) Wells

2012 USGS Orthophoto

Figure 1
Well Network

Port of Seattle
Terminal 30

PGG



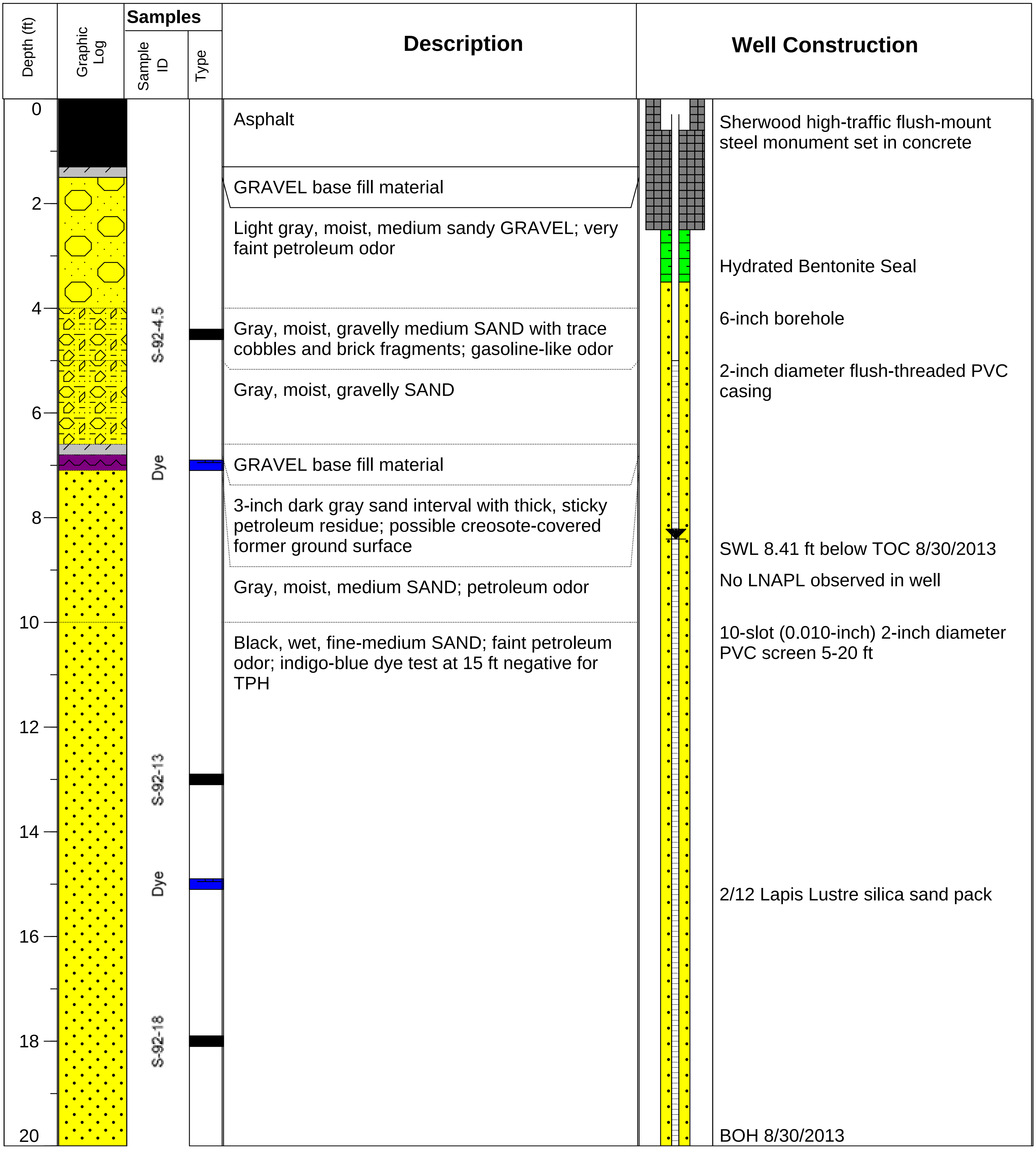
Address: 1901 E Marginal Way
City, State: Seattle, WA
Tax Parcel ID: 7666207830
Location (TRS): T24N R04E S07; SW1/4 of NE1/4
Lat/Long: Not Surveyed
Consulting Firm: Pacific Groundwater Group
Logged by: Glen Wallace

Drilling Firm: Cascade Drilling
Drilling Method: Sonic
Ecology ID: BIC-765
DTW: 10.67
MP Elevation: Not Surveyed
V. Datum: Not Surveyed
Completed Date: 8/29/2013

Figure 2
MW-58A Boring Log and As-Built

Port of Seattle Terminal 30
Data Gaps
JE1005

PGG



Address: 1901 E Marginal Way
City, State: Seattle, WA
Tax Parcel ID: 7666207830
Location (TRS): T24N R04E S07; SW1/4 of NE1/4
Lat/Long: Not Surveyed
Consulting Firm: Pacific Groundwater Group
Logged by: Glen Wallace

Drilling Firm: Cascade Drilling
Drilling Method: Sonic
Ecology ID: BIC-766
DTW: 8.41
MP Elevation: Not Surveyed
V. Datum: Not Surveyed
Completed Date: 8/30/2013

Figure 3
MW-92 Boring Log and As-Built

Port of Seattle Terminal 30
Data Gaps
JE1005

PGG

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Kurt Johnson, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

September 20, 2013

Glen Wallace, Project Manger
Pacific Groundwater Group
2377 Eastlake Ave East
Seattle, WA 98102

Dear Mr. Wallace:

Included are the results from the testing of material submitted on September 3, 2013 from the T30 JE1005, F&BI 309001 project. There are 6 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you should have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
PGG0920R.DOC

CASE NARRATIVE

This case narrative encompasses samples received on September 3, 2013 by Friedman & Bruya, Inc. from the Pacific Groundwater Group T30 JE1005, F&BI 309001 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Pacific Groundwater Group
309001 -01	S-92-4.5
309001 -02	S-92-13
309001 -03	S-92-18

The samples were sent to Amtest for COD/BOD analysis. The report is enclosed.

All quality control requirements were acceptable.

Date of Report: 09/20/13
Date Received: 09/03/13
Project: T30 JE1005, F&BI 309001
Date Extracted: 09/06/13
Date Analyzed: 09/06/13

**RESULTS FROM THE ANALYSIS OF SOIL SAMPLES
FOR TOTAL PETROLEUM HYDROCARBONS AS GASOLINE
USING METHOD NWTPH-Gx**

Results Reported on a Dry Weight Basis
Results Reported as mg/kg (ppm)

Sample ID Laboratory ID	Gasoline Range	Surrogate (% Recovery) (Limit 50-150)
S-92-4.5 309001-01 1/5	110	119
S-92-13 309001-02	5.0	103
S-92-18 309001-03	23	117
Method Blank 03-1742 MB	<2	104

Date of Report: 09/20/13
Date Received: 09/03/13
Project: T30 JE1005, F&BI 309001
Date Extracted: 09/04/13
Date Analyzed: 09/04/13

RESULTS FROM THE ANALYSIS OF SOIL SAMPLES FOR TOTAL PETROLEUM HYDROCARBONS AS DIESEL AND MOTOR OIL USING METHOD NWTPH-Dx

Results Reported on a Dry Weight Basis
Results Reported as mg/kg (ppm)

Sample ID Laboratory ID	Diesel Range (C_{10}-C_{25})	Motor Oil Range (C_{25}-C_{36})	Surrogate (% Recovery) (Limit 53-144)
S-92-4.5 309001-01	2,600 x	3,900	113
S-92-13 309001-02	<50	<250	112
S-92-18 309001-03	<50	<250	115
Method Blank 03-1751 MB2	<50	<250	118

Date of Report: 09/20/13
Date Received: 09/03/13
Project: T30 JE1005, F&BI 309001

QUALITY ASSURANCE RESULTS FOR THE ANALYSIS OF SOIL SAMPLES FOR TPH AS GASOLINE USING METHOD NWTPH-Gx

Laboratory Code: Laboratory Control Sample

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Percent Recovery LCSD	Acceptance Criteria	RPD (Limit 20)
Gasoline	mg/kg (ppm)	20	95	95	71-131	0

Date of Report: 09/20/13
Date Received: 09/03/13
Project: T30 JE1005, F&BI 309001

QUALITY ASSURANCE RESULTS FROM THE ANALYSIS OF SOIL SAMPLES FOR TOTAL PETROLEUM HYDROCARBONS AS DIESEL EXTENDED USING METHOD NWTPH-Dx

Laboratory Code: 309004-05 (Matrix Spike)

Analyte	Reporting Units	Spike Level	Sample Result (Wet Wt)	Percent Recovery MS	Percent Recovery MSD	Acceptance Criteria	RPD (Limit 20)
Diesel Extended	mg/kg (ppm)	5,000	<50	114	117	73-135	3

Laboratory Code: Laboratory Control Sample

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Diesel Extended	mg/kg (ppm)	5,000	118	74-139

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

A1 – More than one compound of similar molecule structure was identified with equal probability.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for this range fell outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte indicated may be due to carryover from previous sample injections.

d - The sample was diluted. Detection limits may be raised due to dilution.

ds - The sample was diluted. Detection limits are raised due to dilution and surrogate recoveries may not be meaningful.

dv - Insufficient sample was available to achieve normal reporting limits and limits are raised accordingly.

fb - Analyte present in the blank and the sample.

fc – The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. The variability is attributed to sample inhomogeneity.

ht - Analysis performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of normal control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j – The result is below normal reporting limits. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The analyte result in the laboratory control sample is out of control limits. The reported concentration should be considered an estimate.

jr - The rpd result in laboratory control sample associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the compound indicated is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc – The sample was received in a container not approved by the method. The value reported should be considered an estimate.

pr – The sample was received with incorrect preservation. The value reported should be considered an estimate.

ve - Estimated concentration calculated for an analyte response above the valid instrument calibration range. A dilution is required to obtain an accurate quantification of the analyte.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

Am Test Inc.
13600 NE 126TH PL
Suite C
Kirkland, WA 98034
(425) 885-1664
www.amtestlab.com

Professional Analytical Services

ANALYSIS REPORT

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Attention: MICHAEL ERDAHL
Project #: 309001
PO Number: C-519
All results reported on an as received basis.

Date Received: 09/03/13
Date Reported: 9/18/13

AMTEST Identification Number **13-A012602**
Client Identification **S-92-4.5**
Sampling Date **08/30/13, 09:30**

BOD	140	mg/g		1.0	SM 5210B	NG	09/04/13

Demand

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANALYST	DATE
Chemical Oxygen Demand	10000	ug/g		10	EPA 410.4	MB	09/11/13

AMTEST Identification Number **13-A012603**
Client Identification **S-92-13**
Sampling Date **08/30/13, 10:00**

BOD	150	mg/g		1.0	SM 5210B	NG	09/04/13

Demand

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANALYST	DATE
Chemical Oxygen Demand	< 400	ug/g		10	EPA 410.4	MB	09/11/13

AMTEST Identification Number **13-A012604**
Client Identification **S-92-18**
Sampling Date **08/30/13, 10:05**

BOD	210	mg/g		1.0	SM 5210B	NG	09/04/13

Demand

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANALYST	DATE
Chemical Oxygen Demand	< 400	ug/g		10	EPA 410.4	MB	09/11/13

Aaron W. Young
Laboratory Manager

Am Test Inc.
13600 NE 126th PL
Suite C
Kirkland, WA, 98034
(425) 885-1664
www.amtestlab.com

Professional Analytical Services

QC Summary for sample numbers: 13-A012602 to 13-A012604

DUPLICATES

SAMPLE #	ANALYTE	UNITS	SAMPLE VALUE	DUP VALUE	RPD
13-A012602	BOD	mg/g	140	160	13.

STANDARD REFERENCE MATERIALS

ANALYTE	UNITS	TRUE VALUE	MEASURED VALUE	RECOVERY
BOD	mg/g	200	170	85.0 %
Chemical Oxygen Demand	ug/g	100	94.	94.0 %

BLANKS

ANALYTE	UNITS	RESULT
BOD	mg/g	< 1
Chemical Oxygen Demand	ug/g	< 10

SUBCONTRACT SAMPLE CHAIN OF CUSTODY

Send Report To Michael Erdahl

Company Friedman and Bruya, Inc.

Address 3012 16th Ave W

City, State, ZIP Seattle, WA 98119

Phone # (206) 285-8282 Fax # (206) 283-5044

SUBCONTRACTER Amtest

PROJECT NAME/NO.	PO #
309001	C-519

REMARKS

Please Email Results

Page # 1 of 1

TURNAROUND TIME
☒ Standard (2 Weeks)
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Return samples
☐ Will call with instructions

Sample ID	Lab ID	Date Sampled	Time Sampled	Matrix	# of jars	Dioxins and Furans by 8290	EPH	VPH	Nitrate	Sulfate	Alkalinity	BOD	COD			Notes
S-92-4.5	26602	8/30/13	930	Soil	1							X	X			
S-92-13	03	↓	1000	↓	1							X	X			
S-92-18	04	↓	1005	↓	1							X	X			

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282
Fax (206) 283-5044

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Michael Erdahl	Friedman & Bruya	9/3/13	1445
Received by: [signature]	Justin Miller	Amtest	9/3/13	1650
Relinquished by:				
Received by:				

309001

SAMPLE CHAIN OF CUSTODY

ME 09-03-13 E01 / VS1 / CI3

Send Report To Glen Wallace

Company PGG

Address 2377 Eastlake Ave E

City, State, ZIP Seattle, WA 98102

Phone # 206 329 0141 Fax # ______

SAMPLERS (signature)

PROJECT NAME/NO. T30

PO# JE1005

REMARKS
Please provide EDD in PGG-Format.

Page # ____ of ____

TURNAROUND TIME
- ☐ Standard (2 Weeks)
- ☐ RUSH ______

Rush charges authorized by ______

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Return samples
- ☐ Will call with instructions

Sample ID	Lab ID	Date Sampled	Time Sampled	Sample Type	# of containers	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by8260	SVOCs by 8270	HFS	COD/BOD						Notes
S-92-4.5	01A-E	8/30/13	930	S	5	\	\					\						
S-92-13	02A-E	8/30/13	1000	S	5	\	\					\						
S-92-18	03A-E	8/30/13	1005	S	5	\	\					\						

Samples received at 20 °C — Ice was melted. Large amounts of water

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282
Fax (206) 283-5044

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Glen Wallace	PGG		
Received by: [signature]	M. NABIL	POSTAL	9/3/13	9:50
Relinquished by:				
Received by:				

FORMS\COC\COC.DOC

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

James E. Bruya, Ph.D.
Yelena Aravkina, M.S.
Michael Erdahl, B.S.
Kurt Johnson, B.S.
Eric Young, B.S.

3012 16th Avenue West
Seattle, WA 98119-2029
(206) 285-8282
fbi@isomedia.com
www.friedmanandbruya.com

October 31, 2013

Glen Wallace, Project Manger
Pacific Groundwater Group
2377 Eastlake Ave East
Seattle, WA 98102

Dear Mr. Wallace:

Included are the results from the testing of material submitted on October 11, 2013 from the T30 Port of Seattle JE1005.09, F&BI 310208 project. There are 15 pages included in this report. Any samples that may remain are currently scheduled for disposal in 30 days. If you would like us to return your samples or arrange for long term storage at our offices, please contact us as soon as possible.

We appreciate this opportunity to be of service to you and hope you will call if you should have any questions.

Sincerely,

FRIEDMAN & BRUYA, INC.

Michael Erdahl
Project Manager

Enclosures
PGG1031R.DOC

CASE NARRATIVE

This case narrative encompasses samples received on October 11, 2013 by Friedman & Bruya, Inc. from the Pacific Groundwater Group T30 Port of Seattle JE1005.09, F&BI 310208 project. Samples were logged in under the laboratory ID's listed below.

Laboratory ID	Pacific Groundwater Group
310208 -01	MW89
310208 -02	MW92
310208 -03	MW42
310208 -04	MW58A

The samples were sent to Aquatic Research for COD and BOD analyses. Review of the enclosed report indicates that all quality assurance were acceptable.

An 8270D internal standard failed the acceptance criteria for samples MW92 and MW58A due to matrix interferences. The data were flagged accordingly. The samples were diluted and reanalyzed.

All other quality control requirements were acceptable.

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Date of Report: 10/31/13
Date Received: 10/11/13
Project: T30 Port of Seattle JE1005.09, F&BI 310208
Date Extracted: 10/15/13
Date Analyzed: 10/15/13

RESULTS FROM THE ANALYSIS OF WATER SAMPLES FOR BENZENE, TOLUENE, ETHYLBENZENE, XYLENES AND TPH AS GASOLINE USING METHODS 8021B AND NWTPH-Gx

Results Reported as ug/L (ppb)

Sample ID Laboratory ID	Benzene	Toluene	Ethyl Benzene	Total Xylenes	Gasoline Range	Surrogate (% Recovery) (Limit 50-150)
MW89 310208-01	<1	2.7	1.6	4.2	590	101
MW92 310208-02	<1	<1	2.4	<3	360	100
MW42 310208-03	18	5.0	1.1	5.6	650	101
MW58A 310208-04	<1	1.6	<1	<3	250	98
Method Blank 03-2025 MB	<1	<1	<1	<3	<100	89

Date of Report: 10/31/13
Date Received: 10/11/13
Project: T30 Port of Seattle JE1005.09, F&BI 310208
Date Extracted: 10/15/13
Date Analyzed: 10/18/13

RESULTS FROM THE ANALYSIS OF WATER SAMPLES
FOR TOTAL PETROLEUM HYDROCARBONS AS
DIESEL AND MOTOR OIL
USING METHOD NWTPH-Dx
Sample Extracts Passed Through a
Silica Gel Column Prior to Analysis
Results Reported as ug/L (ppb)

Sample ID Laboratory ID	Diesel Range (C_{10}-C_{25})	Motor Oil Range (C_{25}-C_{36})	Surrogate (% Recovery) (Limit 47-140)
MW89 310208-01	170 x	<250	62
MW92 310208-02	150 x	<250	72
MW42 310208-03	170 x	<250	64
MW58A 310208-04	180 x	<250	67
Method Blank 03-2064 MB2	<50	<250	63

Analysis For Semivolatile Compounds By EPA Method 8270D SIM

Client Sample ID:	MW89	Client:	Pacific Groundwater Group
Date Received:	10/11/13	Project:	T30 Port of Seattle JE1005.09, F&BI 310208
Date Extracted:	10/16/13	Lab ID:	310208-01 1/0.25
Date Analyzed:	10/20/13	Data File:	102013.D
Matrix:	Water	Instrument:	GCMS6
Units:	ug/L (ppb)	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
Anthracene-d10	86	50	150
Benzo(a)anthracene-d12	83	50	129

Compounds:	Concentration ug/L (ppb)
Naphthalene	<0.05
Acenaphthylene	0.062
Acenaphthene	0.92
Fluorene	0.47
Phenanthrene	0.29
Anthracene	0.060
Fluoranthene	0.061
Pyrene	0.051
Benz(a)anthracene	<0.01
Chrysene	<0.01
Benzo(a)pyrene	<0.01
Benzo(b)fluoranthene	<0.01
Benzo(k)fluoranthene	<0.01
Indeno(1,2,3-cd)pyrene	<0.01
Dibenz(a,h)anthracene	<0.01
Benzo(g,h,i)perylene	<0.05
2-Methylnaphthalene	1.5

Note: The sample was centrifuged prior to extraction.

Analysis For Semivolatile Compounds By EPA Method 8270D SIM

Client Sample ID:	MW92	Client:	Pacific Groundwater Group
Date Received:	10/11/13	Project:	T30 Port of Seattle JE1005.09, F&BI 310208
Date Extracted:	10/16/13	Lab ID:	310208-02 1/0.25
Date Analyzed:	10/20/13	Data File:	102014.D
Matrix:	Water	Instrument:	GCMS6
Units:	ug/L (ppb)	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
Anthracene-d10	76	50	150
Benzo(a)anthracene-d12	81 J	50	129

Compounds:	Concentration ug/L (ppb)
Naphthalene	0.21
Acenaphthylene	<0.05
Acenaphthene	0.15
Fluorene	0.11
Phenanthrene	0.17
Anthracene	<0.05
Fluoranthene	<0.05
Pyrene	<0.05 J
Benz(a)anthracene	<0.01 J
Chrysene	<0.01 J
Benzo(a)pyrene	<0.01 J
Benzo(b)fluoranthene	<0.01 J
Benzo(k)fluoranthene	<0.01 J
Indeno(1,2,3-cd)pyrene	<0.01 J
Dibenz(a,h)anthracene	<0.01 J
Benzo(g,h,i)perylene	<0.05 J
2-Methylnaphthalene	1.2

Note: The sample was centrifuged prior to extraction.

Analysis For Semivolatile Compounds By EPA Method 8270D SIM

Client Sample ID:	MW92	Client:	Pacific Groundwater Group
Date Received:	10/11/13	Project:	T30 Port of Seattle JE1005.09, F&BI 310208
Date Extracted:	10/16/13	Lab ID:	310208-02 1/2.5
Date Analyzed:	10/22/13	Data File:	102214.D
Matrix:	Water	Instrument:	GCMS6
Units:	ug/L (ppb)	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
Anthracene-d10	121	50	150
Benzo(a)anthracene-d12	82	50	129

Compounds:	Concentration ug/L (ppb)
Naphthalene	<0.5
Acenaphthylene	<0.5
Acenaphthene	<0.5
Fluorene	<0.5
Phenanthrene	<0.5
Anthracene	<0.5
Fluoranthene	<0.5
Pyrene	<0.5
Benz(a)anthracene	<0.1
Chrysene	<0.1
Benzo(a)pyrene	<0.1
Benzo(b)fluoranthene	<0.1
Benzo(k)fluoranthene	<0.1
Indeno(1,2,3-cd)pyrene	<0.1
Dibenz(a,h)anthracene	<0.1
Benzo(g,h,i)perylene	<0.5
2-Methylnaphthalene	1.3

Note: The sample was centrifuged prior to extraction.

Analysis For Semivolatile Compounds By EPA Method 8270D SIM

Client Sample ID:	MW42	Client:	Pacific Groundwater Group
Date Received:	10/11/13	Project:	T30 Port of Seattle JE1005.09, F&BI 310208
Date Extracted:	10/16/13	Lab ID:	310208-03 1/0.25
Date Analyzed:	10/20/13	Data File:	102015.D
Matrix:	Water	Instrument:	GCMS6
Units:	ug/L (ppb)	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
Anthracene-d10	81	50	150
Benzo(a)anthracene-d12	79	50	129

Compounds:	Concentration ug/L (ppb)
Naphthalene	0.24
Acenaphthylene	0.10
Acenaphthene	0.22
Fluorene	0.20
Phenanthrene	0.097
Anthracene	<0.05
Fluoranthene	<0.05
Pyrene	<0.05
Benz(a)anthracene	<0.01
Chrysene	<0.01
Benzo(a)pyrene	<0.01
Benzo(b)fluoranthene	<0.01
Benzo(k)fluoranthene	<0.01
Indeno(1,2,3-cd)pyrene	<0.01
Dibenz(a,h)anthracene	<0.01
Benzo(g,h,i)perylene	<0.05
2-Methylnaphthalene	4.9 ve

Note: The sample was centrifuged prior to extraction.

Analysis For Semivolatile Compounds By EPA Method 8270D SIM

Client Sample ID:	MW42	Client:	Pacific Groundwater Group
Date Received:	10/11/13	Project:	T30 Port of Seattle JE1005.09, F&BI 310208
Date Extracted:	10/16/13	Lab ID:	310208-03 1/2.5
Date Analyzed:	10/23/13	Data File:	102314.D
Matrix:	Water	Instrument:	GCMS6
Units:	ug/L (ppb)	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
Anthracene-d10	82	50	150
Benzo(a)anthracene-d12	120	50	129

Compounds:	Concentration ug/L (ppb)
Naphthalene	<0.5
Acenaphthylene	<0.5
Acenaphthene	<0.5
Fluorene	<0.5
Phenanthrene	<0.5
Anthracene	<0.5
Fluoranthene	<0.5
Pyrene	<0.5
Benz(a)anthracene	<0.1
Chrysene	<0.1
Benzo(a)pyrene	<0.1
Benzo(b)fluoranthene	<0.1
Benzo(k)fluoranthene	<0.1
Indeno(1,2,3-cd)pyrene	<0.1
Dibenz(a,h)anthracene	<0.1
Benzo(g,h,i)perylene	<0.5
2-Methylnaphthalene	5.2

Note: The sample was centrifuged prior to extraction.

Analysis For Semivolatile Compounds By EPA Method 8270D SIM

Client Sample ID:	MW58A	Client:	Pacific Groundwater Group
Date Received:	10/11/13	Project:	T30 Port of Seattle JE1005.09, F&BI 310208
Date Extracted:	10/16/13	Lab ID:	310208-04 1/0.25
Date Analyzed:	10/20/13	Data File:	102016.D
Matrix:	Water	Instrument:	GCMS6
Units:	ug/L (ppb)	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
Anthracene-d10	89	50	150
Benzo(a)anthracene-d12	86 J	50	129

Compounds:	Concentration ug/L (ppb)
Naphthalene	2.1
Acenaphthylene	<0.05
Acenaphthene	3.6 ve
Fluorene	1.5
Phenanthrene	4.1 ve
Anthracene	0.35
Fluoranthene	0.97
Pyrene	0.68 J
Benz(a)anthracene	0.01 J
Chrysene	<0.01 J
Benzo(a)pyrene	<0.01 J
Benzo(b)fluoranthene	<0.01 J
Benzo(k)fluoranthene	<0.01 J
Indeno(1,2,3-cd)pyrene	<0.01 J
Dibenz(a,h)anthracene	<0.01 J
Benzo(g,h,i)perylene	<0.05 J
2-Methylnaphthalene	0.84

Note: The sample was centrifuged prior to extraction.

Analysis For Semivolatile Compounds By EPA Method 8270D SIM

Client Sample ID:	MW58A	Client:	Pacific Groundwater Group
Date Received:	10/11/13	Project:	T30 Port of Seattle JE1005.09, F&BI 310208
Date Extracted:	10/16/13	Lab ID:	310208-04 1/2.5
Date Analyzed:	10/25/13	Data File:	102509.D
Matrix:	Water	Instrument:	GCMS6
Units:	ug/L (ppb)	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
Anthracene-d10	112 ds	50	150
Benzo(a)anthracene-d12	90 ds	50	129

Compounds:	Concentration ug/L (ppb)
Naphthalene	2.3
Acenaphthylene	<0.5
Acenaphthene	4.4
Fluorene	1.9
Phenanthrene	4.9
Anthracene	<0.5
Fluoranthene	1.2
Pyrene	0.75
Benz(a)anthracene	<0.1
Chrysene	<0.1
Benzo(a)pyrene	<0.1
Benzo(b)fluoranthene	<0.1
Benzo(k)fluoranthene	<0.1
Indeno(1,2,3-cd)pyrene	<0.1
Dibenz(a,h)anthracene	<0.1
Benzo(g,h,i)perylene	<0.5
2-Methylnaphthalene	0.91

Note: The sample was centrifuged prior to extraction.

FRIEDMAN & BRUYA, INC.

ENVIRONMENTAL CHEMISTS

Analysis For Semivolatile Compounds By EPA Method 8270D SIM

Client Sample ID:	Method Blank	Client:	Pacific Groundwater Group
Date Received:	NA	Project:	T30 Port of Seattle JE1005.09, F&BI 310208
Date Extracted:	10/16/13	Lab ID:	03-2092 mb 1/0.25
Date Analyzed:	10/20/13	Data File:	102009.D
Matrix:	Water	Instrument:	GCMS6
Units:	ug/L (ppb)	Operator:	VM

Surrogates:	% Recovery:	Lower Limit:	Upper Limit:
Anthracene-d10	98	50	150
Benzo(a)anthracene-d12	95	50	129

Compounds:	Concentration ug/L (ppb)
Naphthalene	<0.05
Acenaphthylene	<0.05
Acenaphthene	<0.05
Fluorene	<0.05
Phenanthrene	<0.05
Anthracene	<0.05
Fluoranthene	<0.05
Pyrene	<0.05
Benz(a)anthracene	<0.01
Chrysene	<0.01
Benzo(a)pyrene	<0.01
Benzo(b)fluoranthene	<0.01
Benzo(k)fluoranthene	<0.01
Indeno(1,2,3-cd)pyrene	<0.01
Dibenz(a,h)anthracene	<0.01
Benzo(g,h,i)perylene	<0.05
2-Methylnaphthalene	<0.05

Note: The sample was centrifuged prior to extraction.

Date of Report: 10/31/13
Date Received: 10/11/13
Project: T30 Port of Seattle JE1005.09, F&BI 310208

QUALITY ASSURANCE RESULTS FOR THE ANALYSIS OF WATER SAMPLES FOR BENZENE, TOLUENE, ETHYLBENZENE, XYLENES, AND TPH AS GASOLINE USING EPA METHOD 8021B AND NWTPH-Gx

Laboratory Code: 310232-02 (Duplicate)

Analyte	Reporting Units	Sample Result	Duplicate Result	RPD (Limit 20)
Benzene	ug/L (ppb)	<1	<1	nm
Toluene	ug/L (ppb)	<1	<1	nm
Ethylbenzene	ug/L (ppb)	<1	<1	nm
Xylenes	ug/L (ppb)	<3	<3	nm
Gasoline	ug/L (ppb)	<100	<100	nm

Laboratory Code: Laboratory Control Sample

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Acceptance Criteria
Benzene	ug/L (ppb)	50	82	65-118
Toluene	ug/L (ppb)	50	89	72-122
Ethylbenzene	ug/L (ppb)	50	90	73-126
Xylenes	ug/L (ppb)	150	91	74-118
Gasoline	ug/L (ppb)	1,000	103	69-134

Date of Report: 10/31/13
Date Received: 10/11/13
Project: T30 Port of Seattle JE1005.09, F&BI 310208

QUALITY ASSURANCE RESULTS FOR THE ANALYSIS OF WATER SAMPLES FOR TOTAL PETROLEUM HYDROCARBONS AS DIESEL EXTENDED USING METHOD NWTPH-Dx

Laboratory Code: Laboratory Control Sample Silica Gel

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Percent Recovery LCSD	Acceptance Criteria	RPD (Limit 20)
Diesel Extended	ug/L (ppb)	2,500	66	73	61-133	10

Date of Report: 10/31/13
Date Received: 10/11/13
Project: T30 Port of Seattle JE1005.09, F&BI 310208

QUALITY ASSURANCE RESULTS FOR THE ANALYSIS OF WATER SAMPLES FOR PNA'S BY EPA METHOD 8270D SIM

Laboratory Code: Laboratory Control Sample

Analyte	Reporting Units	Spike Level	Percent Recovery LCS	Percent Recovery LCSD	Acceptance Criteria	RPD (Limit 20)
Naphthalene	ug/L (ppb)	1	82	85	67-116	4
Acenaphthylene	ug/L (ppb)	1	87	89	65-119	2
Acenaphthene	ug/L (ppb)	1	87	89	66-118	2
Fluorene	ug/L (ppb)	1	87	89	64-125	2
Phenanthrene	ug/L (ppb)	1	87	90	67-120	3
Anthracene	ug/L (ppb)	1	90	92	65-122	2
Fluoranthene	ug/L (ppb)	1	92	94	65-127	2
Pyrene	ug/L (ppb)	1	90	92	62-130	2
Benz(a)anthracene	ug/L (ppb)	1	87	89	60-118	2
Chrysene	ug/L (ppb)	1	89	93	66-125	4
Benzo(b)fluoranthene	ug/L (ppb)	1	93	96	55-135	3
Benzo(k)fluoranthene	ug/L (ppb)	1	87	95	62-125	9
Benzo(a)pyrene	ug/L (ppb)	1	90	95	58-127	5
Indeno(1,2,3-cd)pyrene	ug/L (ppb)	1	93	99	36-142	6
Dibenz(a,h)anthracene	ug/L (ppb)	1	79	92	37-133	15
Benzo(g,h,i)perylene	ug/L (ppb)	1	82	91	34-135	10
2-Methylnaphthalene	ug/L (ppb)	1	85	88	63-122	3

Data Qualifiers & Definitions

a - The analyte was detected at a level less than five times the reporting limit. The RPD results may not provide reliable information on the variability of the analysis.

A1 – More than one compound of similar molecule structure was identified with equal probability.

b - The analyte was spiked at a level that was less than five times that present in the sample. Matrix spike recoveries may not be meaningful.

ca - The calibration results for this range fell outside of acceptance criteria. The value reported is an estimate.

c - The presence of the analyte indicated may be due to carryover from previous sample injections.

d - The sample was diluted. Detection limits may be raised due to dilution.

ds - The sample was diluted. Detection limits are raised due to dilution and surrogate recoveries may not be meaningful.

dv - Insufficient sample was available to achieve normal reporting limits and limits are raised accordingly.

fb - Analyte present in the blank and the sample.

fc – The compound is a common laboratory and field contaminant.

hr - The sample and duplicate were reextracted and reanalyzed. RPD results were still outside of control limits. The variability is attributed to sample inhomogeneity.

ht - Analysis performed outside the method or client-specified holding time requirement.

ip - Recovery fell outside of normal control limits. Compounds in the sample matrix interfered with the quantitation of the analyte.

j – The result is below normal reporting limits. The value reported is an estimate.

J - The internal standard associated with the analyte is out of control limits. The reported concentration is an estimate.

jl - The analyte result in the laboratory control sample is out of control limits. The reported concentration should be considered an estimate.

jr - The rpd result in laboratory control sample associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

js - The surrogate associated with the analyte is out of control limits. The reported concentration should be considered an estimate.

lc - The presence of the compound indicated is likely due to laboratory contamination.

L - The reported concentration was generated from a library search.

nm - The analyte was not detected in one or more of the duplicate analyses. Therefore, calculation of the RPD is not applicable.

pc – The sample was received in a container not approved by the method. The value reported should be considered an estimate.

pr – The sample was received with incorrect preservation. The value reported should be considered an estimate.

ve - Estimated concentration calculated for an analyte response above the valid instrument calibration range. A dilution is required to obtain an accurate quantification of the analyte.

vo - The value reported fell outside the control limits established for this analyte.

x - The sample chromatographic pattern does not resemble the fuel standard used for quantitation.

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: FBI011-95 **PAGE 1**
REPORT DATE: 10/21/13
DATE SAMPLED: 10/10/13 **DATE RECEIVED:** 10/11/13
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM FRIEDMAN & BRUYA, INC. / PROJECT NO. 310208

CASE NARRATIVE

Four water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

SAMPLE DATA

SAMPLE ID	BOD5 (mg/L)	COD (mg/L)
MW89	5.62	47.5
MW92	2.22	60.4
MW42	5.68	59.2
MW58A	13.3	19.4

AQUATIC RESEARCH INCORPORATED
LABORATORY & CONSULTING SERVICES
3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**FBI011-95**		**PAGE 3**
REPORT DATE:	**10/21/13**		
DATE SAMPLED:	**10/10/13**	**DATE RECEIVED:**	**10/11/13**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM FRIEDMAN & BRUYA, INC. / PROJECT NO. 310208

QA/QC DATA

QC PARAMETER	BOD5 (mg/L)	COD (mg/L)
METHOD	SM 5210B	SM18 5220D
DATE ANALYZED	10/11/13	10/20/13
DETECTION LIMIT	2.00	10.0
DUPLICATE		
SAMPLE ID	BATCH	BATCH
ORIGINAL	615	19.4
DUPLICATE	576	19.4
RPD	6.55%	0.00%
SPIKE SAMPLE		
SAMPLE ID		BATCH
ORIGINAL		19.4
SPIKED SAMPLE		131
SPIKE ADDED		100
% RECOVERY	NA	111.72%
QC CHECK		
FOUND	4.41	94.6
TRUE	4.62	100
% RECOVERY	95.45%	94.62%
BLANK	<2.00	<10.0

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

SUBCONTRACT SAMPLE CHAIN OF CUSTODY

FB1011-95

Page # 1 of 1

Send Report To: Michael Erdahl
Company: Friedman and Bruya, Inc.
Address: 3012 16th Ave W
City, State, ZIP: Seattle, WA 98119
Phone #: (206) 285-8282 Fax #: (206) 283-5044

SUBCONTRACTER: Ag. Research.

PROJECT NAME/NO.: 310208

PO #: C577

REMARKS: Please Email Results

TURNAROUND TIME
- [x] Standard (2 Weeks)
- ☐ RUSH
- Rush charges authorized by:

SAMPLE DISPOSAL
- ☐ Dispose after 30 days
- ☐ Return samples
- ☐ Will call with instructions

Sample ID	Lab ID	Date Sampled	Time Sampled	Matrix	# of jars	Dioxins and Furans by 8290	EPH	VPH	Nitrate	Sulfate	Alkalinity	BOD	COD			Notes
MW89		10/10/13	21:10	water	2							X	X			
MW92		↓	18:25	↓	2							X	X			
MW42		↓	21:00	↓	2							X	X			
MW58A		↓	19:00	↓	2							X	X			

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282
Fax (206) 283-5044

SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by: [signature]	Michael Erdahl	Friedman & Bruya	10/11/13	12:35
Received by: [signature]	S. Killeen	[illegible]	10/11/13	1800
Relinquished by:				
Received by:				

310208

SAMPLE CHAIN OF CUSTODY ME 10-11-13 V2/BI4/C03

Send Report To Glen Wallace
Company Pacific Groundwater Group
Address 2377 Eastlake Ave E
City, State, ZIP Seattle, WA 98102
Phone # 206 329 0141 Fax # 206 329 6968

SAMPLERS (signature)

PROJECT NAME/NO. T30 Port of Seattle. PO # JE1005.09

REMARKS

Page # ____ of ____

TURNAROUND TIME
☐ Standard (2 Weeks)
☐ RUSH
Rush charges authorized by:

SAMPLE DISPOSAL
☐ Dispose after 30 days
☐ Return samples
☐ Will call with instructions

ANALYSES REQUESTED

Sample ID	Lab ID	Date	Time	Sample Type	# of containers	TPH-Diesel	TPH-Gasoline	BTEX by 8021B	VOCs by 8260	SVOCs by 8270	HFS	NWTPH-Dx w/ silica gel cleanup	NWTPH-G	BTEX by 8021B	PAH SIM 8270D w/ centrifuge prep	COD	BOD	Notes
MW89	01 A-H	10/10/13	21:10		8							X	X	X	X	X	X	
MW92	02		18:25		8							X	X	X	X	X	X	
MW42	03		21:00		8							X	X	X	X	X	X	
MW58A	04		19:00		8.							X	X	X	X	X	X	

RL consistent w/ project file.

Friedman & Bruya, Inc.
3012 16th Avenue West
Seattle, WA 98119-2029
Ph. (206) 285-8282
Fax (206) 283-5044

	SIGNATURE	PRINT NAME	COMPANY	DATE	TIME
Relinquished by:	[signature]	Inger Jackson	PGG	10/11/13	11:28
Received by:	[signature]	Eric Young	F&B Inc.	10/11/13	11:20
Relinquished by:					
Received by:					

FORMS\COC\COC.DOC

Samples received at 0 °C

P 206.329.0141 | **F** 206.329.6968

2377 Eastlake Avenue East | Seattle, WA 98102

P 206.842.3202 | **F** 206.842.5041

8150 West Port Madison NE | Bainbridge, WA 98110

P 360.570.8244 | **F** 360.570.0064

1627 Linwood Avenue SW | Tumwater, WA 98512

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